Cognition and Aging

Trajectories of Cognitive Change

How do we rectify the idea that experience/wisdom comes with age, amidst common steroetypes regarding declining cognitive function and poor memory that also comes with age? Some insight into this is provided by clarifying some common misconceptions regarding cognition and cognitive aging as well as by taking into considering how and why specific aspects of cognition change over the course of development and age.

Topics: Brain vs Mind — Fixed Capacity — Dynamic Capacity — Sensory Function Theory — Processing Speed Theory — Resource Pool Theory — Attention Inhibition Theory — Dynamic Capacity Theory — Mild Cognitive Impairment — Dementia — Sundowning

One of the critical concepts to keep in mind with the study of cognition is that **cognitive function is ultimately an artificial construct** — an idea containing a composite of various conceptual components. As a result, there is no singular method of assessing cognitive health that encompasses all of these various conceptual components. Further complicating the matter, the underlying components that make up cognitive function are not uniformly defined. What that means is that there is no singular framework that is commonly accepted for differentiating types of cognitive function. Separating cognitive function into cognitive skills (thinking, problem solving), affective skills (emotional reactivity, interpersonal interactions), and psychomotor skills (manual motor skills) is equally valid as approaches that separate cognitive function into domains associated with attention, memory, and language. So although the Cattell–Horn–Carroll (CHC) theory of intelligence framework of cognitive abilities is popular within neuropsychological specialties, other specialties bringing expertise on neuroanatomical connections and/or neural—network based approaches to artificial intelligence generally view these cognitive abilities differently.

Brain — The primary organ of the central nervous system. A physical structure.

Mind — The psychological phenomena experienced during mental states. An abstract concept.

The reason that there is no singularly accepted framework for differentiating types of cognitive function is that cognition is a manifestation of the psychological phenomena known as the mind.

In some ways it can be appealing to consider these concepts in terms of hardware and software. The physical structures and biochemicals that make up the brain can be characterized as the biological hardware, whereas psychological phenomena form a mental operating system enabling us to interact with the external environment. **Cognitive functions thus reflect our interpretations of how that mental software could be laid out, organized, or described**. But in considering the brain–mind in this manner, it is often easy to get caught in the trap of assigning psychological phenomena to particular structures within the brain. Certainly we can point to evidence regarding how the absence, loss, or damage to particular structures within the brain impacts upon the psychological processes of the mind; but as our conceptualization of psychological phenomena evolves, the particular brain structures that may support a given psychological phenomena would necessarily change as well. So it is relatively common to see both the description of psychological phenomena and the brain tissue associated with the phenomena change and differ across historical and modern perspectives — this is exceptionally common for the concepts of attention and cognitive control. The key is that **cognitive processes do not necessarily have to have a biological basis, and the brain components involved in supporting cognitive processes can change in response to a variety of context**.

Another factor that contributes to difficulty in understanding the link between the brain and mind results from our level of **robustness** — the ability to maintain function despite perturbations (disturbances) and uncertainty. Consider that the across a wide–range of potential issues (infection, disease, accidents, intoxication), aspects of our mental skills remain relatively intact and allow us to continue to function. This robustness is achieved through strategies such as modularity, redundancy, and degeneracy. The organization of neural networks and cellular architecture within the brain exhibit a great deal of **modularity**, being structured into a system of core segments that are spatially or structurally isolated. The benefit of this approach is that even if there is damage to some of these structures, the remaining elements are usually sufficient to continue to enable the organism to function. The idea of **redundancy** is that multiple modules or elements can perform the same essential process. Therefore, even if there is damage within a particular module (such as to a subset of cells), a core process can still be completed by other identical elements. **Degeneracy** in neuroscience refers to the capacity of many different unrelated modules to create the same outcome. So if a particular module becomes damaged or performs suboptimally, other neural regions can compensate to create the same process. Therefore, while a psychological processes of the mind may be primarily supported by a particular region of brain tissue;

it is not uncommon (and in many cases is expected) that other regions of brain tissue and neural networks can create the same psychological processes of the mind. The same is true for cognitive operations. Even when the brain tissue is intact, changes in neural resource availability or strategy may require degeneracy such that compensatory action of other aspects of cognition can make up for the loss of or deficiency of another.

Fixed Capacity Perspective — The idea that each individual has a particular limit to their cognitive abilities. While it is possible to improve cognitive abilities, the ability to improve diminishes as the individual nears this limit.

Dynamic Capacity Perspective — The idea that cognitive abilities reflect their utilization. Improvement in cognitive abilities therefore reflects the way those abilities are consistently used and stressed.

The analogy of hardware–software also sometimes contributes to fixed perspectives regarding systems of the brain and mind. Although the fixed capacity perspective actually predates the emergence of computers, this perspective exerted a particularly prominent influence in views that guided early concepts related to intelligence. When combined with sociocultural biases it then enabled problematic social behaviors to be justified. A child growing up in a poor farming family would have less opportunity to gain exposure to certain vocabulary, ways of speaking, and general access to early childhood education. As a result they would tend to perform more poorly on tests of intelligence. When viewed through the lens of the fixed capacity perspective, this was interpreted as suggesting that the child would likely have a lower educational ceiling and formed the basis for excluding them from educational opportunities.

