Original Article

# A Biopsychospiritual Framework For The Investigation Of Khushu'

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## Abstract

Khushu' is a state that is required of every Muslim in prayer specifically and humans generally. It includes a state of utter humility with the Devine in an absorbed fashion in prayer and an overall approach to life out of prayer, the result being resilient human beings and a state of mindfulness, with an utmost respect for The Creator as well as creation. Not everyone achieves it. It has been attributed as a function of the "spiritual heart". Thus, the physical heart as well as the brain will be primary regions of interest. Thus far it has only been explored as a religious concept. A framework is thus needed to investigate the biopsychospiritual dimensions of this construct. A framework thus comprising of psychocardiological mechanisms, brain microvascular pulsatility, systamatic biomarkers and neuroimaging techniques such as fMRI and DTI and/or tractography that enable in vivo assessment of the spatial and temporal pattern of functional and structural changes was proposed. This framework can contribute to the elucidation of critical aspects in Khushu', in terms of physiological regulation and modulation as well as brain remodeling in individuals contributing to the understanding of as well as applying Khushu' for the betterment of individuals.

**KEYWORDS:** Khushu' – Spirituality – Biological Psychology – brain-heart axis - Neuroimaging

## Introduction

In Islam the term Khushu' is crucial, whereby every Muslim who has studied the five compulsory prayers have encountered this term. It is fundamental in having a valid, acceptable, as well as fulfilling prayer and prayer experience. While being defined and attained by many over the centuries, it is considered a work in progress in every individual's lives, there are many dimensions of Khushu' which needs to be elucidated. The term Khushu' has been linked to the words "khudu" (veneration) and "tawadu" (humility) (Jurjani, 1997). Therefore, it is stated that Khushu', encompasses, lowering oneself, being submissive, having humility, being deeply affected, and moved (Ibn Manzur, 2003). Khushu' has been technically applied in terms of succumbing to the truth, having constant fear of Allah, attesting to slave hood to Allah, enacting obedience, refraining from disobedience to Allah as well as various acts of obedience (Ibn Manzur, 2003). It has also been described, as what is in the heart manifested in the lowering of the gaze and apparent in the voice specifically as Khushu' is for the rest of the limbs, however many have stated its it synonymous in that it includes all the limbs as well. Furthermore, Khushu' has been attributed to being a state ("hal") (Firuzabadi, 1998).

The term appears in the Quran states "Successful indeed are the believers. Those who offer their Salah (prayers) with all solemnity and full submissiveness ("khashioon") (118:1-2)." Khushu' is therefore the state of submission (Qurtubi, 2013). Khushu' has also been linked to the state of speech on the day of reckoning (Qurtubi, 2013), "On that Day will they follow the Caller (straight): no crookedness (can they show) him: all sounds shall humble ("khashaa") themselves in the Presence of (Allah) Most Gracious: nothing shalt thou hear but the tramp of their feet (as they march) (20:108)," which will be humbled in the presence of Allah. When refereeing to the earth it has been used "And among His Signs in this: thou seest the earth barren and desolate; but when We send down rain to it, it is stirred to life and yields increase. Truly, He Who gives life to the (dead) earth can surely give life to (men) who are dead. For He has power over all things (41:39)," to mean void of anything. When relating it to the mountains as a potential vessel for receiving revelation it is stated (Qurtubi, 2013), "Had We sent down this Qur'an on a mountain, verily, thou wouldst have seen it humble itself and cleave asunder for fear of Allah. Such are the similitudes which We propound to men, that they may reflect (59:21)," even the mountains context humility is the state.

Khushu' is therefore as the prophetic tradition by Hakim al-Tirmidhi states, is what is in the heart manifest on the physicality of the individual. It can therefore be postulates that the physical heart plays a role in the manifestation of conscious state of the spiritual heart. Ghazzali (2014) also states that the spiritual heart and the brain has a connection. Thus, the relation with the physical heart, spiritual heart and that brain should all play a role in the state and manifestation of Khushu'. Furthermore, the fact that Khushu', can be present or absent and is a criterion for the perfection of prayer means that it is in the control of the individual to bring about or not.

Until the present Khushu' has solely been discussed in terms of an abstract concept with various religious dimensions as means for improving it. It is however more than an abstract religious concept, with biopsychological factors involved in achieving it.

When turning to Islamic religious research there have been various studies done on the Quran and its neural-correlates (Al-Galal & Fakhri Taha Alshaikhli, 2017; Vaghefi et al., 2019), prostration in prayer (Harun et al., 2020; Yousefzadeh et al., 2019) and prayer itself (Alwasiti et al., 2010; Doufesh et al., 2014). These studies are sparse and are focused on a single modality. Furthermore, none have been found focused on exploring khushu' as a construct in all its dimensions neither in terms of heart-brain axis, neurobiological and spiritual pathways. Therefore, a framework is needed to understand the mechanism involved the biopsychospiritual mechanism of Khushu' and its effects on the individual.

