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NEUROSCIENCE AND THE LEARNING STAGES OF SANTRI: THE TRADITION OF QUR'AN MEMORIZATION IN ISLAMIC EDUCATION

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ABSTRAK

Tradisi hafalan Al-Qur'an di pesantren telah berlangsung berabad-abad, namun belum dikaji dari perspektif neurosains untuk memahami mekanisme pembelajaran otak santri. Pesantren menghadapi tantangan mengoptimalkan efektivitas pembelajaran hafalan, terutama untuk santri dengan kemampuan beragam, termasuk *slow learner*. Penelitian ini bertujuan menganalisis integrasi neurosains dalam tradisi hafalan Al-Qur'an, mengkaji relevansi metode tradisional dengan prinsip kerja otak, dan merumuskan rekomendasi pengembangan pembelajaran berbasis neurosains. Penelitian menggunakan metode kepustakaan dengan pendekatan kualitatif interdisipliner yang mengintegrasikan perspektif neurosains, pendidikan Islam, dan studi pesantren. Data dikumpulkan melalui studi dokumentasi literatur primer dan sekunder, dianalisis secara deskriptif, komparatif, dan sintetik dengan triangulasi sumber. Hasil penelitian menunjukkan metode hafalan tradisional seperti tiktir, tallaqi, murajaah, dan wahdah memiliki landasan neurobiologis kuat yang sejalan dengan prinsip neuroplastisitas, spaced repetition, dan pembelajaran sosial. Integrasi neurosains mengoptimalkan tahapan belajar santri melalui aktivasi otak kanan, kiri, dan tengah, serta strategi pembelajaran berbasis visualisasi, asosiasi, dan motivasi. Pendekatan ini efektif untuk berbagai karakteristik santri, termasuk implementasi metode tasmi', kitabah, dan hipnomotivasi bagi *slow learner*, yang berkontribusi pada peningkatan efektivitas pembelajaran tahfidz dalam pendidikan Islam kontemporer.

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Keywords:	ABSTRACTS
Neuroscience, Quranic memorization, pesantren, tahfidz	The tradition of Quranic memorization in pesantren has lasted for centuries, but has not been extensively studied from a neuroscience perspective to understand the learning mechanisms of students' brains. Pesantren face challenges in optimizing the effectiveness of memorization learning, especially for students with diverse abilities, including slow learners. This research aims to analyze the integration of neuroscience in the Quranic memorization tradition, examine the relevance of traditional methods with brain working principles, and formulate recommendations for neuroscience-based learning development. The research employs library research methods with an interdisciplinary qualitative approach that integrates neuroscience, Islamic education, and pesantren studies perspectives. Data were collected through documentary studies of primary and secondary literature, analyzed descriptively, comparatively, and synthetically with source triangulation. Research findings show that traditional memorization methods such as <i>tikrar</i> , <i>tallaqi</i> , <i>murajaah</i> , and <i>wahdah</i> have strong neurobiological foundations aligned with neuroplasticity principles, spaced repetition, and social learning. Neuroscience integration optimizes student learning stages through right, left, and middle brain activation, as well as learning strategies based on visualization, association, and motivation. This approach is effective for various student characteristics, including implementation of <i>tasmi'</i> , <i>kitabah</i> , and hypno-motivation methods for slow learners, contributing to improved <i>tahfidz</i> learning effectiveness in contemporary Islamic education.

A. INTRODUCTION

Qur'an memorization (*tahfidz*) is a tradition that has been deeply rooted in Islamic education for centuries. Dhofier states that this tradition is not only regarded as a means of preserving the purity of the sacred text, but also as a method for shaping the character and spirituality of Muslims (Dhofier, 2011). Jensen notes that in the context of modern education, the significance of Qur'an memorization lies not only in its spiritual and religious dimensions, but also in the cognitive impacts it produces (Jensen, 2018). The process of memorizing the Qur'an involves complex brain activities, ranging from auditory perception and linguistic processing to long-term memory storage.

However, according to Haryono et al., *tahfidz* practices in traditional Islamic boarding schools (*pesantren*) still rely on classical methods passed down through generations, such as *tikrar* (repetition), *tallaqi* (direct instruction from the teacher), and *muraja'ah* (regular review) (Haryono et al., 2023). Although these methods have proven effective in producing high-quality *hafidz*, a more systematic and scientific approach is needed to optimize the learning process, particularly in facing the challenges of the digital era and the diversity of students' learning styles. A study by Ikhwanuddin (2024) also explains that classical methods such as *talaqqi* and *halaqah* have advantages because they emphasize values of manners, sincerity, and the transformative relationship between teacher and student. Meanwhile, modern methods through digital means offer high accessibility but often neglect spiritual development and the depth of meaning. One approach suitable for memorization methods in bridging these two methods is the value-based digital learning model as an integrative approach, emphasizing the role of virtual teachers, strengthening the digital sanad, and internalizing values of manners and spirituality within a technology-based *tahfidz*.

ecosystem. However, the weakness of the *tahfidz* method digitalization needs to be managed with a value-based approach so that it is not only technically efficient but also maintains the authenticity and depth of Islamic education. There is a need for the development of value-based digital *tahfidz* platforms as a strategic agenda for Qur'anic education in the digital era.

