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THE ROLE OF LONG-TERM MEMORY IN QUR'AN LEARNING: COGNITIVE NEUROSCIENCE PERSPECTIVES

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Abstract :

Memorizing the Qur'an (tahfidz) constitutes a fundamental practice within Islamic education that integrates spiritual discipline with complex cognitive mechanisms. This study investigates the role of long-term memory in tahfidz learning through a cognitive neuroscience framework. Employing a literature review approach, the analysis synthesizes scholarly sources in neuroscience, cognitive psychology, and Islamic pedagogy to elucidate how memory processes—encoding, consolidation, storage, and retrieval—operate in Qur'anic memorization. The reviewed evidence indicates that neural structures including the hippocampus, prefrontal cortex, medial temporal cortex, and amygdala play essential roles in organizing, stabilizing, and retrieving memorized verses. Empirical findings also support the effectiveness of strategies such as spaced repetition, mushaf-based visual mapping, semantic association, and mnemonic patterning in strengthening synaptic connectivity and retention. Furthermore, emotional regulation and spiritual engagement are shown to facilitate memory consolidation via activation of the limbic system, while restorative sleep, peer interaction, and collaborative learning in halaqah settings enhance long-term recall. Collectively, these insights demonstrate that tahfidz represents a holistic neurocognitive process that synergistically integrates devotional motivation, affective states, and memory system dynamics. The study underscores the pedagogical significance of developing neuroscience-informed tahfidz methodologies that align cognitive, emotional, and spiritual elements within instructional design. Future research opportunities include experimental neuroeducation models to quantitatively evaluate the efficacy of memory-enhancement protocols in broader Islamic learning contexts.

Keywords : *Long-Term Memory Qur'anic, Memorization, Cognitive Neuroscience*

Abstrak :

Menghafal Al-Qur'an (tahfidz) merupakan praktik penting dalam pendidikan Islam yang memadukan disiplin spiritual dengan proses kognitif yang kompleks. Penelitian ini menelaah peran memori jangka panjang dalam pembelajaran tahfidz melalui pendekatan neurosains kognitif. Dengan metode studi pustaka, analisis dilakukan terhadap berbagai sumber ilmiah di bidang neurosains, psikologi kognitif, dan pedagogi Islam untuk menjelaskan bagaimana proses memori—meliputi pengkodean, konsolidasi, penyimpanan, dan pengambilan kembali—berfungsi dalam menghafal Al-Qur'an. Temuan menunjukkan bahwa struktur otak seperti hippocampus, prefrontal cortex, medial temporal cortex, dan amygdala berperan penting dalam mengorganisasi dan menstabilkan ayat yang telah dihafal. Strategi seperti pengulangan bertahap (spaced repetition), visualisasi mushaf, asosiasi makna, serta teknik mnemonik terbukti meningkatkan konektivitas sinaptik dan daya ingat. Selain itu, regulasi emosi dan keterlibatan spiritual membantu proses konsolidasi memori melalui aktivasi sistem limbik, sedangkan tidur yang cukup, dukungan sosial, dan pembelajaran kolektif dalam halaqah turut memperkuat retensi jangka panjang. Secara keseluruhan, temuan ini menegaskan bahwa tahfidz adalah proses neurokognitif holistik yang

mengintegrasikan motivasi ibadah, kondisi emosional, dan fungsi memori secara sinergis. Penelitian ini menyoroti urgensi pengembangan metode tahfidz berbasis neurosains yang seimbang antara aspek kognitif, afektif, dan spiritual dalam desain pembelajaran.

Kata Kunci: Memori jangka Panjang, Neurosains Kognitif, Tahfidz Al-Qur'an;

INTRODUCTION

Memorizing the Qur'an (tahfidz) is a noble tradition in Islam that not only maintains the authenticity of revelation, but is also a form of worship of high value. In the context of education, tahfidz has become an important part of the learning system in Islamic boarding schools and religious institutions, and even an indicator of student success. On the spiritual side, tahfidz is a cognitive activity that demands the ability to store and access large amounts of verbal information with high precision, making it a combination of worship and long-term memory function exercises (Ulfah et al., 2024).

