Neurophysiology of Religious Experience

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Outline

• Brief review of neuroanatomy
• Correlations of brain activity with religious experiences
• Epilepsy and religious experience
• Induction of religious experience with magnetic stimuli or drugs
• Where do we go from here?
Lobes of the cerebral cortex

(a) Lateral view
Brain regions implicated in emotion:
Yellow: orbitofrontal prefrontal cortex
Blue: Anterior cingulate cortex
Green: Posterior cingulate cortex
Purple: Insula; Red: amygdala
Two different hemispheres

Left Brain

- Expressive, verbal
- Logical, detailed
- Concrete
- Social emotions
- Factual Memory
- Positive emotions and approach behaviors

Right Brain

- Perceptual, spatial
- Holistic, creative
- Metaphorical
- Primary emotions
- Emotional autobiographical memory
Right Hemisphere

- Close relationship to limbic system and emotional expression.
- Rhythmicity, including chanting, poetry and music (whirling dervishes, Voodoo)
- Stimulation of right temporal-parietal junction → out of body experiences.
Universal spiritual behavior includes:

- A feeling of extended self, awe, ecstasy or serenity.
- A connection with a non-material world.
- Belief in magic or the supernatural.
- Priesthood, sacred objects and places, communication with spirits of the dead.
- Dualism: Physical and spiritual.
Heredity

• **Minnesota Twin Experiment**
  - Identical and fraternal twins reared apart
  - 43% of religiosity is inherited.

• **The God Gene**—proposed by Dean Hamer
  - The gene for the “pump” that puts serotonin into vesicles in the axon terminal has been linked in one study to predisposition to spirituality.
Disease and Injury

- Alzheimer patients lose spirituality with decline in cognitive function.
- Head injury is frequently associated with change in religious attitudes.
- Dementias due to injury to the frontal and temporal lobes have been associated with religious experiences.
- Out of body experiences have been triggered by brain hypoxia from cardiac arrest.
- Schizophrenics attribute internal thoughts to external sources.
Brain imaging

• Note in the slides below that various emotions activate overlapping brain areas.

• Also, note that a lot of the brain areas that were activated or deactivated are not labeled.
PET images during recall of emotions

Red, yellow: increase; Purple: decrease

(a) Sadness

↑ Anterior cingulate cortex
↓ Posterior cingulate cortex
↑ Insula
↑ Dorsal pons

(b) Happiness

↑ Right posterior cingulate cortex
↑ Left insula
↓ Left anterior cingulate cortex
(c) Fear

↑ Midbrain

↓ Orbitofrontal cortex

(d) Anger

↑ Pons

↑ Left anterior cingulate cortex

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Perceived pain in anterior cingulate cortex
• There is no simple one-to-one relation between an emotion and brain areas activated
• Much overlap among different emotions
How about religious experience?

• Beauregard & Paquette (2006): Used fMRI to study Carmelite nuns in a state of union with God.
  - This state was characterized as being timeless, spaceless, in union with mankind & the universe, peaceful, joyful, and full of unconditional love.
  - fMRI: subtract Baseline from Mystical and Control conditions.
How about religious experience?

- To produce the mystical condition: Nuns were told to relive the most intense mystical experience they had ever felt.
- For the control condition: They were to relive the most intense state of union with another human.
Phenomenology:

• Scores of 15 or greater were scored for 3 items of Mysticism Scale:
  – I have had an experience in which something greater than my self seemed to absorb me.
  – I have experienced profound joy.
  – I have had an experience that I know to be sacred.
In the mystical state: Increased blood flow to numerous areas

**Mystical > Baseline**

- L ACC
- L MOG
- L Insula
- L Caudate
- R Caudate
- L Brainstem
- R MOFC
- R GTM
- R SPL
- R IPL
- L IPL

Z-Score

1 2 3 4 5 6 7
**Mystical vs. Baseline**

- Medial orbitofrontal cortex: subjective pleasantness, conscious awareness of feelings
- Caudate nucleus: positive emotions (also motor ability & obsessive-compulsive disorder!!)
- Insula: integrates visceral stimuli (including disgust!!)
  - Face recognition
  - Recent report: lesion of insula → loss of nicotine addiction
Mystical vs. Baseline (continued)

