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Investigating the Effects of Dhikr Stimulation on Auditory Brainstem Response: A Case Study of a Healthy-Normal Hearing Adult

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ABSTRACT

Dhikr has been studied to a limited extent in its impact on human auditory brainstem response. The article describes the processes involved in preparing Dhikr stimuli and analysing the auditory brainstem waves produced. A total of 18 words of 'Allah' recited by male and female Muslims were saved as 16 bit WAV files with sampling rates of 30,000 Hertz (Hz) and 1.09227 seconds (sec) with a sampling rate of 16 bits. Nevertheless, we calibrated and installed only six stimuli in Eclipse EP25 software. A healthy 23-year-old male underwent routine audiological examinations, including click ABR tests, for the purpose of ensuring normal hearing and brain stem function. To produce Dhikr-ABR waves, the subject listened to all six stimuli, initially presented at 100 dB peSPL to the left and right ear. Later, the tester reduced the intensity level and determined whether there were any significant peaks, namely DI, DIII, and DV, as well as IPLs and IALDs. There were robust waves associated with each stimulus. A few waves, however, displayed early peaks. Depending upon the presence or absence of peaks, the IPLs for DI-DIII, DIII-DV, and DI-DV would be about 2.0, 2.0, and 4.0 milliseconds, respectively. A reduction in intensity alters the amplitude and absolute latency of the waves.

Keywords*: Auditory, Dhikr, Brainstem, Spiritual, Electrophysiology*

People's spirituality varies based on their religious beliefs. Due to its multidimensional nature, spirituality also relates to life experiences (Selby et. al. 2017). Dhikr is a spiritual practice among Muslims and is highly demanded in Islam (Geels 1996) and saying the word Allah is the simplest and easiest way (Melki 2011). Dhikr recitations produced delta and theta waves which reflect brain function when focused on a task and when relaxed (Fauzan & Abdul Rahim 2015). A few scientific studies have examined the effects of Dhikr on the auditory brainstem, a neuroanatomical structure connecting the central auditory cortex to the peripheral auditory system. The structure actively interacts with the brain where it shapes auditory perception and influences brain behaviour (Skoe & Kraus 2010). Also, Dhikr may affect the reticular activating

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system (RAS) in the brainstem that controls human behaviour. Thus, the fundamental step towards studying the effect of Dhikr on the auditory brain stem is to produce the stimulus itself.

ABR is an objective measure of the neuroplasticity and auditory function of the brainstem that clinicians use to test patients with specific clinical disorders, such as auditory processing disorders and mental illnesses (Tarasenko et al. 2014; Kumar and Sanju 2016). Clinically, simple-non-meaningful auditory stimuli like clicks, chirps, and tone bursts produced ABR waves. Recent research has applied more complex stimuli to investigate the brainstem reactions to these challenging stimuli (Binkhamis et al. 2019). Due to subtle pathologies involving the brainstem, challenging stimuli are necessary. Researchers previously documented ABR anomalies in schizophrenia patients when using complex sounds (Tarasenko et al., 2014; Wahab et al., 2019) which were not captured using routine clinical ABR stimuli. Despite not being used clinically, these complex ABR (c-ABR) stimuli can contribute to future knowledge on assessing patients with specific clinical disorders.

Current speech-based ABR stimuli consist of non-meaningful consonant-vowel syllables such as / ba /, / da / or / ga /. Auditory brainstem adaptation to experience-dependent auditory stimulation across the lifespan is possible due to its neuroplasticity (Skoe et al. 2015). It can re-organize its neural-network function, improving the electrophysiological response to auditory input (Sanju & Kumar 2016). Studies found that musicians showed more robust ABR responses than non-musicians (Musacchia et al. 2008), which suggest music as an alternative rehabilitation method for people with specific clinical disorders (Montánchez Torres et al. 2016). Therefore, Dhikr could be an alternative to music for Muslims.

The paper first describes how we generated Dhikr stimuli for ABR. Second, we analysed the physiological responses of a normal-hearing person's brainstem waves using the stimuli. Thus, we named the waves Dhikr-ABR (D-ABR). These findings may be helpful for future research on complete word stimuli and benefit clinicians in monitoring patients with auditory-related processing disorders.

