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Biological Factors Influencing the Acquisition of Arabic as a Foreign Language

Mukmin Ridoan Simamora[1], Arif Rachman Ritonga[2], Mufidah Asri Azizah[3], Yanda Rismawati[4], Muhammad Hamdani[5]
[12345]Universitas Islam Negeri Sunan Kalijaga Yogyakarta; Indonesia
Correspondence E-mail; mukminridoar2001.sra@gmail.com

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Abstract

This study aims to provide an in-depth examination of how biological factors, including brain development, cognitive capacity, neurological processes, and age-related maturity, influence the acquisition of Arabic as a foreign language. The research method used a literature review method, analyzing empirical studies, books, and relevant academic articles published between 2015 and 2025. The literature was systematically selected through Scopus, Google Scholar, and Crossref, following PRISMA guidelines, and analyzed using a thematic narrative approach. The research findings indicate that Arabic language acquisition is strongly influenced by the phenomenon of the critical period, which is the phase when language learning is most optimal before the age of 12, when neural plasticity is at its peak. Nevertheless, neurological studies have shown that the adult brain is still capable of acquiring Arabic through neuroplastic processes that allow the reorganization of neural networks and the activation of key linguistic areas. Furthermore, differences in cognitive capacity also help explain variations in vocabulary retention and grammatical competence among learners. His study emphasizes the importance of understanding biological factors, such as brain maturation, neurolinguistic processes, working memory capacity, and age differences, in Arabic language learning. Teachers need to adjust teaching methods and materials according to learners' cognitive stages and age, using consistent language exposure and guided practice. Integrating these biological findings can enhance learning effectiveness and support the development of an adaptive curriculum.

Keywords Biological Factors, Language Acquisition, Arabic Language.

INTRODUCTION

The acquisition of Arabic as a foreign language is a highly complex process and is not solely determined by pedagogical approaches or learning environments, but also by biological factors that influence an individual's basic capacity to comprehend, produce, and internalize language (Oktaviani et al., 2024). Many learners experience difficulties in recognizing Arabic sounds, structures, and vocabulary, not merely due to a lack of practice or learning strategies, but because of biological conditions that determine the readiness of the nervous system to process linguistic information (V. H. Huda & Ghufron, 2025). This indicates that biological factors are a fundamental component that must be understood in the context of Arabic language acquisition, especially when the language is learned as a foreign language (N. Huda, 2017)

In language acquisition studies, biological aspects play a crucial role because they are directly related to brain function, cognitive capacity, and neurological development, all of which support an individual's ability to understand and produce language (Vygotsky, 1978). Arabic, with its distinctive phonological, morphological, and syntactic characteristics, requires optimal biological and cognitive abilities to be learned effectively, particularly by non-native speakers (Annisa et al., 2023; Syahid, 2020)

Brain development from an early age has a significant influence on the ability to receive linguistic input, including the unique phonemes of Arabic (Syahid, 2020). Broca's and Wernicke's areas, for example, play essential roles in language production and comprehension, while neurological processes such as brain plasticity, neural network reorganization, and language-function lateralization determine the success of language acquisition (Burhanuddin & Fitriani., 2024). Cognitive capacities such as working memory, attention, and cognitive flexibility serve as the foundation for processing the complex structures of Arabic (Istiqomah et al., 2025). Meanwhile, age factors within the framework of the Critical Period Hypothesis (CPH) create an important distinction between language acquisition abilities in children and adults (Mubarak, 2024).

Arabic possesses linguistic characteristics that make the role of biological factors even more crucial (N. Huda, 2017). Unique sounds, such as **ص، ض، ط، ظ**, and interdentals like **ث، ذ**, require high auditory sensitivity and mature articulatory abilities. Additionally, its root-based morphological system, e.g., (**ز د ج**), requires strong analytical cognitive capacity to understand word patterns and semantic relations (Ulum, 2024). The complex syntactic structure of Arabic also

requires robust working memory performance, enabling learners to process and organize sentence elements simultaneously (Yunisa, 2022). These unique features show that acquiring Arabic is strongly linked to the learner's biological conditions and readiness (Burhanuddin & Fitriani, 2017).

