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Kids Judge Neuroscience Fair 2006 Exhibit
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How Big is Your Leg in Your Brain?

Abstract

The Kids Judge! Neuroscience Fair was a way for us, as neuroscience students, to learn how to present important concepts in neuroscience to a general audience, in this case, being local area fifth-graders. Our purpose was to effectively convey to our audience how sensitivity to touch in different areas of the body are correlated with the density, size, and arrangement of the receptive fields of sensory neurons innervating the skin and how this relates to the somatosensory cortex. When a sensory neuron detects a stimulus, it changes its firing rate and the action potential it generates produces a signal that travels in the dorsal column and eventually to the somatosensory cortex. To demonstrate this concept, we formulated a model that we hoped would enable us to fulfill our goal of educating these young students about neuroscience. In our model, the kids were asked to participate in a two-point discrimination test, to learn about the sensitivity of the skin by touching different objects and to do a short receptive field game. We found that the kids understood a good amount of the material, but they did not think our model was fun nor did they particularly want to learn more about it. Thus, we can conclude that, in the future, it would be beneficial for us to include a fun activity that we could incorporate into our model which would probably stimulate the kids to want to learn more about this subject.

Introduction

The somatosensory cortex is a part of the brain whose purpose is to sense external stimuli on the body and is arranged somatopically, which means that it is like a map of the body. Different sections of the somatosensory cortex are devoted to different areas of the body, and the total amount of the somatosensory cortex devoted to each part of the body is proportional to the sensitivity of the body to external stimuli, like the sense of touch, temperature and pain. We know that the primary significance of the activity of a single sensory neuron is the presence of a stimulus at that particular location (DiCarlo, 2626). The size and number of the receptive fields of sensory neurons that innervate the skin is also proportional to the sensitivity of that body area. This is because a large receptive field can only detect one stimulus on its surface, so if two stimuli are present on one receptive field, the person will not be able to distinguish between the two stimuli. Where there are smaller and more numerous receptive fields, like on the lips and tongue, sensitivity is greater due to the receptive fields being spaced closer together so stimuli that are spaced closer will be detected as two stimuli, rather than one single stimulus. The size and number of receptive fields and the amount of somatosensory cortex devoted to each part of the body are related because each sensory neuron projects eventually to the somatosensory cortex to tell the brain what is happening on its body.

Mechanoreceptors, such as Pacinian corpusles and Merkel endings, undergo a deformation of their channels, which leads to a change in their firing rate. This process involves converting an mechanical signal to an electrical signal.

Touch discrimination and proprioception are mediated through the dorsal column/medial lemniscus pathway. Touch and proprioceptive afferent fibers enter the dorsal column through the dorsal root ganglion and ascend through the gracile and cuneate fascicles and synapse in the medulla on the ipsilateral gracile and cuneate nuclei, respectively. From the medulla, second order neurons send axons across the midline where they ascend in the medial lemniscus. They synapse on third order neurons in the ventral posterolateral nucleus of the thalamus. The third order neurons send axons through the internal capsule to the primary somatosensory cortex of the postcentral gyrus. Some light touch is conveyed by the spinothalamic tract of the anterolateral system, which travels in a similar pathway to the postcentral gyrus as well.

We wanted to teach the kids how the amount of somatosensory cortex devoted to sensing each part of the body is proportionally related to the size of receptive fields located beneath the skin. We hope that they learned that their fingers and face are so sensitive to touch because the neurons innervating those areas have very small and numerous receptive fields, and because the somatosensory cortex has a very large amount of its area devoted to those body parts. Just the opposite is true for areas like the back and arms. We also wanted them to relate how their sense of touch is dependent on their brain. Finally, we used the two-point discrimination test to show them how you can determine which parts of the body are most sensitive to touch.

The two-point discrimination test allowed the kids to physically measure and record the maximum distance where they can still feel two distinct points on different parts of their body (this is proportional to the size of the receptive fields). This was a good test of spatial resolution and it will show them that our ability to discriminate the detailed features of a stimulus varies widely across the body (Bear, 401). Essentially, they learned that different areas of the body are more or less sensitive to tactile stimuli. It helped them understand why they are more sensitive to touch on their fingers as opposed to their back, due to the difference in size of receptive fields of sensory neurons innervating that part of the body.

Methods and Materials

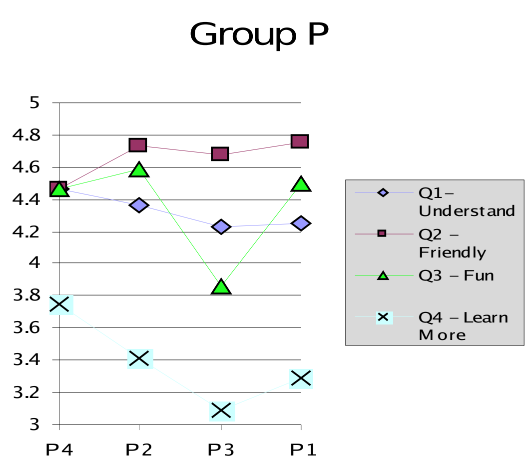
The basic model for our project included a receptive field game, a two-point discrimination test and a couple of objects for touching. The receptive field game consisted of a piece of paper with two different sizes of "receptive fields" for the skin. There were more receptive fields for the small receptive fields and the opposite for the larger receptive fields, but equal area devoted to each. We had pieces of paper that represented the sensory neurons for each receptive field that could be place on the "somatosensory cortex" represented on the sheet of paper. The kids could place each piece of paper on the somatosensory cortex to see that areas of fine touch have more somatosensory cortex devoted to them, whereas areas of rough touch have less somatosensory input devoted to them (see figure).

