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## Reflections on Neuroethical Issues in Neuroimaging Research Advances from the Islamic Perspective

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### ABSTRACT

*The growth of neuroscientific research from the progress of neurotechnologies imposed an evolving range of potential bioethical issues. In this context, neuroethics offers insightful guides for researchers to deal with such emerging ethical issues in neuroscience research. However, with diverse brain-related research areas worldwide, potential frictions on moral and ethical grounds are likely to surface which inevitably compounded by local traditions and/or belief systems. Potential ethical issues may originate from shared or distinct perspectives depending on the region that can vary from histories, philosophies, moral values, and social stances. Herein, we focused on Islam as the second-largest religious group globally with such diversities. This narrative review aims to highlight the potential neuroethical issues arising from the advances of neuroimaging in neuroscience research from an Islamic perspective through the lens of Islamic legal maxims (al-qawa'id al-fiqhiyyah).*

**Keywords:** Ethical issues, Islamic legal maxims, neuroethics, neuroimaging

Islam is a religion that encompasses all living aspects of human life (i.e., from before birth to the afterlife). Al-Quran, the words of God (Allah), and al-Sunnah, which contains all the actions, sayings (*hadiths*), and wisdom of the Prophet Muhammad, are the two primary sources of the Islamic law that must be followed by Muslims' life (Hashi 2011). Aside from these primary and supreme sources of Islamic law, *ijma'* (Muslim scholars' consensus) and *qiyas* (analogical reasoning) are the secondary sources that can be accepted to guide Islamic law (A. C. Miller, Ziad-Miller & Elamin 2014). In essence, the two sources ensure that the debate on specific rulings can reach a consensus that meets the need of the ever-changing modern world with the assurance of conforming to the two primary sources of Islam (i.e. Al-Quran and al-Sunnah).

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One of the comprehensive methods used to discuss new rulings is via *al-qawa'id al-fiqhiyyah al-'aliyyah* (Islamic legal maxims) are derived from the thorough study of Islamic jurisprudence (*usul al-fiqh*) by leading Muslim jurists on various topics. These Islamic legal maxims consist of general *fiqh* guidelines that can be applied to pertinent issues where applicable within common rulings (Saiti & Abdullah 2016). Kamali (2008) highlighted that the words used or contained in Islamic legal maxims are taken from Islam's two supreme primary sources, which Muslim jurists have often refined over the centuries. Thus, the Islamic legal maxims also represent the peak product of the cumulative progress to address multiple problems in specific periods that could not have happened during the formative phase of *fiqh* development.

Islamic legal maxims are closely linked to the objectives and purposes of Islamic law, known as *maqasid al-shariah*. The most crucial objective of *maqasid al-shariah* is to conserve human benefits by the protection of human faith (*hifz al-din*), life (*hifz al-nafs*), progeny/lineage (*hifz al-nasl*), intellect (*hifz al-'aql*), and wealth (*hifz al-mal*) (Mustafa 2014). Therefore, Islamic legal maxims could provide discernible insight into Islamic law (Kamali 2008). The knowledge on *maqasid al-shariah* also has been advocated as a complementary framework to conventional bioethics in resolving the various bioethical issue (Ibrahim, Rahman, Saifuddeen, & Baharuddin, 2019; Saifuddeen, Rahman, Isa & Baharuddin 2014).

There are five major Islamic legal maxims grouped under the term *al-qawa'id al-fiqhiyyah al-'aliyyah*: (i) principle of *qasd* (intention), (ii) principle of *yaqin* (certainty), (iii) principle of *darar* (injury), (iv) principle of *darurah* (necessity) and (v) principle of *'urf* (custom). These principles are deemed to be the most encompassing maxims that can be applied to the whole *fiqh* spectrum (Kamali 2008). Owing to this comprehensiveness, these five Islamic legal maxims can be tailored to address contemporary life issues in a variety of fields, such as medical ethics (Mustafa 2014), finance (Saiti & Abdullah 2016) and environment (Awang & Abidin 2011) without losing their essence.

