

REVIEW ARTICLE

Preliminary Insight on Neural Correlates of Quranic Impacts on Cognition: A Review

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ABSTRACT

Perception and synchronization of rhythms are vital for human health and social functioning, and cognition, which calls for rhythmic acoustic stimulation as a potential therapy. Quranic sound contains high energy and rhythmic structure of sound signal which has a soothing effect, comfort human feeling and evokes the limbic and reward systems. However, less is known about how the neural interaction between brain rhythms and sound rhythms. Here we review the Quranic listening effects on human cognition from the neuronal correlates perspective. The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) was used to review articles from no earlier than 2000 for scientific reports in the English language. Navigation terms used were 'Quran and cognition', 'Quran and memory' and 'Quran and attention'. Nine papers were fulfilled our criteria and assessed. We discussed issues related to the neural correlations regarding Quranic impacts on cognition. Three main factors contribute to the effects of the Quranic listening on human cognition: linguistic rhythms, physical aspect, and neuroscientific aspect. The neuroscientific aspect delineated the brain activation due to brainwave entrainment, event-related desynchronization and synaptic plasticity, which were associated with attention, memory and speech fluency. Quranic recitation contains rhythmical sound and physical characteristics that interact with the human's auditory system, producing changes in the brain oscillations and improving cognitive performance such as attention, memory and speech fluency. Instead of a conclusion, it is hoped that this review entices other researchers to explore further scientific and health benefits of the Holy Quran.

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INTRODUCTION

Musical stimulation is one of the most studied rhythmic auditory stimulation from neuroscientific perspective. Musical stimulation impacts all ages in such a way to maintain self-esteem, increase the feeling of competence and contentment, independence, avoid the sense of loneliness and isolation, suggesting that it plays an essential role in upholding human health, well-being and emotion (1).

Musical sound therapy marks its history from ancient civilisations. It was benefitted a wide-variety therapeutic purposes such as toothache, hormonal disorders, stopping bleeding, alleviating pain from poisonous insect bites, treating microbial diseases, psychological

disorders, mental disorders, strengthening the spirit, improving cognitive functioning, promoting physical rehabilitation, enhancing interpersonal communication and so forth (2,3). Islam also has its 'music with spirituality' elements like adzan, Quranic recitation, Talbiyah, zikr and tasbih, which have long been used for therapeutic purposes.

Researchers argued that music therapy is a useful strategy for promoting emotional relaxation and cognitive processing from a neuroscience standpoint (4). A study on Mozart's music on brain activities showed that music activates task-relevant brain areas (5) besides cortical circuits associated with attention and cognitive functions in young and healthy older people (6). In the theta, alpha, and gamma frequency bands, musical verbal learning increased coherence within and between the left and right frontal lobes (7). Psychological research, on the other hand, have discovered that listening to rhythmic sounds improves mental performance in a variety of cognitive activities by eliciting favourable effects

and increasing alertness. Sound that is pleasurable improves information processing speed, reasoning, and attention (8) and memory, besides, induces creativity. The auditory stimulus easily synchronises people's motions in a regular sequence (9). This shows that there is a strong psychological connection between rhythm perception and movement production. This capacity was given to humans early in childhood and appeared organically, implying that humans can anticipate a rhythmic stimulation and transmit a motor order at the same time (10).

These effects posed by musical stimulation are also apparent in Quranic sound stimulations. Quranic listening also produces movement, as seen in human heart rate improvement. Besides, electroencephalographic changes also were reported in higher alpha magnitude levels in Quranic sound stimulus compared to rest or musical listening (11) and in the balance between both right and left hemispheres during listening to Quranic acoustic stimulation indicated of brain hemispheres synchronization (12). Research by (13) also showed an improvement in anxiety by music and Quranic sound, but the latter group were more succeeded. Rafique and colleagues also hypothesized that listening to Ar-Rahman Chapter efficiently managed depression. The study concluded that such treatment had a considerably greater influence on depression decrease, implying that depression treatment is possible (14). However, a lack of study has been done on Quranic listening effects on cognition and its neural mechanisms, calling for more intensive research. Here we review several reports on neural correlates of how listening to the Quranic recitation may improve human cognition. Although there is a limited number of articles published regarding the Quranic impact on cognition and its neural correlates, several studies showed meaningful information regarding this.

MATERIALS AND METHODS

The literature search strategy employed including utilizing online databases and search engines for specific keywords combination. Review for scientific reports published no earlier than 2000 from Google Scholar, Scopus, PubMed, IEEE and Clavirate database were explored using navigation terms of 'Quran and cognition', 'Quran and memory' and 'Quran and attention' which found nine studies (Table I) fulfilling this criteria. A qualitative content analysis was conducted to see the relationship between the connotations.

