Thank you for remembering to come to this lecture on a Monday evening. I’m a neuropsychologist with the Epilepsy Program at VGH. I see primarily patients who are undergoing investigations for surgery to help identify location of their seizures from a cognitive perspective, and also provide information to the patients about possible changes in thinking skills with surgery.

No lecture on epilepsy and memory can go without remembering henry molaison, aka patient HM. I shall start today’s lecture with a story of henry molaison.
Henry was in his preteens when he started experiencing partial seizures. By his sixteen’s birthday, he had several grand mal seizures. Because of the debilitating frequency of his seizures, he was referred to Dr. William Scoville a neurosurgeon in Connecticut. Dr. Scoville discovered that Henry’s seizures were coming from both sides of the medial temporal lobes. Dr. Scoville was a maverick of his time. With Henry’s consent, he decided to try an experimental brain surgery procedure. With a drill and a skinny vacuum, he opened Henry’s skull and sucked out both of Henry’s hippocampus and other medial temporal lobe structures. This next picture shows you the location of the hippocampus.
For those of you who are foreign to reading brain images, this is a coronal cut of the brain. Imagine that you are looking at the front of the person, and the brain is sliced opened. The left picture is that of a normal brain with hippocampus. On the right, you have a sketch of HM’s brain with both middle part of the temporal removed. OK back to Henry.

This was the 1950s when the medical world did not know very much about the functions of the temporal lobe. The surgery was a success because Henry’s seizures were well controlled; however, Henry’s memory of the world stood still. He was able to recall where he was born or where he lived during his childhood. However, he was not able to form new memories, memories that happened AFTER his surgery. He perpetually said his age to be somewhere in the mid twenties, the age he underwent brain surgery. He would repeat himself minutes after telling a story. If Henry was unable to form new memories after the removal of the hippocampus, surely there was a link between those two. Since then, Henry has been one of the most studied patient in the history of medicine. It was because of him that we have a much better understanding of the link between the hippocampus and memory.
There are different types of memory. When you learn how to ride a bicycle, you can’t exactly explain how you do it, but you learned it anyway, not before falling a few times after removing your training wheels. This type of memory is called procedural memory or implicit memory. The brain structures basal ganglia and cerebellum are involved in this type of memory.

How about your ability to learn facts of this world, such as who is the president of the United States, or the meaning of the word “umbrella”? This type of memory is called semantic memory. It is unusual for people with neurological conditions affecting their memory to lose this type of memory. Except in the case of a type of dementia called semantic dementia. But that’s another story.

In my work as a neuropsychologist, I often hear people tell me about their short-term memory loss. They tell me that they forget conversations, what movies they saw a month ago, or where they left their belongings. These are all episodic memories. The hippocampus is involved in consolidating both semantic and episodic memory.

Some times, experts also classify people’s knowledge of themselves, such as where they lived as a child or who their best friends were in their teenage years as a form of episodic memory called autobiographical memory. It is only in rare cases that people with epilepsy forget their autobiographical memory.
Here is a simple diagram to explain formation of new memories. We start by attending to the information, and then the brain processes and encodes the information before it can be stored for retrieval at a different time.
Here is a pictorial version. The frontal lobe attends to and organizes the information that we take in. And then the hippocampus encodes the information for storage in the other parts of the brain. Information is not stored in the hippocampus. And so, if the hippocampus is removed, the memories that have already been formed are not lost. One can also hold new information in mind for a few seconds but new information cannot be consolidated and stored. This also means that depending on the type of epilepsy one has, people can have different types of memory problems.
The impact of epilepsy on memory depends on the cause and location of the seizures. Temporal lobe epilepsies are the most common type of epilepsy. Seizure arising from the temporal lobe can cause disruption in the functioning of the hippocampus and so, people with TLE have trouble consolidating information they learned and they show a pattern of rapid forgetting of information. A common cause of temporal lobe epilepsy is from mesial temporal sclerosis, meaning scar tissues in the medial temporal lobe.

The second most common type of epilepsy arise from the frontal lobe. The frontal lobe acts like the executive of a company. The frontal lobe plans, organizes, multi-tasks, problem solves. People with frontal lobe epilepsy experience executive dysfunctions. They have trouble learning information because of poor planning and organizational skills but once the information is learn, perhaps by providing external structure, the new information is retained.