The recent growth in neuroscientific research and the advancement of neurotechnologies have led to an expanding ground for numerous ethical challenges. There are a few neurotechnologies that have been used in neuroimaging research such as electroencephalography (EEG), magnetoencephalography (MEG), functional magnetic resonance imaging (fMRI), computed tomography (CT), positron emission tomography (PET) and single-photon emission computerized tomography (SPECT) that have different procedures and functionality.

Neuroethics has been coined to tackle the various ethical, legal, and social implications as the repercussions of neuroscience research expansion (Farah 2012; Safire 2002). Neuroethics overlaps with some pertinent issues in biomedical ethics (Roskies 2002), which revolve around the four main biomedical ethics principles: autonomy, non-maleficence, beneficence, and justice (Beauchamp & Childress 2001). This is not surprising as neuroethics can be regarded as a section under biomedical ethics that caters to neuroscience research that is acknowledged to impose more complex questions that may stretch well beyond the scope of the four principles. Notwithstanding, the four principles serve as the starting ground for neuroethics deliberation, which was previously the framework for ethical debate involving the progress in genetics and genomics (Mezinska et al. 2021) and are not covered in this review.

Corroboratively, these bioethical issues are frequently encountered in global neuroscience research. Though prominent in Europe and the United States, other nations such as China, Japan, India, Africa, the Middle Eastern, and Southeast Asian countries are also conducting a diverse range of neuroscience research. Furthermore, numerous ethical issues may result from such diversities due to the differences in the respective countries or regions' histories, philosophies, moral values, and stances. While some issues may not be directly relevant to the science we currently know, they still fall within the ethical framework in research. With Islam having an estimated 1.8 billion believers worldwide and the fastest-growing religion globally (Lipka & Hackett 2017), such diverse cultural and religious frictions pertaining to ethical questions will emerge and warrant appropriate attention.

Hence, in this paper, we explore the potential neuroethical issues that may arise from the advent of neuroimaging and their potential repercussions on ethical, legal, and social implications, with a focus on the Islamic legal maxims (*al-qawa'id al-fiqhiyah al-'aliyyah*) as the guiding principles to approach and reflect on these emerging neuroethical issues.

### An Overview of the Five Islamic Legal Maxims

The five Islamic legal maxims are a rehash of the Quranic verses and also renowned hadith. Table 1 elucidates the meaning of the leading five Islamic legal maxims and the Quranic verses and hadith that they are sourced from.

**Table 1: The Five Leading Islamic Legal Maxims**

Maxim	Definition	Quranic Verses Related to Maxim	Hadiths Related to Maxim	Conditions
Principle of <i>Qasd</i> (Intention)  <i>"Innama al-A'mal bi al-Niyat"</i>  ( <i>al-A'mal</i> = Actions/ Deeds; <i>al-Niyat</i> = Intention).	-Any acts are judged by their objectives and purposes.  - Actions are valued as per their underlying intentions.	Al-Shura (42:20): "Whoever desires the harvest of the Hereafter, We will increase their harvest. And whoever desires only the harvest of this world, We will give them some of it, but they will have no share in the Hereafter".  Al-Baqarah (2:42): "And cover not truth with falsehood nor conceal the truth while you know [what it is]".	Narrated 'Umar bin Al-Khattab that the Allah's Messenger (PBUH) saying, "The reward of deeds depends upon the intentions, and every person will get the reward according to what he has intended. So whoever emigrated for worldly benefits or for a woman to marry, his emigration was for what he emigrated for" ( <i>Sahih Bukhari</i> , Book 1, Hadith 1).	The actions will be judged according to the intent of the doer.  Intentions can be judged into 5 categories: <ol style="list-style-type: none"> <li>Intention of the heart.</li> <li>Intention that permeates/grows in the heart.</li> <li>Intention that grows in thoughts but are refrained from doing it.</li> <li>Intention to commit overshadows the thought of refraining from doing it.</li> <li>Intention is solidified and determined to act on it.</li> </ol>
Principle of <i>Yaqin</i> (Certainty)  <i>"Al-yaqin la yazalu bi al-syak"</i>  ( <i>Al-Yaqin</i> = Certainty; <i>Al-syak</i> = Doubt).	-Certainty is not overruled by doubt.  - Something that has been certain, can only be overruled by same certainty not by doubt.	Al-Baqarah (2:29): "He is the One Who created everything in the earth for you."  Yunus (10:36): "Most of them follow nothing but inherited assumptions. And surely assumptions can in no way replace the truth. Allah is indeed All-Knowing of what they do".	The Prophet was asked about doubts (concerning ablution) during prayer. He said that one should not leave until he hears a sound or detects an odor ( <i>Sunan Ibn Majah</i> , 514).  Prophet Muhammad said that when one of you is in doubt about his prayer (i.e, how much he has prayed), he should throw away his doubt and base his prayer on what he	Certainty, and its ruling based on certainty, cannot be set aside by doubt  It can be considered in the scientific community as the basis for evidence-based medicine. It should be noted that any interpretation of the research findings and subsequent interventions from the research must be based on valid evidence and data.