Materials and Methods

Stimulus Production: The current study recorded male and female voices of normal hearing Malay Muslims, aged 46 and 40 years old, respectively, for Dhikr stimuli. Subjects have no history of speech and language disorders such as stuttering, disfluency, articulation, or voice disorders.

Subject: The current study obtained its ethical approval from the research ethics committees of Universiti Kebangsaan Malaysia (JEP-2019-808). A 23-year-old-healthy normal hearing male consented as a subject. He has no significant history of extrapyramidal disorders, neurological disorders, and/or other auditory disorders.

Instrumentation: A Welch-Allyn otoscope, Interacoustics Titan Tympanometer and Interacoustics AC40 Audiometer were used to ensure that the subject had normal hearing and middle ear function. Finally, using both standard clicks and Dhikr stimuli (i.e., the word "Allah"), we conducted the ABR test using the Interacoustics Eclipse EP25 software. These clicks were used to ensure normal brain stem function and later compared to the D-ABR waves.

Producing Dhikr Stimuli: We recorded the subjects' voices in a soundproof room with measured ambient noise at 30 dBA. Each speaker started with a carrier phrase, "I will say….", prior to the recitation of the word Allah. The act was to minimize the volatility of pitch and loudness of the word. Each subject underwent two recording sessions where both subjects managed to recite nine repetitions of the word Allah within approximately 10 seconds at the end of each session. Overall, the sessions generated 36 recordings of the word 'Allah'. Subsequently, we cleaned the recordings from background noise using Sound Forge software version 11.0 and edited them to meet the requirements of Interacoustics Eclipse EP25 software, i.e., the audio file was in WAV files format of 16 bit with the sampling rate and maximum length of 30,000 Hertz (Hz) and 1.09227 seconds (sec), respectively. Subsequently, a sound engineer analysed the pre-generated Dhikr stimuli that best fulfilled the Eclipse EP25 software requirements to assure optimum stimulus.

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Once analysed, the sound engineer calibrated and installed a total of six Dhikr stimuli, three each from both speakers, in the Interacoustics Eclipse EP25. The calibration requires Eclipse EP25 software, preamplifier, laptop, insert Eartone 3A(ABR), 711coupler artificial ear, sound level meter (SLM), an oscilloscope. Calibration began with measuring peak-to-peak voltages. The sound level meter and oscilloscope ensured the peak-to-peak voltage level was 100 dB. The level (peSPL) was set to 100 dB, and the slider was adjusted until the oscilloscope showed the same peak-to-peak voltage. Then, we played the 'Allah_Cropped_F1' Dhikr stimulus at 100 dB SPL and repeated the process for the other five Dhikr stimuli. As an aid to tracking the D-ABR waves, we labelled the Dhikr stimuli with "M" and "F," respectively, followed by a roman numeral, i.e., 1, 2 and 3. After all six Dhikr stimuli had been calibrated, a new protocol was created in EP25 software. A record of the traces from the six calibrated D-ABR waves was kept within the same instrument.

D-ABR recording: The subject was placed in a soundproof room during the testing and instructed to remain calm as much as possible. Following the preparation of the skin, the audiologist placed the electrodes at the mastoid process and on the subject's forehead. Afterwards, the audiologist checked the skin impedance to ensure it was less than 3 kohms.

Comparing the morphology of D-ABR and click-ABR was done with all six Dhikr and clicks stimuli. In the D-ABR protocol, the rate was set at 45.1 Hz with alternating polarity. The testing started with a click stimulus on the right ear, followed by the first Dhikr stimulus, labelled "F1", at an intensity level of 100 dB pe SPL. We reduced the intensity to find the lowest intensity that produced clear wave peaks of DI, DIII, or DV. We applied the same procedure to the other ear. In the following phase, we presented the remaining Dhikr stimuli sequentially, i.e., F2, F3, M1, M2, and M3, which were alternately delivered between ears.

Students with expert audiology training and two senior audiologists defined and identified the three major D-ABR peaks, wave DI, DIII, and DV generated by each stimulus. From the observations, the D-ABR waves were subjectively categorized as good, fair, or poor according to morphology. By detecting the peak using click-ABR standard practice, the highest peak defines wave V. Good morphology permits the observers to identify the three waves easily. With fair morphology, observers could still distinguish peaks when they observed carefully. Finally, poor morphology was evident when observers had difficulty identifying the three-wave peaks, even at high intensities.