Several previous studies have highlighted factors influencing the acquisition of Arabic as a foreign language. For instance, the study by (Annisa et al., 2023), indicates that strong and sustained motivation, a good understanding of differences between the first language and Arabic, and social factors are key elements influencing Arabic acquisition. Meanwhile, a study by (Oktaviani et al., 2024) It states that the learning environment, motivation, and the availability of resources play a crucial role in the language acquisition process.

Another study by (Ungu & Asyatibi, 2023), argues that language acquisition in children tends to occur unintentionally, with emphasis placed on the role of the environment, which can help minimize phonemic errors produced by learners. Furthermore, research by (Simorangkir et al., 2024), shows that language acquisition results from a complex interaction between innate biological abilities and environmental stimulation, especially social interaction. Similarly, (Muzaqi, 2024), emphasizes the need to understand second language acquisition from several aspects, namely the language environment, learning methodology, and learner motivation.

Previous studies indicate that most research has focused on external factors, such as motivation, social interaction, teaching methods, and the learning environment. Moreover, no prior studies have systematically mapped biological developmental stages (e.g., neurological maturation, working-memory capacity, phonological sensitivity) to learners' abilities in understanding Arabic phonemes, morphology, and syntax. The absence of such data limits our understanding of the biological–linguistic relationship in Arabic language learning. This gap suggests that the literature on Arabic language acquisition has yet to provide a comprehensive explanation of how biological mechanisms operate in learners.

The urgency of this study lies in the need for a more specific understanding of how biological readiness influences an individual's ability to learn Arabic. Knowledge of biological factors can help teachers determine learning strategies that align with students' neurological and cognitive conditions, making the language acquisition process more effective. Moreover, findings related to biological factors can serve as a basis for developing curricula, teaching methods, and assessments that are adaptive to the actual needs of learners. This is important so that Arabic language learning does not rely solely on pedagogical approaches but also on scientific understanding of the learners'

biological capacities.

Based on these conditions, research on biological factors in the acquisition of Arabic as a foreign language is crucial. This study aims to provide an in-depth explanation of how biological aspects, ranging from brain development and cognitive capacity to neurological processes and age maturity, play a role in the acquisition of Arabic. Thus, the study is expected to provide both theoretical and practical contributions to the development of more effective, evidence-based Arabic language learning.

METHOD

This study employs a qualitative approach using library research(Assyakurrohim et al., 2022). This approach was chosen because all analyzed data were derived from scientific literature, including journals, books, and relevant academic articles, without field data collection. Such an approach enables the researcher to thoroughly examine theories, previous research findings, and scientific concepts related to biological factors influencing the acquisition of Arabic as a foreign language (Syahrizal & Jailani, 2023). Additionally, this method facilitates comparative analysis and the synthesis of information from various sources, allowing the researcher to construct a comprehensive and conceptual understanding of the role of biological factors in Arabic language acquisition.

The literature search strategy was carried out through three academic databases Scopus, Google Scholar, and Crossref, considering their multidisciplinary coverage relevant to cognitive development, neurolinguistics, and second language acquisition (Fadl, 2021). The keywords used included: foreign language acquisition, cognitive development, neurological processes, brain development in language acquisition, and age maturity.

To ensure the relevance of the literature, inclusion and exclusion criteria were established(Crisweel, 2016). The inclusion criteria consisted of: (1) empirical research articles, both quantitative and qualitative; (2) published between 2015–2025; (3) centered on biological factors; (4) discussing brain development, cognitive capacity, neurological processes, and age maturity in Arabic language acquisition; and (5) published in reputable scientific journals. The exclusion criteria included: (1) studies focusing solely on non-biological factors such as motivation, social environment, or pedagogy without incorporating biological aspects; and (2) articles in the form of non-systematic narrative reviews.

The literature selection process followed the PRISMA flow, which consists of four stages: (1) identification of articles from the databases; (2) initial screening based on titles and abstracts; (3) eligibility evaluation through full-text reading; and (4) inclusion based on alignment with the established criteria.

To enhance data reliability and analytical quality, this study employed peer review checking by involving academic supervisors or colleagues to assess the relevance, accuracy, and validity of the selected literature (Rukhmana et al., 2022). This process was reinforced with cross-source triangulation, ensuring that the findings obtained are methodologically stronger. The selected literature was then analyzed using a thematic narrative approach, with findings categorized into four main dimensions: (1) brain maturation; (2) neurological processes; (3) cognitive capacity; and (4) age of language acquisition. These findings were synthesized to provide a holistic description of the role of biological factors in the acquisition of Arabic as a foreign language. Through this methodological procedure, the study is expected to produce a valid and systematic literature synthesis that can serve as a reference for developing learning strategies and evidence-based educational policies.