			is sure of ( <i>Sunan Abi Dawud</i> , 1024).	
<p>Principle of <i>Darar</i> (Injury)</p> <p><i>"Al-dararu yuzal"</i></p> <p>(<i>Al-darar</i> = injury; <i>Yuzal</i> = removed)</p> <p><i>"La darar wa la dirar"</i> No retaliation of harm with harm</p>	<p>-Harm must be eliminated and not to inflict harm to others.</p>	<p>Al-Baqarah (2:188): "Do not consume one another's wealth unjustly, nor deliberately bribe authorities in order to devour a portion of others' property, knowing that it is a sin".</p> <p>Al-Nisa (4:29): "O believers! Do not devour one another's wealth illegally, but rather trade by mutual consent. And do not kill each other or yourselves. Surely Allah is ever Merciful to you".</p>	<p>Narrated from Ibn 'Abbas that the Messenger of Allah (PBUH) said: "There should be neither harming nor reciprocating harm" (<i>Sunan Ibn Majah</i>, 2341).</p>	<p>A person should not cause harm. One also not to cause harm to another person in order to reciprocate the harm he has caused.</p> <p>Choosing between various action to remove harm must be applied according to the scale of priorities under the <i>Maqasid al-Shariah</i>:</p> <ol style="list-style-type: none"> <li>Religion (Hifz al-Din).</li> <li>Life (Hifz al-Nafs).</li> <li>Lineage (Hifz al-Nasl).</li> <li>Intellect (Hifz al-'Aql).</li> <li>e) Property (Hifz al-Mal).</li> </ol>
<p>Principle of <i>Darurah</i> (Necessity)</p> <p><i>"Al-mashaqqatu tujlab al-taysir"</i>.</p> <p>(<i>al-Mashaqqah</i> = hardship; <i>al-Taysir</i> = facility)</p>	<p>-Hardship begets facility.</p> <p>-In exceptional circumstances, it is necessary to lighten the burden and disregard rules if it will cause hardship.</p>	<p>Al-Baqarah (2:185): "Allah intends ease for you, not hardship".</p> <p>Al-Maidah (5:6): "It is not Allah's Will to burden you, but to purify you and complete His favour upon you, so perhaps you will be grateful".</p>	<p>Narrated from 'Aisha that whenever Prophet Muhammad (PBUH) was given the choice of one of two matters, he would choose the easier of the two, as long as it was not sinful to do so, but if it was sinful to do so, he would not approach it. (<i>Sahih Bukhari</i>, 3560).</p> <p>'Imran bin Husain had said, "I asked the Prophet (PBUH) about the prayer of a person while sitting. He said: 'It is better for one to pray standing; and whoever prays sitting gets half the reward of that who prays while standing; and whoever prays while lying gets half the reward of that who prays while sitting."</p>	<p>Any ruling that causes hardship or is unable to be carried out for any reasonable reason, an alternative can be found to alleviate the hardship.</p> <p>Facility (<i>Rukshah</i>) can be given for:</p> <ol style="list-style-type: none"> <li>Omission (Exceptions).</li> <li>Reduction (Qasar).</li> <li>Combining (Jama').</li> <li>Delay (Ta'khir).</li> <li>Advance (Ta'qdim).</li> <li>Lawful the unlawful (Dispensation).</li> </ol> <p>Reasons for <i>Rukshah</i>:</p> <ol style="list-style-type: none"> <li>Travel.</li> <li>Sickness.</li> <li>Compulsion (permitted under duress).</li> <li>Forgetfulness.</li> <li>Ignorance (with commitment to learning).</li> <li>Difficulty.</li> <li>Incapacity (Children/Women/Insane persons).</li> </ol>