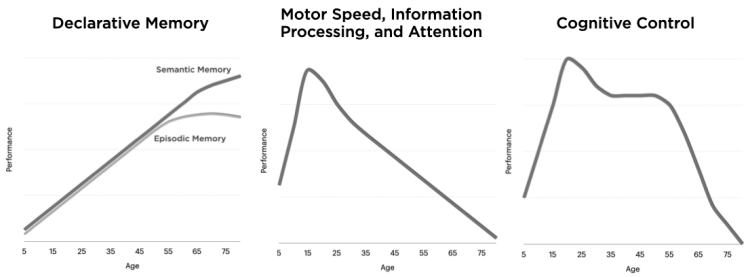
Yet unlike conventional computer hardware that limits what is possible for the computer software (or operating system) to do, psychological phenomena of the mind can induce alterations in the physical structures of the brain to better support those phenomena — a concept referred to as **neural plasticity**. Thus, although some remnants of the fixed capacity perspective still exist; more modern approaches generally follow the dynamic capacity perspective. The reason a child growing up with more highly educated parents tends to have greater 'intelligence' is generally explained by having a greater opportunity to gain exposure to certain vocabulary, ways of speaking, and greater general access to early childhood education. Early exposure and stressing of those abilities results in changes in cognitive processes and the physical structures of the brain; which then enable higher

educational attainment. Critically, evidence indicates that this is not dependent upon age.

Take for instance evidence showing that relational memory (a subtype of declarative memory) is enhanced through experience as a taxi driver. Relational memory describes a critical cognitive ability regarding remembering how things are linked together and is supported by the hippocampus (a structure of the brain located in the medial temporal lobe). In a fixed perspective, an individual would be limited in their relational memory abilities. Thus, either in terms of their mental relational memory capacity or by the size and functioning of this neural structure, an individual would have some maximum ceiling at which the mind–brain become limited. Thus, relational memory could only improve up to this point. However, research has found that the volume of the hippocampus expands in response to experience as a Taxi driver (who has to remember how to navigate across complex urban environments) in association with increases in relational memory. Thus, as a cognitive ability is utilized, the brain tissue/networks supporting that process also undergo changes to allow the enhanced function. Given such abilities both the brain and mind are considered as dynamic, rather than fixed, systems prone to alterations reflecting their use/disuse. In this context, an increasingly common view is to consider cognitive operations much like a muscle; **with consistent progressive overload these processes will enhance their capacity, but with disuse/neglect these processes will atrophy**.

One of the difficulties with studying how human cognition changes across the lifespan is our relatively long lifespan. As a result, much of our understanding of this area of research comes from cross–sectional comparisons of individuals at different stages of life and longitudinal studies that follow individuals across a smaller window of time. Nevertheless, such research generally aligns to indicate that although aging is associated with general declines in cognition, it is not universal for all aspects of cognition.

Figure: Trajectories of Cognitive Aging.



Throughout development, semantic memory (crystallized intelligence, what you already know) tends to increase in a relatively linear trajectory from infancy throughout late adulthood (around 65 years of age). But interestingly, longitudinal studies of older adults have observed that semantic memory can still continue to improve even after this point. From a dynamic capacity perspective this would seem to make a great deal of sense. As an individual goes through their life, they accumulate greater exposure to new information, facts, and details. Although encoding (storing) this information into memory takes effort, that information which is stored then accumulates to enable semantic memory to increase over the course of the lifespan.

Episodic memory (what you experienced) tends to similarly increase throughout late adulthood (around 65 years of age), but then tends to stabilize (no longer continue to increase, but does not necessarily decrease) during older adulthood. Research in this area has taken a number of different views on this stability, but the general argument is that stabilization necessarily reflects loss of function (if we assume that episodic memory should increase similar to semantic memory). In the context of visiting your grandparents, this view becomes more readily apparent by their ability to easily retell a story about the neighbors/friends that happened 50 years ago — even in regards to something as mundane as that they took a fence down. Yet despite this your grandparents might have trouble remembering new information — such as asking your parents about their 'new' car even though they got the car a decade ago. Although episodic memory tends to remain relatively intact during older adulthood; this is only for memories that were formed earlier in life.

Unfortunately, fluid intelligence and virtually every other cognitive process begins to decline after the age of 20. For aspects of cognition relating to motor speed, information processing, and attention these declines are relatively linear in nature, with each decade of life after age 20 contributing to gradually reductions (about a quarter of a standard deviation each decade) in performance on measures of these domains. Developmentally, these aspects of cognition also appear to reach optimal levels relatively early. Although their remains debate

as to exactly how early this may be, the general consensus is that these reach peak levels between the ages of 12 and 15 years of age. This generally aligns with evidence from e–sports indicating peak performance generally occurs when the individual is between 12 and 20 years of age, with retirement from professional e–sports generally occurring after the age of 25.

