Brain Morsels: Packet 11

Cognitive changes with aging:
It's not all doom and gloom!

EACH BRAIN MATTERS
THE CENTER FOR NEUROSCIENCES FOUNDATION

Another pillar! Keeping your brain as cognitively able as possible! You know from previous packets that sleep, exercise, and good diet all contribute, as do keeping stress under reasonable control and, very important, having a positive attitude about aging. Certainly, many of us face challenges in these areas through genetics, happenstance, and life choices made over the years. Nevertheless, each of us can still protect or enhance our brain's cognitive capacity, even if only in small ways.

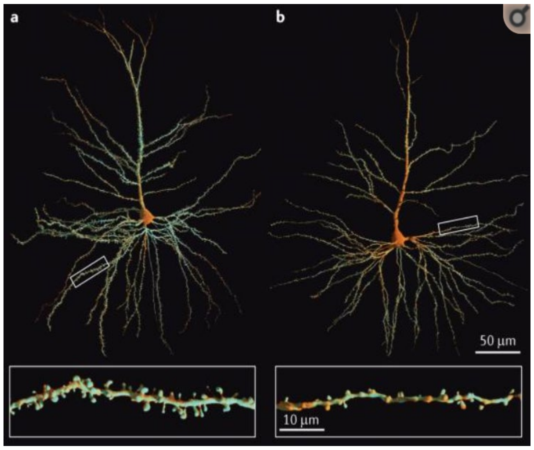
Are there cognitive changes typical of aging? Of course! What recent research is discovering, however, is that the normally aging brain is quite capable of reorganizing and compensating. We'll revisit the idea of neuroplasticity a little later.

Structural and functional changes

Let's begin with what we know about structural changes in the brain but understand from the outset of our discussion that **(1) there is almost wild variation across individuals and (2) all parts of the brain do not undergo changes to the same degree, even within circuits or networks.**

For example, in general, aging brains show a reduction in brain volume, but not consistently across the cortex. Some regions, like the very important prefrontal cortex (executive control, attention, modulation of emotion, working memory), seem to be especially vulnerable, tending to lose more volume than other regions. The caudate nucleus (planning how to move, plus roles in learning and memory and in reward and motivation), the cerebellum (coordinating movement, maintaining muscle tone, posture and balance, motor learning, and some cognitive functions that are not yet understood), and the hippocampus and nearby regions in the temporal lobe (certain aspects of memory) all seem to undergo greater loss than other cortical regions, even those that are engaged with these vulnerable regions.

Remember that the gray matter, the outer margin of the cortex, comprises highly organized layers of neurons. The neurons are highly branched and connected by synapses. Until you are in your 90s, you likely will have lost less than 10% of your neurons. So, the volume loss that does occur in gray matter reflects a minor loss of neurons and mostly a gradual loss of synapses and loss of branches. On the left is a reconstruction of a neuron from a young brain and on the right is one from an aging brain. Comparing carefully, you will see loss in number of branches. The higher-power view at the bottom shows loss of spines that are the sites of connections (synapses), but not bad overall! More good news is that the remaining synapses often become more effective. In Alzheimer's, the person *does* lose many neurons, so the situation is very different from that in the normally aging brain.



Samson & Barnes (2013)[1]

And, quite wonderfully, in human brains there is ongoing birth of new neurons that continues throughout our lives, though at a very slow rate. Those new neurons are added in the hippocampus, that important memory region. You also saw in an earlier packet that a few studies have suggested that exercise, especially aerobic exercise, and the effort to learn new things or learn something better can increase the production of neurons in the hippocampus.