Another important piece is the functioning of the left vs. the right hemisphere. For most right-handed people, their left brain is the expert at processing verbal information, and their right brain is the expert at processing visual information. So people in my field say the brain processes material specific memory. Verbal memory is encoded by the left hippocampus for most right handed people, while visual memory is encoded by the right hippocampus. People with visual memory impairments are most likely to complain of trouble remembering their way around town, or with remembering faces. Knowledge of material specific memory is important when assessing someone for surgery because we do not wish to have another case of HM. People with verbal memory impairments are most likely to complain of trouble remembering conversations or what they saw on TV.
There are a number of different ways we assess memory. With verbal memory, we often give a list learning task like the one on the screen. This list is read to the patient and the patient repeats the words on the list. Multiple learning trials are provided for the patient to learn the list. After some delay, the patient has to recall all the words on the list without any cues. People with frontal lobe epilepsy tend to show learning inefficiencies, whereas people with temporal lobe epilepsy may learn the list, but they forget what they learned after a delay. Verbal memory can also be assessed by reading a short story to the patient for immediate recall and recall after a short delay. It is thought that the meaningful structure of the story format helps people with frontal lobe epilepsy learn the information better.

For visual memory, or to assess the integrity of the right hippocampus, we may show the patient a display and ask the patient to draw the display from memory, both immediately and after a delay. We may also have the patient copy a complex figure with the display in view, and have them redraw the figure from memory after a time delay.
Epilepsy and Memory

- Severity depends on
  - Type
  - Frequency
  - Chronicity
  - Status Epilepticus

The severity of memory impairment in people with epilepsy depends on the type, frequency, and chronicity of the seizures. Experts are not in full agreement about the effect of seizures on thinking skills. However, people who only get auras are least likely impacted cognitively in the long run whereas complex partial seizures and generalized tonic clonic seizures (or aka grand mal seizures) likely do. Those who get these seizures frequently are likely more affected. It is difficult to study the long-term effect of seizures because of the different causes, types, and frequency of seizures in people. What we do agree is those who experience status epilepticus, which is prolonged seizure that can only be terminated by medications, these people are most at risk of sudden drop in their memory following each episode.
Other factors affecting memory

Part of the difficulty with studying the impact of chronic seizures on thinking skills is also the cognitive side effects of seizure medications. Older medications such as phenobarbital and valproic acid are notorious for causing slowing in thinking and attentional problems. The newer generation of seizure medications are much better for side effects, except for topiramate, which has word finding problem as a common complaint among users.

People with epilepsy are also frequently suffering from sleep problems, perhaps because of night time seizures or disrupted sleep pattern. I don’t know about you, I cannot function properly when I don’t get my full 8 hours of sleep. We know that people who suffer from chronic poor sleep show problems in focus, concentration, and slowed thinking. Good quality sleep is also important in helping our brain regenerate.

Lastly, people with epilepsy frequently suffer from mood issues, both because of their reaction to having a chronic medical condition, as well as the chemical changes in the brain as a result of seizures. People with epilepsy tend to complain of subjective memory problems, and these memory complaints are compounded when there is also mood issue. Here’s a study that look at that.
This is a complicated table so let me take you through it.

This table shows the correlation between subjective memory complaints, various mood/anxiety and objective cognitive test results among healthy people and people with partial or generalized epilepsy.

The items in the box shows significant positive correlation between depression/anxiety and subjective memory complaints for all the participants. People who are more depressed and anxious regardless of medical status are more likely to complain of memory issues.

However, only healthy people show a correlation between their objective memory test performance and subjective memory complaints. Those who perform poorly on the objective memory tests are likely to complain of more memory issues.

Objective measures of memory had nothing to do with subjective memory complaints among people with epilepsy. Measures of attention, focus, intelligence, and visual skill also have no correlation with subjective memory complaints for everyone.
And so, subjective memory complaints usually go away when the depression is treated.
What about brain surgery?
Well it depends on the area of the brain that is removed. As part of presurgical investigations, patients usually undergo a comprehensive neuropsychological evaluation. That is, assessment of their memory, language, executive skills, and visual skills. The neuropsychological evaluation can help to pinpoint the problematic brain location, and help make predictions about the cognitive outcome of surgery. As we learn from patient HM, people undergoing temporal lobe surgery can be at risk of memory decline, so the neuropsychologist will assess the type of memory decline to be expected.