- Superior parietal lobe: spatial perception of self
- Inferior parietal lobe: distinction between self and other, motor imagery
- Medial occipital cortex: visual imagery
Control vs. Baseline

- Superior parietal lobe (same as with Mystical condition): spatial perception of self
- Left caudate nucleus (same as with Mystical condition): positive emotions (& motor ability & obsessive-compulsive disorder (OCD))
- Inferior occipital cortex: visual imagery
- Dorsal cingulate cortex: emotional awareness
Summary

• Considerable overlap between Mystical and Control areas of activation:
  – Superior parietal lobe: spatial sense of self
  – Caudate nucleus: positive emotions + OCD
  – Occipital cortex: visual imagery
Summary

• Mystical > Control
  – Insula: visceral stimuli
  – Prefrontal cortex: conscious awareness of feelings
  – Medial temporal cortex: complex visual imagery
Azari et al. (2001) Neural Correlates of Religious Experience

- They studied positron emission tomography (PET) images of religious teachers vs. science students (6 of whom were religious and 6 were not).

- Subjects did not differ on scales of imaginability or verbal traits or on personality or life satisfaction measures.
Azari et al. (2001) continued

- Subjects either read or recited (eyes closed) 1st verse of Psalm 23 or a “happy” children’s rhyme.
- Control condition: read instructions for using a phone card from the Düsseldorf phone book.
Religious: Recite vs Rest

Dorsomedial frontal cortex

Dorsolateral prefrontal cortex
Azari et al. (2001) Neural Correlates of Religious Experience

- Religious subjects reported a trend toward a decrease in negative emotions.
- Religious vs. nonreligious:
  - Increased activation of right dorsolateral and dorsomedial prefrontal cortex during the religious state.
Azari et al. (2001) Neural Correlates of Religious Experience

- Religious vs. nonreligious (continued):
  - Dorsolateral prefrontal cortex: memory retrieval and conscious monitoring of thought
  - Dorsomedial prefrontal cortex: readiness for action
Azari et al. (2001) continued

- Nonreligious vs. religious:
  Left amygdala activation during happy state
Comparison of the 2 studies

• Both showed activation of prefrontal cortex in religious states

• Only the study of nuns showed activation of areas that process visceral (insula) or visual (occipital, medial temporal) information or subcortical areas (caudate).
Cautionary notes

• These studies show correlations, not causes.
• There is much overlap of areas activated in religious and nonreligious states.
• The descriptions of the functions of areas are extremely broad (!!!)
• There is great variability among subjects.
Functional MRI scans of six people who took the same spatial memory test show how varied brain activation patterns can be. Scientists must design fMRI experiments carefully to avoid misleading conclusions.
Try an experimental approach to get at causation

- Administer magnetic stimulation or drugs and measure religious experience.
Targeted Stimulation

Localized brain cell excitation results from the use of a transcranial magnetic stimulation (TMS) machine. When researchers operate a TMS coil near a subject’s scalp, a powerful and rapidly changing magnetic field passes safely and painlessly through skin and bone. Each brief pulse, lasting only microseconds, contains little energy. Because the strength of the magnetic field falls off rapidly with distance, it can penetrate only a few centimeters to the outer cortex of the brain (top right). The precisely located field induces electric current in nearby neurons, thus activating targeted regions of the brain (bottom right). A principal benefit of TMS is that it requires no direct electrical connection to the body, as is required for electroconvulsive therapy.
Bipolar EEG activity over the temporal lobes during applications of weak magnetic fields over the right hemisphere of a professional journalist who had experienced a "haunt." Top panel: normal activity; Middle panel: paroxysmal discharges during subjective experiences of intense fear and a sensed presence. Bottom panel: seconds marker. (M. A. Persinger, 2001)
Epilepsy

- 25% temporal lobe epileptics report symptoms of religious fervor.
- Some historians report St. Paul, Joan of Arc, and Mohammed were epileptic.
Reports of epileptic activity and religious experience

- Temporal lobe epilepsy has also been associated with non-religious “transcendent” experience.
  - One agnostic woman was relieved to learn that there was a physical explanation for her experiences.
  - Several patients deliberately tried to re-initiate these experiences by putting themselves into the same state of mind as before. (Hansen & Brodtkorb, 2003)
The “sensed presence”: An epileptic aura with religious overtones. Epil. Behav., 9:186-188