Although aspects of cognitive control also begin to decline after the age of 20, there appear to be two critical windows when changes occur most dramatically. An initial small reduction (about a quarter of a standard deviation) in cognitive control abilities tends to occur as individuals transition between the 20th and 30th decade of life. Cognitive control then tends to stabilize from the 30th to 60th decade of life before exhibiting a large reduction (nearly half a standard deviation) each decade after. However, it is important to note that such findings are only present when the cognitive task is sufficiently difficult. **So long as the level of cognitive control necessary to complete a task is low there are minimal or nonexistent age differences**.

Mechanisms of Cognitive Aging

Although there is no singular common perspective on cognitive aging, the various views generally center around the issue that with aging comes declines in the ability to utilize mental resources quickly. These views ultimately differ in the way in which they view the mechanism contributing to this decline. Critically, it is important to acknowledge that these perspectives are not mutually exclusive to each other, as there may be multiple factors that ultimately contribute to such dysfunction.

Sensory Function Theory of Cognitive Aging —

Age–related effects in performance are the result of impaired sensory function.

The central tenant of the sensory function theory of cognitive aging is that nearly all tests of cognition rely upon intact sensory processing, particularly within visual and auditory domains. Therefore, if sensory function is diminished, then it takes a longer period of time for sufficient information to accumulate before decisions can be made. Thus, the assertion is that the core processes of cognition remain intact, it is just a matter of getting sensory information to them. The problem is that nearly every sensory system shows diminished responsivity in association with age. In particular, both vision and hearing function gradually show sensory impairments the progressively increase with each decade of life. This theory, thus, explains why an older adult would tend to exhibit a greater tendency to sit for a long period at a stoplight after it turns green as it simply takes longer for such visual

information to be perceived. It also explains why aspects of cognition relating to motor speed and information processing tend to manifest with aging–related impairments earlier as methods of assessing them tend to be the most relient upon obtaining sensory information quickly.

Processing Speed Theory of Cognitive Aging — Age–related effects in performance are the result of a generalized decrease speed of performing mental operations.

Most cognitive tasks and real–world decision making behaviors occur within context where the appropriate response is time–limited. The processing speed theory of cognitive aging argues that deteriorations in performance associated with aging are the result of two related issues. The first issue is that the general speed of processing information is impaired over the course of aging. Although processing is ultimately dependent upon obtaining sufficient information, evidence indicates that older adults tend to exhibit prolonged time in processing stages prior to making a decision. Even when relying upon situation–recognition, it simply takes a longer period of time to sift through the various situations that have accumulated over the course of their lifetime. Problematically, this delayed processing time has a cascade effect as decisional processes are multi–step processes where information flows from one system to another. So the second major issue is that the the within the time–limited context of these behaviors, decisions must be made before enabling processing to be complete. When given task–related context or social situations where decision making is not bounded by time constraints, older adults appear to be able to perform tasks at similar levels as younger adults. However, task situations which require more rapid or more complex processing in time–limited context manifest with the largest impairments for older adults, relative to younger adults.

Resource Pool Theory of Cognitive Aging — Age–related effects in performance are the result of having a decreased pool of resources that could be brought online at any given moment.

The resource pool theory of cognitive aging is conceptually similar to the processing speed theory of cognitive aging, but argues that with aging there becomes insufficient resources to support rapid processing. The core concept is that cognitive operations are effortfull and require energetic/metabolic resources to be completed, the more rapid or more complex the cognitive operations are the greater resources that are

necessary. As processes associated with aging result in the pool of resources diminishing, it becomes more difficult to be able to allocate sufficient resources to support more rapid or more complex cognitive operations. As a result, cognitive systems adopt less resource intensive approaches such as slower processing time, skipping processing steps, and bringing online compensatory cognitive operations to try to make up for deficiencies in the resources that they have available. Interestingly, when environmental supports minimize the number of concurrent (happening at the same time) cognitive processes that are required to complete a task, older adults exhibit performance much more similar to that of younger adults.

Attention Inhibition Theory of Cognitive Aging

— Age–related effects in performance are the result of difficulty sustaining attentional engagement and gaiting out irrelevant information, as well as suppressing responses.

The attention inhibition theory of cognitive aging attributes age–related declines in cognition to reductions in the capacity to sustain attention on task relevant details. Older adults appear to take in and maintain a considerable amount of unnecessary/irrelevant information during the completion of cognitive tasks. As a result, cognitive operations must work harder to process the additional information contributing to reductions in available resources and delays in processing and evaluation. Thus, as older adult exhibit difficulties in narrowing attention to reduce irrelevant information and suppress potentially distracting or conflicting details; there is a cascade effect that contributes to impairments across a wide range of cognitive processes. Reductions in the ability to sustain attentional focus provides some justification for why older adults exhibit greater levels of distractibility and wandering attention. Similarly, as they take in additional unnecessary information, it can be more difficult to discern the relevant information from the irrelevant making them more prone to becoming confused.