In various cultures, the academic environment plays a significant role in strengthening the learning process in *pesantren*. The unique characteristics of *pesantren*, including the boarding school system, close teacher-student relationships, and an academic culture deeply rooted in Islamic values, create a learning ecosystem that holistically supports the *tahfidz* process. Madjid asserts that *pesantren*, as the oldest Islamic educational institutions in Indonesia, hold a strategic role in preserving the tradition of Qur'an memorization (Madjid, 2019). As centers of education that integrate intellectual, spiritual, and social dimensions, *pesantren* provide a conducive environment for developing Qur'an memorization abilities.

A Study states that *pesantren* face challenges in maintaining the quality of *tahfidz* outcomes while accommodating advancements in science and technology (Azis, 2023). The integration of neuroscience-based approaches into the *pesantren* education system may offer a solution for enhancing the effectiveness of *tahfidz* learning without diminishing the spiritual and traditional essence that characterizes *pesantren* education. Moreover, Ahmad & Rahman find that comparative studies show similarities between *pesantren* in Indonesia and those in Brunei Darussalam in their use of traditional *tahfidz* methods; however, variations exist in the implementation of technology and modern pedagogical approaches (Ahmad, 2019). This indicates the need for standardization and innovation in *tahfidz* learning methods that still maintain the traditional values of *pesantren*.

Bear (2020) states neuroscience is the science that studies the nervous system and brain functions, offering a new perspective in understanding learning processes and memory formation. In the context of Al-Qur'an memorization (*tahfidz*), the neuroscience approach can provide a scientific explanation of the brain's mechanisms during the memorization process, from sensory input to long-term memory consolidation. Meanwhile, in the study by Squire (2021), it is explained that the neuroscience approach shows that the memorization process involves various areas of the brain, including the hippocampus for the formation of new memories, the prefrontal cortex for executive control, and the Broca and Wernicke areas for language processing. Understanding these neurobiological mechanisms can help in developing learning strategies that are more effective and aligned with the brain's natural workings. Furthermore, the study by Willis (2017) shows that the neuroscience approach can provide solutions to overcome various challenges in *tahfidz*, such as learning difficulties in slow learner students, optimizing learning time, and developing objective evaluation methods. Integrating neuroscience principles into the *tahfidz* curriculum can also increase students' learning motivation through a better understanding of the processes occurring in their brains.

Furthermore, the neuroscience approach can offer solutions to various challenges in the *tahfidz* learning process, such as learning difficulties among slow-learning students, optimizing learning time, and developing objective evaluation methods (Willis, 2017). Integrating neuroscience principles into the *tahfidz* curriculum can also enhance

students' learning motivation through a better understanding of the processes occurring in their brains that can last long and be strong.

The reality strengthened by these various studies makes this paper important to present, with a focus on the idea that neuroscience principles can be integrated into the Qur'an memorization tradition in pesantren, adapted to the neurobiological characteristics of students through traditional tahfidz learning methods that are most compatible with findings from modern neuroscience. Therefore, the purpose of this paper is to analyze the relevance and application of neuroscience principles to tahfidz learning in pesantren to enhance students' memorization by examining the compatibility between traditional tahfidz learning methods and contemporary neuroscience findings. In addition, this paper aims to formulate recommendations for developing a neuroscience-based tahfidz curriculum and learning methods for pesantren.

This study is expected to contribute to the development and enrichment of learning theories using a neuroscience approach within Islamic education, particularly regarding the integration of modern science with traditional Qur'an memorization practices. Practically, this study can provide guidance for pesantren administrators and tahfidz instructors in developing a tahfidz curriculum that aligns with the scientifically understood workings of students' brains; help students understand the processes occurring in their own brains so that they can optimize personal learning strategies; and assist policymakers in formulating standards and regulations for tahfidz education based on evidence-based practice.