			(Sahih Bukhari, 1115).	
Principle of 'Urf (Custom) "Al-'adah muhakkamatun". {Al-'Adah = Adat/Custom; Muhakkamatun = judgement/regulation).	Custom is the basis of judgement.  'Urf: Something widely known by individuals or society either by: a) Word. b) Action. c) Abstinence that are not regulated by text.	Al-A'raf (7:199); "Be gracious, enjoin what is right ('urf), and turn away from those who act ignorantly".	Based on the statement of the Companion, 'Abdullah Ibn Mas'ud: "What the Muslims deem to be good is good in the eyes of God." This statement from the Companion is sometimes referred to as an elevated (marfu') hadith because the Prophet himself upheld Arabian society's customary practises on numerous occasions. Prophet Muhammad (PBUH) said: "Righteousness is good character and sin is what gnaws at your conscience and that which you dislike for other people to become aware of." (Al-Adab Al-Mufrad, Book 14, 295).	Local customary practices can be considered to have a legal basis as long as: a. It does not conflict with Islamic law. b. The custom is predominant among individuals and society. c. Has been practiced by society. d. No contradiction in practice.

### Addressing Neuroethical Issues Emerging from Neuroimaging Research through Islamic Legal Maxims

#### 'Mind-read'

In neuroscience research, one specific ethical issue is the usage of neuroimaging devices to 'mind-read'. The development of functional MRI (fMRI) in subsequent years after the development of positron emission tomography (PET) continued to revolutionise cognitive neuroscience studies. fMRI provides an increased spatial resolution of in-vivo brain state representation for researchers with the added advantages of being non-invasive, using non-ionising radiation and requiring no exogenous radiopharmaceutical administration compared to other neuroimaging methods, i.e., PET (Li, Guo, Nie, Li & Liu 2009). As a result, the ability of fMRI to locate and delineate parts of the brain involved in specific processes without causing further harm to healthy subjects enables the researchers to understand brain function better. In fact, many studies in the field of 'mind-reading' such as neuromarketing (Breiter et al. 2015) and neuropolitics (Schreiber 2017) favoured fMRI because of its ability to display whole-brain images and the familiarity of the images to the public (Keehner, Mayberry & Fischer 2011).

Recently, a state-of-the-art 20 Tesla MRI has been introduced with a superior spatial resolution and accessible for neuroscience research (Budinger & Bird 2018; Budinger et al., 2016). With this advancement, Hoffman (2018) anticipated that over the next 5 decades, neuroimaging would produce a precise and reliable method for detecting lies and memories that can be applied as legal precedence. Meanwhile, in the coming 5 to 10 years, progress in neuroimaging will serve

as a significant tool to assist in diagnosing neuropsychiatric disorders alongside the conventional method of clinical diagnosis (Hoffman 2018).

In addition, the neuroimaging modality may also be utilised in pre-employment and insurance screening. For instance, in pre-employment screening, employers may request prerequisite neuroimaging results for potential employees, especially those applying for a high-ranking position. However, this will be conflicted with the societal conception of personhood, individuality and free will of the human being and may result in injustice towards the potential employees if the employer justifies the business need for prior assessments of a specific brain function (Ramos et al. 2019). Neuroprediction of violent behaviour has also been developed, which has the potential to significantly impact the legal system as well as the prevention and/or personalised therapy (Poldrack et al. 2018).

