Halle Berry as a Computational Brain Abstraction

Depth electrodes employed for the localization of epileptic seizures are further utilized in Quiroga et al [1]to record information from individual neurons. His research team looked at the reactions of neurons around clinically-placed electrodes in the medial temporal lobe (MTL) of epileptic patients, an area of the brain known to respond to complex visual images. Throughout history this area of the brain has been associated with higher-level recognition through loss-of-function observations, as people with damage to this area cannot name familiar images or create memories around new images. More technologically advanced studies conducted by modern fMRI machines show increased oxygenation and therefore use of this area in visual recognition tasks. Through cutting-edge experimentation with the depth electrodes, Quiroga's team found specific MTL neurons to respond selectively to specific people, places, and things. These results contribute towards understanding the brain's computational method of mechanically holding abstraction, yet do not disqualify the theories of either the "grandmother cell" or of distributed representation. Conceptual abstractions are therefore concluded to be based on cells that receive abstracted input through their connections to lower-level neurons, providing a computational framework for conceptualization in a manner similar to the way a computer abstracts the user away from it complex hardware. The results provide further evidence that the brain holds mechanics for abstraction in the outer cortex, which has evolved to elicit more complicated output responses and give organisms higher cognitive functions.

The researchers report that they recorded a specific cell firing in response to a visual concept in the medial temporal lobe of epileptic patients. The claim that the recording was from a specific cell was possible through the use of depth electrodes that record highly localized responses in the brain. To show that the localized neuron fired to abstract concepts, the researchers ensured that the visual images presented to each patient did not share any metric similarities beyond the abstract person, place, or thing. Once a cell was found to respond to a recognized person for example, it was shown to not fire to similar-looking people (people with the same metric features) and to fire selectively to images whose only similarity was the shared concept. In the Halle Berry example the cell fired in to extreme presentational cases of drawings, inconsistent positions, different costume appearances, and the letter string of her name. Since this created a localized response in the MTL region of the patient's brain, researchers concluded that the concept of Halle Berry created a singular response. This result suggests the existence of the grandmother cell, a theoretical cell that fires in recognition of a complex input, such as a person's grandmother. However, these recordings cannot be the ultimate proof of such a theory. First, there was usually a sparse recording of multiple neurons during the localized response. The brain is very noisy, so such multiplicity is an unavoidable feature of neuroscience as the other cells are consistently firing to uncontrolled variables. This noise does not completely rule out the grandmother cell theory since similar experience-related features between pictures such as the environment of the room could account for the noise. Second, all cases for the possible overlapping of presented concepts could not be tested. It is possible that the cells that preferred Halle Berry also respond to something the experimenters did not present to the patient, such as broccoli. However, the researchers choose the visual stimuli in an articulate manner that successfully reduced possible noise enough to draw reliable conclusions from the data. Though the experiment does not absolutely prove that the localized cells fire exclusively to one conceptual input, the results support that computational abilities of the mind convert metric visual stimuli into abstracted patterns in these localized MTL regions.

The sparse collection or singular grandmother cells must respond to complex objects by connection to neurons at a lower level of abstraction, since sensory input to the visual system is in the form center-surround ganglion cells that respond in binary ways to light in response to activation of discriminative parts of their receptive fields. The researchers measured a 300-millisecond response time from presentation of stimuli and cell response. The researchers related this phenomenon to the p300 wave that is measured in EEG recordings of decision-making. Just as a computer has a processing speed as it does calculations to perform abstracted tasks, the brain must take the time to run through its processing subsystems to perform the things recognized as its functions. Three hundred milliseconds and above is a standardly realized time for a “thinking brain” to run its processors and compute a conceptualized idea. As the brain categorizes the researcher’s presented stimulus, it delays the cells in the higher levels from firing. An abstract object in computer science consists of a state and functions that can be performed with this state, while the presentation of an abstract object to the brain is created through a series of elicited functions that then create the state. When you open Facebook, functions written by various engineers are run to give you the experience on the site. When you open your eyes in the morning, the functions your brain learned to run as your genetic code and experience shaped your brain give you the experience of sight. But these programs must take the processing time to run to create the experience. Therefore the 300-millisecond response time in the MTL cells indicates that an underlying sequence of neuronal connections is required to compute an abstracted neuronal response.

The cortex has been shown to develop from the inside out. Developing fetal brains have chemoattractants that guide the neurons outwards toward the skull, growing increasingly complex cortical layers on top of each other. Quiroga’s results support the conclusion that animals evolved to hold abstracted thoughts and recognition patterns in the outermost layers, following the growth pattern of the cortex. As these layers develop function they rely on input from lower layers, just as abstracted computer languages rely on the functioning of assembly languages and hardware. In the research’s case, the hardware would be the visual input cells. The visual cells respond to binary metrics in movement, lines, and color, then pass this information through various computing structures made of neurons to be synthesized into a visual experience. By testing specific neurons in the medial temporal lobe, Quiroga’s research team recorded specific responses from neurons in outer layers that link such a visual experience to the higher-level function of memory. Recognition is in fact a test of memory, which relates the brain back to the computational way a computer stores data. In a tabular format, the computer uses pointers to pages holding memorable data, so the localized responses recorded by Quiroga's research team could be a form of the brain's "page lookup" experience. The fact that the lookup is on a more abstract developmental level means that it can have connections that synthesize data from lower layers.

Ray Kurzweil states in *How to Create a Mind* that humans can think in a hierarchal way because our brains have the capability of synthesizing diverse elements from a recognized pattern into a symbol. Thus the localized response recorded in the Quiroga's experiment could be evidence that neurons are capable of holding symbols to be used in further computational abstraction. Quiroga's research team demonstrated that a symbol such as Halle Berry could elicit a highly localized response in the more computationally abstract layers of the brain. However, their recordings do not exclude either the distributed representation theory or that of the grandmother cell in explaining exactly how the concept is held mechanically. The localized response took the standard "thinking" time of 300 milliseconds, suggesting that processing was involved in computing the output firing pattern. Just as computer programs abstract the user away from the hardware, Quiroga's research provides supportive evidence that the brain can abstract metric input into meaningful memories and experiences in the visual recognition centers of the medial temporal lobe.

[1] Quiroga etc
[2] P300 ref
[3] Kurzweil book