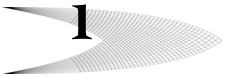


How Your Memory Works

To know how to improve your memory, it helps to have a general understanding of how your memory works. I have created specific exercises based on this knowledge, exercises that will help you improve in each of the areas of your memory.

The roots for the way we think about memory today actually have a long history, dating at least back to the time of the Greeks, and perhaps earlier. Accordingly, I have included a little history about the way psychologists have thought about memory that has developed into the model of memory that psychologists commonly hold today and that I use in this book.

A Quick Historical Overview

The Beginnings of Studying Memory

Even before philosophers and other theorists began to study human thought processes, including memory, memory played an extremely important part in the development of human society. It was critical for teaching new skills, customs, and traditions. Before the development of printing, people had to remember many things that now are recorded on the printed page or can be shared through audio and video recordings. For example, consider all of the rituals, songs, and stories that people had to learn and then pass on to others. This

might be like learning the contents of dozens of books. Anthropologists have estimated the extensive scope of such learning by speaking with the culture bearers of once nonliterate cultures and speculating as to what kind of learning might have been passed on by distant cultures.

Then, to skip ahead to about 2,300 years ago, the Greek philosopher Aristotle was one of the first to systematically study learning and memory. Besides proposing laws for how memory works, he also described the importance of using mental imagery, along with experience and observation—all of which are key aids for remembering anything.

However, the formal study of memory by psychologists didn't begin until the late 19th century, when Wilhelm Wundt set up a laboratory in Leipzig, Germany, and launched the discipline of psychology, based on studying mental processes through introspection or experimental studies.[1] There, along with studying other mental processes, he began the first studies of human memory.

Many of these memory studies used assorted clinical trials, which may seem a far cry from the practical tips on memory that are described in this book. But the work of these researchers helped to discover the principles of how we remember that provide the theoretical foundation for what works in effective memory training today. For example, back in 1894, one of the first memory researchers—and the first woman president of the American Psychological Association, Mary Whiton Calkins—discovered the recency effect, the principle that we more accurately recall the last items we learn.[2] These early researchers generally used nonsense syllables to determine what words a person would best remember after a series of tests of seeing words and trying to recall them, but the recency principle still applies when you try to remember something in day-to-day life. Want to better remember something? Then, learn it or review it last when you are learning a series of things at the same time.

The well-known psychologist William James was also interested in memory, discussing it in his 1890 textbook *Principles of Psychology,* along with many of the cognitive functions that contribute to memory, such as perception and attention. He even noted the ''tip-of-the-

tongue'' experience that we have all had: trying to recall a name that seems so close—but not quite able to grasp it.[3]

During the first half of the 20th century the behaviorists, with their focus on outward, observable behaviors and the stimuli contributing to different behaviors, dominated psychological research in the United States. They weren't interested in mental processes or in introspection about them, though their methods of measurement were later adopted by memory researchers.[4]

But in Europe, in the early 1900s, Gestalt psychology got its start. It brought a new perspective of looking at meaning and at the way humans organize what they see into patterns and wholes. They pointed up the importance of the overall context for learning and problem solving, too.[5] It's an approach that is very relevant for understanding ways to improve memory; their work helped us understand that by creating patterns and providing a meaningful context to stimulate better encoding of a memory in the first place, that memory could more easily be retrieved later. For example, Frederick C. Bartlett, a British psychologist, who published *Remembering: An Experimental and Social Study* in 1932, who used ''meaningful material'' such as long stories (rather than random words or nonsense syllables), found that people made certain *types* of errors in trying to recall these stories for the researchers. Significantly, these were errors that often made the material more consistent with the subject's personal experience, showing the way meaning shapes memory.[6] Like the recency findings discussed above, these findings—that you will remember something better if you can relate it to your own experience—are the basis for some of the techniques described later in the book.

Modern Research on Memory

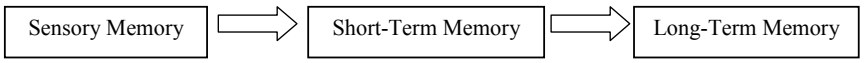
According to psychologists, building on the work of these early precursors, cognitive psychology—the study of mental processes, including memory—really begins in 1956. So the foundations of modern memory research only go back 50 years. As Margaret W. Matlin writes in *Cognition,* an introduction to cognitive psychology, initially published in 1983 and now in its sixth edition, ''research

in human memory began to blossom at the end of the 1950s. . . . Psychologists examined the organization of memory, and they proposed memory models.''[7] They found that the information held in memory was frequently changed by what people previously knew or experienced—a principle that can also be applied in improving your memory. For example, if you can tie a current memory into something you already know or an experience you have previously had, you can remember more.

