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Independent Small Group Discussion Write-up

1. What was the motivation for this study? (e.g. big picture questions motivating experiments, prior work motivating experiments, etc)

The motivation of this study came from previous research on the role of the superior colliculus on attentional mechanisms. Selective attention is a particular aspect of attention that involves processing a subset of the available sensory inputs, either to guide an action or even for things like perception or thinking. It is selective because, depending on the context, the subset of what is important in the visual field is appropriately chosen so that it matches the internal representation of those goals in the animal. For example, under one circumstance you may choose a particular visual or auditory signal as the thing you are processing, but if your goals change, even though you may have the same inputs, what you process changes. It has long been known that, when animals are trained to devote their visual attention to a spatial location, the activity of sensory neurons in that location is enhanced. The superior colliculus (SC) was known to be important for orienting, in particular for movements of the eyes and head, and there was work showing that even if you don't physically move the SC is also important for orienting internally, such as orienting attention. However the SC may be less important then previously thought in cue integration. Most work has been done in later stages of visual processing, such as area V4, where the neurons respond to orientation and color, and middle temporal area (MT), which is specialized for processing motion.

2. List the key methodological details (species, preparation, recording/ anatomical techniques, data analysis methods)

Reversible pharmacological inactivation of the SC also impairs performance on attentional tasks. They trained monkeys to perform a motion discrimination task at a cued location in the presence of distracting stimuli. Inactivation of a portion of the SC impaired discrimination performance at the corresponding spatial location, but only in the presence of potentially competing distractor stimuli. Surprisingly, when further experiments examined the effects of SC inactivation during this task on responses in visual cortex (MT and the medial superior temporal area, MST), which are modulated by attentional deployment, they found that the attentional modulation of these visual responses was unaffected by SC inactivation. To show this, you can give the animal just one stimulus to judge and they can do this about as well as a normal animal, but when you put competing stimuli in the visual field, then their performance is severely degraded. This is similar to what you see in clinical cases of human neglect, where patients tend not to notice or engage with things in their environment that are in the affected side of space. This was a good paradigm for the experimenters to have manipulated potential attentional source areas and recorded from visual cortex during covert attention tasks.

They did a series of experiments using functional imaging to identify areas of the brain that were modulated as the animal was doing an attention task. Then the same manipulation of reversibly focally inactivating the SC and then see what parts of the brain changed. The results showed some things they expected from what was in the literature, such as changes in cortical areas like frontal cortex, parietal cortex and sensory cortex, but they also found a spot in the brain that was totally unexpected.

The study also used transgenic mice so they had genetic tools to target specific populations of neuron. As they had hypothesized there may be circuits through the basal ganglia that might be important, as this area is a set of subcortical nuclei in the

forebrain that's important for learning what actions you should engage with in a particular context.

3. For each figure, describe the important points including how the authors interpret the findings and what the findings may actually show.

Figure 1)

a) Two motion stimuli moving in opposite directions were shown in opposite locations. After a variable delay, the motion direction of one of the stimuli changed slightly- the monkey responded to this change with a button press

b) Single neuron recording in the MT in the monkey.

c) Response rates for changes at cued location indicate that unimpaired for stimuli outside the affected region of the visual field (covert attention).

d & e) Cued change-detection rate, cue-related modulation was there despite the deficits in detection performance observed simultaneously during the SC inactivation. This high false alarm rate in e might indicate the monkey's simply found the cost of pushing a button as more beneficial.

Figure 2)

a) Diagram of experiment recording MST before SC inactivation.

b) Diagram of experiment recording MST after SC inactivation.

c &d) Response of the same sample MST sample seemed too elicit similar responses in both a and b conditions. But there was higher discharge rates when the motion stimulus in their receptive field was cued in figure c.

e) Diagram of experiment recording MT before SC inactivation.

f) Diagram of experiment recording MT after SC inactivation.

h) higher discharge rates when the motion stimulus in their receptive field was cued.

Figure 3)

a) The modulation idea- area under ROC curves. Average increases in the discharge rate of 24% and 15%, respectively for MST and MT.

b) ROC areas were significant before and during SC inactivation in both MST. The ROC curve measures how an ideal observer classifies the condition based on the activity of the neuron. This depended on whether the cued or un-cued stimulus was in the receptive field of the neuron and if there was high false alarm/missed hits rates.

c) Fano factor indices (variance over the mean, relates to difference in interneuronal correlations) showed that attention decreases the variability of neuronal activity.

d) Interneuronal correlation was significant for MT and MST before SC inactivation, lost of gain loss with SC inactivation- conferring noise correlations between neurons is important for attention.

4. What is your assessment of the overall findings? Did the experimental data support the authors' interpretation? Why or why not?

This study shows that this enhancement is still observed even when the behavioral effects of attention are abolished. Normally, a spatial cue indicating where to attend produces an improvement in detection performance at that location. It has been

assumed that changes in the cortical representation caused by this cueing are the substrate for this behavioral effect. In this study, following inactivation of the superior colliculus, animals were no longer able to make use of a spatial cue to improve their performance. Changes in the cortical sensory representation with cueing were not affected. Thus, these cortical changes are not sufficient to support the behavioral effects of attention. What was surprising in these result was that the SC was thought to be another source of these controlling signals that regulate what's happening in visual cortex, but when theychecked, by recording from neurons in the visual cortex as they did these manipulations, they didn't change. The neurons in visual cortex showed all the normal signatures of attention, even though behaviorally the animal had an attention deficit because of the manipulation in the SC. So the SC function- as per these results indicate that it is not doing it through this standard, well-understood mechanism of changing how signals are represented in visual cortex. Instead this may be a function of gain control and population mechanics.

5. Describe new insights that you gained from the small group discussion of this paper.

I learned about how the task was performed and it was different from other experimental paradigms- allowing them to isolate activity. I also learned that compared with selective attention, selective orienting is clearly reduced in terms of the number of things you can interact with and the types of responses you can have.

6. List all of your questions and/or points in the paper that you did not understand.

I don't understand why the lack of activity doesn't indicate that it might be part of an ensemble activity.