## The Proposed Framework

### Psychocardiological Mechanism of Khushu': The Roles of Heart-Brain Axis

The heart-brain axis has been investigated in numerous ways. One of the focuses is on the intrinsic cardiac nervous system (ICNS) also known as the little brain which includes a network of the intracardiac ganglia and interconnecting neurons (Fedele & Brand, 2020). The ICNS has been shown to influence the activity of frontal-cortical areas, the motor cortex, attention, motivation, perceptual sensitivity, and emotional processing (Lane et al., 2001; McCraty et al., 2004; McCraty et al., 2009; Montoya et al., 1993; Sakaki et al., 2016; Zhang et al., 1986). The neural output, or messages from the intrinsic cardiac nervous system travels to the brain via ascending pathways in the both the spinal column and vagus nerves, where it travels to the medulla, hypothalamus, thalamus, and amygdala and then to the cerebral cortex (Durães Campos et al., 2018). All these areas are involved with areas covered in Khushu'.

Moreover, coherence describes the degree of order, harmony, and stability in the various rhythmic activities within living systems over any given period of time. When a person is in a more coherent state there is a shift in the relative autonomic balance toward increased parasympathetic activity (vagal tone), increased heart-brain synchronization and entrainment between diverse physiological systems. Coherence has been shown to influence anxiety, depression, sleep, and cognition (Amjadian et al., 2020; Brown et al., 2020; Celka et al., 2020; McCraty& Zayas, 2014). This is thus an area worth exploring when it comes to the construct of Khushu'.

### Brain microvascular pulsatility

Heart rate variability (HRV) which is not simply the result of random variability, instead, much of the variability is due to the heart responding to physiological oscillatory signals such as breathing and blood pressure feedback, such that heart rate slows down and speeds up in a rhythmic fashion at certain frequencies is another pathway by which the heart influences an individual (Mather & Thayer, 2018). It also influences emotion regulation brain networks and can be used to monitor emotion as well as emotional disorders (Mather & Thayer, 2018; Zhu et al., 2019). HRV has also been linked to emotional control as well as unwanted thought regulation (Williams et al., 2015). Moreover, it has been studied in terms of global cognitive function (Forte et al., 2019; Mahinrad et al., 2016), attention (Williams et al., 2016), memory (Zeki Al Hazzouri et al., 2014), executive function, language (Frewen et al., 2013) and visuospatial skills (Forte et al., 2019). Decision making, regulation, the feelings of humility all play a role in Khushu'.

Aortic stiffness increases dramatically with advancing age and is associated with increased risk for major cardio-cerebrovascular disease events (Ecobici&Stoicescu, 2017; Bonarjee, 2018; Mitchell et al., 2019) including clinically recognized (Chen et al., 2017). Moreover, aortic stiffness increases with age and vascular risk factor exposure and is associated with increased risk for structural and functional abnormalities in the brain (Mitchell et al., 2011). High ambient flow and low impedance are thought to sensitize the cerebral microcirculation to harmful effects of excessive pressure and flow pulsatility. However, hemodynamic mechanisms contributing to structural brain lesions and cognitive impairment in the presence of high aortic stiffness remain unclear. It is hypothesized that disproportionate stiffening of the proximal aorta as compared with the carotid arteries reduces wave reflection at this important interface and thereby facilitates transmission of excessive pulsatile energy into the cerebral microcirculation, leading to microvascular damage, impaired function and disrupt heart-brain axis (crosstalk).

Several studies have evaluated relations between arterial stiffness and various measures of brain structure and function in selected (Zhai et al., 2018; Cooper et al., 2017; Cooper et al., 2016) and community-based samples (Palta et al., 2019). These studies have demonstrated relations between aortic pulse wave velocity (PWV) or pulse pressure and brain lesions or cognitive function; however, a comprehensive evaluation of relations of PWV and pressure and flow pulsatility with segmented brain volumes, subclinical infarcts and cognitive function in an Asian suburban community-based sample has not been performed. Therefore, exploring the relations of PWV parameters of the central (carotid artery and proximal aorta) domain with brain structure and function in relation with Khushu' and Khushu' interventions, and how Khushu' may modulate the PWV readings is imperative for measuring the effects of Khushu' on the individual.