FINDINGS AND DISCUSSION

Findings

The results of the literature review in this study affirm that biological factors play a crucial role in the acquisition of Arabic as a foreign language. To comprehensively understand the contribution of biological factors, this study emphasizes four main dimensions: brain maturation, neurological processes, cognitive capacity, and age. The selection of literature focused on sources that explicitly discuss the relationship between biological aspects and the mechanisms of Arabic language acquisition, thereby providing a comprehensive understanding of the internal foundations of language acquisition.

To clarify the relevance of each study to the research focus, a summary of the literature is presented in the table below. The table summarizes the researchers, study focus, biological relevance, and the contribution of each finding to the understanding of biological factors in the acquisition of Arabic as a foreign language.

Table 1. Summary of Literature Review

No.	Researchers & Year	Focus of Study	Biological Relevance	Contribution to the Discussion
1	Arturo E. Hernández et al. (2022)	Critical Period for Second Language Acquisition	Brain maturation & critical period	Explains that language acquisition ability declines after age 17, supporting the discussion on age and neural plasticity.
2	Simorangkir et al. (2024)	Language acquisition & speech organs	Articulatory organs & neuromotor readiness	Shows the role of articulatory organs and neuromotor development in producing Arabic phonemes.
3	Sruni Rama Lestari et al. (2024)	Language acquisition & biological development	Brain development & phonological processing	Supports the argument that brain maturation influences children's ability to acquire Arabic phonemes.
4	Primadasa et al. (2023)	Multilingual ability & brain areas	Broca's area, Wernicke's area, prefrontal cortex	Explains the activation of brain areas involved in phonological, syntactic, and semantic processing of Arabic.
5	Muliana & Fatmawati (2025)	Language comprehension process	Neurological system, memory, and semantic processing	Strengthens the discussion on how the brain functions to understand Arabic structure.
6	Indah (2017)	Language disorders	Neurological functions & speech organs	Used to describe the link between neurological impairments and difficulties in language acquisition.
7	Istiqomah et al. (2025)	Speech delay	Neural development & brain maturation	Explains how delays in neurological development affect children's language acquisition.
8	Nelwati & Sasmi (2022)	Language development according to Piaget	Cognitive capacity & mental development	Supports the discussion on the role of cognitive capacity in understanding Arabic grammar.
9	Burhanuddin & Fitriani (2024)	Neuroscience-based learning	Nervous system, neuroplasticity, memory	Provides theoretical support regarding changes in brain structure during second-language learning in adults.
10	Tjahajawati et al. (2019)	Brain lateralization	Left–right hemisphere & language function	Relevant to discussions on hemispheric specialization in reading Arabic's unique visual patterns.
11	Susilawati et al. (2024)	Brain activity & stimulation	Neuronal activation & neural reconstruction	Supports arguments about neural reorganization during Arabic language acquisition.
12	Sembiring (2021)	Child language acquisition	Language development stages & nervous system	Strengthens the claim that children have biological advantages in language acquisition.
13	Hidayah et al.	First language	Acquisition process &	Serves as a comparative

	(2024)	acquisition	cognitive development	reference between L1 and L2 acquisition.
14	Boudelaa & Marslen-Wilson (2013)	Arabic morphology in the mental lexicon	Linguistic processing in the brain	Relevant to discussions of how Arabic root-and-pattern morphology is mapped in the mental lexicon.
15	Oktaviani et al. (2024)	Dynamics of Arabic acquisition	Psycholinguistic & neurological interaction	Supports the idea of interaction between internal (biological) and external factors in acquiring Arabic.

Based on the synthesized literature analysis above, brain maturation emerges as a fundamental foundation in the acquisition of Arabic, particularly in the ability to distinguish phonemes and understand Arabic morphological structures. The study by (Hernandez et al., 2022) emphasizes that language acquisition ability declines after approximately age 17, supporting discussions on the critical period and brain plasticity. Similarly, the research of (Simorangkir et al., 2024) and (Sruni Rama Lestari, Silvina Noviyanti, 2024) Demonstrates that neuromotor readiness and the development of speech organs influence an individual's ability to produce Arabic effectively.

