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Make a Memory!

Abstract

Memory is a concept which is very accessible to the school-aged child, and is extensively studied in the research setting. Historically, memory storage in the brain was studied in lesioned patients. Today, fMRI makes it possible to identify which parts of the brain are activated during different types of memory tasks. A two part model was created to familiarize fifth graders with these concepts. The first part was a memory game, followed by a map of the brain on which important structures for memory were outlined, which the kids used to trace the route that memories take in the brain. This model placed third out of four in its group, but received the lowest scores in the four categories in which the kids itemized their opinions.

Introduction

The neuroanatomy of memory is a concept with which fifth graders can easily become familiar with based on its accessibility. It is something that they encounter every day, and which can easily be tested through a demonstration. Furthermore, historically and currently there is a lot of research pertaining to memory and memory stores.

Memory can broadly be classified into two catagories: working and long-term. Working memory is "a limited capacity system that is responsible for the temporary storage and processing of information while cognitive tasks are performed" (Collette and Van der Linden, 2002). Alternatively, long term memory requires consolidation and can be retrieved after extended periods of time. What is known about the location of these processes comes first from lesion studies. Recent technologies such as functional magnetic resonance imaging (fMRI) have made possible great advances in locating the neural substrates of memory because healthy people can be studied while performing a memory task. The knowledge to date will be used to build a model of memory stores accessible by fifth graders.

The hippocampus was first recognized as crucial for some aspects of memory by the case of H.M. in the 1950's (Banich, 1997). H.M. underwent a medial temporal lobectomy, removing his hippocampus and parts of nearby structures. Subsequent tests revealed that HM was still capable of performing short term memory tasks, could still retrieve memories from long term stores, but was unable to make new memories. This placed the hippocampus as an important organ of memory.

Working memory does not take place in just one area. Verbal working memory tasks activate the lateral prefrontal cortex when using fMRI (Barde and Thompson-Schill, 2002). Spatial working memory tasks, such as remembering orientation, engage the superior parietal lobe bilaterally, the middle occipital gyrus bilaterally and the left dorsolateral prefrontal cortex as measured by PET (Cornette, Dupont, and Orban, 2002). Those that perform well on verbal working memory tasks show extensive connections between the PFC and the anterior cingulate cortex (Kondo et al 2004). These studies highlight that the prefrontal cortex is integral to working memory, but also show that other brain regions are required as well.

Long term memory is a different system than working memory, but shares some overlapping components. Based on the lesion studies with HM and later work, it is well established that the hippocampus is required for making declarative memories (Squire 1987). fMRI studies have shown that the medial temporal lobe and inferior prefrontal cortex are also activated when forming declarative memory (Weis et al, 2004). The storage and retrieval of declarative memories for a complex visual stimulus showed activation of the inferior prefrontal cortex, the parietal cortex, and the cerbellum (Weis et al, 2004). Lesion studies in animals demonstrated that procedural memories are stored in the basal ganglia, also the location of motor plans (Phillips and Carr, 1987). It requires large regions of the neocortex to form, store, and retrieve episodic memories, complex memories involving sequentially linked visuospatial scenes. As with other memory types, the frontal neocortex is mainly involved in coordinating episodic encoding and retrieval and that the medial temporal lobes store aspects of episodic information. The prevailing thought is that the posterior portions of the neocortex that process perceptual and semantic information also store these memories (Mayes and Roberts, 2001).

For the sake of brevity and clarity, the model will highlight mainly those structures outlined here, which cover most forms of memory. The brain structures listed above will be identified on a brain map by the insertion of a nail. Also, we will identify the sensory modalities through which information reaches the cortex to begin with. Strings will connect the senses to the memory stores and will highlight pathways through working memory, the hippocampus, and into long term memory stores. The kids will be provided with paper on a loop on which they can write down things or events they want to remember and will be able to move them around the model of the cortex to approximate the way the brain performs this task. This will introduce the kids to how memories are formed, the complexity of the interconnections of the brain, and some neuroanatomy.

Methods

The first portion of the model consisted of a memory game. When the children approached the exhibit, there was a piece of cloth covering half of the table. Under the cloth were twenty common place objects, consisting of a teddy bear, toilet paper, comb, whistle, CD, cup, paint brush, scissors, orange, playing card, marker, book, pencil sharpener, duct tape, dog bone, ping pong ball, base ball, light bulb, coke can, and screw driver, but any twenty common objects would work. The kids were allowed to look at these objects for thirty seconds, and then the objects were covered up again. The kids were provided with half sheets of notebook paper on which to write as many of the objects that they could remember.

After the memory game, a short explanation of working memory, as exhibited in the game, and long term memory, as illustrated on the memory board, was given. We explained that what we remember comes in through our senses. For example, what we see and hear is consolidated in the hippocampus, and stored throughout the cortex in an organized manner. Then, the use of the memory board was demonstrated.

The memory board consisted of a piece of plywood about two feet by three feet. A horizontal section of the brain through the thalamus showing the hippocampus was printed from the Digital Anatomist (Sundsten, 1994) to fit the board. Since the photo used was a two dimensional slice of the brain, anatomy was greatly simplified. The hippocampus was outlined in gold paint, and a large nail was driven through that structure. Small nails and magazine cut outs indicating function were placed next to additional structures. For inputs, these included the somatosensory cortex with a picture of a hand for touch, the insula with a picture of a nose and mouth for taste and smell, the temporal cortex with a picture of an ear for hearing, the occipital lobe with a picture of eyes for vision, and the limbic lobe with a picture of a happy and a sad face for emotion. Each of these nails was connected to the hippocampus by a string of yarn of a particular color. Yarn of another color connected the hippocampus with long term memory stores. These stores included the prefrontal cortex with a picture of a foot ball game for episodic memory, the frontal lobes with a picture of a date for memory for date and time, the parietal lobe with a picture of a house for spatial memory, the basal ganglia with a picture of a man ice skating for procedural memory, and the visual association areas with a picture of a crowd for memory of complex visual stimuli.