B. METHOD

This study uses a qualitative approach with a library research method, which is a series of activities related to the method of collecting library data, reading, and taking notes, as well as processing research materials (Zed, 2014). The selection of the library research method in this study is based on the consideration that the topic of neuroscience and the stages of students' learning in the tradition of Qur'an memorization requires in-depth analysis by exploring and analyzing theoretical concepts as well as empirical findings from various relevant disciplines, especially neuroscience, Islamic education, and pesantren (Islamic boarding school) studies.

- a. Data sources. The data sources in this study are classified into two main categories, namely primary and secondary data sources.
 - Primary data sources consist of the Qur'an and its translation as the main text that becomes the object of memorization, the hadiths of Prophet Muhammad PBUH related to the virtues and methods of memorizing the Qur'an, as well as classical literature on methods of Tahfidz written by previous scholars. In addition, recent scientific journals have discussed neuroscience in the context of education.
 - Secondary data sources include books, journals, articles, and references on neuroscience in education that provide a theoretical foundation, previous studies examining methods of memorizing the Qur'an from various perspectives, and reports and documentation of tahfidz practices in various pesantrens in Indonesia and other Muslim countries.
- b. Data collection in this study was carried out through systematic and in-depth documentation studies, in several steps, namely: 1) This process began with the identification of relevant literature sources through searches of academic databases,

- digital libraries, and university library catalogs; 2) the stage of evaluating the quality and relevance of each source based on established criteria; 3) the stage of collecting and classifying documents based on the main research themes, namely neuroscience in education, the tradition of Qur'an memorization, traditional tahfidz methods, and the integration of neuroscience in Student learning. Each collected document is then read in depth by taking notes on important points, key concepts, empirical findings, and relevant theoretical arguments.
- c. Analysis Techniques. The use of content analysis techniques to analyze the meaning and patterns found in the collected literature. Data analysis in this study is conducted through three main complementary approaches, namely:
- First, descriptive analysis is used to provide a comprehensive and systematic overview of various aspects being studied, and to detail the tradition of memorizing the Qur'an in Islamic boarding schools, from its history and underlying philosophy, the methods used to the challenges faced in its implementation. This analysis also includes an explanation of the principles of neuroscience in learning, how the brain works in the memorization process, and its relevance to the context of spiritually based education.
 - Second, a comparative analysis is conducted to compare various memorization methods and neuroscience approaches in learning. This comparison includes an analysis of the strengths and weaknesses of traditional memorization methods, such as *tikrar*, *tallaqi*, *murajaah*, and *wahdah*, compared to approaches based on neuroscience findings. The researcher also compares tahfidz practices in various pesantren to identify variations in their implementation and effectiveness.
 - Third, a synthesis analysis is used to integrate findings from various literature sources into a comprehensive understanding of the integration of neuroscience in the tradition of Qur'an memorization. Through synthesis analysis, the researcher develops new theoretical propositions that combine traditional wisdom in tahfidz methods with the latest findings in neuroscience. This synthesis process results in practical recommendations for the development of more effective and appropriate learning methods for the human brain.

C. RESULT AND DISCUSSION

Neuroscience from the Perspective of Islamic Education

Educational neuroscience is an interdisciplinary field that examines the nervous system, brain structure, and neurological functions in relation to human behavior and cognitive processes (Goswami, 2019). By integrating knowledge from neurobiology, cognitive psychology, and educational science, this field seeks to optimize teaching and learning strategies. (Howard-Jones, 2014) identifies key aspects of this scope, including memory formation, attention, language development, executive functions, and the role of emotions. In the context of Islamic education, specifically Tahfidz (Qur'an memorization), these neurological principles provide a scientific foundation for methods that align with human nature (*fitrah*).

1. Neural Mechanisms and the Three Stages of Learning

The human brain is a complex organ containing approximately 86 billion neurons connected by trillions of synapses (Kandel, 2021). Modern neuroimaging, such as fMRI and EEG, allows researchers to observe how these neural networks process information in real-time (Zadina, 2014). For a *santri* (student) memorizing the Qur'an, the brain moves through three critical stages:

Table 1. The Three Stages of Learning in Qur'anic Memorization

Stage	Brain Activity	Impact on Memorization
Encoding	Sensory inputs (auditory, visual, motor) encode verses into the brain.	Engages auditory, visual, and motor channels to strengthen initial memorization.
Consolidation	Repetition and sleep stabilize encoded verses into long-term memory via neural pattern replay.	Achieved through consistent repetition (<i>tikrar</i>) and periodic review (<i>murajaah</i>).
Retrieval	Retrieval accesses stored verses via strong, established neural connections.	Active recall and hidden cues turn fleeting verses of the Qur'an into lasting memories.