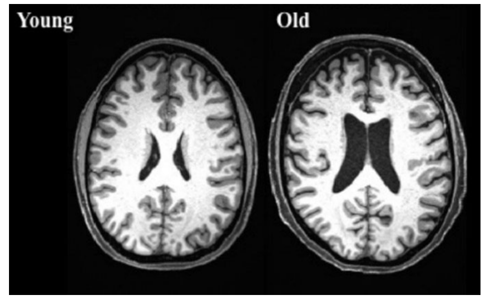
In addition to losses in the gray matter part of the cortex, there is volume loss in the white matter. Remember that the regions below the thin layer of gray matter at the outer edge of the cortex are filled with the long processes of neurons, called axons, that extend between cortical regions and between cortex and deeper nuclei in the brain as well as to and from the spinal cord. The axons are insulated by fatty material called myelin, which enhances the rate of transmission of electrical signals along the axons. These deeper axon regions comprise the white matter. As we age, the volume of white matter begins to decrease, but again, those losses are not consistent across the different tracts in the brain. White matter loss seems especially to occur in frontal regions and in the anterior corpus callosum, which is part of the axonal bridge between the two sides of the brain. The anterior part connects the two halves of the frontal part of the brain, allowing communication and coordination between them.

An additional effect of impaired white matter integrity in the frontal regions is poor connection between different parts of networks with which the frontal lobes are connected, like the emotional network. That in turn makes coordination of activity or sharing of information less effective, slows reaction time during memory retrieval, and makes attention more difficult.

So how would this loss of volume look if you were to compare images of a young and an old brain? Look carefully at the image to the right on the next page. You will see in the image of the "old" brain that it appears slightly shrunken with less white and gray matter; not so noticeable, I

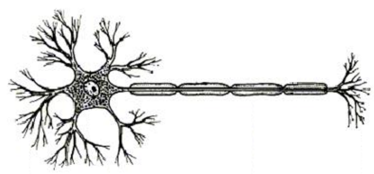
[1] Samson, RD and Barnes, CA (2013) Impact of Aging Brain Circuits on Cognition. *European Journal of Neuroscience* 37:1903-15.

know. But the ventricles – the black butterflies in the center of each brain, are obviously larger in the old brain. Why? Cells at the edges of the ventricles make the fluid that fills the ventricles and eventually bathes the brain and spinal cord. When the gray and white matter of the brain lose volume, the pressure of fluid in the ventricles simply pushes out the borders of the ventricles.



Susan Bookheimer (2019)[2]

In general, reduction in white matter and reduction in synapses in the gray matter can mean that processing speed slows in the brain's networks, so the time to complete a mental task tends to increase with age. Thinking and reacting are slower.



Speaking of networks….

Remember that the brain is organized into distinct and coordinated subsystems that we refer to as networks or circuits. Each of these circuits has a particular function, but they also interconnect to support higher-order functions. For example, the attention network and the executive control network may be called upon to coordinate with the social network. Young adults typically have very strong individual networks while the networks of older adults are less distinct but typically have stronger connections between networks[3]. To complicate matters, aging does not affect all circuits in the same way or to the same degree. In trying to unravel this, scientists are pursuing the idea that aging may affect the connections between networks more than changing the activity within a given network. Overall**, network efficiency within and between is somewhat reduced leading to longer processing times, slower thinking and more difficulty with complex tasks.** And, sometimes that slower thinking means that the response comes late and thus is less effective, even if it is an appropriate response. Sometimes the task is abandoned as just too difficult.

In addition to somewhat slower processing and thinking, especially under high cognitive demand, the aging brain **is slower to acquire information and takes longer to retrieve it.** That decreased connectivity is sometimes like a phone or internet connection that goes in and out, a sort of hit-or-miss connection that can drive you crazy. It's as if the brain doesn't quite make that connection. And then, a minute or 10 minutes later (or maybe tomorrow), we can remember that person's name or that piece of information. A temporary poor connection, *not* loss of information.

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[2] Bookheimer, J, Joaquin Fuster Professor of Cognitive Neuroscience at UCLA. neurosciencenews.com/aging-sharpness-7281

[3] Gutchess, A (2019) *Cognitive and Social Neuroscience of Aging*. Cambridge, UK: Cambridge University Press.

