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Review article

Brain mechanisms in religion and spirituality: An integrative predictive processing framework

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ABSTRACT

We present the theory of predictive processing as a unifying framework to account for the neurocognitive basis of religion and spirituality. Our model is substantiated by discussing four different brain mechanisms that play a key role in religion and spirituality: temporal brain areas are associated with religious visions and ecstatic experiences; multisensory brain areas and the default mode network are involved in self-transcendent experiences; the Theory of Mind-network is associated with prayer experiences and over attribution of intentionality; top-down mechanisms instantiated in the anterior cingulate cortex and the medial prefrontal cortex could be involved in acquiring and maintaining intuitive supernatural beliefs. We compare the predictive processing model with two-systems accounts of religion and spirituality, by highlighting the central role of prediction error monitoring. We conclude by presenting novel predictions for future research and by discussing the philosophical and theological implications of neuroscientific research on religion and spirituality.

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1. Introduction

The last decades have seen an increased interest in studying the biological and neurocognitive basis of spirituality and religion. Through the use of neuroimaging techniques, brain stimulation studies and studies with neuropsychological patients, our understanding of the brain areas and networks involved in religion has increased dramatically, thereby providing unique insight in the *proximate* mechanisms that support supernatural beliefs and experiences. However, many findings in the literature often appear to be contradictory, lack appropriate methods and analyses, and the results are inconclusive [e.g., Schjoedt, 2009]. Furthermore, there is currently no up-to-date review and integrative framework that accounts for the different findings that have been reported in the literature. The most recent systematic reviews of neuroimaging studies on religion and spirituality date from before 2010 (Schjoedt, 2009; Cahn and Polich, 2006; Fingelkurts and Fingelkurts, 2009) and since then many new studies have been conducted that are highly relevant for our understanding of the neurocognitive basis of religion and spirituality. Therefore the aim of this review article is to develop a theoretical framework to account for the neurocognitive basis of religious and spiritual beliefs and experiences and to show how this framework is substantiated by empirical findings. To this end we will discuss neuropsychological studies, experimental studies using brain stimulation techniques and psychopharmacological manipulations, and neuroimaging studies that have focused on the topic of religion and spirituality.

First, we present a novel integrative model regarding the neurocognitive basis of religion and spirituality. Building on concepts derived from predictive processing accounts (Apps and Tsakiris, 2014a; Clark, 2013; Seth, 2013), we propose a model in which religious beliefs and experiences are primarily related to a differential weighting of interoceptive and exteroceptive information. Next, to substantiate our model with empirical evidence, we distinguish four neurocognitive mechanisms underlying specific religious beliefs and experiences (see: Table 1). First, we describe the role of the temporal cortex and the limbic system in religious experiences and self-transcendent emotions. Second, we highlight how brain areas supporting multisensory integration and the default mode network (DMN) are involved in spiritual and self-transcendent experiences. Third, we focus on the so-called theory-of-mind (ToM) network that could play a role in personal experiences of God (Spreng et al., 2009). Fourth, the role of top-down processes (i.e., expectations, inhibition and prediction error-monitoring mechanisms) in religious beliefs and experiences is discussed.

Table 1
Overview of brain mechanisms and regions, their respective function and the supposed relation with religious and spiritual beliefs and experiences (R/S). STS = Superior Temporal Sulcus; MTL = Medial Temporal Lobes; FFA = Fusiform Face Area; TPJ = Temporo-Parietal Junction; SPL = Superior Parietal Lobe; IPL = Inferior Parietal Lobe; PCC = Posterior Cingulate Cortex; MPFC = Medial Prefrontal Cortex; ACC = Anterior Cingulate Cortex.

1. Temporal brain areas Brain Structures: Hippocampus; Amygdala; STS; MTL; FFA Function: Memory retrieval; Emotional coloring of experience; Biological motion perception; Face perception R/S: Visions; Hallucinations; Déjà-vu experiences
2A Multisensory Integration Brain structures: TPJ; SPL; IPL Function: Bodily self-consciousness; Multisensory integration R/S: Mystical experiences; self-transcendence; out-of body-experiences; feeling of a presence
2B Default Mode Network Brain structures: PCC; Precuneus; IPL; Lateral Temporal Cortex Function: Self-referential processing; Mind-wandering R/S: Mystical experiences; Ego-dissolution; Reflective religious beliefs
4. Theory-of-Mind Network Brain structures: MPFC; STS; TPJ Function: Social Cognition; Communication; Intentionality perception R/S: Prayer; Belief in personal God; Over-attribution of agency
5. Error-Monitoring Mechanisms Brain structures: ACC; MPFC; dopaminergic system Function: Prediction error-monitoring; Belief-maintenance and updating R/S: Openness to religious authority and rituals;

Our proposed model is unique as it provides a unifying account of the neurocognitive basis of religiosity and spirituality thereby integrating recent findings from different fields (e.g., contemporary cognitive psychology and neuroscience, the psychology and anthropology of religion). The model also provides a systematic overview of cognitive elicitors of religious and spiritual experiences and thereby allows generating novel and testable predictions to be addressed in future studies and we discuss the hypothesis-generating potential of our framework in Section 4. We also relate the predictive processing model to dual process accounts of religion and spirituality, such as the corrective model (Risen, 2016; Kahneman and Frederick, 2005) and cognitive-experiential self-theory (Kirkpatrick and Epstein, 1992; Epstein, 1994). In the final section we discuss the potential shortcomings and limitations of the different studies that we presented and we discuss the philosophical and theological implications of neuroscientific research on religion and spirituality.

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