Memory functions are categorized by duration and capacity, as proposed by (Atkinson & Shiffrin, 1968), and later expanded by (A. , & H. G. Baddeley, 1974):

- Short-Term Memory, with a limited capacity of roughly 7 ± 2 items (Miller, 1956). Short-Term Memory holds new verses briefly. This biological limit validates the *Wahdah* method of memorizing one verse at a time to prevent cognitive overload.
- Working Memory is a more complex system, including the phonological loop, which is essential for verbal processing. It allows students to maintain an "internal voice" and engage in mental rehearsal of the verses.
- Long-Term Memory: This system has nearly unlimited capacity and stores information for a lifetime. It is divided into explicit memory (understanding the meaning and context of verses) and implicit memory (the unconscious automatization of *tajwīd* and rhythmic recitation).

Integrating neuroscience into value-based education requires a holistic, non-materialistic approach (Davidson & Lutz, 2008). Rather than reducing faith to biology, neuroscience explores how physical brain structures support spiritual experiences. Spiritual practices like Qur'anic recitation have been shown to increase activity in brain regions associated with empathy, attention, and emotional regulation.

In the *pesantren* setting, this scientific perspective empowers students to understand the wisdom behind traditional practices. By recognizing that *murajaah* and *tikrar* are biologically necessary for synaptic strengthening, students gain confidence in their methods, viewing Tahfidz as both a sacred spiritual journey and a sophisticated cognitive achievement (Newberg, 2009).

2. The Living Tradition: A Narrative of Tahfidz and Modern Science

At the heart of Islamic education lies the profound tradition of tahfidz (Qur'anic memorization). Philosophically, this is not a mere rote exercise; it is a sacred endeavor based on the belief that the Al-Qur'an is the speech of Allah Swt. By memorizing it, a student acts as a guardian of the text's purity while forging their own spiritual integrity (Qattan, 2001). As Ibn Khaldun (2005) famously noted, memorization serves as the "intellectual bedrock" upon which deep analysis and wisdom are later built. In the legacy of excellence, the journey began with the Prophet Muhammad (PBUH) and the first *huffaz*, his Companions (Al-Suyuti, 1996). In Indonesia, this legacy found a home in the *pesantren*, where memorizing the Al-Qur'an became a dual pursuit of academic mastery and divine worship (Dhofier, 2011). (Mas'ud, 2018) identifies why these traditional methods have survived: they offer a proven track record, ensure precision in *tajwid* through the oral tradition, and foster a unique *talaqqi* (teacher-student) bond that transfers moral character alongside knowledge. Within the *pesantren* walls, students find a supportive social ecosystem that engages the mind, heart, and body.

Meanwhile, in navigating modern hurdles, however, even the most venerable traditions face the winds of change. Imam Sofii (2024; Puspitasari, 2024) remind us that today's "digital-native" students bring different needs. Traditional models sometimes struggle with: a) Cognitive diversity, not every student learns at the same pace or in the same way; b) Engagement, a lack of variety can lead to "mental fatigue" or boredom; c) Standardization, without modern data and neuroscience, evaluating progress can remain overly subjective, missing opportunities to optimize the brain's natural learning rhythms.

The practical application of *tahfidz* varies across borders, offering a rich landscape for collaboration. In Indonesia, Pesantren Gontor blends a 30-juz target with a modern curriculum, while Pesantren Darunnajah uses the *wahdah* and *tikrar* methods, paired with reward systems to balance secular and religious mastery ((Al-Munawwar, 2018). Meanwhile, Brunei Darussalam, through institutions like KISSA, showcases a highly standardized and technologically integrated system. While Indonesia provides a wellspring of creative, diverse pedagogical methods, Brunei offers a blueprint for systematic documentation and evaluation. By sharing these strengths, both nations can ensure that the ancient art of *tahfidz* remains vibrant, scientifically grounded, and spiritually transformative for the next generation. This synergy proves that faith and neuroscience do not just coexist, they thrive together.

Several classical Qur'an memorization methods traditionally taught in *pesantren* to students (Mu'minatun & Misbah, 2022), presented in Table 2 as follows:

**Table 2. Memorization Methods in the Classical Tradition
According to Neuroscience**

Memorization Method	Description	Neuroscience Process
Tikrar	The most fundamental memorization method in the <i>pesantren</i> tradition, consisting of repeating a Qur'anic verse.	Steady practice strengthens neural bonds, turning fleeting thoughts into lasting, cherished memories known as long-term potentiation (LTP).
Tallaqi	A direct learning method in which students (<i>santri</i>) receive and imitate the Qur'anic recitation orally from a teacher (<i>ustadz</i>), including <i>tajwīd</i> , <i>makhārij al-ḥurūf</i> , and intonation.	A multimodal learning process, auditory (hearing), visual (observing the teacher's lip movements), and kinesthetic (articulatory movements), which is more effective for memory formation (Shams & Seitz, 2008).
Murajaah	A review method in which previously memorized verses are revisited to maintain and strengthen memory; conducted daily, weekly, or monthly (Maliana et al., 2022).	The spaced repetition method is more effective for long-term retention than massed practice because it prevents the forgetting curve (Ebbinghaus, 2013).
Wahdah	A method of memorizing by focusing on one verse at a time before moving to the next (Salsabila & Darwis, 2023).	This method aligns with the limitations of human working memory, allowing optimal allocation of cognitive resources for the encoding and consolidation of each Qur'anic verse.