Neurological processes also make a significant contribution. The activation of the Broca area, Wernicke area, and the prefrontal cortex indicates the involvement of multiple brain regions in processing phonology, syntax, and semantics (Primadasa et al., 2023). Furthermore, neural network reorganization and neuronal stimulation play a role in strengthening the integration of linguistic information, enabling learners to adapt to the complexity of the Arabic language (Susilawati et al., 2024)

In terms of cognitive capacity, the literature highlights analytical ability, working memory, and semantic processing as determining factors of learning effectiveness. Studies by (Nelwati & Rahman, 2022) and (Muliana et al., 2025) show that optimal cognitive capacity allows learners to understand Arabic structures more quickly and accurately. Meanwhile, the age factor affects phonological sensitivity and the brain’s adaptability to second language learning, which is particularly important for non-native learners (Boudelaa & Marslen-Wilson, 2013; Tjahajawati et al., 2019).

Discussion

Brain Maturation and Neural Plasticity in the Acquisition of the Arabic Language

Brain maturation is a fundamental biological factor that influences an individual's ability to acquire Arabic as a second language (Lenneberg, 1967; Mondal & Prakash, 2024). Arabic possesses unique linguistic features such as emphatic phonemes (ص، ض، ط، ظ), guttural consonants (ج، خ، ع، غ), and a root-based morphological system (*al-jidhr al-tsulāthī*), which require optimal neurological development for learners to process these complexities effectively (Hidayah et al., 2024). During childhood, the development of Broca's and Wernicke's areas progresses rapidly, enabling children to process phonological and syntactic stimuli in Arabic with greater sensitivity than adults (Nur Tanfidiyah & Ferdian Utama, 2019).

Phonologically, the ability to distinguish Arabic-specific sounds is closely related to the maturation of the auditory cortex and Wernicke's area. Phonemes such as /ḍ/ (ض) or /ṣ/ (ص) demand precise phonetic perception and complex coordination between articulatory organs and the central nervous system. Children in the early stages of brain development possess higher phonological plasticity, allowing them to imitate and internalize Arabic sounds more naturally (Annisa et al., 2023). In contrast, adults often reproduce these sounds using the phonological patterns of their first language, resulting in persistent accents or articulation errors (Huszka et al., 2024).

From syntactic and morphological perspectives, the maturation of the prefrontal cortex directly influences the ability to map *wazan* patterns and root structures (Ciaccio et al., 2025). Arabic morphology is non-linear, requiring learners to associate specific vowel patterns with consonantal roots to generate derived words with different meanings (Cometa et al., 2024; Sruni Rama Lestari, Silvina Noviyanti, 2024). Children with well-developed working memory can store *wazan* patterns such as *fa'ala–yaf'alu*, *fa''ala–yufa''ilu*, or *istaf'ala–yastaf'ilu* in a short time and apply them in new contexts (Isbah et al., 2022). Conversely, limited working memory in adult learners slows their ability to understand and apply complex morphological patterns (Hanifansyah, 2025).

The Critical Period Hypothesis (CPH) posits that the ability to achieve native-like proficiency in a second language (L2) is restricted to a specific age range, particularly before late adolescence (Birdsong, 1999; Hernandez et al., 2022). identifies the upper limit of this period at around age 17, after which learning Arabic phonology and syntax becomes more challenging (Hernandez et al.,

2022; Putri, 2020). However, the neural plasticity present in children enables them to acquire Arabic's unique phonemes more naturally than adults (Boudelaa & Marslen-Wilson, 2013).

Neural plasticity in children allows for the formation of new neural pathways for processing phonemes and morphological patterns in Arabic. Children can assimilate subtle differences between sounds such as /ḥ/ (ح) and /h/ (ه), or between /ʿayn/ (ع) and /hamzah/ (ء), because their phonological system has not yet solidified and remains highly responsive to new input (Nelwati & Rahman, 2022). In adult learners, phonological pathways are relatively stable, requiring repeated articulation practice, explicit instruction, and phonetic correction to overcome first-language phonological interference (Boudelaa & Marslen-Wilson, 2013).