As interdisciplinary studies between religious science and science develop, the cognitive neuroscience approach in the tahfidz of the Qur'an is increasingly recognized as the scientific foundation that supports this traditional practice. Understanding the working mechanisms of the brain not only helps explain why repetition, visualization, and appreciation of meaning are effective strategies, but also opens up opportunities for the development of more measurable and evidence-based learning methods. This integration between spiritual values and cognitive neuroscience findings suggests that the strengthening of long-term memory in tahfidz is not just a matter of technique, but a holistic process that involves cognitive, affective, and religious dimensions simultaneously (MAHDI, 2024; Putri et al., 2022).

Cognitive neuroscience explains that long-term memory is formed through three stages: encoding, storage, and retrieval. Brain structures such as the hippocampus, prefrontal cortex, and limbic system play an active role in the process of storing and organizing memorization. Factors such as scheduled repetition, the involvement of spiritual emotions, and the understanding of verse meaning scientifically strengthen memory imprints. Techniques such as mnemonic strategy, spaced repetition, and dual coding theory have been shown to increase memory storage and have great potential to be applied in tahfidz to improve memorization effectiveness (Bhinnety, 2018; Alibasya et al., 2024; Hidayah, 2016)

However, integration between the tahfidz tradition and neuroscience findings is still rare. In fact, a cross-disciplinary approach that combines Islamic science and cognitive science can significantly enrich the tahfidz method. This article aims to bridge this gap by examining the relationship between the neuroscience principles of long-term memory and tahfidz learning strategies. This approach is expected to make a practical contribution in designing a tahfidz curriculum that is more adaptive, structured, and in accordance with the working mechanism of the human brain.

RESEARCH METHOD

This study uses a descriptive qualitative approach with a library research method to critically examine the relationship between the principle of long-term memory in cognitive neuroscience and the Qur'anic tahfidz learning strategy. The study is both exploratory and theoretical, integrating literature from the fields of neuroscience, cognitive psychology, and Islamic pedagogy. Data sources include scientific journals, academic books, dissertations, and research reports of the last ten years that meet certain inclusion criteria, such as a focus on memory mechanisms (encoding, storage, retrieval) and neuroscience-based Qur'an memorization methods.

Literature search was conducted through databases such as Google Scholar, ScienceDirect, PubMed, SpringerLink, and Garuda Portal with specific keywords such as long-term memory, mnemonics, Qur'anic memorization, and Islamic education. The results of the relevant literature were thematically analyzed to identify patterns of memory working principles and their application in tahfidz. The analysis was carried out in a descriptive-critical manner by grouping the data into two main categories: the neuroscientific concept of long-term memory and its application in tahfidz strategies. Through this approach, research builds a deep theoretical understanding and enables cross-disciplinary integration between cognitive science and Islamic education. The results are expected to be the conceptual basis for the development of a more effective tahfidz strategy, based on scientific evidence, and in accordance with the way the human brain works.

FINDINGS AND DISCUSSION

The results obtained from the research must be supported by adequate data. The results of the research and findings must be the answers or research hypotheses that have been stated previously in the introduction

Basic Concepts of Long-Term Memory

Long-term memory in cognitive neuroscains is the storage of information for long periods of time, ranging from minutes to decades. This memory has a much larger capacity than short-term memory and can be divided into explicit (declarative) and implicit (non-declarative) memory. Long-term memory allows the storage and retrieval of information that has been previously learned or experienced. Long-term memory has a type, Declarative (explicit) memory is a memory that can be consciously remembered, including facts and events in a person's life. This memory is usually associated with the hippocampus system and the medial temporal lobe. Examples are autobiographical memory and general knowledge. Non-declarative (implicit) memory is memory that does not involve awareness, such as skills, habits, and priming effects. This memory usually involves the amygdala and other systems related to motor learning and habits. These types involve different nervous systems in the brain and have different functions as well (Thorup, 2024; Sridhar et al., 2023).

The memory process consists of three main stages, namely encoding, storage, and retrieval. Encoding is the process of converting information received

by the nervous system into a form that can be stored, through visual, acoustic, or semantic means. Information in short-term memory (STM) is generally acoustically encoded, while in long-term memory (LTM), encoding is more predominantly semantic, although it can also be visual or acoustic. This is in harmony with the QS. Al-A'la: 6–7 which shows that the ability to memorize is the result of God's will and focused cognitive attention. After being encoded, the information will enter the storage stage, which is the storage process both in the short and long term. which is reinforced by the hadith narrated by Bukhari which states that the Qur'an can be lost if it is not actively maintained. This emphasizes the importance of continuous memorization maintenance (Nomovera, 2019; Lee & Jung, 2025).