3. Integration of Neuroscience in the Stages of Student Learning

Brain lateralization divides functions between hemispheres, though they work integratively during Qur'an memorization (Nielsen et al., 2013). The left hemisphere typically dominates structured, sequential language processing (Gazzaniga, 2019). while the right manages holistic, spatial, and emotional dimensions. Popular "right-brain vs. left-brain" dichotomies are often oversimplified, as both sides contribute uniquely yet complementarily to learning (Brain, 2023).

Based on this concept, the division of brain functions in the Qur'an memorization process for *santri* can be explained more specifically, as shown in Table 3 below:

Table 3. Division of Brain Functions in Qur’anic Memorization

Process	Left Hemisphere (Left Brain)	Right Hemisphere (Right Brain)	Midbrain
Memorization	<ol style="list-style-type: none"> 1. The left hemisphere manages phonological processing for <i>tajwīd</i> (Broca’s area). 2. Syntactic analysis for meaningful memorization 3. Sequential processing to maintain the precise order of Qur’anic verses and words. (Gazzaniga, 2019). 	<ol style="list-style-type: none"> 1. Deep khusyu’ and spiritual joy release chemicals that etch verses into your heart. 2. Spatial visualization ability contributes to visualizing the position of verses in the <i>mushaf</i> and recalling page layout. 	<ol style="list-style-type: none"> 1. Dopamine sparks joy, rewarding your hard work and turning effort into success. 2. The thalamus acts as a guide, filtering noise to help you focus.

The right hemisphere provides a holistic dimension to *tahfidz* by processing the unique melodies and rhythms of Qur’anic recitation. This rhythmic "coding" serves as a crucial retrieval cue for many students (McGilchrist, 2019). Furthermore, its visual-spatial superiority allows *huffaz* to mentally "see" a verse’s position on the *mushaf* page, aiding recall. Complementing this, the midbrain integrates both hemispheres, regulating the sensorimotor coordination required for learning. This area aligns auditory input (hearing the teacher) with motor output (articulation), fostering the "muscle memory" essential for precise pronunciation (Kandel et al., 2021). Together, these regions transform memorization from a linguistic task into a multi-sensory, rhythmic, and spatial experience. (Kandel et al., 2021).

4. Neuroscience-Based Learning Strategies in Qur’an Memorization

The implementation of neuroscience-based learning strategies in the context of *tahfidz* requires a deep understanding of how the brain processes, stores, and retrieves information. These strategies are not only grounded in long-established traditions proven effective over generations, but are also supported by scientific evidence regarding the neurobiological mechanisms underlying learning and memory. These strategies can be elaborated further in Table 4 below:

Table 4. Learning Strategies for Qur’anic Memorization

Neuroscience-Based Learning Strategy	Activity	Qur’anic Memorization
Repetition	1. <i>Spaced repetition</i>	Students (<i>santri</i>) follow a systematic <i>murajaah</i> schedule
	2. <i>Distributed practice</i> (DP) vs. <i>massed practice</i> (MP).	Santri can divide memorization time into six sessions of 30 minutes with 15–30 minute breaks between them.
	3. <i>Transfer-appropriate processing</i>	Santri may repeat memorization while walking, sitting, or changing body positions.
Association	Utilizing the brain’s natural ability	Connecting verses through shared themes builds a stronger, more meaningful heart.
Temporal	Utilizing <i>context-dependent memory</i> ,	Memorizing during spiritually meaningful times, such as prayer times, Ramadan, or special personal moments can enhance recall.
Emotional	A highly powerful technique because it connects learning with deep emotional experiences.	Peaceful recitation and spiritual joy etch verses deeply into the heart.
Visualization	1. <i>Mental imagery</i>	Santri can imagine scenes or events described in the verses, creating a “mental film” of Qur’anic narratives.
	2. <i>Mind mapping</i> ,	Santri may create a mind map for each surah, connecting verses by theme or producing visual structures for the entire Qur’an (Buzan, 2018).
	3. <i>Spatial memory</i>	Santri can associate each

		verse or group of verses with specific “mental locations,” such as rooms or areas of a mosque.
Motivation	<ol style="list-style-type: none"> 1. Motivation 2. <i>Goal setting</i> based on SMART principles (Specific, Measurable, Achievable, Relevant, Time-bound) 3. Social recognition and peer support 	Personal meaning and clear goals spark inner joy, while a supportive community sustains the long journey of the heart.

