<u>Inside Thoughts</u>

3D LED sculpture of an anatomically correct and transparent human brain and spinal cord mimicking brain activity during decision making, experiencing emotion and somatosensory processing

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Further Reading

Pain and Empathy:

There is a fine line between pain and empathy.

Two new brain-imaging studies describing the origins of empathy and how placebos work provide insights into the nature of pain, the mind-body connection and what it means to be human. Whether we're feeling empathy when a loved one endures pain, or enjoying pain relief thanks to a placebo, pain-sensitive regions of our brains are at work — either creating or diminishing the experience of human pain. These findings appear in two papers published in Friday's issue of the journal Science, published by AAAS, the nonprofit science society.

Empathy is the human ability to feel what others feel. Humans use empathy to better navigate the social environment and answer questions such as: Is this person going to attack me? Faint? Run away? Cry?

Here, the ability to "tune in" and empathize with others is a prerequisite for understanding, attachment, bonding and love — all of which are important for our survival, according to Singer.

Empathy is pain … sort of

In their studies on human volunteers, Singer and her colleagues found that feeling empathy activates some, but not all, of the pain-processing regions of the brain.

In a classical example of pain, such as grabbing a hot spoon handle, the burning pain shoots into temperature receptors on your skin, through nerves, up your spine and into your brain. Some regions of your brain process information such as where the pain comes from and how hot the spoon really was. Other regions of the brain process how unpleasant you felt the pain to be. Thus, how much the burn hurts and how bothersome this pain is differs for each situation and depends, among other things, on what else is going on in your head and the environment.

During a noxious stimulus, the bilateral anterior insula (AI), rostral anterior cingulate cortex (ACC), brainstem, and cerebellum were activated when subjects received pain and also by a signal that a loved one experienced pain. AI and ACC activation correlated with individual empathy scores. Activity in the posterior insula/secondary somatosensory cortex, the sensorimotor cortex (SI/MI), and the caudal ACC was specific to receiving pain. Although, If you are involved in a serious car accident, your survival system is so busy that you hardly feel any pain even though you are severely injured.

The researchers found that empathy activates the same regions of the brain that process these context-dependent aspects of pain, including the anterior insula and anterior cingulate. Knowing your loved one is in pain automatically activates the subjective pain-processing regions of your brain, which leads to empathy. But the areas involved in processing the exact location of the pain in your body as well as the objective intensity of the pain are involved only when you experience pain in yourself.

I have in my sculpture tried to depict the pathways of brain activity during pain and juxtaposed it to the observed similar brain activity during empathy recall. I invite the viewer to see these thoughts played outside their bodies on a transparent brain, and, through the view of this model, also to question their philosophical constructs of empathy and why bringing physical pain related neuronal activity helps us feel better about relating to others.

Singer, T. et al. Empathy for pain involves the affective but not sensory components of pain. *Science* **303**, 1157–1162 (2004)

Yarns, B. C., Cassidy, J. T., & Jimenez, A. M. (2022). At the intersection of anger, chronic pain, and the brain: A mini-review. *Neuroscience & Biobehavioral Reviews*, *135*, 104558. https://doi.org/10.1016/j.neubiorev.2022.104558

Death Vs Memory Recall & Dreaming:

Many people who have come close to death or have been resuscitated report a similar experience: Their lives flash before their eyes, memorable moments replay, and they may undergo an out-of-body experience, sensing they're looking at themselves from elsewhere in the room.
Although death has historically been medically defined as the moment when the heart irreversibly stops beating, recent studies have suggested brain activity in many animals and humans can continue for seconds to hours. In 2013, for instance, University of Michigan neurologist Jimo Borjigin and team found that rats' brains showed signs of consciousness up to 30 seconds after their hearts had stopped beating. We have this binary concept of life and death that is ancient and outdated.

Studies done by Borjigin and team, followed the medical records of patients who were in comas and on life support on whom physicians had placed electroencephalography caps. None of the patients had any chance of survival. The caps continually monitored the electrical signals moving across the surface of each patient's brain: before and after physicians removed their ventilators, during each patient's last measurable heartbeat, and up until all brain activity had ceased. Seconds after their ventilators were removed, the patients' brains suddenly lit up with a burst of neuronal activity in high-frequency patterns called gamma waves that continued as the heart stopped beating. Other studies have found the same pattern when a healthy person is actively recalling a memory, or dreaming, and some neuroscientists have linked these oscillations with consciousness. Her team also saw increased electrical activity in a brain region called the temporo-parieto-occipital junction, which is believed to be involved in consciousness and is activated during dreaming, seizures, and out-of-body hallucinations. She thinks the burst of brain activity is part of a survival mode that the brain is known to enter once it is deprived of oxygen. Studies of animals undergoing brain death have found that the organ begins to release numerous signaling molecules and creates unusual brainwave patterns to try to resuscitate itself, even as it shuts down external signs of consciousness. “It shuts the door to the outside world and takes care of internal business because the house is on fire,” she says

Ajmal Zemmar, a neurosurgeon at the University of Louisville, says gamma waves may signal that different brain regions are working together to combine disparate sensations into the conscious awareness of an object—putting together the sight and smell and sound of a car, for instance. How the brain does this, he says, “is one of the biggest mysteries in neuroscience,” but seeing the same gamma waves in dying people suggests a biological mechanism for the reports of the brain replaying memorable events in those final moments.

In his study patients exhibited a rapid and marked surge of gamma power, surge of cross-frequency coupling of gamma waves with slower oscillations and increased interhemispheric functional and directed connectivity in gamma bands. High-frequency oscillations paralleled the activation of beta/gamma cross-frequency coupling within the somatosensory cortices. Importantly, both patients displayed surges of functional and directed connectivity at multiple frequency bands within the posterior cortical “hot zone,” a region postulated to be critical for conscious processing. This gamma activity was stimulated by global hypoxia and surged further as cardiac conditions deteriorated in the dying patients. After cardiac arrest, delta, beta, alpha and gamma power were decreased but a higher percentage of relative gamma power was observed when compared to the interictal interval. Cross-frequency coupling revealed modulation of left-hemispheric gamma activity by alpha and theta rhythms across all windows, even after cessation of cerebral blood flow. The strongest coupling is observed for narrow- and broad-band gamma activity by the alpha waves during left-sided suppression and after cardiac arrest. These data demonstrate that the surge of gamma power and connectivity observed in animal models of cardiac arrest can be observed in select patients during the process of dying.

I have in my sculpture tried to depict these pathways of brain activity during death and juxtaposed it to the observed similar brain activity during dreaming and memory recall. I invite the viewer to see these thoughts played outside their bodies on a transparent brain, and through the view of this model, also to question their philosophical constructs of death, memory recall and dreaming.

Vicente, R., Rizzuto, M., Sarica, C., Yamamoto, K., Sadr, M., Khajuria, T., Fatehi, M., Haw, C. S., Llinas, R. R., Lozano, A. M., Neimat, J. S., & Zemmar, A. (2022). Enhanced Interplay of Neuronal Coherence and Coupling in the Dying Human Brain. *Frontiers in Aging Neuroscience*, *14*, 813531. https://doi.org/10.3389/fnagi.2022.813531

Xu, G., Mihaylova, T., Li, D., Tian, F., Farrehi, P. M., Parent, J. M., Mashour, G. A., Wang, M. M., & Borjigin, J. (2023). Surge of neurophysiological coupling and connectivity of gamma oscillations in the dying human brain. *Proceedings of the National Academy of Sciences*, *120*(19), e2216268120. https://doi.org/10.1073/pnas.2216268120