For a time, psychologists studying memory used an information-processing model developed by Richard Atkinson and Richard Shiffrin in 1968 that came to be known as the Atkinson-Shiffrin model. While some early memory improvement programs were based on this model, it has since been replaced by a new model that is discussed in the next section.

In the Atkinson-Shiffrin model, memory is viewed as a series of distinct steps, in which information is transferred from one memory storage area to another.[8] As this model suggests, the external input comes into the sensory memory from all of the senses—mostly visual and auditory, but also from the touch, taste, and smell—where it is stored for up to two seconds and then quickly disappears unless it is transferred to the next level. This next level is the short-term memory (now usually referred to as ''working memory''), which stores information we are currently using actively for up to about 30 seconds. Finally, if you rehearse this material, such as by saying the information over and over in your mind, it goes on into the long-term memory storage area, where it becomes fairly permanent.[9]

Thus, if you want to improve your own memory, it is critical to rehearse any information you want to transfer into your long-term memory and thereby retain. Such rehearsal can take the form of self-talk, where you say the ideas to remember over and over again in your mind to implant them in your long-term memory. Graphically, this process of moving memory from sensory to short-term to long-term memory looks something like this:



Current Thinking on Memory

While the Atkinson-Shiffrin model was extremely popular at the time, today psychologists think of sensory memory as a part of perception, held only so briefly in consciousness, and they think of short-term and long-term memory as more part of a continuum, with no clear distinction between them.[10] Still, psychologists usually distinguish between these two types of memory, and I will too, in discussing ways you can improve both types of memory. In fact, with the development of neuroscience and the recognition that we are engaging in multiple forms of mental processing at the same time—a process called ''parallel distributed processing''—psychologists have recognized that memory is much more complex than earlier scientists might have thought. Currently, the commonly accepted model views memory in a more dynamic way, in which a central processing system coordinates different types of memory input, which may be visual or auditory or both. After taking into consideration personal knowledge and experience, this central processor passes selected bits of memory from the working memory into the long-term memory. It's a model that I'll be using as a backdrop to different types of memory techniques that are designed to make improvements in each area of processing. In the next section, I'll explain in a little more detail how this works.

Understanding the Process

From Perception to Working Memory to Long-Term Memory

Memory starts with an initial perception as you are paying attention to something, whether your attention is barely registering the perception or you are really focused on it. So, as described in Chapter 5, one of the keys to improving your memory is paying more attention in the first place.

The next stop is your working memory, which is your brief, initial memory of whatever you are currently processing. A part of this working memory acts as a central processor or coordinator to organize your current mental activities.[11] You might think of the process as having a screen on your computer that has the information you

are currently reading or writing. As psychologist Margaret Matlin explains it, your ''working memory lets you keep information active and accessible, so that you can use it in a wide variety of cognitive tasks.''[12] Your working memory decides what type of information is useful to you now, drawing this out from the very large amount of information you have—in your long-term memory or from the input you have recently received. Think of yourself sitting in front of a desk with expansive drawers representing what's in your long-term memory and a cluttered top of your desk representing what's in your working memory. Then, you as the central executive (the working memory) decide what information you want to deal with now and what to do with it.

The Power of Your Working Memory

How much information can you actually hold in your working memory—what can you deal with on your desktop at one time? Well, when researchers began studying the working memory, they came up with some of the findings that are still accepted and incorporated into models of memory today.

One of these findings is the well-known Magic Number Seven principle, which was first written about by George Miller in 1956 in an article titled ''The Magical Number Seven, Plus or Minus Two: Some Limits on Our Capacity for Processing Information.'' He suggested that we can only hold about seven items, give or take two—or five to nine items—in our short-term memory (which was the term originally used for the working memory). However, if you group items together into what Miller calls ''chunks''—units of short-term memory composed of several strongly related components—you can remember more.[13] And in Chapter 12 you'll learn more about how to do your own chunking to improve your memory capacity.