After the introduction of the memory board, the kids were provided with loops of pipe cleaner with pieces of paper attached to them on which to write something they wanted to remember. A demonstration was given of procedural memory – a person receives information to their brain about what it feels like when they ride a bike, which comes in through the somatosensory cortex, to the hippocampus, and is stored in the basal ganglia.

Results

When we told the kids that the first part of our model would be a memory game, most of them were really excited. Many boasted that they would be able to remember all twenty objects. Some even came close to this. The most objects anyone remembered was sixteen. On average, most remembered between 9 and 11. Some of the kids obviously had trouble paying attention to the task and only remembered a few. They were all very eager to share which ones they had remembered, and check which they had forgotten.

The explanation of memory after the game had to be brief in order to keep the kids attention, and was based on what could be pointed to on the memory board. After a few examples, most seemed to understand the general process of memory, as demonstrated by their use of the memory board. Most of the kids chose to make memories similar to our demonstrations. The demonstrations involving sports were the ones that they kids got the most excited about. We used a procedural memory example of how to play hockey and an episodic memory example of scoring a winning goal in an important game. Both of these resulted in the kids excitedly telling us about their favorite sports and moments on the field, and us showing them how their brain goes about remembering such things. Some kids even wanted to make more memories. Most of their questions were along the line of “how do I remember. . .” such things as their names, how to eat, multiplication, etc. Although these types of memories were not included on the board, we were able to give them explinations. If there was time at the end of the presentation, we talked a bit about HM, and what happens when you don’t have a hippocampus. Also, many had recently seen the movie “50 First Dates”, a movie I am unfamiliar with but that apparently features a person with memory deficits similar to HM’s, so they were readily able to understand his deficits. Those that had seen the movie seemed excited that this related to what they were learning about at our station.

Make a Memory! was group B1. We placed third out of four in our category. However, in each of the individual categories that the kids voted on, we placed last. Table 1 shows how we placed compared to the average of our group of four.

	Make a Memory!	Group B Averages
Able to Understand	4.43	4.64

Presenters were Friendly	4.75	4.83
Had Fun	4.07	4.51
Want to Learn More	3.7	4.04
Average	4.24	4.50

Table 1. The scores in the four categories in which the kids voted were averaged for all the groups to compare to Make a Memory.

For the group averages, the highest marks went to friendliness of the presenters. Next was the ability to understand the presentation, followed by its degree of fun. Last was the desire to learn more, which on average ranked about four out of five. Make a Memory followed this trend, with slightly lower scores. The comments about Make a Memory nearly exclusively said that the memory test/game at the beginning of the presentation was the best part.

Discussion

Overall, the kids gave the projects very high scores – the lowest scores were all above a 3.5 out of five. This would indicate that all of the stations were positive experiences for the kids. The category they ranked the highest was the friendliness of the presenters, which is positive as well. Next was understandability, which averaged 4.64 in Group B. This is very important because it indicates that the models and presentations were at a level that the kids were able to grasp. Another encouraging point was that I could hear them using the terminology from the introduction as they came to the booths, indicating that they were really learning about neuroscience. Also, when I quizzed them on the lobes using the memory board, they were able to identify several of them.

The next highest scoring category was fun. This is the category in which the memory board scored the lowest from the average. Judging by the surveys, the kids all had a lot of fun with the memory game at the beginning of the presentation. However, this only lasted for the first two minutes of the total ten, and was designed more to get the kids thinking and to catch their interest than to teach them anything specifically. The rest of the time involved the memory board, which clearly was not as popular. Some of the kids had a really good time with it, and asked for more opportunities to make memories. Its downfall, I think, is that it can only be used interactively by one kid at a time. While one kid would be making their memory, the other kids were writing down what they wanted to do, but this still left some down time for those who were not interested in what their class mates were doing. I think it was this down time that made our group the least fun.

Finally, the lowest ranked category was how much the kids wanted to learn more. Besides having fun, an important goal of Kids Judge! is for the kids to leave with a desire to learn more about that topic. While the kids still gave Group B a ranking of four out of five, it was the lowest of the four categories. There could be several reasons for this. One possibility is related to our low score in the fun category. It is likely that the kids wanted to learn more about the topics which they found to be the most fun. Another reason could be that the sciences are just not that interesting for some kids, and while they may have had a good time with the activities, it is simply something they do not want to pursue. Also, this lower score just indicates how the kids felt after seeing the exhibit. It is possible that in a couple of years when they are taking a science class that mentions one of the topics they learned about at Kids Judge!, it may rekindle their interested in part due to this early exposure.

For Group B, the rankings did correlate with the scores fairly well, except that we should have been in fourth instead of third place. I do not know how many votes were the difference between third and fourth place, but I would assume that it was very few. With a larger sample size (more kids), the scores probably would have correlated more closely with the placing.

Overall, I think that Kids Judge! was a great success. The kids really seemed to have learned a lot, and had a great time. It was also a good experience for me as a presenter, to have to think about neuroscience from the level of a fifth grader. Hopefully, it will have kindled the interest of a few future neuroscientists.

Citations

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