Chapter 1: Education
Section 3: Brain and Memory Basics

I. Attention Failures

The Most Common Types of Memory Problems Aren’t Related To Memory Loss At All

Some types of memory problems are not so much a kind of memory loss as much as they are inattentive errors. Inability to remember infrequent or unfamiliar words, where you might have left your car keys or why you walked into a room, are common signs of distractibility or forgetfulness. Occurrences like these represent attention failures rather than a form of actual memory loss.

The act of remembering requires goal-directed behavior associated with the frontal lobe like active attention and strategic planning. While forgetfulness can occur at any age, attentional lapses become more frequent as we get older because of vulnerability to fatigue, medical problems or emotional duress.

A. Absent Minded Mistakes

Action Slips

Examples include going home to lock the door and finding it already locked or taking your medications twice. The reason we forget is that we don’t pay much attention to habitual actions. Because the action has become part of our daily routine, we don’t devote singular attention to it or we are usually trying to do something else at the same time.

Substitution Actions

Examples include finding yourself driving to work on your day off or putting the butter in the dishwasher instead of the refrigerator.

Confused Actions

Examples include leaving out ingredients in a recipe or putting an empty ice cube tray in the freezer. (Well, maybe that last one is laziness!)
B. Prospective Memory Loss

The most common form of forgetfulness is failure to remember future events, or "forgetting to remember". While you may be able to recall the batting statistics of your favorite pitcher, this doesn’t make you reliable at picking up milk on the way home from work, remembering your wife’s birthday or to make your dentist appointment next month.

Immediate memory loss or problems recalling the details from recent events is usually unrelated to memory failures involving future events and intentions. Prospective memory is different than other types of memory.

It is especially difficult because it requires you to remember out of the ordinary events without prompts. For example, remembering to return a book to the library or to defrost the chicken for dinner. In contrast, immediate memory is more easily called to mind by the appearance of a trigger, whereas prospective memory lacks such a prompt.

Prospective memory is further complicated by having to remember to perform an action, like taking medications at a certain time. Also making future based memory more difficult is the fact that older adults have more difficulty monitoring the passing of time, especially when busy or distracted.

C. Intentional Memory Loss

Even more frequent and frustrating than failure to remember to perform a task later in the day or next week is forgetting to perform an action within the next few minutes. When one is just about to do something, then one does not make an active effort to remember it. For example, you walk into a room to get something, you are momentarily distracted, and find that you are doing something other than the intended task or walking out of the room without the needed object. AAGGHH!

Anything that places additional demands on active memory, such as mental fatigue or cognitive slowing, will make future retrieval more difficult.

The following occurrences can happen more frequently with normal aging, neurological disease or emotional stress:

Failing to Remain Mindful

Knowing if something really happened or whether we imagined the memory is a frequent side effect of mental fatigue. The problem occurs with routine actions that we perform in the same context day in and day out. Memories for daily habits like whether one has taken medications, turned off the iron or locked the door can blend together over time, especially when under duress or fatigued.

Underestimating the Passing of Time

Inability to accurately gauge time can not only make us harried and late, it also affects our ability to recollect events that occur during that time frame.
Failure to Rehearse Intentions

In cases where one is “just about to do something,” it is likely that by the time one gets around to it, the memory has already faded or one has become distracted by something else. The need to rehearse an intention right up until the point of completion becomes of greater consequence as we get older.

The caveat to this is older adults are as good as their younger counterparts at remembering general types of future based memory tasks. Retrieval that is aided by to do lists, like returning a library book or picking something up at the grocery, seems to come easier for adults who live more routine lives or structured lives. Or, older adults may be more aware of cognitive slowing and decline in working memory and are already using environmental cues to offset these changes.

Greater Susceptibility to Distraction

Prospective memory usually requires that we remember intentions in the hub bub of our normal day. Good attentional control involves both the ability to keep focused on the information you want to keep active as well as the ability to avoid being distracted by competing and irrelevant stimuli going on around you.

Most Frequent Types of Forgetfulness

II. Types of Learning

Good Memory Starts with Learning

Most people think that good memory means good retrieval. But actually, that’s putting the cart before the horse. Good memory starts with good learning and forming a strong association when acquiring new information.