Dynamic Capacity Theory of Cognitive Aging —

Age–related effects in performance are the result of societal tendencies that minimize the need for some aspects of cognition after retirement.

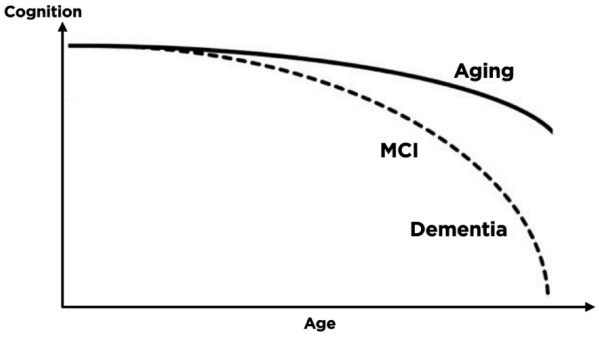
The dynamic capacity theory of cognitive aging is generally more commonly focused upon age–related declines in cognitive control and declarative memory. The argument is that when looking at the trajectories of how cognition changes with age, there is considerable

overlap between the two major time points when cognitive control and memory show dramatic reductions and major life events. The first drop off aligns when students leave college and enter into their careers, while the second drop off aligns with when adults enter into retirement. In each case, these transitions represent shifts in the way high level cognitive operations and memory are needed. Thus, in the context of the dynamic capacity perspective, as individuals are no longer being cognitively challenged then it is to be expected that cognitive abilities would then begin to diminish. Compellingly, evidence has demonstrated that cognitive control and memory tend to be sustained when students continue with graduate and post-graduate studies and by adults who continue to stress these cognitive abilities after retirement (such as by working for non-for-profit organizations and community groups; or interacting with children to a greater extent).

Dementia

While aging is associated with gradual reductions in most cognitive abilities, a key characteristic of both **healthy** and **normal aging** is that reductions in cognitive abilities should not interfere with daily function or independence. However, popular culture generally clusters typical reductions in cognition associated with aging alongside terms such as mild cognitive impairment, dementia, and Alzheimer's Disease without realizing that these terms reflect different things.

Figure: Trajectories of Mild Cognitive Impairment to Dementia.



Mild Cognitive Impairment — Age-related changes in cognition where one or more aspect of cognition is significantly impaired, but does not interfere with daily activities.

The classification of mild cognitive impairment represents the initial stage at which declines in cognition reach clinically significant levels. Accordingly, individuals in this stage exhibit clear evidence of diminished cognitive abilities in at least one of the following aspects of cognition: motor speed, attention, cognitive control, learning/memory, or language. However, despite exhibiting a clear diminishment

of cognition, an individual with mild cognitive impairment is able to maintain their independence while going about their daily life. Although some tasks may take additional time or may be performed less efficiently than before; they can still do these tasks with minimal aid or assistance. This clinical state represents approximately 15% of individuals over the age of 70, with diminished cognitive abilities more commonly occurring within declarative memory and cognitive control. The most common presentation is the need to re–ask questions; either as a result of not being able to remember the prior answer, not sustaining attention long enough to listen to the answer, or failures in inhibiting repeating the question. Beyond such a characteristic behavior, other common presentations include frequent impairments in finding/using the right words and impaired orientation (unaware of date, location, has difficulty navigating previously familiar routes). The more domains of cognition that exhibit significant declines, the more likely the individual is to progress into dementia.

Dementia — Age–related changes in cognition where more than one aspect of cognition is significantly impaired to the point of interfering with daily function or independence.

The classification of dementia reflects the decline of multiple aspects of cognition (motor speed, attention, cognitive control, learning/memory, or language) to such an extent that the individual is no longer able to engage in activities of daily living without substantial interference. An individual in this stage may still be able to maintain some basic activities (bathing, dressing, personal hygiene activities), but other more intensive or complex activities such as paying bills, preparing a meal, or shopping may no longer be possible. When individuals reach this stage, brain imaging and blood tests are also typically used to ensure that brain tumors or brain lesions (wounds, damage) are not causing the cognitive impairment. **Brain imaging and blood tests are not actually used for the diagnosis of dementia itself** — because dementia is a disease of the mind. Although no treatments have been found effective at resolving either mild cognitive impairment or dementia, they may help to slow the progression of these disease states to reduce further deterioration.

However, despite dementia being a disease of the mind; efforts in the late 1990′s and early 2000′s pushed medical specialties to adopt a very brain based view. As a result, specific subtypes of dementia are usually differentiated based upon the common symptom presentation (reflecting the issue in the mind) as well as the issue in the brain that is thought to cause the symptom presentation. Around 10% of cases of dementia reflect **Fronto–Temporal dementia** which is characterized by dramatic changes in personality, relationships, and conduct (swearing,

stealing, impulsive/repetitive/inappropriate behaviors) and is usually attributed to progressive loss of brain tissue in the frontal and temporal lobes (essentially deterioration of structures involved with cognitive control). In some individuals this also relates to progressive lost in the ability to speak and even understand language.