Certain thinking (cognitive) operations are more affected. In particular, cognitive operations that depend on the prefrontal cortex are more affected, as would be predicted from the earlier discussion that it is one of the vulnerable regions. For example, mental flexibility may decrease and thinking then becomes more concrete, more based on what is physically evident rather than on what patterns and connections might be present. The ability to detect errors and switch strategies when the first attempt is not working well also may be reduced. Another common difficulty is inferring the mental state of others, which clearly can be problematic in social situations. How many of you have noticed that elderly individuals sometimes say things that may be hurtful or rather mean when they never would have done so earlier in their lives? This is partially a result of poor inferring of the other's state but also reflects a reduction in the ability of the prefrontal cortex to inhibit behavior. The prefrontal cortex is the last region of the brain to develop, typically completing its development in the mid-20s; it also is the first to start losing function as the brain ages. Sigh.

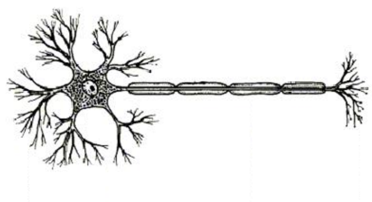
On the other hand, elders are typically better at pattern matching thanks to years of experience, and they are better at seeing the big picture, even when they are slower at things like mathematical calculation. Some would call this the wisdom of accumulated experience.

General knowledge – facts and stores of knowledge - is usually intact. But *fluid intelligence* often decreases somewhat. Fluid intelligence involves being able to think and reason in the abstract, such as when a problem arises that you haven't quite dealt with before. Fluid intelligence is essential for problem-solving and strategizing.

Attention control is another function of the prefrontal cortex. As we age, our ability to maintain attention wanes a little so we are more distractible, with predictably widespread cognitive effects. Elders can get pulled off a topic with greater ease than young adults can. For example, you're telling a story when somebody says something that briefly takes you off in another direction, often never to return to that story because you can't remember where you were, or perhaps even what the story was. That's a minor problem, but what about greater distractibility in task completion, especially difficult tasks, or in social interactions, or – heaven help us – in driving! Memory, too, can be affected. We are more likely to remember things to which we pay attention, so reducing attention control likely contributes to what we think of as memory issues in aging.

As to other major functions in the brain, *language* is generally well preserved with age. Indeed, many elders maintain or even expand their language capability – more new words, broader exposure to language. Those with bilingual or multi-lingual capability have been found to have a lower risk of dementia, so consider adding language learning to your portfolio of complex cognitive tasks to take on, *even* if doing so requires a lot more repetition and attention than you might like.

Well-learned motor patterns, which are sequences of learned movements that we hardly need to think about – walking or playing an instrument you have played for years – these are generally well preserved. On the other hand, there are some age-related declines in basic motor abilities that can have rather widespread consequences, such as declines in balance, strength, or joint range of motion. Compensating for these often demands that the individual use more cognitive resources to support motor function. You no longer run lightly down the stairs, for example! Keeping motor capability clearly is important, as you know from the packet on exercise, but still, it becomes more expensive from the brain's perspective, requiring greater engagement of more of the brain's circuitry.



<u>Memory</u>

Oh, this is a brain function that many of us worry about: the specter of some sort of dementia sending its tendrils into our thoughts and maybe even into our dreams. Two things to note: (1) There are many different kinds of memory and the storage and operation of these different kinds of memories are differently distributed in the brain; (2) Not all types of memory are affected by aging. Here are some examples.

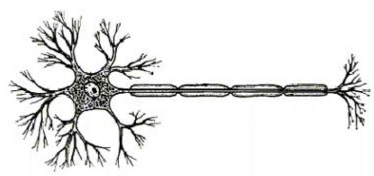
We know that *working memory* capacity decreases, meaning that kind of temporary memory that lets us manipulate information without losing track of what we're doing, like remembering the series of numbers that get texted to us for two-stage verification, or remembering an address, a series of directions, or perhaps accessing the multiplication table so that we can solve a problem. Computing in your head and holding the information in mind can become harder. When your physician asks you to remember a series of numbers for 5 or 10 minutes while proceeding with the visit, the efficacy of your working memory is being tested.

We may have difficulty with things like remembering where we put our keys or where we parked the car on a shopping trip. We experience momentary lapses of memory. Notice though, it's not that we never experienced this when we were younger. It's just that when we were young, those lapses were simply trivial moments of forgetfulness but in elders, now the stigma of aging gets attached to those situations and the first thought is often – oh my gosh, Alzheimer's is waiting in the wings. These small lapses generally don't have a significant effect on how well you run your life – they're mainly annoying. Well, maybe except for naming things or people.