## Systemic Biomarkers

The heart communicates with the brain via the hormones it produces. The atrial natriuretic factor (ANF/ atrial natriuretic peptide (ANP)/atrial peptide which has a function in regulation and balance in many systems including many centers in the brain (Ogawa & Bold, 2014). Furthermore, it also influences motivation, emotion, and behavior (Koopmann et al., 2013; Telegdy, 1994). The heart also contains cells that synthesize and release of neurotransmitter and hormones such as catecholamines (e.g., norepinephrine, epinephrine, and dopamine), which are involved in many dimensions of human emotion and behavior (Lehmann et al., 2013). Additionally, the heart also manufactures and secretes oxytocin, which has been shown to be involved in cognition, tolerance, trust and friendship and the establishment of enduring pair-bonds (Gutkowska& Jankowski, 2008; Jankowski et al., 2020). When looking at the heart and the hormones it produces, these may also influence Khushu'and thus have to be taken into consideration.

Moreover, the microvasculature health of the cardio-cerebral vasculature is maintained by normal functioning endothelial cells that lines the vessel wall. However, the formation of microparticles (MPs) have been reported to contribute to the disorganization of the proper function of endothelium layers. For example, Martinez et al., 2011, have shown that endothelial dysfunction caused by MPs can induce vascular inflammation that potentially leads to a prothrombotic state in arteriolo- and atherosclerosis. Besides, the dysfunction is also demonstrated by the shedding of endothelial MPs that express platelet-endothelial cell adhesion molecule-1 (i.e., CD31) that has been implicated to feature cardiocerebrovascular disease such as in ischemic stroke subtypes (Grammas et al., 2011). Aside from endothelial dysfunction, recent review by Nassir et al., 2021 has shown the production and increase levels of MPs can be influences by individuals' lifestyles (i.e., dietary patterns and stress).

Hence it is MPs may affect the organization of the arterial segmental walls, luminal narrowing, pulsatility and eventually the heart-brain cross talk. Therefore, we postulate that measuring the level of MPs may give better informion pertaining vascular health and how Khushu' may modulate the level of MPs in systemic circulation.

## Neuroimaging: Structural and Functional Connectivity

While the heart plays a pivotal role in investigating Khushu', the brain mechanisms involved can undeniably not be overlooked. Modesty (Zheng et al., 2017), well-being (Dahl et al., 2020), humility in language (Cui et al., 2022) as well as personal spiritual states (Miller et al., 2019) have all been studied in terms of brain research. These areas will also be areas of interest when investigating Khushu'.

Neuroimaging modalities, such as MRI, may significantly contribute to the neuroscientific research by enabling serial in vivo whole-brain measurements of functional and/or structural changes in healthy or injured brain. Established MRI methods such as T2-, diffusion-, and perfusion-weighted MRI are frequently applied for assessment of brain pathophysiology in clinical diagnosis and preclinical research (Farr et al., 2010), but MRI may also be employed to characterize long-term alterations in brain structure and function after stroke (Jiang et al., 2010; Weber et al., 2006). Over the years, various studies have demonstrated that functional MRI (fMRI) can be used to study alterations in cortical and subcortical activation patterns in human and animal models for various brain pathology (Van der Zijden et al., 2007). In addition, structural changes in grey and white matter areas have been successfully measured with diffusion tensor imaging (DTI) (Assaf et al., 2008).

Resting-state fMRI

A fMRI method, known as resting-state fMRI (rs-fMRI), assesses spatial functional correlations within neural networks without the need of a stimulation paradigm (Lv et al., 2018). During the last decade, rs-fMRI has been increasingly applied as a tool to study alterations in the brain's intrinsic functional architecture as potential physiological correlates of neurological and psychiatric disorders (van den Heuvel et al., 2010; Auer et al., 2008). Spontaneous fluctuations in baseline ("resting-state") neuronal signaling are reflected in low-frequency fluctuations (<0.1 Hz) of the blood oxygenation level-dependent (BOLD) signal and show temporal coherence between anatomically connected brain regions within a particular neuronal network, such as the sensorimotor system (Lv et al., 2018). Throughout the grey matter, the extent of synchronization between these low-frequency BOLD fluctuations is related to functional connectivity. The correlation of these signals with electroencephalographic brain activity has indicated that these slow hemodynamic fluctuations are associated with neuronal function (He et al., 2008).

Functional connectivity has been most often computed by calculating correlations between the low-frequency BOLD fluctuations in and a priori-selected brain region and low-frequency BOLD fluctuations from other voxels in the brain. Besides region-based functional connectivity analyses, functional connectivity may also be assessed at a whole network level using graph analysis of rs-fMRI data (van den Heuvel et al., 2010; Bullmore et al., 2009). Networks can be represented as graphs containing nodes and edges. In the case of rs-fMRI, the image voxels represent the nodes, and the intervoxel correlations between low-frequency BOLD fluctuations represent the edges. The network's structure can be assessed by measuring its clustering coefficient, a measure of segregation that reflects the degree to which nodes are clustered, and the shortest path length, a measure of integration that reflects the minimum number of edges between any pair of nodes. A high clustering coefficient and low average shortest path length indicate a small-world network topology, which is proposed to be an optimal network configuration for global information transfer and local processing (Bullmore et al., 2009). In terms of Khushu' the Default Mode Network which is involved when the brain is in a relaxed state and the executive network which the brain uses to do a specific task is of particular interest (Buckner, 2013).