Results

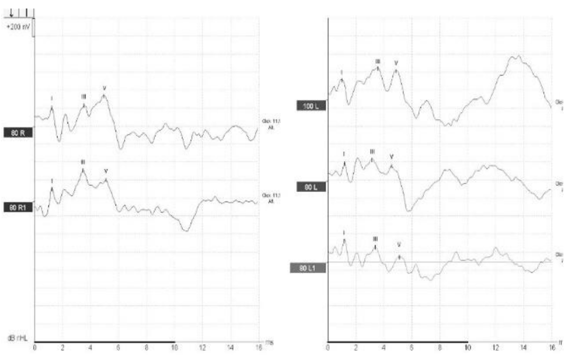
Figure 1 shows four panels. Panel A: ABR wave tracings with click stimulus recorded on the normal hearing subject. Panel B: The effect of reducing F1 stimulus intensity level on D-ABR wave tracings. Panel C: The effect of reducing F2 stimulus intensity level on D-ABR wave tracings. Panel D: The effect of reducing F3 stimulus intensity level on D-ABR wave tracings. Note: The alphabet R and L refer to the Right and Left ear, respectively. The number before and after each alphabet refers to the intensity level and the number of repetitions at a particular intensity level. Latency for each wave peak was noted in brackets.

Panel A shows the ABR wave patterns with a click stimulus. With a latency of around 5.0 msec in both ears, a robust wave V was noted at high intensity levels, i.e., 80 and 100 dBnHL, respectively. Based on the results, it appears that the subject has normal and intact auditory brainstem pathways. Since the subject was healthy with normal hearing, we assumed that his ABR could be recorded at normal levels.

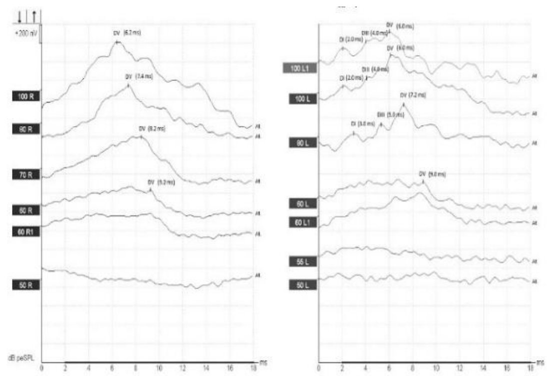
Panel B of Figure 1 reveals the response of D-ABR waves when the intensity level of F1 is reduced. As a result of these reductions, major waves' peak amplitudes decreased, while their absolute latencies shifted rightward. The right ear clearly showed wave DV at 6.2 msec at 100 dB peSPL. With a reduction in intensity to 60 dB peSPL, wave DV was spotted at lower peak amplitudes and longer latency, i.e., 9.2 msec. There were no distinct early waves either at the initial or lower intensity levels. The left ear experienced waves DI, DIII, and DV approximately at 2.0, 4.0, and 6.0 msec at 100 dB peSPL. When the intensity was reduced to 80 dB peSPL, waves DI, DIII, and DV were spotted at 3.0, 5.0, and 7.2 msec. However, at 60 dB peSPL, only wave DV was identified at 9.0 msec. At 100 dB peSPL, the interpeak latencies (IPLs) between wave DI-DIII, DIII-DV, and DI-DV were approximately 2.2, 1.8, and 4.0 msec. At 80 dB peSPL, the IPLs occurred at 2.0, 2.2, and 4.2 msec, respectively. As we did not observe absolute latencies for the earlier waves for the right ear, IPLs were not recorded for that ear. It was observed that DV's inter-aural latency (IALDs) between ears was 0.2 milliseconds at 100 dB peSPL. In general, the F1 stimulus had good morphology, since observers could easily identify wave DV.

Panel C shows the effects of the F2 stimulus on the subject. A repeatable DV measurement of 100 dB peSPL was obtained in the right ear at 7.8 msec. However, although wave DI and DIII were present at the same intensity level, their presence was indecisive. The latency of wave DV at 90 dB peSPL was 8.3 msec. At 100 dB peSPL, DV could be detected around 7.0 msec, but DI and DIII were not noticeable. There were no major waves and poor morphology as a result of the decreased intensity level. The IALD at 100 dB peSPL was approximately 0.8 msec. In general, F2 morphology was poor as DV, and earlier waves could not be distinguished, especially at lower intensity levels. Due to the fact that the subject is a healthy-normal hearing person, the subject is unlikely to tolerate a large IALD.