- The aura was described by the patient: “I have a feeling that someone stands behind me, someone with a distinct wish to support and comfort me. This person will follow me anywhere I would like to go.” The sensation was characterized as pleasant, but it usually progressed to a state of altered consciousness, nausea, irritation of the throat, and an urge to urinate. The patient did not interpret this experience as religious.
Cerebral blood flow with decreased flow to the temporal lobe, especially on the left, during an epileptic aura with religious overtones. (Landtblom, 2006)

There was a bilateral decrease in blood flow to the temporal lobes (1) and local increase in activity in the left frontoparietal area (2).

EEG records showed increased activity in temporal lobes. (Not clear why decreased blood flow there.)
Dostoyevsky’s report of his personal experience with epileptic religious experiences:

“The air was filled with a big noise and I tried to move. I felt the heaven was going down upon the earth and that it had engulfed me. I have really touched God. He came into me myself, yes God exists, I cried, and I don’t remember anything else. You all, healthy people can’t imagine the happiness which we epileptics feel during the second before our fit. Mahomet, in his Koran, said he had seen Paradise and had gone into it.”
Dostoyevsky’s report of his personal experience with epileptic religious experiences (continued):

“All these stupid clever men are quite sure that he was a liar and a charlatan. But no, he was a victim of this disease like I was. I don’t know if this felicity lasts for seconds, hours or months, but believe me, for all the joys that life may bring, I would not exchange this one.”

Although he realized that this vision was due to his epilepsy, he insisted on the validity of these visions and the ultimate truth and knowledge he experienced.
Administer serotonergic drugs

- LSD, mescaline, and other serotonergic drugs have been used to elicit religious experiences for centuries.
- They stimulate certain types of serotonin receptors.
Drugs of Abuse: Hallucinogens
Hallucinogens

- Include: LSD, psilocybin, mescaline, MDMA or ecstasy.
- All stimulate (cortical) serotonin 5-HT$_{2A}$ receptors
- These receptors usually ‘gate’ sensory input to cortex: keep it from being too powerful.
- Hallucinogen action at these receptors may impair this sensory gating.
LSD by itself increases glutamate release in sensory association cortex. Administration of a serotonin antagonist with LSD blocks the effect.

Increased glutamate in sensory association cortex may produce the hallucinations elicited by LSD.
There were negative correlations between “self-transcendence” and binding of a different type of serotonin receptor (5-HT1A) (Lorenzi et al., 2006).


*Ratings were made with the Swedish version of the Temperament and Character Inventory, a self-report questionnaire (13).*
• The interpretation of this finding is not clear.

• Some 5-HT1A receptors are “autoreceptors” that → negative feedback, keeping serotonin release within “normal” bounds. Therefore, decreased autoreceptor binding may suggest less negative feedback and higher serotonin levels.

• Decreased binding may also result from a generally high level of transmitter.
  - I.e., this is a compensation for the high levels.
  - This is similar to the decrease in cannabinoid receptors when rats were given cannabinol for several weeks.
Summary

• Religious experience has been associated with increased activity in several brain areas, including prefrontal cortex, occipital, temporal, and parietal cortex, and some subcortical areas.

• Temporal lobe epilepsy has been closely linked with “transcendent” experience.

• However, there is a great deal of overlap with other types of experience.
Summary

• There is considerable variability in brain areas activated, both between studies and among individuals.
• Often the functions ascribed to brain areas in these studies are very vague.
• Those brain areas participate in a wide range of activities.
• Blood flow is not always a good predictor of activity.
Summary

- Temporal lobe epilepsy and alterations of serotonin activity may be associated with religious experience.
- Humans naturally try to find an explanation for their feelings.
  - If there is no obvious physical explanation, they may enlist a spiritual one.
Summary

- Religious experience, like all other experience, is brain-based.
- However, the interpretation of the experience may be unique to the person who has the experience.
- Of course, one could always say that God caused the epileptic experience or serotonergic activity in order to impart a religious experience.
- However, when we induce magnetic stimulation or take LSD, WE are eliciting the aura. The person can still interpret its meaning.