Moreover, learning Arabic demands a high level of morphosyntactic processing, such as understanding meaning changes caused by vowel alternations, distinguishing between *fiʿil māḍī* and *muḍāriʿ*, and mastering *iʿrāb*. These complex processes require integration between Broca's area (language production) and the prefrontal cortex (executive control) (Al-Finatunni'mah & Nurhidayati, 2020; Hernandez et al., 2022). In children, these integrative pathways develop naturally through repeated use in communicative contexts. In adults, the process is slower due to their reliance on analytical strategies and reduced neural plasticity (Muhammad Peri Syaprizal, 2021).

In conclusion, the acquisition of Arabic is significantly influenced by brain maturation and the learner's level of neural plasticity. Children possess biological advantages that allow them to master Arabic phonology and morphology more naturally, whereas adult learners require more explicit and systematic learning strategies. These findings underscore the importance of initiating Arabic language learning at an early age, especially for the uniquely challenging phonological and morphological aspects, to ensure optimal and sustainable acquisition.

Neurological Processes in the Acquisition of the Arabic Language

Neural Network Reorganization

An in-depth examination of neurological aspects in the acquisition of Arabic reveals that learning Arabic as a foreign language in adulthood is a highly complex process that extends far beyond ordinary learning activities (Aldhaheri et al., 2024; Oktaviani et al., 2024). Neurologically, this process triggers significant reorganization of neural networks in the brain, indicating that the brain does not merely store new information but actively reshapes its internal structures and functions to adapt to new linguistic challenges (Chomsky, 1965; Susilawati et al., 2024). This reorganization involves changes in brain areas responsible for working memory, phonological and

semantic processing, and executive control, such as the prefrontal cortex, superior temporal gyrus, and hippocampus (Hasanah et al., 2019).

Recent neuroscience studies show that learning Arabic in adulthood can stimulate increased synaptic connectivity, dendritic growth, and the reactivation of previously dormant neural pathways (Burhanuddin & Fitriani., 2024). Moreover, intensive use of a second language has been associated with increased gray matter volume in specific brain regions and enhanced efficiency of neural networks overall (Rahman, 2024). These neural adaptations not only support the acquisition of the language itself but also strengthen other cognitive capacities such as selective attention, problem-solving, and long-term memory (Burhanuddin & Fitriani., 2024).

This phenomenon demonstrates that although the critical period of brain development during which children naturally acquire language more easily has passed, the adult brain still retains an adaptive neuroplastic capacity (Hernandez et al., 2022). With appropriate learning methods, strong motivation, and consistent exposure, the adult brain is capable of undergoing neurological transformations that enable effective acquisition of a new language (Burhanuddin & Fitriani, 2017). These findings hold important implications for teaching Arabic to adult learners, emphasizing that age limitations are not absolute barriers but challenges that can be addressed through approaches grounded in brain function and internal cognitive processes.

Lateralization of Language Functions

Research in neurolinguistics continues to uncover the complexity of functional distribution between the brain's left and right hemispheres in language processing, including in the acquisition of Arabic as a second language (Rianita, 2024). Lateralization where certain functions are predominantly controlled by one hemisphere is dynamic and adaptive, depending on language proficiency levels and the type of linguistic activity involved (Tjahajawati et al., 2019). Generally, the left hemisphere is the primary center for language functions, particularly those related to syntactic structure, morphology, and verbal articulation (Muliana et al., 2025). However, in the context of learning Arabic, this pattern of lateralization exhibits unique variations due to the involvement of distinct visual-spatial features in the Arabic writing system (Boudelaa & Marslen-Wilson, 2013).

Specifically, reading Arabic triggers heightened activation of the right hemisphere, which is responsible for spatial processing, visual form recognition, and directional orientation. This is attributed to the unique characteristics of Arabic script: right-to-left writing, connected letter forms, and positional variations of letters within words. The right hemisphere plays a significant role in

interpreting these complex visual patterns, while the left hemisphere continues to contribute to phonetic decoding and lexical understanding. Thus, reading Arabic requires more intensive cross-hemispheric coordination compared to languages written with Latin-based alphabets (Muliana et al., 2025).