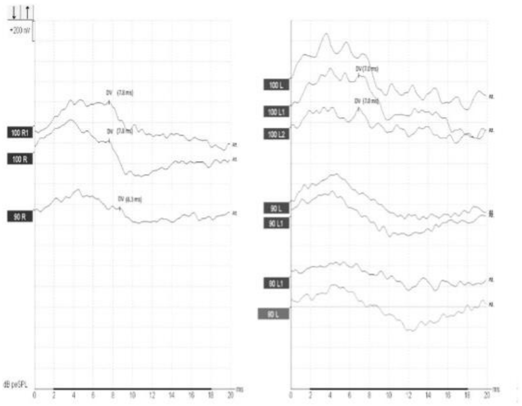
Finally, Panel D shows the effects of the F3 stimulus. At 100 dB peSPL delivered to both ears, without earlier waves, wave DVs were spotted for the right and left ears at 6.5 and 7.0 msec, respectively. There was still clear wave DV in both ears at 75 and 80 dB peSPL with an absolute latency of approximately 9.5 and 7.9 msec, respectively. Additionally, with the attenuation of intensity level, the absolute latency of wave DV for both ears shifted to the right and the amplitude was reduced, and IALDs were measured at 0.5 msec. Generally, the F3 stimulus had fair morphology as wave DV could be identified separately at 75dB peSPL on the right and left ear and 80dB peSPL on the right.