Thus, any claims made from the results projected from these 'mind-reading' scenarios should be based on principle of *yaqin* and to ensure that the benefits are far outweigh the risks. Corporations engaged in 'mind-reading' research that made specific claims about their findings should have solid evidence and valid methodology. The act of 'mind-read' could also be related to the principle of *qasd* that judged intentions into five categories (Table 1). Unless the intentions or thoughts manifest into action or speech, evil intentions or thoughts per se that the researcher gain from neuroimaging method of 'mind-read' do not hold (Al-Delaimy 2012). This also shows how Islam cherishes the privacy of thought processes.

### Sharing of Research Findings

Another ethical issue that emerges from this is how the results of these studies will be disseminated. Any results from research on political attitudes must be disseminated accordingly and not used in a biased way by favouring a specific group or ideology. Any biased results from the study may compromise decision-making autonomy, jeopardising the fundamental pillar of the democratic system (Feenstra & Pallarés-Domínguez 2017; Rainey, Martin, Christen, Mégevand & Fournier 2020; Schreiber 2017). Therefore, the principal investigators and institutions involved in such studies play an essential consultative role in promoting transparency in which they should publish consultation contracts and other interactions on a publicly accessible domain, such as the institution's website, and declare any conflict of interest (Bianchi et al. 2018; Fisher, Chin, & Klitzman 2010).

They must also ensure that no violation of individual privacy against the agreed consent would occur, for example, if the investigator discloses data or information from the imaging data beyond the study's scope and aims (Ariely & Berns 2010; Kellmeyer 2021). In addition, the research team must uphold a certain level of ethical conscience to prevent any reporting bias and any vital information from such studies from being withheld from public knowledge. This aligns with the guiding principles of neuroethics to encourage proper information sharing for public education in neurosciences (Bianchi et al. 2018).

One of the Islamic legal maxims that can help in tackling the emerging ethical issues related to the above discussion is upholding the principle of *qasd* by all neuroimaging researchers, specifically Muslim researchers. This maxim states all acts are judged by the intent behind them. Therefore, researchers or medical practitioners need to evaluate their intentions prior to the act (Mustafa 2014). In neuroimaging research, researchers must conduct the study with good intentions.

For example, any results gained from research on political attitudes must be disseminated accordingly and not be used in a biased way by favouring a specific group or ideology. For instance, industry-based research on political attitudes showed that the self-identified political conservatives group portrayed considerably higher activation in the right amygdala area of the brain during risk-taking, although risk-taking behaviour did not show any distinctions in imaging (Kanai, Feilden, Firth & Rees 2011; Schreiber et al. 2013). From this, they interpreted those conservatives encountered a higher emotional response when dealing with dangerous endeavours. It was also understood as the need to provide them with some level of safety and

assurance to shift them towards a more liberal stance on particular issues (Napier, Huang, Vonasch, & Bargh 2018).

If the researcher intends to pursue truth, all the results, whether fulfilling the hypothesis or not, he/she must be transparent and made known to the scientific community and the public. Hence, all researchers must conduct the study with good intentions. With good intentions, they will uphold good ethics and conscience when conducting the research. They will avoid any conflict of interest or unethical acts such as plagiarism, data falsification, and fabrication to maintain a high ethical standard and uphold the integrity of the research. In pursuing the intention or the aim of doing research, it is of utmost importance for any actions taken to be ethical. The good intention must also be followed with good action as stated in the Al-Quran, Al-Baqarah 2: 42: “*And cover not truth with falsehood nor conceal the truth while you know [what it is]*”.

### Validity of the Research Findings

Research that employs neuroimaging modality for ‘mind reading’, such as lie detection studies, often raises the question of how far the outcomes from such studies are authentic enough to be used in a convincing manner. The main ethical issue concerning using neuroimaging in the lie detection approach is the violation of privacy in the thought process. In the case of mental privacy being compromised, cognitive liberty may suffer. ‘Cognitive liberty’ refers to the idea that one should be free from brain manipulation in order to think one’s thoughts (Rainey et al. 2020). It remains unclear how we can be sure that the images and the data from the neuroimaging are accurate portrayals of the individual thought or whether they are deceptive.