Another 10% of cases of dementia reflect **Lewy Body dementia** which is characterized by visual hallucinations, highly variable levels of confusion, muscle rigidity/stiffness, and loss of coordination. Lewy Body dementia is a progressive disease attributed to the accumulation of lewy bodies proteins, with most individuals surviving around eight years after symptoms begin to present. Around 30% of cases of dementia reflect **Vascular dementia** which occurs when blood vessels flowing to the brain become obstructed (essentially the brain version of coronary heart disease). The nature of the cognitive impairment depends upon the location of the reduced blood flow.

Finally, around 40% of cases of dementia reflect **Alzheimer's Disease** which is characterized by cognitive impairments specific to language and memory and the abnormal accumulation of beta–amyloid (plaques) and tau proteins (tangles) on the brain. However, despite the wide—spread cultural awareness of Alzheimer's Disease, there is considerable variability in how this disease is viewed. As a result, by some definitions Alzheimer's Disease is alleged to be the underlying cause of 80% of cases of dementia as they attribute this disease to any cases of dementia that include at least one symptom that overlaps with Alzheimer's Disease. Although we would generally reject such claims for any other disease state, this approach is quite prevalent for dementia.

Although not recognized as a symptom or subtype of either mild cognitive impairment or dementia, a common phenomenon that tends to occur in these populations and populations at risk for mild cognitive impairment and dementia is **Sundowning**. Sundowning refers to reductions in cognitive abilities and behavioral changes that tend to occur late in the afternoon or evening. Thus, early in the day or after waking up from a nap; the individual appears to have fully intact cognitive abilities or only minor symptoms of mild cognitive impairment/dementia. Yet after a prolonged period awake the individual exhibits substantially greater severity of symptoms and impairments indicative of mild cognitive impairment/dementia.

Despite being a well documented phenomenon for almost a century, the presence of sundowning has only recently became commonly accepted within the medical community. In part, this lack of recognition was a reflection upon clinical biases where patient assessments predominately occurred in early morning hours when patients exhibited intact cognitive abilities or only minor symptomatology. Since patients

did not appear to exhibit any issues during their assessments, caregiver and nursing reports of impairments later in the day were disregarded and attributed to lack of tolerance or fatigue over having to care for elderly individuals. As a result, there are currently no formal diagnostic criteria or procedures for assessing this clinical phenomenon; simply a characterization that patients exhibit increased agitation, aggression, anxiety, wandering, disorientation, hallucinations, delusions, and/or deterioration of cognitive function that appear in the evening.

While the cause of sundowning is not fully understood, a popular assertion has been that it is the result of alterations in sleep and the circadian rhythm. The presumption being that as these symptoms tend to occur in the evening, they must therefore be associated with aspects of the suprachiasmatic nucleus (SCN) inputs into the dorsomedial hypothalamic nucleus (DMH) ultimately disrupting sleep–wake cycles. However, such assertions are not well supported either by the evidence which shows no difference in sleep duration or other sleep metrics and disorders between those who experience sundowning and those who do not; nor does it align with fundamental understanding of circadian pathways beyond poor sleep contributing to poor cognitive abilities.

More modern perspectives of sundowning attribute this phenomenon to two prominent theories of cognitive aging, the sensory function theory of cognitive aging and the resource pool theory of cognitive aging. These perspectives do not discount the potential contributions associated with sleep disorders that are common in this population, but rather focus on trying to explain why particular factors seem to be more relevant in predicting the onset of sundowning related behaviors. For instance, sundowning behaviors tend to be more commonly expressed when there is very low levels of sunlight as well as in poorly lit environments, and in environments where sound is kept to very low levels. As these populations tend to exhibit reduced visual and auditory sensory function, the lack of an ability to see and hear in such environments contributes to a greater sense of confusion, disorientation, and fear; exacerbating underlying cognitive dysfunctions and manifesting such sundowning behaviors. Indeed, if over the course of the day you began to lose the ability to see and hear within the environment it would be unsurprising that you began to exhibit symptoms such as agitation, anxiety, seemed to wander in the environment or became disorientated. Although memory care centers have traditionally used lighting levels as a cue for their patients to better regulate and understand if they should be awake or sleeping; having low lighting and quiet periods may actually contribute to the occurrence of sundowning. As a result many such facilities now use different wavelengths of light to indicate when during the day it is; but

the overall lumnience is kept high to facilitate vision.