Repetition-based learning, particularly the traditional *tikrar* method, aligns with the (Ebbinghaus, 2013) forgetting curve: consistent repetition extends retention by slowing exponential memory loss. This process facilitates long-term potentiation (LTP), strengthening synaptic connections as information moves from short-term to long-term storage (Cepeda, 2006). Furthermore, spaced repetition and contextual variation provide the brain with vital consolidation intervals and diverse retrieval cues (Roediger, 2011).

Meanwhile, memory is further bolstered through: a) Associative learning, which is linking verses to specific times, like *Sahur* (Smith, 1979) or using emotional strategies, as high-arousal memories are more enduring (McGaugh, 2004); dual coding & spatial memory such as utilizing the hippocampus to associate verses with physical locations (O’Keefe, 1978; Palenza, 2025; Paivio, 1986); and motivation that self-determination theory emphasizes that intrinsic motivation leads to deeper engagement (Deci & Ryan, 2000). Balanced challenges prevent frustration (Locke & Latham, 2002). while social recognition activates the brain’s reward system, specifically the ventral striatum (Sumiya et al., 2017).

Characteristics and Categories of Qur’an Memorization Learning for Slow Learners

In the context of inclusive education, *pesantren* face the challenge of accommodating students with varying learning abilities, including those categorized as *slow learners*, who require specialized approaches based on their neurobiological characteristics, such as slower processing speed, limited working memory, or difficulty maintaining sustained attention. Three innovative methods that have been developed and proven effective for this group are the Tasmi’ method, Kitabah method, and Hypno-motivation method, which are described further in Table 5 below:

Table 5. Characteristics and Categories of Qur'an Memorization Learning for Slow Learners

Method & Time	Characteristics	Neuroscience Phase	Qur'an Memorization
Tasmi' — Weeks 1–2	An auditory-based learning approach.	The function of the auditory cortex and temporal lobe. (Wright & Zhang, 2022).	Students (<i>santri</i>) repeatedly listen to Qur'anic recitation before attempting to memorize it; this is suitable for students who struggle with conventional learning and rely more on visual processing.
		1. Passive listening phase	Santri listen to professional <i>qāri'</i> recitations for 15–20 minutes without following the text or attempting active memorization.
		2. Active listening,	Santri listen while following the text in the <i>mushaf</i> , integrating auditory input with visual representations of Arabic script.
		3. Shadowing,	Santri attempt to follow the recitation by whispering or reading quietly.
		4. Independent recitation,.	Santri attempt to recite independently without audio support, occasionally checking accuracy using recordings or mobile devices(Suyadi, 2019).
Kitabah—Weeks 3–4	Writing-based memorization method.	Activates multiple brain regions simultaneously.	Involves writing Qur'anic verses as an integral part of the memorization process.
		1. Copying phase.	Santri copy verses from the <i>mushaf</i> into a notebook with correct and neat handwriting to

			train visual-motor coordination and build familiarity with Arabic script.
		2. Dictation phase	Santri write verses dictated by the teacher without looking at the <i>mushaf</i> ; supports spelling and writing proficiency in Arabic and strengthens language learning.
		3. Free writing phase	Santri write verses from memory without audio or visual aids, serving as retrieval practice and diagnosing weak areas.
		4. Correction	Santri correct their writing using the <i>mushaf</i> and rewrite incorrect sections.
Hypno-motivation — Weeks 5–6	A method for detecting anxiety and negative self-talk, which often hinder learning.	Works by shifting brainwave patterns (Jensen, 2000).	An innovative approach combining relaxation techniques and positive suggestion to improve motivation and learning ability.
		1. Relaxation induction	Santri are guided into relaxation during Qur'an memorization using breathing techniques and progressive muscle relaxation.
		2. Positive suggestion,	While relaxed, santri receive positive affirmations such as: "I have an extraordinary ability to memorize the Qur'an" or "Every repetition strengthens my memorization."
		3. Visualization,	Santri visualize themselves successfully memorizing the Qur'an fluently with deep focus.