Table 1. Brain Structure and Its Function in Qur'an Memorization

Brain Structure	Main Functions	Relevance in Tahfidz Al-Qur'an
Hippocampus	Consolidation of declarative memory (facts, information) from short to long term.	Storing verses that have been memorized into long-term memory.
Cortex Prefrontal	Focus settings, attention, decision-making, and executive functions.	Maintain concentration when memorizing, regulate muroja'ah strategies, and regulate distractions.
Amygdala	Processes positive/negative emotions and strengthens emotional memory.	Strengthening memory with spiritual attachment and feelings of gratitude, love, longing for the Qur'an.
Korteks Temporal Medial	Storage of verbal representations and language processing.	Helps remember the order of words and the position of the verses in the mushaf.

The last stage is retrieval, which is the retrieval of stored information. Difficulty in remembering is often caused by a failure in the retrieval process. The information in the STM tends to be accessed chronologically, while in the LTM it is more based on association, so the organization of the information can go a long way in speeding up the retrieval process. This is supported by QS. Al-Qamar: 17 which affirms that dhikr and repetition strengthen the traces of memory. Meanwhile, the dimensions of emotion and spirituality are reflected in QS. Al-Baqarah: 2 and QS. Taha: 14, which shows that the involvement of the heart and positive emotions in the interaction with the Qur'an has a strengthening effect on memory retention (Mujawar et al., 2021; Kang, 2016) . The hadith narrated by Tirmidhi about an empty house shows the aspect of focus and attention. The empty house symbolically depicts the spiritual and cognitive emptiness in the Qur'an. The combination of these principles shows that the scientific approach in tahfidz does not contradict Islamic values. Rather, this approach is very much in line with Islamic values. (Agustono & Firdaus, 2025; Bayati, 2024)

Encoding occurs when a verse is first heard or read, and becomes more effective when it is accompanied by meaningful repetition and spiritual appreciation. The frequently repeated information is then consolidated from the hippocampus to the neocortex, especially during night's sleep, to form long-term memory (storage). The retrieval stage occurs when memorization is accessed

again, such as during muroja'ah, and is influenced by the depth of encoding. The hippocampus plays a central role in converting short-term memory into long-term memory through a consolidation process that involves connections with other areas of the brain such as the medial prefrontal cortex. The hypocepmal synaptic plasticity allows for the strengthening of neural pathways and the formation of new neurons that support the continuous storage of declarative memory. The prefrontal cortex plays an important role in executive function, including the regulation, decision-making, and control of neural activity through extensive connections with the associative cortex, limbic cortex, and subcortical structures. In addition, this area is involved in free-choice decision-making by running a top-down process that allows individuals to vote independently without adequate initial information. (Liu, 2024; Funahashi, 2017)

The activation of the amygdala plays an important role in strengthening emotional memory related to spiritual and affective connectedness. The amygdala manages positive emotions such as a sense of peace and connectedness in worship, thus becoming the center of intense religious experiences and helping to deeply internalize religious values (Raychan Assabiq & Wantini, 2024). The medial temporal cortex plays an important role in storing the verbal representations of the Qur'an by helping to encode and retain semantic and linguistic information related to memorized verses. Activities in this area allow for the organization of long-term verbal memory so that memorization can be accurately remembered when needed. The hippocampus, prefrontal cortex, as well as the limbic system play an important role in this entire process, suggesting that tahfidz is not only a spiritual activity, but also a complex and thorough neurological exercise (Abdullah & Ismail, 2022; Fairuzillah & Listiana, 2021; Sirin et al., 2021).

Mechanism of Long-Term Memory Formation in Quran Memorization

Encoding in the Qur'an memorization method involves several techniques such as repetition (repetition), visualization of mushaf, and auditory rehearsal (oral repetition). Repetition is done by reading and memorizing verses repeatedly until fluently, then repeating the previous verses in sequence to strengthen memory. Visualization of the mushaf that helps the memorizer remember the position of the verses in the mushaf so that it makes it easier to remember in order and authentically. Auditory rehearsals are carried out by listening to the recitation of verses and imitating them several times, for example after dawn and magrib-isha prayers, to strengthen memory through listening and pronunciation (Wandini et al., 2020). In tahfidz, students can imagine verse scenes such as the Ababil bird or the story of the Prophet Yusuf. Coupled with the association of meaning, i.e. connecting the verses to personal, social, or spiritual experiences, this strategy forms a strong semantic network in the brain that strengthens memorization retention and comprehension as shown in table 1.