Explicit memory.is memory for information that you learn consciously and includes details about the context of where or how information was initially encountered. As a category, explicit memory includes fact memory that you likely spent time studying to remember, especially in school or on your job or with a hobby or interest. It depends on a well-functioning hippocampus. It's not clear yet from research studies how aging affects this type of memory.

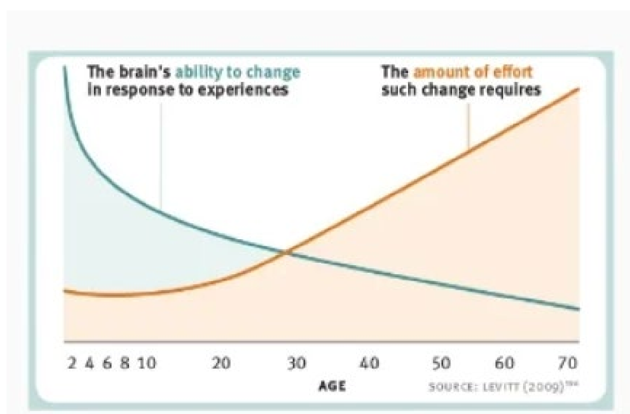
Implicit memory includes behaviors that reflect prior learning or experience, but these don't depend on you being consciously aware of where and how and under what circumstances you learned whatever it is. Furthermore, you now carry out the behavior routinely and with little thought. You learned how to type at some point and you do it automatically. Much of driving is carried out without thinking about it. Implicit memory is mostly spared with aging.

Autobiographical.memory?your memories of your life, includes memory of the events as if you were re-experiencing them, as well as memories of the details, so this kind of memory includes both explicit and implicit memories. These are generally long-term memories, and every time one of these memories is retrieved, it can be edited without consciously doing so because it is edited with what you now know and what your current goals are and how you are feeling about things. In addition, the details tend to get a bit fuzzy and unreliable, maybe even quite seriously fuzzy. You might think those memories are entirely accurate but then find them exposed as factually wrong or hugely subjective! For some, realizing how much detail about your past is evaporating can be demoralizing, but possibly also simultaneously fascinating.



Neuroplasticity

What is this again? Neuroplasticity is the brain's capacity to change – to learn, to remember, and to adapt to our changing experiences. That happens because the brain continually builds new synaptic connections and modifies old ones. That, in turn, allows change in the circuitry connecting neurons in our brain, helping to keep them efficient. We admit that there is a catch, which is shown nicely in the schematic to the right. You've seen this graph before. In normal aging, our brains remain plastic, right to the end, as shown by the green line, BUT the amount of effort it takes does increase! That's the tan line. None of this is surprising given what we know about changes in the normally aging brain, like decreased network efficiency, decreased attention control, and so forth as described earlier. And predictably, as the thing we are trying to deal with or learn becomes more complex, even greater effort is required. **The take-home message though is that keeping our brains engaged keeps that plasticity enabled.**



Cognitive Reserve

A related concept is *cognitive reserve*. Think of it as brain power. By way of analogy, think of a time when perhaps you had been sick for a week – perhaps the flu. Or you had had to expend a great deal of physical energy for some reason over a week or more. In the end, you had run down your physical resources quite thoroughly so there was little reserve left if some other physical demand was imposed. Quite similarly, we have cognitive reserve, but here we are extending the idea to the long term, not just that short time after you, say, completed a complex project on short deadline and now consider yourself effectively brain-dead. Lifelong high cognitive reserve can be protective. If there *is* any cognitive decline, that reserve can slow the rate of decline because there is the cognitive wherewithal to adapt or compensate for reduced capability. Cognitive reserve reflects both nature (what you were born with) and nurture (what we do over time to stimulate our brains).

How do we build cognitive reserve?