RESULTS AND DISCUSSION

The Quranic sound has rhythmic structures that was believed to activate human brain which contributes to neuronal activation. Not many studies performed in terms of its effects on human cognition and its

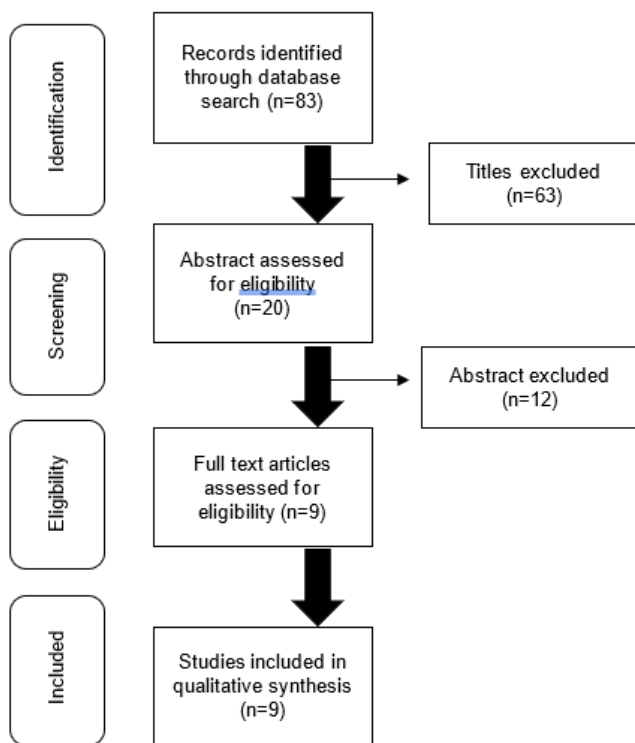


Figure 1 : Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) flow diagram of study selection.

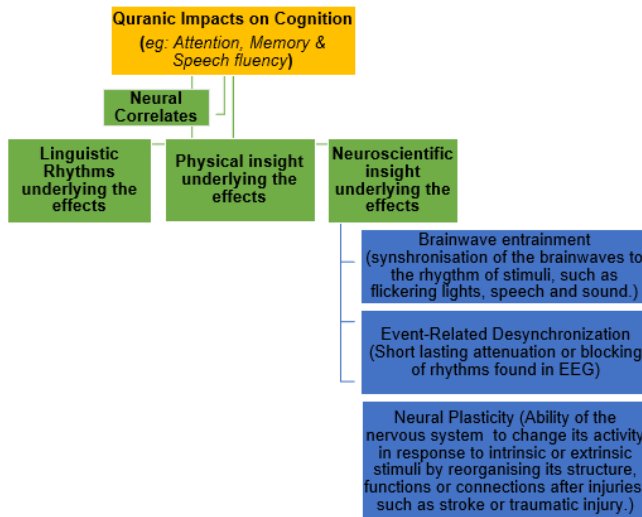


Figure 2 : Schematic diagram on preliminary insights of the neural correlates of the Quranic impacts on cognition.

underlying neuronal mechanisms, hence our study is attempting to uncover the knowledge. Current techniques that are used in Quranic study include electroencephalography (spectral power changes, event-related synchronisation/desynchronisation, source localisation), heart-rate variability and magnetic resonance imaging. In the current study, firstly, we found that the most contributing factor is the linguistic

Table I : Summary of the Quranic studies' effects on cognition included in this review