There are basically two ways of learning, one depends rehearsal of written or spoken information while the other relies on motor skills and practice. For example, if you want to learn a telephone number, you could either memorize it using various mnemonic strategies or learn it by dialing the number over and over to create a habit.

Both approaches depend on the information or actions being sufficiently repeated or rehearsed, through a process called consolidation, to the point it is reliably stored in long term memory and can be retrieved at a later time.
Types of Learning

A. Declarative Learning

Refers to what we know, based upon what we have been taught or read. Information is factual, impartial, reliable and objective. The “Ford” approach to learning, with the engine upfront, relies on frontal lobe skills, such as active listening, mental rehearsal and note taking. Traditional education programs rely on declarative learning techniques. Semantic memory relies on the declarative learning process.

B. Procedural Learning

Refers to the things we do, the skills and habits we have practiced to perfection and perform on a daily basis. The “Volkswagen model” places the engine in the rear, and relies on brainstem and midbrain regions for optimal learning. Experiential education programs rely on procedural learning techniques.
Intentional Learning

Learning to play the violin or nail a jump shot in basketball requires active, effortful, purposeful or goal driven behavior. If your heart’s desire is to become a professional athlete, artist or musician then it is given that you would be spending hours and hours a day perfecting your skills. Even if your intention is to become better at a skill for your own enjoyment, you should be prepared to exert concerted effort towards that goal.

Unintentional Learning

It is possible to acquire new behaviors though unintended means, simply by watching others or subtle forms of positive or negative reinforcement. Basically we engage in behaviors that get our needs met. Once the behaviors become practiced over time, they become the habits we perform on a daily basis. These habits, for good or bad, become hard wired into the brain, and are very resistant to change, until life no longer delivers the expected reward or return on our investment.

III. General Memory

Different Types of Memory

- Explicit Memory Requires Effort
  - Semantic Objective Reliable, Facts
  - Episodic Subjective Personal Events
- Implicit Memory Automatic
  - Procedural Skills, Habits
  - Emotional Negative Reinforcement
- Immediate Under Construction
- Long Term Resilient
A. Explicit Memories

Some memories appear under conscious or executive control; meaning that use of intentional or effortful learning practices can increase the likelihood of retrieving information at a later time. Episodic and semantic memories are both types of explicit memory.

1. Semantic Memory

Memories that involve facts that a person learns over time are called semantic memory. Word-based memories depend on left brain functions, and include knowledge of historical events and figures, state capitols, planets in the solar system, vocabulary, writing and mathematical skills. Again, information is objective and impartial.

Common Words

Word finding problems involving common, everyday words such as “spoon,” a direct family members name, or a phone number used on a daily basis would be considered an unusual occurrence. Like remote memories, frequency of use has ensured they have been well encoded and should remain easily assessable throughout the aging process. High frequency word loss is considered a form of semantic aphasia and a potential risk for Alzheimer’s disease.

Uncommon Words

The inability to think of infrequent and uncommon proper nouns such as the first names of an acquaintance is examples of forgetfulness or emotional duress. Problems with low frequency word retrieval can happen at any age and are considered normal.

2. Episodic Memory

Episodic memory involves recall for events that are tied to a specific time and place in our lives. Think of it like recalling a movie, in which you are one of the actors. Recall is dependent on right brain function, images and memories of life experiences centered on oneself. Remembering what one did the previous day or recalling the details of one’s childhood years are both kinds of event-based memories. In contrast to declarative memories, episodic recall is subjective, personal and sometimes unreliable.

Immediate Recall

Events which occurred within the recent past are temporarily stored in short term or immediate memory. Learning is considered still “under construction”, and without further action on our part information is at risk of being lost. Effortful encoding strategies, such as mindfulness training, rehearsal and repetition, are critical to help strengthen the connections and complete the consolidated learning process.

One of the best strategies for improving immediate memory is to employ the same techniques you used in school to learn new information, such as frequent repetition or memorization, elaboration or simply writing it down. With just a little bit more effort, we can encode the everyday episodes of our life, into semantic memoires, that are reliable, accurate and resistant to fading.
Long-Term Memory

Remote memory involves recall of prior autobiographical events and life experiences that happened many years ago. Memories of your childhood, wedding or the dates when your children were born are examples of long term episodic memory. As these events have likely been recalled numerous times throughout your life, they have consolidated and are considered well learned and not likely to fail.