You can see examples of how this Number Seven principle and chunking work if you consider your phone number and social security number. One reason the phone number was originally seven numbers and divided into two groups of numbers is because of this principle—then when the area code was added, the phone number was split up or chunked into three sections. Similarly, your social

security number is divided into three chunks. And when you look at your bank account, you'll see that number is chunked up into several sections. As for memory experts who can reel off long strings of numbers, they do their own mental chunking so they can remember. They don't have a single, very long string of numbers in their mind.

However you chunk it, though, whatever material comes into your working or short-term memory is frequently forgotten if you hold it in your memory for less than a minute[14]—a finding repeatedly confirmed by hundreds of studies by cognitive psychologists. That's why you normally have to do something to make that memory memorable if you want to retain it.

Yet, while you want to improve your memory for things you want to remember, you don't want to try to improve it for everything. Otherwise your mind would be so hopelessly cluttered, you would have trouble retrieving what you want. For example, think of the many activities and thoughts you experience each day, many of them part of a regular routine. Well, normally, you don't want to remember the minutia of all that, lest you drown in an overwhelming flood of perceptual data. It would be like having an ocean of memories, where the small memory fish you want to catch easily slip away and get lost in the vast watery expanses. But if something unusual happens—say a robber suddenly appears in the bank where you are about to a make a deposit—then you do want to remember the event accurately. So that's when it's important to focus and pay attention in order to capture that particular memory, much like reeling in a targeted fish.

Memory researchers have also found that your short-term or working memory is affected by when you get information about something, which is called the ''serial position effect.'' In general, whatever type of information you are trying to memorize, you will better remember what you first learn (called the ''primacy effect'') or what you learn most recently (called the ''recency effect'').[15] When psychologists have tested these effects by giving numerous subjects lists of words that vary in word length and the number of words, the results show a similar pattern. Subjects can generally remember two to seven items and are most likely to remember the most recent

items first. In turn, you can use that principle when you want to remember a list of anything, from a grocery list to a list of tasks to do.

Some Barriers to Remembering

Researchers have found that there are some cognitive barriers to a better memory that will slow you down. One is having longer names or words, especially when they have odd spellings and many syllables. Even trying to take a mental picture of the name or word may not work, because saying it verbally to yourself is an important part of putting a new name or word into your memory.

For example, I found the long words and names a real stumbling block when I tried to learn Russian two times—once when I was still in college, and later when I was taking occasional classes at a community college in San Francisco. I could even manage seeing the words in Cyrillic, converting them into their English sound equivalent. But once the words grew to more than seven or eight letters, I had to slow down to sound out each syllable and it was a real struggle to remember. Had I known the principle of chunking back then, I'm sure I would have caught on much sooner.

Another barrier to memory is interference; if some other name, word, or idea that you already have in your working memory is similar to what you are learning, it can interfere with your remembering something new correctly. And the more similar the two items, the greater the interference[16] and the more likely you are to mix them up. Again, researchers have come to these conclusions by looking at words (or even nonsense words) and pictures, and asking subjects to remember these items after learning a series of similar items. But you can take steps to keep what you have learned before from interfering with what you learn in the future. As you'll discover in Chapter 5 on paying attention, you can stop the interference by intensely focusing on what you want to remember and turning your attention away from what is similar and interfering with your memory now.

The Four Components of Your Working Memory

I have been describing the working memory as a single thing—like a temporary storage box. In fact, cognitive psychologists today think

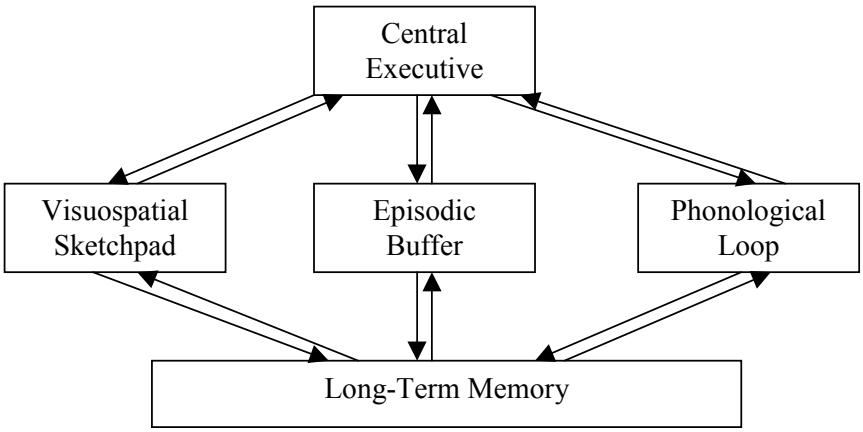
of the memory as having several components, and you can work on making improvements for each of these components to improve the initial processing of items in your memory. You might think of this process as fine-tuning the different components in a home entertainment system. For optimal quality and enjoyment, you need to fully coordinate your big-screen television, VCR, DVD, cable or satellite hookup, and sound system.