The resource pool theory of cognitive aging attempts to explain the presence of sundowning from a metabolic perspective. Associated with aging is a reduction in metabolic processes which diminish the pool of resources that are available to support physical and cognitive functions. Thus, while there is ample metabolic resources to support cognitive abilities early in the morning, as the individual is awake for extended periods of time this pool of resources may shrink to a point at which cognitive functions may begin to suffer — resulting in the emergence of sundowning behaviors. A common misconception then is that to preserve metabolic resources for cognitive abilities then we should limit physical exertions as they would diminish this resource pool. However, the reverse is actually true as metabolic production is increased following physical activity and decreased following extended sedentary behavior. This resource pool theory appears to fit the existent data on sundowning quite well, with sundowning occurring more commonly within populations who exhibit prolonged sedentary behavior, inadequate nutritional and water intake, and lower aerobic fitness – all factors which relate to lower energy metabolism.

Additional Resources:

Park, D. (2012). The basic mechanisms accounting for age–related decline in cognitive function. In D. Park & N. Schwar (Eds.), Cognitive aging: A primer. United Kingdom: Taylor & Francis. https://www.google.com/books/edition/Cognitive_Aging/S2SvjSoPikAC

Knopman, D. S., & Petersen, R. C. (2014). Mild cognitive impairment and mild dementia: A clinical perspective. Mayo Clinic Proceedings, 89, 1452–1459. http://dx.doi.org/10.1016/j.mayocp.2014.06.019

Issues in the study of
Cognition

Cognitive function is ultimately an artificial construct.

An idea containing a composite of various conceptual components.

- There is no singular method of assessing cognitive health that encompasses all of these various conceptual components.
- The underlying components that make up cognitive function are not uniformly defined.
- There is no singular framework that is commonly accepted for differentiating types of cognitive function.

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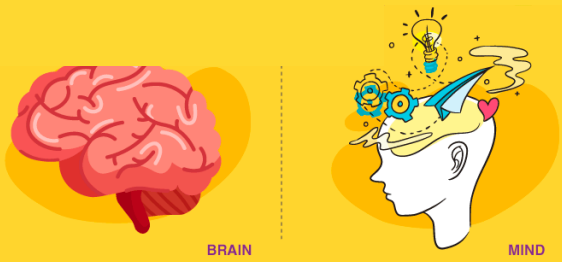
- Other specialties bringing expertise on neuroanatomical connections and/or neural-network based approaches to artificial intelligence generally view these cognitive abilities differently.
- Both approaches are equally valid.



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The psychological phenomena experienced during mental states.

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Cognitive functions reflect our interpretations of how that mental software could be laid out, organized, or described.

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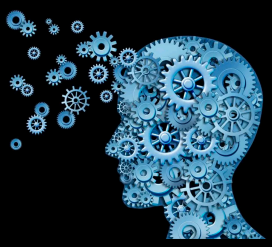
- Many people get caught in the trap of assigning psychological phenomena to particular structures within the brain.
  - Certainly we can point to evidence regarding how the absence, loss, or damage to particular structures within the brain impacts upon the psychological processes of the mind.
  - But as our conceptualization of psychological phenomena evolves, the particular brain structures that may support a given psychological phenomena would necessarily change as well.



Cognitive processes do not necessarily have to have a biological basis, and the brain tissues involved in supporting cognitive processes can change in response to a variety of context.

Issues in the study of

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- Across a wide-range of potential issues (infection, disease, accidents, intoxication), aspects of our mental skills remain relatively intact and allow us to continue to function. This robustness is achieved through strategies such as:
  - Modularity
  - Redundancy
  - Degeneracy

Robustness

The ability to maintain function despite perturbations and uncertainty.

Issues in the study of

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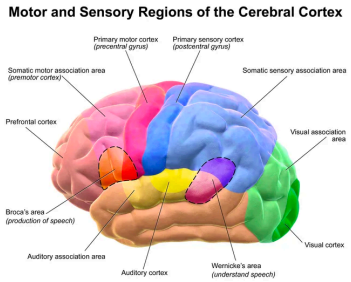
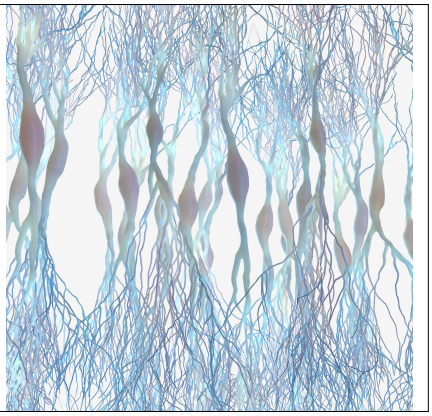
Modularity

- The brain/mind is structured into a system of core segments that are spatially or structurally isolated.
- Even if there is damage to some of these structures/ processes, the remaining elements are usually sufficient to continue to enable the organism to function.



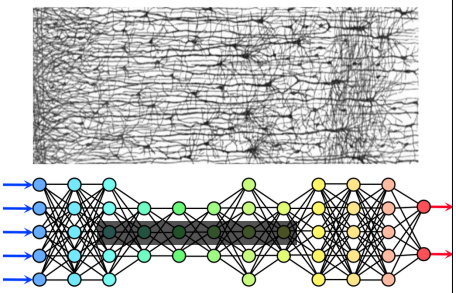
Redundancy

- Multiple modules or elements can perform the same essential process.
- Even if there is damage within a particular module (such as to a subset of cells), a core process can still be completed by other identical elements.