Table 2. Stages of Long-Term Memory Process in Memorization of the Quran

Phase	Main Description	Examples in Tahfidz Al-Qur'an
Encoding	The process of converting	Reading verses repeatedly,

	information into a format that can be stored in memory.	visualizing mushaf, listening to murottal, appreciating the meaning of verses.
Storage	Long-term storage of information through memory consolidation in the hippocampus and neocortex.	Sleep after memorization, periodic repetition (takrir), strengthening semantic and emotional associations with verses.
Retrieval	Retrieve information when needed, influenced by the organization and depth of encoding.	Routine muroja'ah, repeating memorization at a certain time (morning/evening), reading memorization in prayer, discussing the meaning of verses.

The consolidation of the memorization of the Qur'an involves two important things, namely sleep and periodic repetition. Sleeping before memorization helps prepare the brain to absorb new memorization, while continuous repetition or takrir and istiqamah are essential to keep memorization strong and smooth. This repetition can be done alone, listened to by a teacher, or a friend, and is usually done at certain times such as the morning or evening after Asr or Maghrib. In this way, the memorization that has been achieved is not easily lost and is stronger in the memorizer's memory (Supriono & Rusdiani, 2019).

Sleep plays an important role in long-term memory consolidation, especially during the deep sleep phase (NREM) which helps the process of processing and storing new information into a more stable and durable memory. However, in the given document there is no specific information regarding the role of sleep in long-term memory consolidation during the NREM phase. Studies show that sleeping after studying can increase memory retention by up to 30–50%. In tahfidz Al-Qur'an, students who repeat memorization before going to bed usually have stronger memory (Nafiati, 2021) Diekelmann & Born, (2010) . The practice can be in the form of a power nap after morning tahfidz and maintaining sleep hygiene such as getting enough sleep, avoiding gadgets before bed, and creating a calm atmosphere so that memorization consolidation is more optimal (Diekelmann & Born, 2010).

This method works by repeating information in a certain time interval that is scientifically proven to increase long-term memory storage through the long-term potentiation (LTP) mechanism. Muraja'ah is the process of repeating the memorization of the Qur'an which aims to keep memorization from being forgotten and wrong. Muraja'ah activities are not separate from the memorization process because after memorizing, the memorizer must continue to repeat the memorization. The best time for muraja'ah is anytime and can be done alone or with teachers and friends. Some of the methods of muraja'ah include memorizing every month, repeating memorization during prayer, dividing the Qur'an into several hizb for repetition, and repeating memorization before going to bed or by the halaqah (circle) method alternately reading verses

(Caya-Bissonnette & Béïque, 2024; Hendrawati & Syaikh, 2020; Kang, 2016).

Factors Affecting Long-Term Memory

The spiritual aspect of the tahfidz of the Qur'an plays a role in strengthening memory because the memorizers of the Qur'an are often internalized by the values of the Qur'an and Al-Hadith, which builds high discipline and awareness in memory. This cultivates spiritual intelligence which then affects emotional and intellectual intelligence automatically, so that memory becomes stronger through the process. For example, reading a verse about heaven while longing for your hometown or reading in a quiet atmosphere of tahajjud will strengthen the memory trace. This integration of spirituality not only adds religious value, but also strengthens the effectiveness of memorization cognitively and neurologically, making tahfidz more meaningful and sustainable (Huda, 2022).

Attentional focus is the key in the process of storing information into long-term memory, as only information processed with focus can be effectively stored. In tahfidz Al-Qur'an, the concentration of students when memorizing greatly determines the success of memorization. Calm and distraction-free learning conditions, such as without the distractions of gadgets, increase retention. Techniques such as calm dhikr or slow breathing can help optimize the function of the prefrontal cortex that regulates focus. Conversely, attention distractions such as multitasking or digital overstimulation can lead to encoding failure. Therefore, maintaining focus is an important strategy in tahfidz that is in line with how the brain works in memory (Pd et al., 2023).