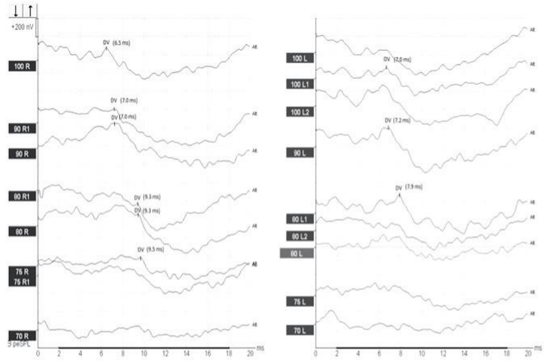
Panel A



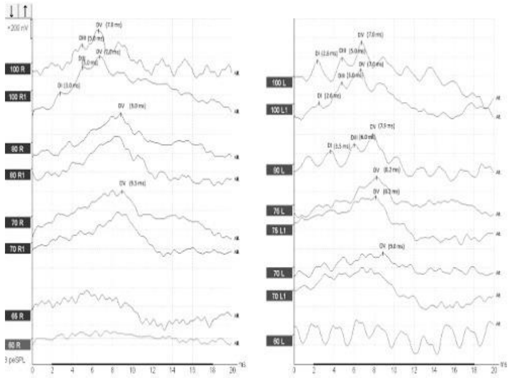
Panel B



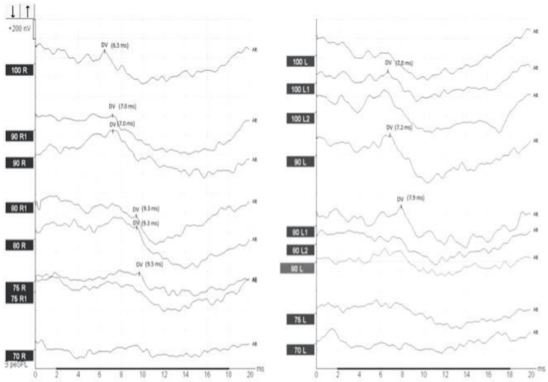
Panel C



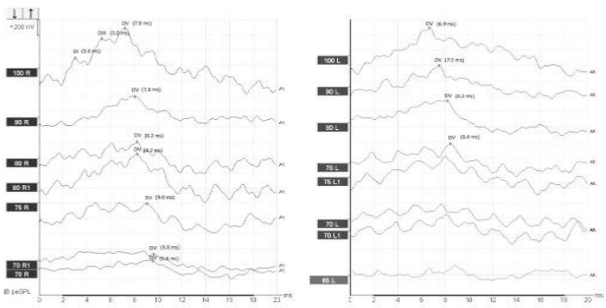
Panel D



Panel E



Panel F



Panel G

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Figure 2 shows three panels. Panel E: The effect of reducing M1 stimulus intensity level on D-ABR wave tracings. Panel F: The effect of reducing M2 stimulus intensity level on D-ABR wave tracings. Panel G: The effect of reducing M3 stimulus intensity level on D-ABR wave tracings. Note: The alphabet R and L refer to the Right and Left ear, respectively. The number before and after each alphabet refers to the intensity level and the number of repetitions at a particular intensity level. Latency for each wave peak was noted in brackets.

Panel E shows the effects of the M1 stimulus. At 100 dB, peSPL, DI, DIII, and DV were spotted on the right ear at approximately 3.0, 5.0, and 7.0 msec, respectively. There were IPLs of 2.0, 2.0, and 4.0 msec for DI-DIII, DIII-DV, and DI-DV, respectively. A decrease in intensity shifted DV to the right while the earlier waves decreased. The lowest intensity level for the right ear that still produced DV was 70 dB peSPL, and the absolute latency was 9.5 msec. As for the left ear, DI, DIII, and DV were spotted in approximately 2.6, 5.0, and 7.0 msec at 100 dB peSPL, respectively. Among the three IPL recordings were DI-DIII (2.4 msec), DIII-DV (2.0 msec), and DI-DV (4.4 msec). As expected, when the intensity was reduced, the absolute latency for wave DV shifted to the right. As of 70 dB peSPL, wave DV occurred at approximately 9.0 msec. In addition, the earlier waves were absent. The IALD was documented at 0.0 msec. Overall, the waves generated by the M1 stimulus had good morphology.

Panel F shows the effects of M2 stimulus on D-ABR tracings. On the right ear, at 100 dB peSPL, wave DIII and DV were observed at latency around 5.0 and 7.0 msec, respectively. As the intensity was reduced, while DV was shifted to the right with reduced amplitude, the earlier waves were absent. The lowest intensity level for the right ear was at 75 dB peSPL with DV absolute latency recorded at 9.8 msec. At 100 dB peSPL, the left ear generated absolute peak latencies of wave DI, DIII, and DV at approximately 3.0, 5.0, and 7.0 msec, which later showed computed IPLs of DI-DIII, DIII-DV, and DI-DV at 2.0, 2.0, and 4.0 msec, respectively. The attenuation in intensity level caused DV to shift to the left with reduced amplitude. The lowest intensity level that could still record DV was at 75 dB peSPL, with DV latency of approximately 9.0 msec. IALD was at 0.0 msec. Overall, when using M2 as the stimulus, it showed fair morphology as wave V could be identified only after careful observation, especially at the intensity level of 75 dB peSPL for both ears.

Finally, Panel G illustrates the effects of the M3 stimulus on D-ABR tracings. The right ear generated absolute peak latencies of waves DI, DIII, and DV in approximately 3.0, 5.0, and 7.0 msec at 100 dB peSPL. DI-DIII, DIII-DV, and DI-DV had IPLs of 2.0, 2.0, and 4.0 msec, respectively. The lowest intensity level measured was 90 dB peSPL, with an absolute latency for DV of 7.8 msec. With 100 dB peSPL, the only marked wave on the left ear was DV at 6.9 msec. At an intensity of 75dB peSPL, clear wave DV was still visible with a DV latency of about 8.4 msec. As a result of further reducing the intensity, all waves were absent. IALD was at 0.1 msec. The stimulus M3 had poor morphology due to the difficulty in identifying the waves that were present when intensity was reduced.

The results suggest that M3 was the best stimulus to trigger D-ABR responses due to its good morphology, presence of all absolute peaks at high intensity levels in both ears, and reliable IALD when compared to other waves.

Discussion

Best of our knowledge, this is the first document that reported a meaningful word stimulus, i.e., Dhikr an ABR test. We described the processes in producing the stimuli as they might be helpful in future studies. We recorded the targeted word 'Allah' multiple times to ensure the extraction of reliable and applicable tokens of stimulus (Skoe & Kraus 2010). Furthermore, the intention behind recording male and female voices was due to differences in fundamental frequency (F0), resulting in discrepancies in the D-ABR waves. In general, males have lower F0 and formants than females, allowing for better phase-locking mechanisms and better D-ABR morphology in the brainstem (Skoe & Kraus 2010). Age, language, emotion, type of text, and discourse can also influence the values.