Interestingly, a recent study found that people who are not depressed and who achieve seizure freedom after surgery are least likely to complain about memory changes even when there are objective evidence of memory loss. Improvements in other thinking skills may also be expected with seizure-freedom after surgery. If you think of the brain as a big apartment building, and the seizure focus as a noisy neighbor, removing that noisy neighbor will bring about peace in your life, and so you are able to work better, just like the other brain areas not directly affected by seizures.
Here is an example of someone who underwent right-sided temporal lobe surgery. The dash line represent the cutoff for impairment, so any bar under the line is an impaired function. As you can see, prior to surgery this person had strong skills across the board, and after the surgery, only visual functions are in the impaired range. Right here, visuospatial, and here, visual memory.

This person had reduced frequency of seizures from 1-2 a week to 1-2 a month. This person did not have cognitive complaints and is able to compensate for the visual memory loss. This person also do not suffer from mood issues.
How about in old age?

As I said, studies on chronic epilepsy is difficult to conduct because of the uncontrollable variables like seizure frequency and causes, seizure medication dosage. However, a group tried to do a cross-sectional study of older adults with chronic epilepsy, and compared them to healthy older adults and those with mild cognitive impairment. MCI is the intermediate stage between normal aging and dementia.
Graph number one is based on the dementia rating scale, a measure of general thinking skills. The dotted line represents the cut-off score typically used to identify dementia. As you can see, seniors with epilepsy performed worse than those with MCI, who in turn performed worse than healthy controls.

These are a matched sample. 
Age>60, partial complex seizure with or without GTC, at least 10 years (to over 30 years) of epilepsy, at least 1 seizure a month, about half of them are taking 2 or more AED.

The next graph looks at memory only.
Memory in this case was measured using story recall. The dark green bars present immediate recall while the light green bars represent recall of the story after a brief delay. As you can see, it is typical to lose information after a delay, even for healthy people, but both MCI and seniors with epilepsy performed similarly. They don’t remember as much of the story as healthy people, and they retain even less after a delay compared to healthy people. The important message from this study is that seniors with chronic epilepsy seem to suffer from memory decline but they did not perform at the level of someone with dementia.
What can I do to protect brain health?

There are a variety of things people can do to protect their brain health. These recommendations are good for both healthy people and those with neurological conditions including epilepsy.
There are many studies that support physical exercise, especially aerobic exercise as the number 1 thing anyone can do for their brain health. Even walking an extra few blocks everyday has measurable impact on the memory. Healthy people who exercise on a regular basis are more likely to delay the onset of dementia than those who do not exercise. In the past, physicians have advised people with epilepsy against aerobic exercise but recent studies suggest otherwise. Aerobic exercise helps to manage stress, which is a trigger for many people with epilepsy. That may be why people who exercise on a regular basis see a reduction in their seizure frequency. That is not to say one should sign up for a triathlon next season. Ideally we recommend 30 sustained minutes of exercise at least 3 times a week for optimal brain and cardiovascular benefits. And also for mood.
So, get your friends and family out jogging with you and get your heart pumping! But before you start any exercise regimen, check with your physician and make sure you exercise seizure precautions!

I should mention that the exercise regimen is probably not recommended for those with established exercise-induced epilepsy.
In addition to exercise, dietary factors are also protective of brain health. Foods rich in anti-oxidants and omega-3 fatty acids have been found to be brain food. So eat more berries, nuts, and oily fish for your brain health! Fresh produce, especially those dark leafy and bright color vegetables are also very rich in brain nutrients. Spices such as cinnamon and curry have also found to have beneficial effects on brain health.
Sleep hygiene

- Sleep routine
- Avoid caffeinated products
- Avoid stimulation
- Dark, quiet, and cool bedroom

If you remember, I mentioned earlier that chronic poor sleep is deleterious to brain health. So practice sleep hygiene. Make sure you maintain a sleep routine, going to bed and waking up at the same time everyday including the weekend. This may include other routine that you do prior to bed, such as drinking warm chamomile tea, or taking a warm bath to help you relax before bed.