According to this current working memory model, which was developed by Alan Baddeley in 2000, there are four major components that together enable you to hold several bits or chunks of information in your mind at the same time, so your mind can work on this information and then use it.[17] Commonly, these bits of information will be interrelated, such as when you are reading a sentence and need to remember the beginning before you get to the end—though as a sentence gets longer and more complicated, you may find that you are losing the sense of it, especially if you get distracted while you are reading. But sometimes you might juggle some disparate bits of information, such as when you are driving and trying to remember where to turn off at the same time that you are having a conversation with a friend. Another example of this juggling is when you use your working memory to do mental arithmetic, like when you are balancing a checkbook; thinking about a problem and trying to figure out how to solve it; or following a discussion at a meeting and comparing what one person has just argued with what someone else said before.

The four key working memory components are coordinated by a kind of manager called the ''central executive,'' which is in charge of the other three components: the ''visuospatial sketchpad,'' the ''episodic buffer,'' and the ''phonological loop.'' Since they work independently of each other, you can handle a series of different memory tasks at the same time, such as remembering a visual image at the same time that you remember something you are listening to. You might think of these separate components as all part of a workbench that processes any information coming into it, such as the perceptions from the senses and any long-term memories pulled out of storage. Then, your working memory variously handles, combines, or transforms this material and passes some of these materials it has worked on into your long-term memory.[18] So one way to improve

your memory is to improve the ability of each of these elements of your working memory to process information so that you can more effectively and efficiently send the information you want into your long-term memory.

A chart of these four components of your working memory, which is based on Alan Baddeley's working memory model, looks something like this[19]:



So what exactly do these four components do? Here's the latest scoop on what modern psychologists are thinking:

1. *Your Visuospatial Sketchpad.* Consider this a drawing pad in which you place visual images as you see something or where you sketch the images you create in your mind when someone tells you something.[20] For example, as you watch a TV show or movie, the series of images you see get placed on this sketchpad, and some of the most memorable will move on to your long-term memory. You won't remember every detail, since there are thousands of such images zipping by in a minute. But your memory for these images will string them together—and as you improve your memory for visual details, you will be able to notice and remember more.

This is also the section of your memory that works on turning what you are hearing or thinking about into visual images. For example, as you read or hear a story, this is where you create images

for what you are listening to, so it becomes like a movie in your mind. Or suppose you are trying to work out a math problem in your mind. This is where you would see the numbers appear, such as if you are trying to multiply 24 × 33 and don't already have a multiplication table for that problem in your mind. You would see the individual rows as you multiply and then add them together.

However, while you might be able to see and keep in memory one image very well, you will have less ability as the number of images increase, and you may find that one image interferes with another. For example, if you are driving while trying to think about and visualize the solution to some kind of problem, your thoughts could well interfere with your driving. I found this out for myself when I was trying to multiply some numbers in my mind and took the wrong turn-off because I was distracted by seeing the problem in my mind. But if you are only listening to music on the radio or to someone speaking without forming images, that will not interfere—or at least to the same degree.

You might think of this process of trying to work with more and more images at the same time as looking at the windows on a computer screen. As you add more windows to work with at the same time, the individual windows get smaller and smaller, as do the images; you are less able to see what is in each image distinctly, and your attention to one window may be distracted by what is flashing by in another.

Intriguingly, brain researchers (also called neuroscientists) have found that these images you see in your visuospatial sketchpad correspond to real places in your brain. As neuroscientists have found, when you work with a visual image, it activates the right hemisphere of your cortex, the top section of your brain, and in particular they activate the occipital lobe, at the rear of your cortex. Then, as you engage in some mental task involving this image, your frontal lobe will get in on the action, too.

Researchers have been able to tell what part of the brain is associated with different types of thinking by using PET (positron emission tomography) scans, where they measure the blood flow to the brain by injecting a person with a radioactive chemical just before they perform some kind of mental task. They find that certain sec-

tions of the brain have more blood flow, indicating more activity there for different types of mental tasks.