B. Implicit Memories

Implicit memories are those which are not under conscious control, and include both procedural and emotional memory.

1. Procedural Memory

Procedural memory, sometimes referred to motor memory, is memory for how to do things. Skills such as playing the violin or nailing a jump shot in basketball are acquired through intentional effort, repeated practice and rely on procedural memory. In addition, some habits are acquired not so much from thoughtful, concerted effort, but and daily routines. Performing these activities has become automatic and no longer requires much conscious effort. Brushing your teeth, singing a familiar song, driving a car or riding a bike are examples.

Similar to long term and semantic memory, procedural recall is considered resistant to aging. However, because these skills and abilities recall motor function, the speed and efficiency in which we perform them will likely decline with advanced age. Unlike factual knowledge, skills and habits require continued practice to stay sharp. Like a library book, you never really own a skill; you have to keep checking it out in order to ensure you can still perform it well.

Once a skill becomes highly practiced, it becomes automatic, and places little demand on the frontal lobe, freeing up active attention and working memory to learn new things. In contrast to declarative learning, which relies almost exclusively on prefrontal cortex function, habits depend on sensory motor skill, speed and efficiency. Key brain structures include the basal ganglia, the cerebellum and the limbic system.

Procedural learning offers an alternate route for developing new behaviors through concerted practice, especially important for those following a head injury or other neurodegenerative diseases affecting attention and processing speed.
2. Emotional Memory

Emotional Centers of the Brain

**Limbic System**

The limbic system, considered a key emotional center of the brain, is also home to learning, motivation and memory functions. Key brain structures located within this half-moon structure include the *anterior cingulate gyrus*, critical for motivation and flexible thinking, as well as the *amygdala* and the *hippocampus*.

The amygdala becomes activated when feeling highly anxious and panicky, triggering avoidance and the conditioned fear response. It sits atop the *hippocampus*, a key area for learning and memory.

**Locus Coeruleus**

The locus coeruleus is located in the brainstem behind the pons and receives and sends input to the amygdala, cingulate gyrus and prefrontal cortex of the brain. Its purpose is to regulate stress and anxiety through the production of *norepinephrine* or noradrenaline, a neurotransmitter essential for mood regulation.

The stress response is generally adaptive and allows the body to quickly react to short term demand situations. It gives us the motivation to arrive on time and meet daily commitments. However, under traumatic or prolonged periods of emotional duress, stress is no longer adaptive. Over activation of the locus coeruleus results in vigilance and overarousal, triggering a *fight or flight reaction* in response to perceived danger.

Next, like a domino, the *hypothalamus* unleashes a cascade of autonomic responses in the body, including accelerated heart rate, breathing, sweating, dizziness and insomnia, all symptoms frequently associated with panic.

It is understandable why hyperarousal can cause the prefrontal lobe to go haywire and interfere with higher order problem solving skills. Various mood spectrum, processing and attention disorders such as PTSD, Over Focused ADD, and Bipolar II are characterized by an overactive locus coeruleus.

Under duress, we are not only more prone to inattentive errors, but limited working memory stores, critical for learning becomes overloaded with internal noise and negative self-talk. In contrast, too little adrenaline can result in hypoactivity, inertia and lack of motivation.

The neuroanatomy of the brain can offer understanding why we struggle to learn under stress, the enduring power of negative reinforcement, why some phobic behaviors persist or the reason why certain memories can be so difficult to let go.
IV. Different Types of Memory Are Processed and Stored In Different Areas of the Brain

Memory is a very complex process that involves many different areas of the brain. Unlike your computer’s hard drive or portable memory stick, the brain does not store memories in one central location. Instead, different types of memory are stored in different regions of the brain.

In addition, neuronal networks connect key midbrain and brainstem structures to the prefrontal cortex ensuring neurotransmitters such as dopamine, serotonin and norepinephrine are available for the regulation of mood and the enhancement of learning.
A. Brain Regions That Affect Emotion and Cognition

1. Prefrontal Cortex

The act of remembering begins with prefrontal cortex. Encoding new information demands active attention, speed of information processing and working memory. The prefrontal cortex is considered the command center for the brain and responsible for higher order strategic problem solving. Planning, organization, task monitoring and self-correction rely on the frontal lobe. Finally, self-awareness, or insight, considered the highest of all brain functions is dependent on frontal lobe regulation.