Furthermore, results from neuroimaging research are based on blood-metabolic activity detected as fMRI signal (known as BOLD) in specific brain regions when the subject is performing certain tasks or being stimulated by a set of stimuli. For example, if this research is used for pre-employment screening, the potential employee must conduct a set of questions or tasks before the results can be interpreted accordingly. However, how sure are we that the outcome obtained reflects the prospective employee’s behaviours in the future since the actual task has not been carried out yet?

Therefore, we must not make judgements solely based on probability and assumptions. With regard to this issue also, the principle of *yaqin* is upheld. Only results with valid evidence should be entertained. If the results from the neuroimaging denied a prospective employee the opportunity to be hired, then injustice has arisen from the Islamic perspective; it is the action, not the thought, that matters. Thoughts will come and go, and they may dissipate. Unless and until they manifest into action or speech, evil thoughts per se do not hold (Al-Delaimy 2012).

### Reproducibility of Research

In order to substantiate the valid findings in neuroimaging research and reduce assumptions, thus upholding the principle of *yaqin*, the research community must uphold the reproducibility of the research. However, the lack of research reproducibility in neuroimaging research is alarming. This may be due to poor research practices that lead to a high rate of false findings in the scientific literature (Poldrack et al. 2017). The lack of study replication to verify previous results may also be due to the research community’s attitude that prioritises novelty over clarification studies, despite the importance of replication in neuroimaging research. Therefore, it is essential to be critical of the results gained from neuroimaging research and ensure that the same research is replicated to reproduce affirming results to strengthen the truth or fact (Evans 2017).

Hence, it is important to prioritise the conduct of continuous research as this would enable researchers to replicate the method used in the previous research to ensure the reproducibility of the results. This can provide the meaningful application of the findings to answer specific questions and hypotheses, thus avoiding any judgment based on pure probability.

We can relate this to another similar maxim from the principle of *yaqin* that states 'knowledge that is based in certainty is to be differentiated from the manifestation of knowledge that is based only on probability' (Kamali 2008). Therefore, researchers must ensure that the research fulfils all the required methodologies that may have real-world implications when interpreting their findings, whilst members of the public could afford some credence in such findings.

### Neuroimaging Devices and Incidental Findings

In neuroimaging research, the usage of specific modalities such as CT, SPECT or PET scans must be justified to reduce the risk to the subjects. This is because devices such as CT scans use ionising radiation to attenuate the tissue of the subject's body. This may cause harm to the body. On the other hand, devices such as SPECT and PET scan function by capturing the radiation (gamma rays) emitted from the radiopharmaceutical compounds that have been injected into/ingested by the body. Without proper handling of the radiopharmaceutical compounds and appropriate post-administration care, the attending personnel, patient, and immediate family are at risk of being exposed to radiation hazards. Therefore, it is important to justify using these devices and to guarantee that the benefits of using them outweigh the risks. This is in line with the biomedical ethics principles of beneficence and non-maleficence (Beauchamp & Childress 2001).

Under principle of *darar*, there are other maxims that observe that greater harm can be eliminated if the two harms overlap to induce lesser damage. This maxim can be applied to the issue of incidental findings in neuroimaging research. According to a meta-analysis, the prevalence of incidental findings of potentially serious health implications on brain MRI of asymptomatic adult subjects is about 1.4% (Gibson et al. 2018). This raises ethical issues on how best to deal with these incidental yet clinically significant findings. Further improvement in MRI technology with better resolution will result in even higher incidental findings on routine examinations (Borra & Sorensen 2011; Illes et al. 2006). To tackle this issue and protect researchers from any legal claim, many institutions have included a section that outlines the incidental findings and any possible actions that can be taken in the consent form to be signed by the subjects before MRI scanning (Illes et al. 2006). On the other hand, researchers are fully accountable for reporting any significant clinical findings and referring the subjects to other specialists, such as neuro-radiologists, to confirm the findings. Ethically speaking, if the researchers do not disclose the findings, they will violate the ethical principle of non-maleficence (F. G. Miller, Mello & Joffe 2008).