2. *Your Phonological Loop*. Just as your visuospatial sketchpad stores images briefly while you are working with them, your phonological loop stores a small number of sounds for a brief period.[21] Generally, researchers have found that you can hold about as many words as you can mentally pronounce to yourself in 1.5 seconds, so you can remember more short words than long ones.[22]

A good example of how this works is when you are trying to remember what you or someone else has just said. Without memory training to put those words in long-term memory, you will normally only be able to clearly remember back what has been said in the last 1.5 seconds, though you will remember the gist of what you or the other person has said. Also, because of this 1.5-second limit, you will be better able to remember more shorter names than longer ones, such as when you are introduced to a number of people at a business mixer or cocktail party. It's simply much easier to remember names like Brown and Cooper than longer and more unusual ones.

You'll also find that just as working with different types of visual imagery can cause interference, so can working with different types of audio sounds. For example, if you are trying to remember a phone number and someone says something to you, that can interfere with your ability to remember that number. But if you are looking at something while you are trying to remember the number, that won't interfere as long as you continue to pay attention to remembering that number, since your visual observation is processed in your visuospatial sketchpad.

Then, too, just as similar visual imagery can cause memory errors, so can hearing similar sounding words or numbers, such as when you find yourself meeting a Margaret, Maggie, and Mary at a party. The names can blend together in your mind and you have trouble remembering who is who. Or say you are trying to remember a phone number you have gotten from a message so you can write it down. Well, if you are given two phone numbers to remember—such as this is my land line and this is my cell phone—the two numbers

can interfere with each other, so you might mix up numbers or just not remember at all. Or if you are trying to recall and write down a number that's close to another phone number you already know, that could interfere with your ability to remember the new one.

But the reason that visual images won't interfere with trying to remember words or other audio sounds, as long as you are attending to both, is that the audio processing occurs in a different section of your brain—in the left hemisphere of your brain, which is the side of your brain that handles language. Plus the auditory information is stored in the parietal lobe of your brain, though when you practice working with this information, your frontal lobe section that processes speech will become active too.[23]

3. *Your Episodic Buffer*. This section of your working memory is essentially a temporary storehouse where you can collect and combine information that you have gotten from your visuospatial sketchpad and phonological loop, along with your long-term memory.[24] Think of this like a notebook or page in a word processing program where you are working with sentences, graphic images, and then thinking about what else you would like to add from what you already know. As Margaret Matlin describes it, the episodic buffer ''actively manipulates information so that you can interpret an earlier experience, solve new problems, and plan future activities.''[25]

For example, say a co-worker says something to you at work that offends you. This is where you might consider the words the person just said, the context in which he said it, and take into consideration what you remember from how this co-worker has acted toward you before (which comes from your long-term memory). Then, this episodic buffer helps you quickly decide what to do in light of how you have interpreted this offending remark.

4. *Your Central Executive*. Finally, your central executive pulls together and integrates the information from these three other systems—the visuospatial sketchpad, the phonological loop, and the episodic buffer. In addition, this executive function helps to determine where you are going to place your attention and suppresses irrelevant or unimportant information, so you can stay focused on

what's important and not be distracted by what isn't. It also helps you plan strategies and coordinate behavior, so you decide what to do next and what not to do. Then you don't get pulled away from what you most want to do.[26]

Think of this as the top executive or senior manager in charge of all of these other systems, which doesn't store information itself. Rather, like the executive of a company, it sets the priorities for what these other sections of your memory should be doing. Or as Matlin puts it: ''like an executive supervisor in an organization . . . the [central] executive decides which issues deserve attention and which should be ignored. The executive also selects strategies, figuring out how to tackle a problem.''[27]

For example, when you decide what task you are going to work on at work and seek to remember what your boss has instructed you to do, along with what else you know about how to best perform the task, that's your central executive pulling together what is most relevant from the other sections of your working and long-term memory, so you can better perform the task.

* * *

So there you have it—the basic structure of how your memory works, according to the latest research from cognitive psychologists. In subsequent chapters, I'll be drawing on this model as I describe different techniques for optimizing your memory. Accordingly, you'll find techniques for strengthening your ability to work with images (your visuospatial sketchpad), with verbal and audio input (your phonological loop), with your ability to temporarily coordinate the input from the other components of your memory (your episodic buffer), and with your ability to use all of this information in a mindful, coordinated, and strategic way (your central executive).