Meanwhile, in listening activities, the interaction between both hemispheres becomes more balanced. The left hemisphere remains dominant in linguistic aspects such as sentence structure recognition and semantics, whereas the right hemisphere contributes to the perception of intonation, rhythm, and emotional nuance (Indah, 2017). In speaking or language production, dominance of the left hemisphere remains consistent, particularly in controlling speech motor functions through Broca's area and constructing syntactic structures (Indah, 2017). These findings demonstrate that, although fundamental patterns of lateralization persist, the acquisition of Arabic elicits uniquely distributed brain activation, depending on the specific linguistic activity being performed.

These insights have important implications for Arabic language teaching, especially in developing instructional strategies that optimally stimulate both hemispheres (Siregar, 2022). Approaches that integrate visual-spatial elements (such as graphic-based Arabic script training) with phonetic and productive language exercises are likely to be more effective in strengthening neural networks involved in language lateralization. This understanding can therefore serve as a scientific foundation for designing teaching methods aligned with brain mechanisms, particularly for adult learners who face greater challenges in second-language acquisition.

Activation of Specific Brain Areas

When individuals, especially adults, are intensively exposed to Arabic linguistic input, significant activation occurs in specific brain areas, particularly the primary and secondary auditory cortices located in the temporal lobe (Lubis & Fitria, 2019). These areas are highly sensitive to acoustic features such as frequency, duration, and intonation patterns, all of which are crucial for distinguishing phonemic characteristics (Dewey & Green, 2024). Arabic possesses unique phonological richness, including emphatic consonants (e.g., /ṣ/, /ḍ/, /ṭ/, /ẓ/) and phonemes not found in many other languages, such as 'Ayn (ع) and Ḥāʾ (ح), which require complex articulatory processes (Lubis & Fitria, 2019).

Neural activation in these areas enables deep phonetic and phonological processing, including the formation of long-term phonemic maps that support the development of listening and speaking skills (Munawarah et al., 2024). Beyond the temporal lobe, the prefrontal cortex also plays

a critical role in integrating semantic and syntactic information and in making linguistic decisions during speech or sentence comprehension (Rustan, 2020). This activation is further reinforced by the involvement of the hippocampus, which aids in consolidating long-term memory, particularly in forming associations between words, their meanings, and usage contexts.

Based on these understandings, it can be concluded that stimulating these brain areas through neuroscience-based learning approaches, such as interactive audiovisual tools, spectral-based phonetic training, or contextual repetition exercises, has substantial potential to enhance the overall effectiveness of Arabic language acquisition. Such approaches not only facilitate stronger mental representations of vocabulary and linguistic structures but also activate and strengthen synaptic connections between brain areas that support language skills. In other words, Arabic language instruction grounded in neuroscientific principles can serve as a revolutionary strategy for optimizing learners' brain potential, whether in formal or non-formal educational settings.

Cognitive Capacity in the Acquisition of the Arabic Language

Cognitive capacity is an essential foundation in the process of second language acquisition, including Arabic. In the context of neuroscience and cognitive psychology, cognitive capacity refers to the brain's ability to manage various higher-order mental functions, including attention, working memory, information processing, cognitive flexibility, and linguistic decision-making. All of these components work in an integrated manner when an individual learns Arabic, which possesses distinctive and complex phonological, morphological, and syntactic structures compared to many other languages (Nelwati & Rahman, 2022). For example, the ability to distinguish and produce unique Arabic phonemes such as /ʿ/ (ع), /ḥ/ (ح), and emphatic sounds like /ṣ/ (ص) or /ḍ/ (ض) requires strong phonological memory and high auditory precision.

In addition, working memory plays a crucial role in retaining linguistic information for short periods while it is being used in sentence decoding or speech production (Yulia Siska, 2020). In mastering the complex grammar of Arabic, such as *iʿrāb* (case endings determined by syntactic function), learners must simultaneously process and store morphological and syntactic information. Strong working memory capacity enables individuals to break down complex sentences, understand contextual meaning, and identify relationships between sentence elements more efficiently (Kurniati, Yusi, Serapina Serapina, 2024).

Selective attention is also an important aspect in acquiring Arabic, particularly when individuals encounter rapid and varied language input in oral or written forms. *Fusha* (standard

Arabic) and *ʿammiyah* (dialects), which differ in vocabulary and pronunciation, require cognitive abilities to focus attention on specific linguistic patterns while filtering out irrelevant information (Ni'mah, 2024). Meanwhile, cognitive flexibility, the ability to switch between thinking strategies or adapt to new rules, greatly helps in differentiating between sentence constructions in one's native language and Arabic, as well as preventing linguistic interference (V. H. Huda & Ghufron, 2025).