If the incidental findings may bring harm to the individual, confidentiality can be waived as the health concern of the individual supersedes it. In addition, in Islam, community benefit takes precedence over individual benefit. Thus, if the incidental findings are infectious in origin and may harm the public if the person is not treated, confidentiality can be waived to enable the proper follow-up management of the person (Al-Delaimy 2012; Mustafa 2014).

### Unbiased Report

Harm should also be minimised in neuroimaging research comparing different groups of ideologies, religions, or traditions. It is crucial to ensure that the study does not discriminate between groups (Al-Delaimy 2012). Islam rejects selective evaluation and emphasises equality between human beings regardless of their descent, race or societal status (Ibrahim et al. 2019). The researcher must be truthful and unbiased when reporting the results, as outlined in the first maxim that the researcher's intention must always be good. Besides, to increase inclusiveness and prevent bias, a more diverse research team should be recruited (Goering & Klein 2020). The researcher must also provide clear and valid justification and assess the scientific merit of choosing such a study design (Al-Delaimy 2012). Without proper dissemination of results and discussion, it may result in prejudice and stigmatisation of certain groups, thereby causing disharmony in the community. Thus, researchers must be aware of the possible consequences of the studies to eliminate and reduce any unintended damages.



### Neuroimaging Research on Complementary and Alternative Practices

Many local practices have been established as complementary and alternative practices in medicine after research has produced valid and definitive results. For instance, extensive neuroimaging research on mindfulness meditation has shown that such practices could enhance frontal lobe activation, which is associated with executive function (Kozasa et al. 2012; Tomasino, Chiesa, & Fabbro, 2014), increase the cortical thickness structurally, improve the integrity of white matter (Posner, Tang & Lynch 2014) and increase the theta, alpha and gamma brainwaves (Braboszcz, Cahn, Levy, Fernandez, & Delorme 2017; Chiesa & Serretti 2009; Kerr et al. 2011; Lee, Kulubya, Goldin, Goodarzi & Girgis 2018) which are vital to produce a positive emotional state in the meditators.

These positive findings have led to the widespread use of mindfulness meditation practices and their derivatives in clinical settings, thus transcending their original cultural and religious specificity (Braboszcz, Hahusseau, & Delorme 2010; Simkin & Black 2014). This is in line with the principle of *'urf*, in which the Prophet had upheld Arabian society's customary practices on various occasions as long as they did not conflict with the Quran and Islamic teaching. Besides that, there are also a growing number of studies that have explored the therapeutic effects of Quranic listening and recitation that cover the various psychological and physical disorders that can benefit people universally, regardless of faith, culture and society (Jabbari, Mirghafourvand, Sehhatie & Mohammad-Alizadeh-Charandabi 2017; Majidipour et al. 2018; Saged et al. 2018).

This shows that neuroscience research on customary practices such as meditation and listening/reciting the Quranic verses helped to transcend their usage beyond their cultural and religious realm. In the future, more research should focus on local practices that purport to affect brain-mind-body connection for empirical neural basis where possible and within the ethical boundaries, thus extending its value beyond its local custom.

### Use of Islamic Legal Maxims to Address Other Contemporary Neuroethical Issues

The consensus on the ruling of the neuroethical issues in the Islamic perspective is ultimately based on the primary and secondary sources of Islamic law. One of the contemporary neuroethical issues on which there is a consensus among Muslim scholars is the ruling on brain death. Brain death is the death of an individual due to permanent loss of function in the entire brain. It is also referred to as death by neurologic criteria, determined by one or more medical professionals using accepted medical standards (Kondziella 2020; Lewis et al. 2020; Russell et al. 2019). Although debate continues about the details of brain death criteria among Muslim scholars, most accept brain death as actual death, with the minority accepting death by cardiopulmonary criteria only (A. C. Miller et al. 2014; Sajjad et al. 2020). The one who accepts brain dead as the true death agrees with the discontinuation of life-support treatment in brain-dead patients with strict neurologic criteria that the medical personnel must observe. From this, the principle of *yaqin* of the Islamic legal maxims is observed when making the decision.