Degeneracy

- Many different unrelated modules can work together to create the same outcome.
- If a particular module becomes damaged or performs suboptimally, other neural regions can compensate to create the same process.



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- While a psychological processes of the mind may be primarily supported by a particular region of brain tissue; it is not uncommon (and in many cases is expected) that other regions of brain tissue and neural networks can create the same psychological processes of the mind.
- The same is true for cognitive operations. Even when the brain tissue is intact, changes in neural resource availability or strategy may require degeneracy such that compensatory action of other aspects of cognition can make up for the loss of or deficiency of another.

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Fixed Capacity Perspective

The idea that each individual has a particular limit to their cognitive abilities. While it is possible to improve cognitive abilities, the ability to improve diminishes as the individual nears this limit.

- This perspective exerted a particularly prominent influence in views that guided early concepts related to intelligence. When combined with sociocultural biases it justified problematic social behaviors.
  - A child growing up in a poor farming family would tend to perform more poorly on tests of intelligence.
  - This was interpreted as suggesting that the child would likely have a lower educational ceiling.

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Dynamic Capacity Perspective

The idea that cognitive abilities reflect their utilization. Improvement in cognitive abilities therefore reflects the way those abilities are consistently used and stressed.

- Psychological phenomena of the mind can induce alterations in the physical structures of the brain to better support those phenomena — called **neural plasticity**.
- Although some remnants of the fixed capacity perspective still exist; more modern approaches generally follow the dynamic capacity perspective.

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- The reason a child growing up with more highly educated parents tends to have greater 'intelligence' is generally explained by having a greater opportunity to gain exposure to certain vocabulary, ways of speaking, and greater general access to early childhood education.
- Early exposure and stressing of those abilities results in changes in cognitive processes and the physical structures of the brain; which then enable higher educational attainment.
- Critically, evidence indicates that this is not dependent upon age.

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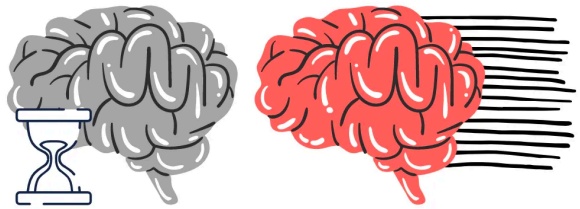
Dynamic Capacity Perspective

The idea that cognitive abilities reflect their utilization. Improvement in cognitive abilities therefore reflects the way those abilities are consistently used and stressed.

- Both the brain and mind are considered as dynamic, rather than fixed, systems prone to alterations reflecting their use/disuse.
- An increasingly common view is to consider cognitive operations much like a muscle:
  - With consistent progressive overload these processes will enhance their capacity.
  - With disuse/neglect these processes will atrophy.



There is no singular common perspective on cognitive aging, but most views point to declines in the ability to utilize mental resources quickly.

Mechanisms of
Cognitive Aging

Sensory Function Theory of Cognitive Aging

Age-related effects in performance are the result of impaired sensory function.

- Nearly all tests of cognition rely upon intact sensory processing, particularly within visual and auditory domains.
- If sensory function is diminished, then it takes a longer period of time for sufficient information to accumulate before decisions can be made.
- The assertion is that the core processes of cognition remain intact, it is just a matter of getting sensory information to them.

Mechanisms of
Cognitive Aging

Processing Speed Theory of Cognitive Aging

Age-related effects in performance are the result of a generalized decreased speed of performing mental operations.

- Most cognitive tasks and real-world decision making behaviors occur within context where the appropriate response is time-limited.
- The processing speed theory of cognitive aging argues that deteriorations in performance associated with aging are the result of two related issues.
  - General speed of processing information is impaired.
  - Decisions must be made before processing is complete.

Mechanisms of
Cognitive Aging

Processing Speed

Theory of Cognitive Aging

Age-related effects in performance are the result of a generalized decreased speed of performing mental operations.

- When given task-related context or social situations where decision making is not bounded by time constraints, older adults appear to be able to perform tasks at similar levels as younger adults.
- Task situations which require more rapid or more complex processing in time-limited context manifest with the largest impairments for older adults, relative to younger adults.

Mechanisms of
Cognitive Aging

Resource Pool

Theory of Cognitive Aging

Age-related effects in performance are the result of having a decreased pool of resources that could be brought online at any given moment.

- Argues that with aging there becomes insufficient resources to support rapid processing.
  - Conceptually similar to the processing speed theory of cognitive aging.
- Cognitive operations are effortfull and require energetic/metabolic resources to be completed.
  - The more rapid or more complex the cognitive operations are, the greater resources that are necessary.

Mechanisms of
Cognitive Aging

Resource Pool

Theory of Cognitive Aging

Age-related effects in performance are the result of having a decreased pool of resources that could be brought online at any given moment.