Avoid caffeinated products such as coffee, tea, cola, chocolate, energy drinks many hours before bed time. Have your emotionally stimulating conversations with your partner earlier in the day, not in bed. Pillow talk is not always a good idea.... Similarly, avoid watching Netflix on your tablet or laptop in bed!

Finally, ensure your bedroom is dark, quiet, and cool for a comfortable sleep. If you have electronic in your bedroom, make sure they do not emit any light, even a small amount can affect your sleep.

If you find that you cannot fall asleep after 20 minutes, get up, do some light stretching or walk around your house before trying to sleep again.

If your sleep remains poor despite rigorous efforts at these sleep hygiene practices, consider seeking help from a psychologist who specializes in behavioral treatment for sleep issues.
Compensatory strategies

- Chunking
  CFLNBAMTV
  CFL – NBA - MTV

- Smart phones
- Active learning
- Use mnemonics
- “Memory” place
- Reduce environmental or visual distracters
- Method of loci

If you find your memory declining, there are several compensatory strategies that you can try.

1. Chunking. It is much harder to remember these 9 letters, but once you put them in 3 chunks, it becomes much easier! The convention is we remember 7 +/- 2 pieces of information.

2. Smart phones have various functions that are helpful. Calendar with alarm reminders can be used for appointments or medication reminders. The voice recording function is handy to record shopping list.

3. Active learning, includes writing summary notes, drawing mind maps for remembering different concepts, enrich the information to be learned, repetition helps.

4. Using mnemonics and visual cues to remember names and faces such as “tall tom is the accountant with brown spikey hair that looks like a troll”

5. Use one memory place for your belongings, and return the item back to the same place immediately after use. Sometimes it may be helpful to put all your personal belongings such as keys, wallet, and glasses in a big bowl by your door so you won’t be looking all over for them when you’re about to leave the house.

6. Keep your work desk tidy to reduce visual distracters. Likewise, when you are working on important tasks such as filing your taxes, turn off the TV or music to prevent distraction.

7. Practice the method of loci. Here’s how you do it.
If you’re hoping to remember your shopping list, use spatial information to aid your memory. Picture a familiar room such as your living room in your head. Make sure you know all the furniture in your living room and you can picture them your head! Then, as you walk around the room, place your grocery item on the furniture. For example, as I mentally walk through the door, I place a dangling bunch of carrots by the picture frame. And then some round apples on the drawer with the round wheel on the wall. Then I place some peppers under the hot table lamp to help them grow in the heat. Then I put my daughter’s favorite grapes on her favorite armchair. Then I grow the sticks of asparagus out of the bowl of pebbles on the coffee table before I leave some hot tomatoes on the white sofa but I must be careful not to sit on it in case I stain my white couch with red tomato juice. And I’m ready to go to the store!
When I arrive at the grocery store, I put up the image of my living room in my head and start to walk through the room, picking up the bunch of carrots dangling off the picture frame, and then I go by the wheel on top of the drawers for my round apples, and then under the hot table lamp are my peppers. My daughter’s favorite armchair holds her favorite fruit. What is that thing growing out of those pebbles? Oh, yes asparagus sticking out. I must be careful not to sit on my white sofa so that I won’t stain it with red tomato juice.

That’s the method of loci utilizing familiar spatial information.

If you want to know more about your cognitive strengths and weaknesses,
Talk to your physician about referral to a neuropsychologist

The neuropsychologist has expertise in assessing your cognitive abilities in order to make recommendations about compensatory strategies most appropriate for you.
Take home messages

1. Memory complaints in epilepsy dependent on cause, type, frequency, and chronicity of seizures
2. Seizure medications, sleep problems, mood disorders, and brain surgery can impact memory
3. Improved mood and seizure control most predictive of memory complaints after surgery
4. Use compensatory strategies - Practice, Practice, Practice
5. Physical aerobic exercises and dietary factors improve brain health
Thank you for coming!

Questions?