Diffusion Tensor Imaging (DTI) and Tractography

Changes in functional brain organization, are often closely associated with structural modification of neuronal elements in the brain. DTI offers an MRI-based means for assessing neuroanatomical or structural changes related to brain injury and repair. DTI informs on the 3D displacement of tissue water, mathematically characterized by an effective diffusion tensor consisting of nine matrix elements, which can be exploited to assess the microstructure of gray and white matter tissue (Basser& Jones, 2002; Mori & Zhang, 2006). As the diffusion of tissue water is restricted by the presence and orientation of biological barriers such as cell membranes and myelinated fibers, certain insult or condition applied to the brain may induced structural modifications therein can significantly alter the characteristics of tissue water diffusion, such as the DTI-derived axial, radial, and mean diffusivity (MD), as well as fractional anisotropy (FA) (Sotak, 2002).

Since white matter tracts are composed of highly oriented fibers, which cause relatively high anisotropy of diffusing tissue water, DTI is very suitable to measure effects on white matter integrity. Previous studies also suggested that rearrangement of white matter in the ischemic boundary is accompanied by preservation or restoration of neuronal connectivity (Van der Zijden et al., 2007). Taken together, the potential of the brain to reorganize following certain intervention for structural and functional outcomes may provide a significant target for understanding Khushu; and interventions to develop Khushu'.

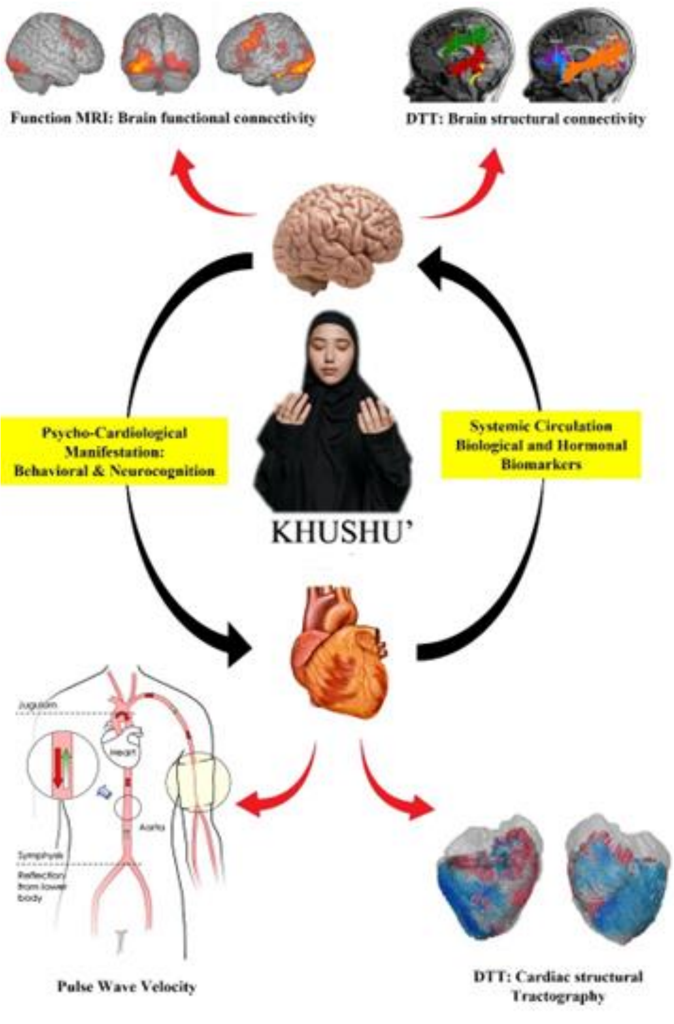


**Figure 1:**Illustration of A Proposed Biopsychospiritual Framework for the investigation of Khushu'

## Conclusion

Despite Khushu' being over millennium, the interaction and significance of morphological and physiological modifications during and because of the state of Khushu' are mostly unclear. A framework thus comprising of psychocardiological mechanisms, brain microvascular pulsatility, systematic biomarkers and neuroimaging techniques such as fMRI and DTI and/or tractography that enable in vivo assessment of the spatial and temporal pattern of functional and structural changes was proposed. This framework can contribute to the elucidation of critical aspects in Khushu', in terms of physiological regulation and modulation as well as brain remodeling. rs-fMRI, enables direct or indirect measurement of functional brain connectivity. Together, thesemethods provide unprecedented means to (a) measure longitudinal changes instructure and function related to Khushu', (b) evaluate the organizational profile of neural networks during Khushu' and following Khushu', and (c) identify the processes that modulate Khushu's structural and functional outcome.


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