2. Parietal Lobe

Like a pinball, information ricochets off various parietal lobe structures, including the basal forebrain, to the mediodorsal nucleus and then to the hippocampus, located in the medial temporal lobe. Learning could be said to be “under construction” at this phase of the encoding process. Information that is complex or new must be rehearsed, revised and consolidated in order for it to be comprehended and retained.

3. Limbic System

The limbic system is a half-moon structure that runs the length of the frontal, parietal and temporal lobes. Key brain structures of the limbic system include the anterior cingulate gyrus, which lies within the frontal region of the brain and allows us to remain alert and motivated. The amygdala, sits deep within the medial temporal lobe and is activated under fear and it determines the fight or flight response to perceived danger. It actually sits atop the hippocampus, a key area for learning and memory. Perhaps this can explain why we struggle to learn when under stress or why certain memories can be so difficult to let go.

4. Basal Ganglia

Located in the forebrain, the basal ganglia is associated with voluntary motor movement, procedural learning and the development of habits and routine behaviors, including obsessive compulsive behaviors. Circulatory loops connect the basal ganglia with the prefrontal cortex, essential for active attention, learning, goal directed behavior, prediction and expectation.

Overlap with the limbic system, including the amygdala, puts the basal ganglia in a central role in reward based learning. The basal ganglia include the substantia nigra, essential for the production of the neurotransmitter dopamine. Dopamine is believed to provide a teaching signal to parts of the brain responsible for acquiring new behavior. A number of highly addictive drugs, including cocaine, amphetamine, and nicotine, are thought to work by increasing the dopamine signal.

5. Medial Temporal Lobe

Over the course of one’s lifetime, autobiographical events, vocabulary and general knowledge are repeated countless times. Familiar memories and information eventually become stored in the medial temporal lobe, the area more or less above your ears.
6. Cerebellum

Habits, skills and daily routines are dependent on repeated motor behaviors which are processed in the cerebellum.

The cerebellum is known to play a part in automating the unconscious process used when learning a procedural skill such as painting, instrument playing and in sports such as golf as well as correcting movement and in fine-tuning the motor agility required for these skills. Damage to the cerebellum, located within the brainstem may prevent the proper relearning of motor skills.

New thoughts in the scientific community suggest that the cerebellar cortex holds the holy grail of memory, the biological place where memory lives. The initial memory trace is thought to form here and then travel outwards to other brain nuclei for consolidation via parallel fibers known

B. Brain Chemicals That Affect Emotion and Cognition

Neurotransmitters

A neurotransmitter or neuromodulator acts as a “chemical messenger” to optimize the excitatory and inhibitory tone of the brain.

1. Dopamine

Dopamine has many functions in the brain, including important roles in behavior and cognition, voluntary motor movement, motivation, punishment and reward, sleep, mood, attention, working memory, and learning.

Dopamine is produced in the substantia nigra located within the basal ganglia. Under production of dopamine is associated with degenerative movement disorders such as Parkinson’s disease with overproduction appearing to overload the frontal lobe circuitry, resulting in racing and disorganized thoughts commonly seen in Schizophrenia.

2. Serotonin

Serotonin is the body’s natural “feel good” hormone and is essential for the regulation of mood, appetite, and sleep as well as various cognitive functions, including mental clarity, memory and learning. Serotonin is produced in the raphe nuclei, located with the brainstem and is transmitted to almost every part of the central nervous system and spread out in the entire brain.

Approximately 95% of the human body’s total serotonin is found in the gastrointestinal tract, sometimes called the body’s “second brain”. The microbes that inhabit the gut are a key player in the gut-brain connection, with research indicating that marked changes in behavior can result from regulating the composition of gut bacteria.

Imbalance in serotonin levels can affect the intestines, GI upset, influencing the cardiovascular, immune and kidney systems. In addition, limited amounts of serotonin can result in depression and craving for carbohydrates, while larger amounts decrease one’s appetite and may result in mood swings and irritability.
3. Norepinephrine

Norepinephrine is a stress hormone that releases an adrenaline like chemical under emotional duress. It triggers the fight-or-flight response, directly increasing heart rate, blood pressure and respiration. It is released from the locus coeruleus, located in the brainstem, behind the pons.