Modern synthesizers and audio editing software make creating natural sound effortless. A /da/ stimulus was synthesized using a Klatt cascade formant synthesizer (Sinha & Basavaraj 2010). Klatt (1980) describes the formant synthesizer as providing a more stable stimulus, avoiding recalibration of the stimulus. Our study used recorded live-voice stimuli to ensure that the word 'Allah' is pronounced correctly. The way Arabic words are pronounced and articulated is unique compared to other languages. In the word 'Allah' itself, the stresses between the phoneme /a/ and /l/, known as *shaddah*, are essential when pronouncing the word. Our attempts to use text-to-speech software such as PRAAT and Natural Reader revealed that the software failed to generate the stresses contrary to live voice. Hence, future research may compare the speech spectrum of the live-recorded and the synthesized word.

The analysis of D-ABR waves has focused primarily on identifying the significant peaks, namely DI, DIII, and DV. The greatest peak was identified DV before a large trough at the highest intensity level. In determining DI and DIII positions, we used two main assumptions: the identified DV and interpeak latencies of DI-DV and DIII-DV. The presence of prominent peaks determined the presence of DI and DIII. Using the difference of DI-DIII, DIII-DV, and DI-DV, we determined the interpeak latencies of these waves. As in click ABR, the difference should be approximately within 2.0, 2.0, and 4.0 msec, respectively. Furthermore, the study also examined IALD for the DV at a high-intensity level, providing additional information on the generated D-ABR. It is noteworthy that we found that stimuli on F1, M1, M2, and M3 gave IALDs of less than 0.3 msec. In ABR, the maximum IALDs have been reported to be 0.3 msec for both clicks and chirps (Cargnelutti et al. 2017; Stürzebecher et al. 1985).

Several findings of this study could be worthwhile to investigate in future research. To begin with, all six of the Dhikr stimuli have produced fairly measurable auditory brainstem responses. In general, we can analyse the patterns of the D-ABR waveforms by comparing them to the typical click ABR response of the subject. This is particularly true of the prominent wave, DV, consistently visible at a high intensity. The presence of earlier waves, however, was not always evident. The waves generated by F2, F3, and M2 stimuli, for example, showed poor morphology because they lacked earlier peaks at high or low intensities. The observers, therefore, had difficulty identifying the absolute and inter-peak latencies of those waves. This may be due to the parameters used, the acoustic characteristics of the stimulus, or the averaging of signals. Considering our study, we recommend that cABR responses be recorded using an experimental stimulus of a novel design (Skoe & Kraus 2010). Future investigations should investigate the issues raised in this study.

The second observation was that each wave, as observed in click ABR, was affected by the reduction in intensity level, i.e., the wave's amplitude and latency increased and shifted to the right, respectively. Our observations indicate that a reduction in intensity prolonged the absolute latencies in D-ABR. However, Dhikr and click ABR are different in that the absolute latencies for the former are delayed. Moreover, the current study failed to detect DV at the intensity level nearest the subject's hearing threshold, i.e., 20 dB HL. Additional studies with larger samples will be needed to investigate these findings further.

Future studies on D-ABR should be encouraged. In the first instance, examining the word's speech spectrum should be carried out due to its unique phonological characteristics. Secondly, at least for different genders and ages, D-ABR norms should be documented. It is interesting to apply the stimulus to pathological groups such as people with varying types of hearing loss and those who have difficulty processing audio information.

To conclude, the current study has shown how reliable waves can be produced by using a complete meaningful word from auditory brainstems. The experience of generating the D-ABR waves and producing the stimuli was explained. For the Dhikr stimulus to be applied in clinical settings, further studies must be performed on the stimulus and normative data must be generated for D-ABR.

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Declaration

Part of this research findings have been presented in the 3rd World Congress of the Integration and Islamicisation (WCII) 2021 and its abstract have been published in the Malaysian Journal of Medicine and Health Sciences Vol.17 Supp 5, August 2021 (eISSN 2636-9346).

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