Cognitive neuroscience shows that social interaction and emotional affiliation play an important role in the formation and strengthening of memory and learning concepts including tahfidz of the Quran. This process involves the integration of individual information and relational structures that can be reinforced during sleep through hippocampal replay, which aids in the representation of shared details and features in the cortical system. Halaqah is not just an administrative forum, but an emotional space that motivates, strengthens engagement, and supports long-term memory. Positive social interactions trigger the release of oxytocin and dopamine that activate the brain's reward system, making the activation of brain areas such as the anterior cingulate cortex when empathy and social relationships reinforce information retention creating a collective atmosphere that strengthens memory and spiritual attachment to memorized verses (Schapiro et al., 2017; Sinta. et al., 2017; Rohmawati & Fauji, 2024)

Emotional balance is essential in the formation and maintenance of long-term memory, since the limbic system, in particular, the amygdala, processes the emotional charge of information. In tahfidz of the Qur'an, verses that have an emotional connection are easier to remember, such as when students memorize verses that are in accordance with their personal experiences. Teachers who are able to convey the meaning of the verses in a touching way also strengthen memorization emotionally and spiritually. Positive emotions such as hope and love for the Qur'an increase dopamine and strengthen motivation, while

excessive stress inhibits memory. Therefore, creating a calm and meaningful learning atmosphere is the key to success in tahfidz (Zavitsanou & Drigas, 2021; Rosyanti et al., 2022)

Experts give a similar definition of mnemonics that a mnemonics is a technique or a verbal and visual device that can increase a person's memory capacity and recall new information easily. In the context of Qur'anic tahfidz, mnemonics can be in the form of visualization of verses, tartil rhythms, emotional associations with personal experiences, and the use of verbal abbreviations. This approach activates various visual, auditory, verbal, and emotional memory pathways known neuroscience as (Rianti Sari, 2018) multiple coding paths, thereby strengthening retention and facilitating the retrieval process. Research conducted on participants at MTS As Syifa revealed that the mnemonic method provides meaning to be easier in helping to remember memorization, and last for a longer period of time Other studies revealed that learning that applies the mnemonic method is effectively able to improve the quality of mathematical reasoning while strengthening students' memory. These findings confirm the importance of using associative and contextual learning strategies in optimizing students' cognitive function in the classroom, especially in mathematics subjects (Irawan & Ruswanto, 2024; Heryani et al., 2021).

Practical Implications of Quran Learning

Memorization accompanied by an understanding of meaning produces a stronger and more durable memory than memorization without context, because it involves deep cognitive processes. In Bloom's taxonomy, this includes the levels of "understanding" and "application," where students not only memorize, but also interpret verses reflectively. Associating verses with personal experiences or thematic discussions, such as social manners verses or prophetic stories, strengthens neural activation and long-term memory. This is in line with the theory of elaborative encoding, which states that the more meaningful the relationship between new information and old knowledge, the stronger the memory imprint formed (Bradshaw & Anderson, 1982).