		4. Anchoring,	Santri create a psychological “anchor” a simple gesture or cue that helps trigger an optimal learning state(Hidayat, 2019).
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For slow learners in *pesantren*, integrating tasmi’ (listening), kitabah (writing), and hypno-motivation is essential. The tasmi’ method leverages auditory perceptual learning to strengthen neural connections through repeated stimuli (Wright & Zhang, 2022). Kitabah acts as a multimodal strategy, creating diverse memory traces that outperform single-modality learning while providing objective progress feedback James & Engelhardt, 2012). Furthermore, hypno-motivation utilizes neurobiological mechanisms to enhance engagement in students who struggle with traditional speeds (Tahir et al., 2025). Program effectiveness is measured through comprehensive assessments: standardized rubrics, pre/post-tests, and validated questionnaires for self-efficacy (Huberman Lab., 2025; Lee, 2025). Neuropsychological tools also track improvements in working memory and processing speed, while daily learning logs ensure data-driven, individualized adjustments.

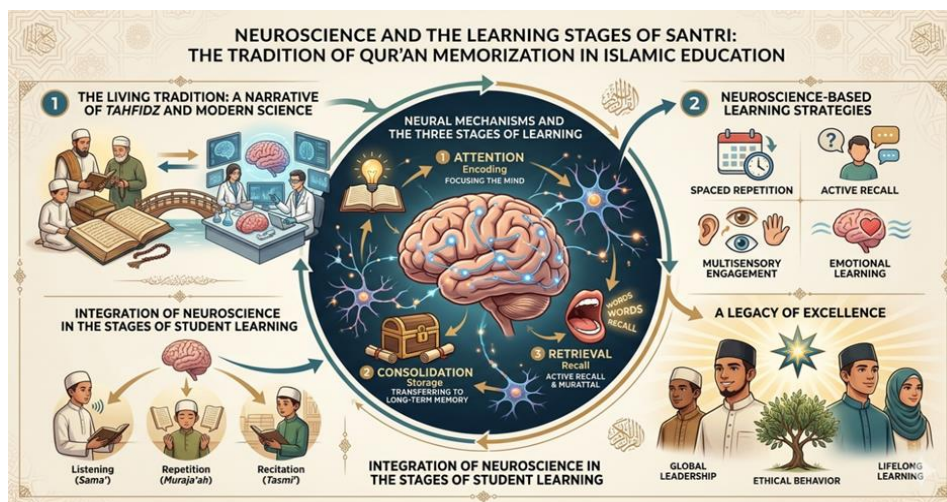


Figure 1. Neuroscience and the Learning Stages of Santri: The Tradition of Qur'an Memorization in Islamic Education

Analysis/Discussion

This neuroscience-based *tahfidz* integration program is designed to assist students particularly those categorized as slow learners in improving memorization ability while simultaneously strengthening their self-confidence and learning motivation. The program evaluation is carried out comprehensively, starting from memorization tests before and after the program, measurement of motivation and self-efficacy through validated questionnaires, to daily monitoring via learning logs (Nurfutriani et al., 2022). Neuropsychological tests are even used to observe the development of brain functions such as working memory, focus, and processing speed.

Furthermore, Partono & Rizqiyah report that the results of preliminary studies show significant improvements among students participating in the program, particularly when learner characteristics are accurately identified (Partono & Rizqiyah, 2022). Hidayat explains that improvements occur not only in Qur'an memorization ability but also in overall confidence and learning enthusiasm (Hidayat, 2019). Pambayun et al. note that brain imaging of participants shows increased connectivity in brain regions responsible for language, memory, and emotional regulation. This indicates that neuroscience-based approaches can produce long-lasting positive effects on brain structure and function (Pambayun et al., 2023).

Interestingly, after the program ended, the students continued to use the learning strategies they had acquired during the program. Tahir et al. explain that this indicates the metacognitive skills instilled in them were successfully internalized. In fact, the benefits of this program extend to other subjects, not only limited to Qur'an memorization (Tahir et al., 2025). To implement this program effectively, careful planning and sufficient resource support are required. Specifically for slow-learner students, Sumiati & Gumindari notes that teachers need training in the methods used as well as a solid understanding of basic neuroscience (Sumiati & Gumindari, 2022). The learning environment must also be designed to support various learning styles and minimize distractions. Technology can be utilized, for example through audio recordings for the *tasmi'* method, digital writing tools for *kitabah*, and relaxation apps for hypno-motivation sessions.

Mujahidin et al. state that there are, of course, challenges that must be addressed. Some teachers may resist the new methods because they are accustomed to conventional approaches (Mujahidin, 2019). The busy schedule of Islamic boarding schools can also pose an obstacle, in addition to the varied responses of students to the methods used. Meanwhile, Suyadi asserts that an evidence-based and systematic documentation approach can help convince all stakeholders of the tangible benefits of this program (Suyadi, 2019).

