Response to Quian Quiroga et al. (2005)

There are two competing theories regarding how the brain codes, represents, and integrates neural processes such as memory, perception, cognition, and sensory awareness (Jamieson 69). The distributed representation theory argues that specific concepts or objects are coded by a unique pattern over a group of neurons, while sparseness argues that there is a specific neuron that represents a specific concept or object (Jamieson 70). In their 2005 paper "Invariant visual representation by single neurons in the human brain," Quian Quiroga et al. investigated the neural response of epileptic patients with electrodes implanted into their medial temporal lobe (MTL) when shown pictures of celebrities and famous landmarks to explore which of the theories appears to be more correct. The authors discovered that out of the 100 pictures they showed each patient, a select group of the pictures elicited a response from a patient. They concluded that the data showed sparseness in the MTL neurons (Quiroga et al p?5). Quian Quiroga et al. have discovered intriguing data, however their conclusion that MTL neurons are sparsely coded is based on limited data.

The authors showed each test subject 100 different pictures based on screenings performed before the tests. Many of the tests showed that the test subject responded selectively to pictures of one subject with high confidence. From the 30 pictures displayed in Figure 2a, 10 of them were of the subject that elicited high response from the test subject, while few other subjects had multiple pictures (Quiroga 3). While the paper does not include every picture that was shown to the test subjects, it is a safe assumption that the subject with the highest response made up at least 10% of the test data. Even though the pictures were shown in random order, the pictures may still have been shown close to each other and test subjects may have recognized seeing the same subject (Halle Berry or Jennifer Aniston) several times, which may lead to spikes in electrode activity due to previous recognition. Considering that the same pictures were shown several times randomly distributed, this repetition effect that I am discussing could be examined by viewing the result of the first time Halle Berry, Jennifer Aniston, or any of the other subjects with active spikes were shown.

Quiroga et al. concluded that their data showed MTL neuron coding is sparse, implying that the distributed representation theory is incorrect. According to the paper "How Does the Brain Solve Visual Object Recognition?" by DiCarlo et al, core object recognition happens in under 200ms. The data was collected from responses from 300ms to 1 second, which is a long time when dealing with neurons in object recognition (DiCarlo 2). In that time, data collected, assuming the distributed representation theory, could either be very specific (spiking only on one subject) or very broad (spiking on subjects unrelated or related in a related group) depending on when the spikes occurred along the neural network. As stated before, the authors only tested 100 pictures per subject, and after screening test subjects, 14% of units responded to at least one picture (Quiroga 1). The chances of the authors selecting the proper images to evoke such strong responses from neurons that are concluded to be sparse are very low. Eight of their 132 responsive units responded to two different subjects with high confidence (Quiroga 4). Considering that over 6% of responsive units responded to more than one individual from a limited supply of test content, the potential for responses to unexplored subjects is very large. It is understandable that the authors had a limited time to test subjects, but there is a wide range of hypotheses left unexplored: Would subjects respond to images of people they said they are not familiar with in the test screening? Would the same neurons that responded to Halle Berry also respond to other individuals in a similar category, such as other actors in her movies or young African American women?

In the supplements to the paper, Quiroga et al. found that some subjects did in fact respond to multiple subjects of a similar class. Their Figure S6 showed that subjects responded both to the Tower of Pisa and the Eiffel Tower, as they are both famous buildings, and Figure S7 showed that subjects responded both to Jennifer Aniston and Lisa Kudrow, as they were both in the popular TV show "Friends" together. Even though it is true that the subjects usually responded with the highest spikes to one subject, it cannot be underscored that they also responded to other test subjects that were completely unrelated with spikes almost as high. For instance, in Figure S11 from the supplemental reading, subjects responded highly to Halle Berry, but also responded almost as highly to various animals such as deer, rabbits, and spiders. The same is true for Figure S3, where even though several pictures of Pamela Anderson elicited a response from the tested subjects, so did pictures of a spider, a snake, a bear, the Eiffel Tower, a dolphin, and the text that said "Spider," all with similar response spikes. Because many of the test subjects responded to pictures that could only be grouped into an extremely large group such as "living things," the authors' claim that their studies showed sparseness in MTL neurons must be questioned. The paper included the few examples in which the MTL neurons did exhibit sparseness, while pushing the results that argued against sparse MTL neurons to the supplemental reading. The fact that subject responses were grouped in some cases by a similar group and a very large group in others may argue towards distributed representations. Considering that it is not known where along the neural network the electrodes were placed, it makes sense that varying levels of specificity were found in neurons.

While the authors do admit that their research does not mean they have proven that grandmother cells exist, it can be questioned if their research even shows that sparseness exists or if their test collection was too limited to show true results (Quiroga 5). Their data are very interesting, but it cannot yet be assumed that MTL neurons are sparsely coded until further tests are done.

Works Cited

DiCarlo, James J., Davide Zoccolan, and Nicole C Rust. "How does the brain solve visual object recognition?". Neuron 73.3 (2012): 415-434.

Jamieson, Graham A. (ed.) (2007). Hypnosis and Conscious States: The Cognitive Neuroscience Perspective. Oxford University Press.

Quian Quiroga, R., L. Reddy, G. Kreiman, C. Koch, and I. Fried."Invariant visual representation by single neurons in the human brain." Nature 435.7045 (2005): 1102-1107.