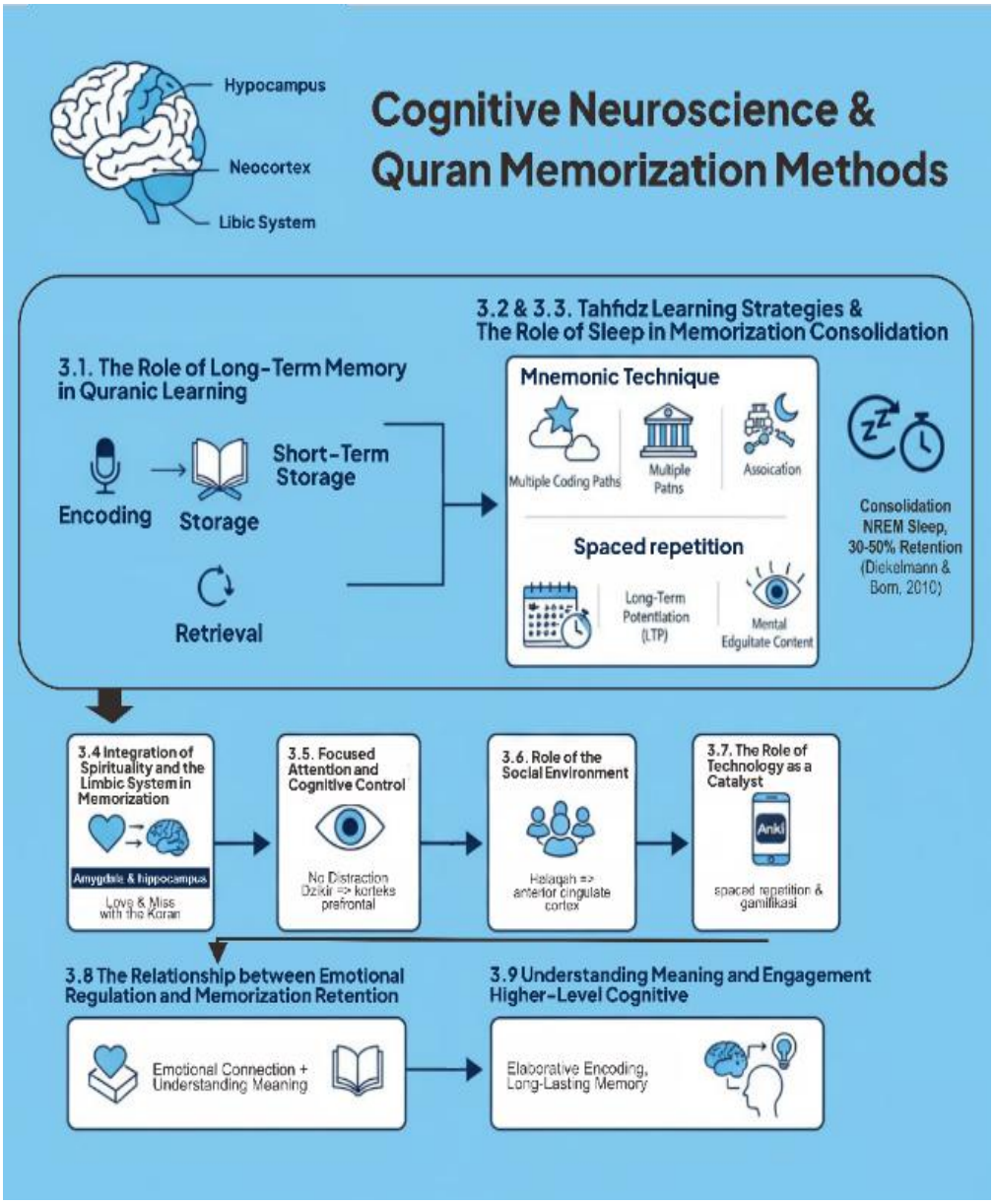

Figure 1. The relationship between neuroscience and tahfidz learning strategies of the Qur'an

The interplay between the principles of neuroscience and the Qur'anic tahfidz learning strategies is illustrated through eight main components. Starting from long-term memory, the encoding–storage–retrieval process involves the hippocampus and neocortex as the center of verse storage. The mnemonic technique uses visual symbols and tartil rhythms to engage multi-senses. In spaced repetition, the calendar illustration shows a scheduled repetition that amplifies the synapse. The visualization and association of meaning is characterized by mental imagery and heart icons, emphasizing the role of emotions in memorization. Focus and attention are drawn from students who memorize calmly with the activation of the prefrontal cortex. The social

environment is displayed through halaqah which strengthens motivation and emotional attachment. Digital technology such as the muroja'ah application helps track the progress of memorization. Finally, the regulation of emotions is visualized through positive expression and activation of the amygdala–hippocampus, confirming the importance of emotional atmosphere in strengthening verse retention (Davis & Montag, 2019; Nurdian, 2019).