A small caveat is in order before addressing this question. Study of the normally aging brain is a field barely out of infancy, which is rather curious since scientists have been conducting research on dementia and other disorders for quite a while. Odd because how does one study abnormally aging brains without a clear understanding of normally aging brains? Well, so be it. The result though is that we are in an early stage of understanding, so when reading the literature, you often encounter the words "the results were variable across studies." Taking that situation into account, what follows is an overview of the strongest data, drawn mostly from two sources: (1) Gutchess, Angela (2019) *Cognitive and Social Neuroscience of Aging*. Cambridge, UK: Cambridge University Press, and (2) Levitin, Daniel (2020) *Successful Aging.* New York: Dutton.

<u>Nature (what doesn't change much)</u>

Personality could matter. For example, in some but not all studies, individuals with high levels of conscientiousness showed less decline in white matter volume with age as well as less decline in some memory structures and parts of the prefrontal cortex.

Intelligence measured in early childhood is a strong predictor of cognition in late life.

Your *genetics* certainly influence your progress through life, including the stage of aging. <u>Recent data show that genetics are *not always* destiny though</u>. What you do, what your environment is, even your attitudes, can shape genetic expression, for better or for worse.

<u>Nurture</u>

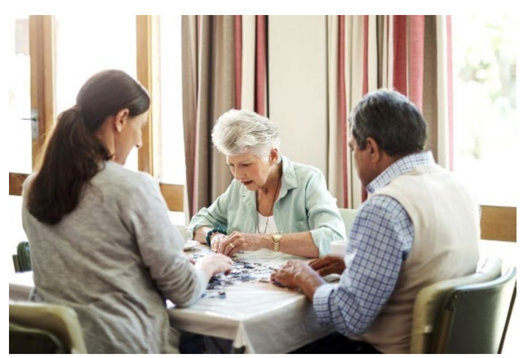
Much of what we have discussed in earlier packets addresses the pillars that nurture our aging brains. *Sleep*, for example, is utterly important across our life spans. *Exercise*, to ensure that our energy-hogging brains are well supplied with oxygen and nutrients, as well as with factors released by muscles that affect neuronal health. Add a *diet* that is high in nutrients required by the brain. Managing stress well, building resilience to stress – also is critical.

Note that research on stress management indicates that meditation may be a powerful tool in optimizing brain health. Imaging the brains of people who are experienced in and regularly practice yoga or meditation showed that those brain networks described earlier were better integrated compared to the networks found in control individuals.

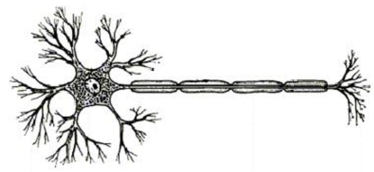
It also is essential to manage physical disorders that affect the brain, especially those that affect energy production. Keeping good control of blood pressure, blood sugar, and heart function, and minimizing exposure to toxins like smoke, alcohol, and other psychoactive drugs is vital to maintaining good brain health.

Ensuring that sensory function is maintained also is central to good brain function. The brain depends on solid information from our sensory receptors to interpret and to engage with the world outside ourselves. Visual and sound information are critical. Hearing loss in particular exacerbates cognitive changes. Research has very clearly shown that poor hearing not only disrupts the auditory cortex that receives sound information, but also affects the thalamus, a sensory relay area, and can cause widespread impairment of various brain networks. Comparison of brain volume of those with hearing impairment vs those without showed more loss over the entire brain in those with hearing loss. That would correlate with more cognitive issues. The short message is: get hearing aids and glasses if you need them and take full advantage of electronic assists for TV, theater, and the like! Not only do those aids help maintain brain function, they also contribute to safe movement, fall prevention, and social engagement.

You might wonder about the usefulness of those cognitive training programs that are constantly being advertised. Unfortunately, there is little support as yet for most cognitive training programs. The problem generally is that programs do not train broadly. For example, crossword puzzle expertise might develop by doing many crossword puzzles, but that skill does not transfer to other domains, like memory. Better that you exercise to whatever extent you can, including aerobic exercises when possible, because those are particularly good at increasing both grey and white matter, especially in the frontal cortex.



A better approach to cognitive fitness overall is putting together for yourself a broad portfolio of means of cognitive engagement that you enjoy – puzzles, theater, concerts, challenging tasks, volunteer activities, playing an instrument, learning a new language, and allowing your creativity to blossom. And don't forget that most of those supplements that promise to boost your brain's cognitive power are unregulated and usually lack any research support for their efficacy. Plus, they are expensive.