Galanin, a neuropeptide, is released during exercise, and is critical to mood regulation, learning and neurogenesis, or enhanced growth of neuronal networks. It inhibits the release of norepinephrine during periods of stress. Engaging in a regular exercise program reduces the amount of norepinephrine released and projected to the prefrontal cortex compared with those who are sedentary.

4. Acetylcholine

Acetylcholine is another neurotransmitter critical to learning and memory. Alzheimer’s disease results in the depletion of acetylcholine. Common memory medications include acetylcholine esterase inhibitors such as Namenda and Aricept, which prevent the reuptake of acetylcholine.

V. Some Memory Functions Will Be More Resilient Than Others

A. Vulnerable Memories

In general, memory functions that are highly dependent upon active attention and the frontal lobe are considered “under construction” and are at greater risk for failure. The fact that we are constantly exposed to new things in our environment requires that we turn over new information at a high rate of speed.

In order to make room for the new episodes in your life, the storage capacity in working memory is limited to about 10 seconds. Much like a conveyor belt in an assembly line, the frontal lobe works well if we can keep up the pace. However, any delays in processing or distractions in the environment can overload our circuits. Remember the Lucille Ball comedy show and the episode of the candy factory?

The more exposure we have to the information, the better it becomes consolidated, pushing it deeper into the medial temporal lobe for safe keeping. The best strategy to prevent the daily episodes in our life from fading away is to increase exposure to information we want to remember. Engage in active listening, clarify points you don’t understand, ask questions, repeat information and take notes.

B. Resilient Memories

Information that is well consolidated moves from the frontal lobe and becomes stored in the medial temporal lobe where it is fairly resistant to loss or failure. It may take over thirty rehearsal trials to complete this process, so expect to be patient.

Normal aging may delay the time it takes to access information stored in long term memory, but actual memory failure is uncommon. The same is true with compulsive habits, skills and routines. For good or bad, once habits and routines are learned and continued to be practiced, they are generally with us for life unless we consciously work at changing them or we lose the motor skills to perform them.
Emotional memories involve a physical pathway that connects the amygdala, or fear-based learning center of the brain, to the hippocampus and the prefrontal cortex. Although these memories can be powerful, and sometimes have a lasting effect, we may or may not be able to access them at will.

VI. The Brain Is Not an Island

It can be difficult to sort out the difference between attention, memory and problem solving functions. Even more confusing is why some activities can be completed with relative ease, while a seemingly less complex task remains such a struggle. Given such an uneven pattern of performance, sometimes it can appear that a person is not trying hard enough.

Factors Contributing to Immediate Memory Loss

A. Poor Memory Can Be a Symptom of another Issue

Try not to jump to conclusions when observing signs of forgetfulness, impaired concentration or a change in cognitive abilities. Identify the elephant in the room first. Remember that good memory starts with good attention, and focus can be easily derailed. Poor memory is frequently the casualty of some other issue, not the primary disorder.

Any number of factors can be associated with a change in cognition, including chronic fatigue or pain, analgesic medications, sleep disordered breathing, recent change in job description, life style or
neurological disease, retirement, stress overload, poor strategic problem solving or a combination of these factors.

B. Injuries, Illness and Mood will Compromise Different Parts of the Brain

It is important to keep in mind that brain injuries, neurological disease, advanced aging and even attention and mood disorders can impair certain memory and reasoning functions while others are left unaffected. For example, a person who is diagnosed with Multiple Sclerosis, Parkinson’s or cardiovascular disease, will likely experience problems with physical fatigue, cognitive slowing and multitasking. In contrast, general knowledge and expressive language can remain well intact.

Consider that stress overload, irritability or depression can result in an uneven pattern of performance as well. On days when one is feeling anxious, overloaded and internally distracted, expect an increase in forgetfulness, inattentive mistakes and poor executive problem solving.

C. Not All Changes in Cognitive Function are related to a Disease

Some tasks are just more demanding than others. Inattentive errors can pop up more frequently at certain times of day, when trying to multitask or if there is excessive background noise present. For some who may have always struggled with planning, time management and establishing daily routines, the result can be increased risk of forgetfulness and absentminded mistakes. Forgetting to remember is not a type of memory loss!

D. Investigate for Potential Attention Problems First

The best strategy when first experiencing immediate memory loss is to do a personal inventory of factors that reduce our attention, including physical or emotional problems, distracters or poor learning habits, and see what is appropriate in the situation.