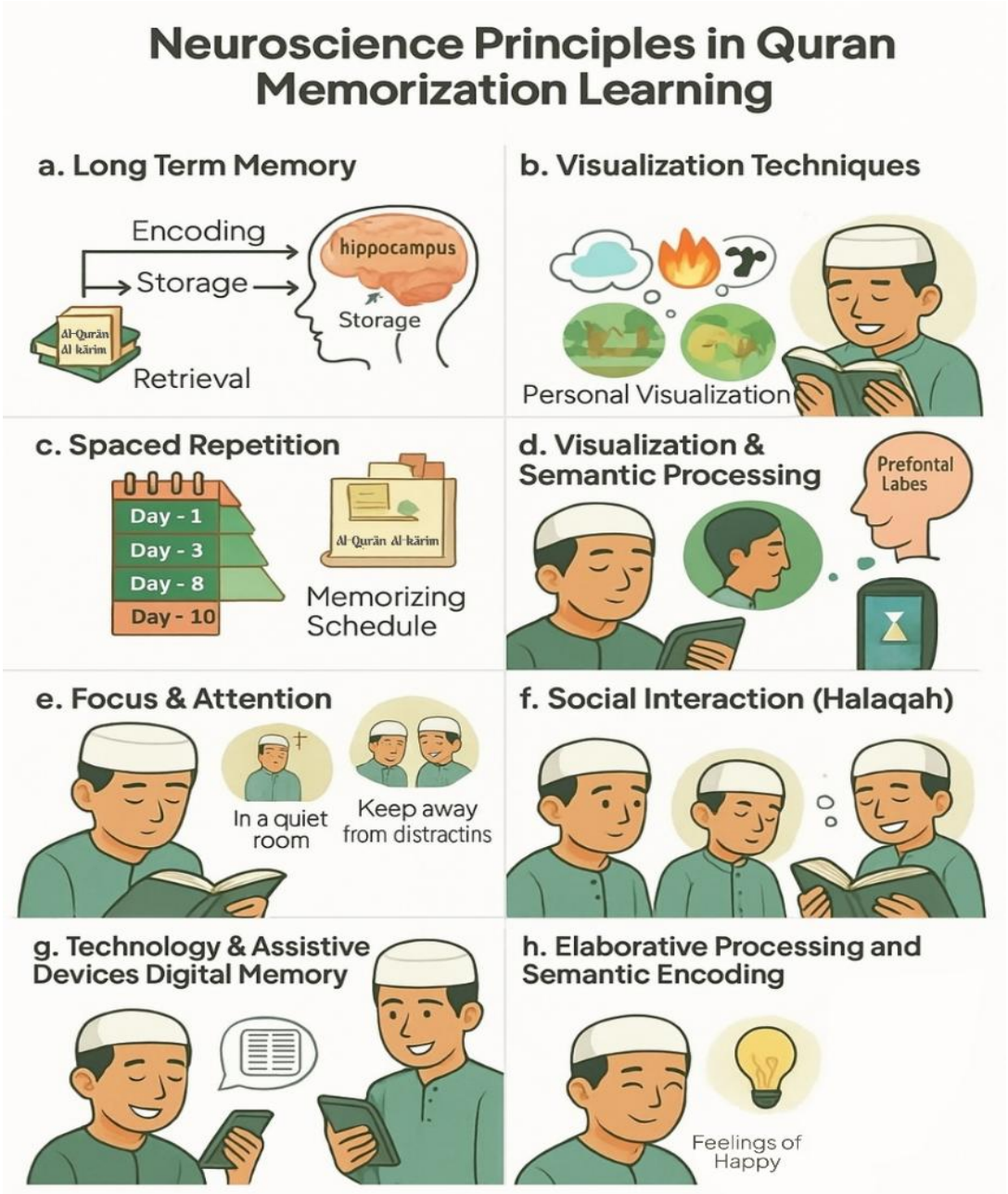

Figure 2. A visual summary of the principles of neuroscience in the learning of tahfidz Al Qur'an

A visual summary of the principles of neuroscience in learning tahfidz Al-Qur'an through eight main points is presented in figure 2. Starting from (a) long-term memory processes through encoding–storage–retrieval involving the hippocampus, then (b) mnemonic techniques such as visualization and personal associations to activate diverse memory pathways. (c) Spaced repetition strengthens synapses through scheduled repetition, and (d) visualization and sentence interpretation deepens retention. (e) Optimal focus in a distraction-free environment enhances cognitive processes, supported by (f) halaqah social interactions that build emotional motivation. (g) Digital technology strengthens memorization through notifications and progress tracking. (h) elaborative encoding emphasizes the importance of understanding meaning. All of these components form a tahfidz strategy that is scientifically and spiritually aligned with the way the brain works.

CONCLUSION

This study confirms that the process of memorizing the Qur'an is not just a spiritual activity, but also a complex and systematic cognitive exercise that involves long-term brain work. Long-term memory mechanisms consisting of encoding, storage, and retrieval stages have been proven to be relevant to tahfidz strategies such as repetition (takrir), mushaf visualization, meaning association, and the use of mnemonic and spaced repetition techniques. Brain structures such as the hippocampus, prefrontal cortex, amygdala, and medial temporal cortex play a central role in the storage and amplification of memorization. Factors such as attention focus, spiritual emotional involvement, sleep quality, and social interaction in halaqah strengthen the memory traces of students. The integration of cognitive neuroscience approaches into tahfidz methods can help design Qur'anic learning strategies that are more effective, adaptive, and in accordance with the mechanisms of the human brain. This study recommends the development of a tahfidz curriculum based on cognitive science as well as advanced studies based on educational neuropsychology to expand the understanding of memory storage in a religious context.

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