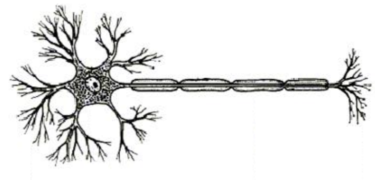


Cognitive decline

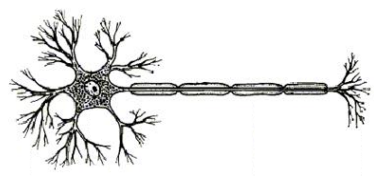
Most of us undergo many of the changes in cognitive function described above, but in the normally aging brain, the decline in capability is generally rather gradual and small, at least compared to those who are beset with dementia. There are those who reach old old age who show virtually no loss at all, yet again reminding us that there is huge variability in how we age. Many of us are quite clear in our understanding that our aging brains are not as reliable functionally as they once were and they fatigue more easily, but then they prove adept and still adaptable, still neuroplastic. Some individuals experience a level of loss that is characteristic of mild cognitive impairment (MCI), but not all of them will progress to dementia. Only a small portion of people go on to a diagnosis of Alzheimer's, around 15% of those over age 70. Your genetics do matter, but as we said earlier, they do not always determine your destiny. Good cognitive reserve can help mitigate the effects of genetics.

But what about those who do follow a path to dementia? How does that look? Early on, there is a more-or-less silent phase where the brain is changing but symptoms have yet to appear. Maybe the individual has a sense that something is amiss. A little later, cognitive changes begin to appear that are of concern to the family and friends, but the individual remains capable of carrying out most normal activities of daily living. Cognitive changes appear in knowledge, comprehension, application of information, and/or in the ability to analyze and synthesize information.

Teepa Snow, a dementia-care education specialist, has a terrific website and YouTube channel for caregivers https://www.youtube.com/watch?v=MA9s2vZflw4. She lists the following as early warning signs of significant cognitive impairment to come: Family and friends may notice frequent repetition, trouble with difficult tasks like managing money or driving or medications, missing appointments, putting things in odd places, difficulty problem solving, changes in personality or behavior, withdrawal from usual interests and activities, and many instances of poor judgment. By the time you reach the threshold of dementia, there is significant enough cognitive impairment to interfere with everyday abilities.

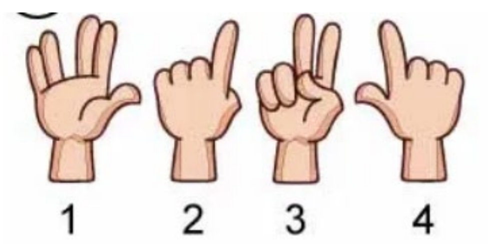


We have not addressed yet the final pillar important in optimizing brain health as we age: social engagement. That's one of the subjects of the final packet.



Puzzles

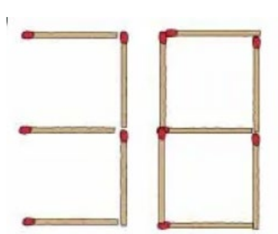
<u>Puzzle 1.</u>   Which hand is the odd one out?



<u>Puzzle 2.</u>   What has one thumb and 4 fingers but is not alive?

<u>Puzzle 3.</u>   What is the missing number? Hint: Look carefully at the numbers.

<u>Puzzle 4.</u>   Move only two matches to make the highest number possible.



Puzzle 5.

What is wrong with this room?

(Don’t cheat and look at the answer below!)

Answers

Puzzle 1. Hand #2. It's a left hand. All the rest are right hands.

Puzzle 2. A glove

Puzzle 3. The missing number is a five. Each number is made of segments. The number of segments in the preceding number determines the following number.

Puzzle 4. Move the middle and bottom matchsticks from the 3, converting it into a 7. Stack those two matchsticks to make a 1 and place them after the 8. That gives you 781.

Puzzle 5. There is no doorknob.

Note: These puzzles come from ESLvault.com*.*