The dynamic of the ruling pertaining to the neuroethical issues proved that Islamic law could provide guidance for medical professionals and society in facing the ever-changing world. An informed decision is being made with guidance from the five objectives of the *maqasid al-shariah*, i.e., the protection of human faith (*hifz al-din*), life (*hifz al-nafs*), progeny/lineage (*hifz al-nasl*), intellect (*hifz al-'aql*), and wealth (*hifz al-mal*) and also the five Islamic legal maxims (Kamali 2008; Mustafa 2014).

When disputes arise, for instance, due to different cultures and backgrounds, a second opinion or *fatwa* is sought regarding the disagreement when dealing with a specific neuroethical issue. For example, the recommendation to abort a fetus with Down syndrome is deemed ethically justifiable in most countries, even in the late stage of pregnancy (Bouzenita 2011). However, for Muslim mothers, the Fiqh Assembly at the Muslim World League (MWL) resolved that it is not

permissible to abort when the fetus has completed 120 days, even if the medical diagnosis shows that it is physically malformed. Though, if medical standards demonstrate that if the abortion is not performed, there is a risk to the mother's life, then it is permissible to do so to avoid the worst of the two harms, i.e. the principle of *darura* and *darar* (Islamweb 2019), in which the necessities overrule the prohibition. However, the default prohibition will resume after the need ends. This is also based on the *maqasid al-shariah* (purpose of Islamic law) that aims to protect human life (*hifz al-nafs*). Muslim personnel who encounter this issue should provide options for the patients so that they can make an informed decision. Thus, naturally, these principles are applicable in neuroscience research if or when the situation necessitates. The difference in ethical justification should not discourage research or treatment but instead open a new discussion and solution on common ground.

With the advancements of neurotechnology, regulatory systems must be established to anticipate neurotechnology-specific problems. These will include how neurotechnologies are presented, how they function, and what kinds of applications they should be limited to (Rainey et al. 2020). Brain technology developers should maintain active links with policymakers as part of their product or application development so that appropriate regulation can be framed. With that, inter-and trans-disciplinary Muslim scholars should hold more dialogues on this matter and should be actively involved in approaching emerging neuroethical issues, as highlighted in this review, within the Islamic legal maxims and mainstream biomedical ethics. The consensus on certain rules should also be disseminated to society openly. This is to ensure that various segments of society, especially Muslims, would have a better awareness and knowledge towards an informed decision when involved in such research and/or treatment. This will certainly help the researcher and medical personnel in conducting research and treatment, specifically in neuroscience.

In summary, neuroethical issues that emerged following the advancement of neuroimaging call for a collaborative debate and deliberation. The complexity of neuroethics extends beyond the well-known four pillars of biomedical ethics and impose unique set of challenges to varying belief systems, for instance Islam. With the diversity of neuroimaging modalities and relentless progress, the field of neuroethics requires wisdom and adaptations that are in harmony with long-held traditions, religion-based ethical values and social stances. Ultimately, the intention is to comply with all the moral codes and ethical limitations throughout the neuroscience research settings, given the diverse background of the participants who are eligible for such research.

In this narrative review, with a focus on neuroimaging progress and its use in neuroscience research, we reflect on the Islamic perspectives on the potential emerging ethical challenges from the angles of *al-qawa'id al-fiqhiyyah* (Islamic legal maxims), which are grounded on the *usul al-fiqh* (Islamic principles of jurisprudence) and *maqasid al-shariah* (purposes of Islamic law). While there may be a variety of views on specific ethical issues as time progresses, it is imperative that the views must remain consistent with the supreme primary sources of the legal rulings of Al-Quran and al-Sunnah, in order for those views to be deemed acceptable in the Islamic perspective.

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