Title of study	Author and year of study	Method	Results
1 Insights from the preliminary autocorrelation analysis of low-frequency neuronal oscillations during Quran listening.	Reza F <i>et al.</i> (2004)	EEG	Slow brainwave oscillations of delta and theta rhythms entrained human brain oscillatory rhythms to give relaxation effects and proposed memory improvement induced by the pleasant sound of Fatihah Chapter
2 Comparison of students' moral judgement and social development in student: investigating the role of teaching the Holy Quran by memorization in independent schools in Tehran.	Zadshir F and Stoki M (2009)	Questionnaire	The social growth and moral judgement of students who completely memorized the Quran were higher than those of normal students. There was no significant difference between the boys and girls.
3 The Qur'an and memory (a study of the effect of religiosity and memorizing the Qur'an as a factor on memory).	Al-Attas R (2011)	Questionnaire	The Quran memorizer group had more A grades on their study test.
4 Quran memorization and its effect on elements of mental health.	Kimiaee S <i>et al.</i> (2012)	Questionnaire	Quran memorizers have better mental health compared to non-Quran memorizers by looking into their level of anxiety, sleep disorder, depression and social function.
5 Effects of memorizing Quran by heart (<i>hifz</i>) on later academic achievement.	Nawaz N and Jahangir SF (2015)	Questionnaire	Memorizing the Quran produces significant improvement in the academic achievement of Huffaz
6 The effect of Quran murottal's audio on short term memory.	Suteja Putra P <i>et al.</i> (2018)	Software design tools (program running memory task)	The study showed that short term memory capacity increased with listening to Quranic recitation
7 Attentional process during listening to the quantitative Quranic verses (Fatihah Chapter) is associated with memory, speech and emotion.	Samhani I <i>et al.</i> (2018)	EEG, FFT	Brain areas modulating attention, emotion, and speech were strikingly significant. The spectral power reduction indicates increased inhibition that suggests improved focus and activation of short-term memory in relation to positive thoughts.
8 Auditory elicitation of event related desynchronization reveals the neuronal mechanism during listening to Sura Fatiha recitation.	Ismail S and Reza MF (2017)	EEG, FFT	Listening to the Fatihah Chapter elicited alpha event-related desynchronization (ERD), pronounced as increased cortical excitability reflecting attentive behaviour. It was suggested that Fatihah Chapter listening modulates neuronal amplitudes.
9 Association between scripture memorization and brain atrophy using magnetic resonance imaging.	Rahman M <i>et al.</i> , (2019)	Magnetic Resonance Imaging	No significant difference with ages. Those who memorized the Quran completely had more brain tissue than those who partially memorized, and those who partially memorized had more brain tissue than those who did not commit to Quran memorization.

* EEG = electroencephalography, FFT = Fast Fourier Transform

rhythms that belongs to the Quranic sound where the rhythms come from the structure of the Quranic words and texts, and even the composition its letter in single words. The Quranic sound also has rhythmic series of intensity, pitch and periodicity which impacts human psychological and spiritual domains. Our brain also response to the rhythmic sound by showing the brainwave entrainment, enhancing the neuroplasticity and inducing event-related desynchronization, which believed to improve human cognition of attention and memory.

Linguistic Rhythms underlying the effects

All natural processes, from heartbeats to sea waves and the day-night cycle, are characterised by rhythm. Another natural rhythmic phenomenon that surrounds people is language (15). The word 'rhythms' comes from the Greek word 'to flow.' Rhythm is an aural pattern established by emphasising certain words or syllables in linguistics. It creates the rhythm by emphasising, elongating, or twisting the tongue to produce an auditory pattern. The hierarchical structuring of temporal sequence in speech sounds into syllables, as well as higher-level prosodic and syntactic structures, is reflected in the rhythmic structure of speech (16).

Variances in vowel duration and syllabic complexity, such as monophthong, diphthong, and coda, appear to be the key variables causing differences in stress patterns and language rhythmic structure (17). Quranic texts are rich in these rhythmic contributing elements, which have an exemplary arrangement of letters and words besides other featuring linguistic properties. Hence, they produce harmonic sounds full of aesthetic cadence.

The Fatihah Chapter of the Quran is a symphony of phonetics. Even if they are not native Arabic speakers, the recitation is clear and harmoniously pronounced and heard thanks to the use of words and beautiful sentences. Its expressions and words are structured in a very unique way. Its literary inimitability, wisdom, rhythmical and phonetically excellence, faultless meaning, literary styles, and grammatical structure have all been studied throughout Islamic history. Despite the fact that it is written in Arabic, Fatihah Chapter defies the natural pattern of the language and goes beyond the natural capacity of any human author to explain because it contains God's words. The Holy Quran and the Fatihah Chapter must be recited in a slow, measured rhythmic tone, as stated in Chapter Al-Muzzammil, verse 4: "And recite the Quran in slow, measured rhythmic tones." Aside from accurately producing sounds, the Quranic sound is enhanced by rhythms from its intrinsic elements. Furthermore, the Fatihah Chapter of the Quran exhibits various oral traits such as redundancy, frequent repetition of standard patterns and refrains in various content contexts, oaths, rhyme, assonance, parable, exhortations, and other linguistic

elements that make it thoughtfully have such a poetic language, but it is neither poetry nor prose. These distinguishing characteristics are not attributable to human manipulation, but rather to the above-mentioned internal linguistic aspects of God's words. The organised hierarchically, Quranic soundwave rhythms allow elements to be released in a temporal pattern like a speech rhythm (18) that will entrain the brainwaves to synchronize them. The synchronous effects were similar to other rhythmic sounds but were not identical. Hence, Quranic sound induces motor movement as musical sound does. But it was not causing the human to dance but made the heart pound calmly and improved the anxiety, sleep and depression.