Furthermore, future research is needed to determine the optimal timing and duration of each method, to adapt the approaches to the diverse cultures of pesantren, and to develop a digital version of the program. Long-term studies are also important to understand their impact on brain development and academic achievement. Collaboration between neuroscientists, educators, and Islamic scholars will be invaluable in refining this approach for the advancement of Islamic education that is more inclusive and rooted in scientific knowledge.

A technology-based curriculum is also recommended to include diversified learning methods tailored to individual learning styles. Teachers' understanding of the differences between right-brain and left-brain functions in pesantren provides a foundation for developing a holistic approach: students with left-brain dominance can be supported with more structural and analytical methods, while those with right-brain dominance can benefit from more creative and intuitive approaches.

**Table 6. Goal and Evaluation
Neuroscience-Based Tahfidz Program for Santri**

Category	Details & Components
Primary Goal	To improve memorization, self-confidence, and motivation, especially for slow learners, by integrating neuroscientific principles into Islamic education.
Comprehensive Evaluation	<ul style="list-style-type: none"> • Pre- and post-memorization tests. • Validation of motivation and self-efficacy via questionnaires. • Daily learning logs & neuropsychological tests (working memory, focus, speed).
Key Program Outcomes	<ul style="list-style-type: none"> • Significant improvement in Al-Qur'an memorization and overall confidence. • Brain Plasticity: Increased connectivity in regions for language, memory, and emotional regulation. • Internalized metacognitive skills and improved performance in other subjects.
Implementation Needs	<ul style="list-style-type: none"> • Teacher training in neuroscience and modern methods. • Technology: Audio recordings (<i>tasmi'</i>), digital <i>kitabah</i>, and relaxation apps. • Support for right-brain (creative) vs. left-brain (analytical) dominance.
Challenges & Future	<ul style="list-style-type: none"> • Resistance to new methods and busy <i>pesantren</i> schedules. • Future Research: Long-term impact on brain development and digital version development.

CONCLUSION

The tradition of Qur'an memorization practiced in *pesantren* is a highly sophisticated and effective learning system when viewed from a neuroscience perspective. The *tikrar* method, with its intensive and tiered repetition, aligns with the principles of neuroplasticity and the formation of strong synaptic pathways. The *tallaqi* practice, which emphasizes direct learning from teacher to student, corresponds with the concept of mirror neurons and social learning. Meanwhile, the *murajaah* tradition, which emphasizes periodic review, is consistent with the principles of spaced repetition that have been proven effective for long-term memory consolidation.

The integration of neuroscience is not intended to replace traditional methods but rather to provide scientific explanations and strengthen the effectiveness of existing practices. Understanding how the brain works in the memorization process enables the optimization of traditional methods and the development of more personalized approaches aligned with the neurobiological characteristics of individual students. This opens opportunities to create more inclusive learning systems that accommodate diverse learning styles and abilities. In addition, the spiritual dimension of Qur'an memorization has a solid neurobiological basis. The involvement of the limbic system in emotionally and spiritually charged learning processes has been shown to strengthen

memory formation and enhance long-term retention. This indicates that the spiritual aspect not only adds value in terms of religiosity but also scientifically contributes to the effectiveness of the learning process.

A scientific or academic approach to the integration of neuroscience in Islamic education particularly within the tradition of Qur'anic memorization opens new horizons for developing an educational system that is more effective and relevant to contemporary advancements. The future of Islamic education can no longer ignore scientific findings about how the brain works; however, it must also not lose the spiritual and traditional values that form its core strengths.

The forward-looking vision is the creation of an Islamic educational system that optimizes the cognitive potential of students while maintaining spiritual depth and Islamic character. Such an educational model will produce graduates with high cognitive abilities, mature emotional intelligence, and profound spirituality. They will become a generation capable of contributing positively to the advancement of human civilization while remaining firmly grounded in noble Islamic values. Ultimately, the integration of neuroscience in Islamic education demonstrates that Islam, as a religion of *rahmatan lil 'alamin*, is highly open to the development of scientific knowledge. This proves that there is no dichotomy between religious sciences and general sciences, nor between spirituality and rationality. Instead, the integration of both will produce a stronger and more meaningful educational system for the holistic development of the human being.

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Conflicts of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest. The involvement of the educational institution in the data collection process was strictly for academic purposes, ensuring that the interpretation of neuroscience-based learning outcomes remains impartial.

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Data availability: The data supporting this study on neuroscientific *Tahfidz* stages are available upon request from the corresponding author, ensuring the privacy and anonymity of the participating *santri* and Islamic institutions.

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