Cognitive capacity is also closely linked to the brain's executive functions, especially in the context of bilingualism or multilingualism (Primadasa et al., 2023). Neurolinguistic studies show that individuals actively learning a second language like Arabic tend to exhibit increased activity in the prefrontal cortex, which is responsible for inhibitory control, linguistic planning, and managing cognitive conflict between languages (Jayakumar et al., 2024). This process not only affects language mastery itself but also contributes to overall cognitive enhancement, such as improved problem-solving skills, emotional regulation, and verbal creativity (Nelwati & Rahman, 2022).

In instructional contexts, strong cognitive capacity can be enhanced through teaching strategies oriented toward the development of brain functions, such as the use of higher-order thinking skills (HOTS), reinforcement of mnemonic strategies in vocabulary acquisition, and activities that encourage language-based problem solving (Aziz et al., 2024). Additionally, the integration of digital media and interactive educational technologies has been shown to enrich cognitive stimulation and accelerate the strengthening of linguistic representations in the brain (Suryadi & Muslhlih, 2019).

Thus, understanding cognitive capacity is not only essential for understanding the process of acquiring Arabic but also serves as the basis for designing adaptive and learner-centered curricula and teaching methods rooted in learners' internal potential. Such an approach indirectly supports the effectiveness of Arabic language instruction, particularly for non-native speakers and adult learners who require more complex cognitive stimulation to overcome barriers in second language acquisition.

Age in Second Language Acquisition

Age is one of the biological factors that significantly determines the success of acquiring Arabic as a second language (Hidayah et al., 2024). Within the framework of the Critical Period Hypothesis (CPH), the period preceding puberty is considered the phase during which the brain exhibits the highest degree of plasticity, enabling the intuitive acquisition of language, particularly in phonological aspects. This finding aligns with Krashen's Acquisition–Learning Hypothesis,

which asserts that children rely more on subconscious acquisition than conscious learning (Krashen, 1988). Consequently, they are more capable of mastering distinctive Arabic phonemes such as the pharyngeal sounds /ʿ/ and /ḥ/ and the emphatic sounds /ṣ/, /ḍ/, /ṭ/, and /ẓ/ through natural imitation (Warseto et al., 2019). Krashen emphasizes that acquisition occurs when sufficient input and optimal affective conditions are present, thus the superior ability of children to imitate sounds indicates that their acquisition device functions more actively than that of adults (Munawarah et al., 2024).

In addition to phonology, early age also influences the intuitive ability to grasp the root–pattern (akar wazan) morphology of Arabic. Studies show that children under the age of 12 recognize morphological patterns and word-form changes (taṣrīf) more quickly, even without formally understanding grammatical terminology. This condition corresponds to the Natural Order Hypothesis, which states that language structures are acquired in a natural sequence rather than according to the sequence of instruction (Warseto et al., 2019). Repeated exposure through natural linguistic environments such as simple Arabic conversations, children's songs, and Arabic educational media, significantly strengthens their foundational Arabic competence (Hidayah et al., 2024).

Meanwhile, adult learners face greater phonological barriers because brain plasticity gradually decreases, acquiring pharyngeal and emphatic phonemes more dependent on conscious learning rather than natural imitation (Fitriyani et al., 2025). This phenomenon is not only related to the CPH but also reinforces the dominance of the learning system in adult learners as explained by Krashen. However, adults excel in learning the complex structural aspects of Arabic. With a higher capacity for abstract thinking, they more easily comprehend grammatical rules such as *iʻrāb*, nominal–verbal sentence structures (*jumlah ismiyyah* and *jumlah fiʻliyyah*), and syntactic relationships that require logical reasoning (Boudelaa & Marslen-Wilson, 2013). At this stage, the Monitor Hypothesis operates more actively because adult learners use explicit knowledge to plan, monitor, and correct their language use (Krashen, 1988).