Physical insights underlying the effects

Sound has been utilised to treat ailments and improve human health and cognition for a long time. This is due to the fact that sound is a temporal and sequential signal that acts as a scaffolding for broad cognitive capacities via neural connections (19). The human auditory sense is the most powerful sensory system, influencing nearly all brain activities, and the ear is sometimes referred to as the 'portal to the brain'. In reaction to pitch, rhythm, melody, and meaning, many brain centres are active during rhythmic and melodic sound processing (20). High-frequency noises increase alpha waves in the brain, engage deep brain regions including the brain stem and thalamus, and improve thalamic circulation and reward responses (21). It boosts blood flow to specific brain locations while also increasing electrical activity. This is due to its effects on the limbic system, which is an important emotional controller system in humans.

Quranic recitation sounds are rhythmic and bring energy to the listeners and reciters (22-26). They have rhythmic series of intensity, pitch and periodicity. Although non-pharmacological interventions are not meant to replace standard interventions, combinations of approaches were reported to be potentially successful (27,28). This leads to suggestions on utilizing psychological and spiritual means of intervention as adjuncts in therapy, including Quranic recitations (29). There is a growing body of evidence on the physiological and psychological effects of the Quranic recitations on patients (27-29).

Neuroscientific insights underlying the effects

Listening to Quranic acoustical stimulus has been described over a long period to produce definite changes physiologically and psychologically. We believe that the sound rhythms alter the cortical functioning and corticofugal controls which may significantly modify the processing of information at brainstem and thalamic levels, producing effects of relaxation and calmness those can be measured from the cortical level of the brain. Since there are lack of information recorded on scientific mechanism on how the Quran affects humans' brains, we are exploring some insights regarding these

mechanisms. From a neuroscientific perspective, here the several mechanisms the Quranic sound commits to modulate human cognition.

Brainwaves entrainment

Brainwaves entrainment is one of the phenomenon that underlined physiological and psychological effects of listening to the Quranic acoustic. The use of external stimuli to produce a frequency is known as brainwave entrainment. Because even low-powered oscillations can have huge impacts on standing waves, brainwave entrainment is an interaction of waves with other waves. Brainwave entrainment is the process of a steady resonant frequency altering the standing frequency by increasing, reinforcing, or prolonging it (Brahmankar, Dange, & Mankar, 2012).³⁰ (30) and (31) reported a considerable decrease in anxiety levels and increased the level of quality of life, raised melatonin and DHEA, relaxed the mental facilitating higher quality of perception and improved the performance of cognitive processing (32).

Advanced biophysical studies also revealed that even single neurons have the intrinsic ability to oscillate and resonate at multiple frequencies (33). Some neurons display oscillatory behaviour in the thalamus and limbic system, which oscillates due to other neurons' input. Brain oscillations arise when a group of neurons are rhythmically and synchronously active, so they are synaptic potential summated (34). Synchronization of oscillatory activities in distributed assemblies has been well-studied, and there is consensus that such synchronization reflects the cooperative activity of neurons (35). These synchronous fluctuations between excitation and inhibition have induced synchronized firing patterns. Synchronization between brain regions is crucial, and disturbance of normal rhythmicity is linked to a variety of neurological disorders like parkinson disease and epilepsy (36).

Brain areas connect with one other in the temporal domain while hearing auditory information, allowing sensory information integration. This was achieved by generating cell assemblies with solid synaptic connectivity whenever cells were triggered or ignited at the same time. Repeated activations strengthen neuron assemblies, which follows the premise that "cells that fire together, wire together." Synchronization patterns and desynchronization of neuronal activity show that brain areas are synchronised. The ability to link spatially scattered neuronal assemblies into functionally integrated and specialised networks is dependent on synchronisation or desynchronization. This coordination is self-organizing, a trait of neural networks that arises from the temporal synchronisation between synaptic transmission and firing of different neuronal populations (33).

The auditory cortex is sensitive to signals in the amplitude

(AM) and frequency (FM) domains, which can help to develop synchronisation or entrainment between The Fatihah Chapter rhythms and brain rhythms (37). All brain operations, including cognition, behaviour, and emotional processes, are based on neural oscillation and entrainment (38). The onset of emotional feeling will be coded by the synchronisation of neuron populations. For example, frontal polar synchronisation represents an individual's attentive state, which is linked to prevention of rumination and negative mental activity, which increases depressive episodes in humans (39).