The two-point discrimination test, which allowed the kids to physically test which areas of their body have fine touch and which do not, was an easy experiment for the kids and required few materials. We simply used paper clips set at specific distances apart (2cm, 1cm, 5mm) and had one person be the recorder, one be the test subject, and one be the experimenter. The test subject was blindfolded and touched with a paper clip on various parts of the body (such as fingertip, back of hand, and cheek) and asked whether he/she could feel one point or two. This was recorded on data tables given to the kids and we helped them determine the relationship between receptor field size and two point discrimination.

We also brought a smooth rock and an orange and we allowed the kids to touch these objects to their fingers, arms and backs of hands to see in which parts of their body they could discriminate the surfaces of the objects the best.

Results

Each child was asked to fill out an evaluation form including; whether they could understand everything we were trying to explain to them, how friendly we were, how fun the model was and whether they wanted to learn more, based on a one to five point scale. In addition, they were asked what they learned and any suggestions they had for the model and/or presenters. At the end, each child was given the opportunity to vote for the best model in their group, which consisted of three other models, including Synaptic Tag (disqualified), The Growth Cone Game, and The Secret Ingredient.



We received one first place vote out of thirteen votes (excluding eleven votes for Synaptic Tag) and came into 3rd place in relation to the other groups (not including Synaptic Tag). As you can see from the graph titled "Group P" representing the questions on the evaluation form and the scores for each as compared to the other groups, we received the lowest scores for every category except for how friendly we were (4.68 out of 5). Our scores were 3.86 for how fun our model was, 3.09 for whether the kids wanted to learn more, and 4.23 for how understandable our model was, which reflected our placement. Based on the evaluation answers, the kids learned about touch in general, that receptive fields can be big and small (small for the hand and fingers, big for the arms), that receptive fields are bigger for areas where you can feel less, and about how much you can feel. We also had a random comment stating that they learned that you need every part of your body. The suggestions they had were that the model was fun, we did a good job and we needed to speak up.

We had the kids do a two-point discrimination test with three different distances between the two points on a paper clip (2 cm, 1 cm, 0.5 cm) and on three different parts of the body (back of hand, finger tip, and cheek). It was very clear that the results the kids found were completely opposite accepted literature values for sensitivity to touch. A statistical test was not performed due to the incompleteness of the data.

Discussion

Through this model, we attempted to explain to fifth-grade students how sensitivity to touch on the skin is related to the receptive fields innervating the skin and the area of the brain detecting that touch and interpreting it. While this concept could be explained at a level that was relatively understandable to fifth-graders, there were some concepts relevant to the subject that we had to skip over in order to simplify our explanations. We mostly left out exactly *how* changes in the shape of the mechanoreceptor leads to an electrical signal (this change in shape causes distortion of ion channels, which open and depolarize the cell), and in which pathways this information travels. We did not explain that somatosensory information travels from the receptive endings of a sensory neuron, into the dorsal root ganglia and then into the spinal cord through pathways such as the spinothalamic tract and dorsal column/medial lemniscus pathway. We also left out that receptive fields are supplied by one neuron, but each neuron can have multiple receptive endings. We decided it would be better to exclude the concept of center surround and how it plays an important part in how we are able to localize stimuli that are touching us. This would have been too complicated and I am certain we would have lost their attention immediately.

We found that the results the kids got for the two-point discrimination test went against accepted literature. One reason for this is we ran out of time and the kids did not get a chance to completely finish their experiments. Some children did not measure their touch discrimination with all widths on one part of their body and some kids did not complete the test for the back of their hand, for example. It also may be that some kids did not perform the test correctly or were not paying enough attention to the stimulus when the test was being done to give an accurate result. We also may not have explained the test well enough.

In light of this evidence, we can conclude that if we were to repeat this model, we would need to improve how we explained our model and make it more fun, which would most likely also increase our scores for whether the kids want to learn more about our project. Based on the answers the kids gave for what they learned from our model, it seems that they had a good grasp of the basics of what we were trying to tell them. They understood that different areas of the body are more or less sensitive to touch, and that depends, in part, on the size of the receptive fields in that part of the body. While we did not get very high evaluations in relation to others in our group concerning how fun the model was and if they wanted to learn more, these comments show that, to a certain degree, we did get our point across to the children.

One thing that I think was not entirely effective was our explanation of the somatotopic organization of the somatosensory cortex and the topographical arrangement of receptive fields innervating the skin relating to that part of the brain. We didn't receive any comments explaining this concept in our evaluations, which suggest a limitation in how we explained it to them. In the future we could try to come up with another model which would more effectively convey this concept, such as a game in which the kids could organize the somatosensory cortex or a puzzle where the cortex and receptive fields are connected in a maze or something like that.

Another problem we noticed was that we had a difficult time keeping the kids' interest for the entire presentation. We did try to keep them involved by asking them questions, giving them things to touch, and an experiment that they could do that demonstrated the concept. I suspect that the biggest problem with our model revolved around the fact that it simply wasn't fun. If we could have come up with a game for them to play they might have enjoyed it more, but that wouldn't have necessarily helped with comprehension.

In conclusion, this model may have conveyed an important concept to the fifth-graders, but it did have some glaring complications, mainly that it was a difficult concept to explain to the kids and that it lacked a truly fun hands-on activity that would have gotten the kids excited about learning about the subject and coming back for more.

References

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