These cognitive advantages enable adult learners to acquire derivational morphology (*ṣarf*) more systematically, including word-formation patterns such as *afʻīl*, *mufāʻalah*, and *istifʻāl*. They also tend to be more effective in reading formal Arabic texts due to their well-developed metacognitive strategies and analytical skills (Nur Tanfidiyah & Ferdian Utama, 2019). This is consistent with Krashen's view that learning can strengthen linguistic ability, yet meaningful input is still required for explicit knowledge to transform into genuine communicative competence

(acquisition) (Warseto et al., 2019).

Although children possess biological advantages in phonological acquisition and linguistic intuition, adolescents and adults can still achieve high proficiency in Arabic when appropriate learning strategies are applied (Annur et al., 2023). Internal motivation, disciplined practice, and intensive exposure to Arabic digital media such as *khithabah* videos, podcasts, or online learning platforms help reduce emotional barriers and create optimal learning conditions. This process aligns with the Affective Filter Hypothesis, which states that high motivation and low anxiety allow linguistic input to be processed more effectively and enter the acquisition system (Gultom, 2020).

Thus, age is not only a determinant of biological capacity for language acquisition but also closely related to the mechanisms of second language acquisition as described by Krashen. Children require contextual learning, play-based activities, and natural input to strengthen phonological acquisition and implicit grammar, in line with the principle of comprehensible input. Conversely, adult learners benefit more from analytical approaches, structural exercises, pattern recognition, and guided communicative practice to master complex syntactic and morphological aspects, while still relying on meaningful input as the core driver of acquisition. Adapting learning strategies based on age and Krashen's theoretical framework enables the acquisition of Arabic to occur more effectively across all age groups.

Implications for Arabic Language Learning

The findings on the role of biological factors in the acquisition of the Arabic language carry several important implications for instructional practice. First, understanding brain maturation and the development of Broca's and Wernicke's areas highlights the importance of aligning instructional methods with learners' cognitive developmental stages. Overly abstract learning activities or that demand advanced language production at a stage when learners are not yet cognitively ready can hinder the effectiveness of language acquisition (Nurlaila, 2021).

Second, insights from neurolinguistic studies indicate that consistent and structured exposure to the language is essential for strengthening neural connections associated with the processing of phonology, morphology, and syntax in Arabic. Therefore, teachers are encouraged to employ guided repetition strategies, intensive listening exercises, and gradual language-production activities to optimize the neurological processes that support learning (Hasanah et al., 2019).

Third, working memory capacity as a biological factor requires teachers to design learning activities that do not overload learners' cognitive processes (Nasution & Fadilah, 2024). Instructional

materials should be presented gradually through scaffolding, integrating visual aids, audio input, and contextual examples to maintain an optimal cognitive load.

Finally, understanding age-related differences in language acquisition provides a foundation for teachers to apply strategies appropriate to learners' developmental characteristics. For younger learners, naturalistic, play-based, and repetitive activities are more effective, whereas older learners benefit from analytical, explicit, and metalinguistic-awareness-based approaches (Chafidzoh, 2020).

Overall, this study highlights that integrating biological and neurolinguistic findings into pedagogical practice can significantly enhance the effectiveness of Arabic language learning. Teachers and curriculum developers must consider these biological factors when designing instructional models that are more adaptive, scientifically grounded, and aligned with learners' developmental needs.

CONCLUSION

Various interrelated biological factors, including brain maturation, neurological processes, cognitive capacity, and age significantly influence the acquisition of Arabic as a foreign language. Brain maturation plays an essential role in determining an individual's readiness to learn a language. When the brain, particularly the Broca and Wernicke areas, has developed well, individuals are better able to comprehend and produce Arabic effectively. Additionally, neurological processes play a vital role, as the central nervous system is responsible for regulating language processing. Neuronal activity and connectivity between different brain regions determine how quickly and accurately linguistic information can be received and understood. Furthermore, cognitive capacity is another important factor that includes memory ability, attention, and thinking skills. Individuals with strong cognitive capacities tend to find it easier to absorb vocabulary, grammatical structures, and meanings in Arabic because they can process information efficiently. Lastly, age also has a significant influence on language acquisition. Children are in a critical period during which brain plasticity is at its highest, allowing them to absorb language naturally and effortlessly. Conversely, adults typically require more structured and analytical learning strategies. Thus, these four biological factors are interconnected and collectively influence the degree of success an individual may achieve in learning Arabic as a foreign language.

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