Event-Related Desynchronization

The Quranic sound was found to synchronize human brainwaves. Our study previously reported that listening to Quranic sound induces event-related desynchronization (ERD), which is described as cortical excitability (40) due to the involvement of an extensive neural network or more cell assemblies producing a more efficient task performance. Desynchronized EEG means that the underlying neural network or neural circuitry works in a desynchronized manner. Synchronization means several synaptic inputs arrive at a postsynaptic at the same time. Such coincident synaptic input promotes rapid depolarization and therefore increases the postsynaptic membrane potential above the firing threshold (41). Rapid depolarization is more effective in triggering action potential than slow depolarization due to sodium channels' fast inactivation time constants (42). Brain cortical centres are also more sensitive to synchronized input, which will produce action potentials to transfer the information. Information theory conveys the information that the brain is in maximal readiness and maximum information capacity (43). The alpha ERD concept was first coined by (44), who described the behaviour of EEG after the reticular formation of the brain stem area was stimulated. Alpha band oscillation is a dominant oscillation related to inhibition capability in time, space and context (45) for its ability to suppress irrelevant stimulus. Silencing weakly excited cells and creating a pulsed pattern of action potentials in cells with a higher excitation level are used to achieve this inhibition.

Semantic memory processing is also linked to the degree of ERD. In the lower alpha range, good memory performers had a considerably bigger ERD magnitude than bad memory performers. This could be explained by memory encoding requiring a higher level of attention and alertness to increase the ERD magnitude (46). Long term memory is implemented by modifying synaptic strength. Hence, this neurodynamical theory of human cognition could explain why listening to the sacred text relaxes people and improves their understanding.

A broad brain network supports memory encoding and retrieval processes. Both encoding and retrieval successes are associated with activation in the middle

temporal, prefrontal and parietal brain regions. Desynchronization during listening to Quranic Fatihah Chapter is suggested for memory consolidation processes and attention. From mathematical models of information theory, synchronization does not serve as a suitable condition for storing information because it reduces information's richness. By following Shannon's entropy, (47) showed that the degree of information encoding in the spiking patterns increased with desynchronization. The wealthiest information being encoded was seen in the most desynchronized firing pattern. This finding illustrates that the more desynchronized the firing of neural assemblies, the more information can be encoded.

Neural Plasticity

Neural plasticity is the ability of the brain to reorganize its structure and function in response to intrinsic or extrinsic stimuli by activating the long-term potentiation and structural remodelling of cellular components. Whether through structural modification of axonal, dendritic branches or spine morphology, the neural plasticity phenomenon causes changes in synaptic strength and is crucially important in learning. Quran memorizers are found to commit neural plasticity. A study by (48) shows that complete Quranic scripture memorizers have more extensive grey matter and white matter volumes compared to those partially memorized, and those who partially memorized the Quran have a larger volume than those who did not memorize any portion of the Quran, suggesting for neural plasticity phenomenon had occurred during memorizing the Quran which may have lower risk from a cognitive impairment that could lead to neurological diseases (49). More active and synchronizing neurons were also predicted due to Quranic memorization. This is not due to the scripture itself, but rather, these verses bring highly rhythmic energy which could activate one's neuronal network in the brain. During memory retrieval, a similar image emerges, implying that power drops reflect memory reactivation (47), mental imagery (50) and stress alleviation (51).

CONCLUSION

Quranic recitation contains rhythmical sound and physical characteristics that interact with the human's auditory system, producing changes in the brain oscillations and improving cognitive performance. Reciting the Quranic verses is an articulation that involves the release an organized speech in a hierarchical temporal pattern that may positively affect cognition enhancement in its listeners, such as attention, memory and speech fluency. However, not much studies performed from its kind. In this sense, Islam is the greatest religion with the worst followers becoming defeatists, suffering from inferiority complex and distant from Quran both intellectually and by practice. It is hoped that this review entices other

researchers to explore further scientific and health benefits of the Holy Quran. Studies should be done concerning the cortical and subcortical structures that would give impacts on cognitive neuroscience field and educational system. The Fatihah Chapter could be a potential candidate for cognitive enhancement where research on auditory stimulation by Quranic sound should be conducted in measuring the psychoacoustic and cognitive effects from demographic measures such as genders, ages, educational background and handedness.

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