- Processes associated with aging result in the pool of resources diminishing.
  - Cognitive systems adopt less resource intensive approaches such:
    - Slower processing time
    - Skipping processing steps
    - Bringing online compensatory cognitive operations to try to make up for deficiencies in the resources that they have available.

Mechanisms of
Cognitive Aging

Attention Inhibition

Theory of Cognitive Aging

Age-related effects in performance are the result of difficulty sustaining attentional engagement and gaiting out irrelevant information, as well as suppressing responses.

- Attributes age-related declines in cognition to reductions in the capacity to sustain attention on task relevant details
- Older adults appear to take in and maintain a considerable amount of unnecessary/irrelevant information during the completion of cognitive tasks.
  - Cognitive operations must work harder to process the additional information contributing to reductions in available resources and delays in processing and evaluation.

Mechanisms of
Cognitive Aging

Attention Inhibition

Theory of Cognitive Aging

Age-related effects in performance are the result of difficulty sustaining attentional engagement and gaiting out irrelevant information, as well as suppressing responses.

- Difficulties in narrowing attention to reduce irrelevant information and suppress potentially distracting or conflicting details creates a cascade effect that contributes to impairments across a wide range of cognitive processes.
- Reductions in the ability to sustain attentional focus provides some justification for why older adults exhibit greater levels of distractibility and wandering attention.

Mechanisms of
Cognitive Aging

Attention Inhibition

Theory of Cognitive Aging

Age-related effects in performance are the result of difficulty sustaining attentional engagement and gaiting out irrelevant information, as well as suppressing responses.

- As older adults take in additional unnecessary information, it can be more difficult to discern the relevant information from the irrelevant making them more prone to becoming confused.

Mechanisms of
Cognitive Aging

Dynamic Capacity
Theory of Cognitive Aging

Age-related effects in performance are the result of societal tendencies that minimize the need for some aspects of cognition after retirement.

- More commonly focused upon age-related declines in cognitive control and declarative memory.
- There is considerable overlap between the two major time points when cognitive control and memory show dramatic reductions and major life events.

Mechanisms of
Cognitive Aging

Dynamic Capacity
Theory of Cognitive Aging

Age-related effects in performance are the result of societal tendencies that minimize the need for some aspects of cognition after retirement.

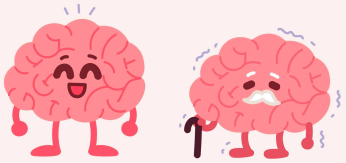
- Transitions represent shifts in the way high level cognitive operations and memory are needed.
  - Shift from college to careers.
  - Shift from careers into retirement.
- In the context of the dynamic capacity perspective, as individuals are no longer being cognitively challenged then it is to be expected that cognitive abilities would then begin to diminish.

Mechanisms of
Cognitive Aging

Dynamic Capacity
Theory of Cognitive Aging

Age-related effects in performance are the result of societal tendencies that minimize the need for some aspects of cognition after retirement.

- Cognitive control and memory tend to be sustained when:
  - Students continue with graduate and post-graduate studies
  - Adults who continue to stress these cognitive abilities after retirement:
    - Working for non-for-profit organizations and community groups
    - Interacting with children to a greater extent



Aging is associated with gradual reductions in most cognitive abilities, but a key characteristic of both healthy and normal aging is that reductions in cognitive abilities should not interfere with daily function or independence.

Classifications of
Cognitive Aging

Mild Cognitive Impairment
(MCI)

Age-related changes in cognition where one or more aspect of cognition is significantly impaired, but does not interfere with daily activities.

- Represents the initial stage at which declines in cognition reach clinically significant levels.
  - Individuals in this stage exhibit clear evidence of diminished cognitive abilities in at least one of the following aspects of cognition: motor speed, attention, cognitive control, learning/memory, or language.
- An individual with mild cognitive impairment is able to maintain their independence while going about their daily life.

Classifications of
Cognitive Aging

Mild Cognitive Impairment
(MCI)

Age-related changes in cognition where one or more aspect of cognition is significantly impaired, but does not interfere with daily activities.

- This clinical state represents approximately 15% of individuals over the age of 70.
- Diminished cognitive abilities more commonly occur within declarative memory and cognitive control.
- The most common presentation is the need to re-ask questions; either as a result of:
  - Not being able to remember the prior answer
  - Not sustaining attention long enough to listen to the answer
  - Failures in inhibiting repeating the question

Classifications of
Cognitive Aging

Mild Cognitive Impairment (MCI)

Age-related changes in cognition where one or more aspect of cognition is significantly impaired, but does not interfere with daily activities.

- Other common presentations include:
  - Frequent impairments in finding/using the right words
  - Impaired orientation (unaware of date, location, has difficulty navigating previously familiar routes).
- The more domains of cognition that exhibit significant declines, the more likely the individual is to progress into dementia.

Classifications of
Cognitive Aging

Dementia

Age-related changes in cognition where more than one aspect of cognition is significantly impaired to the point of interfering with daily function or independence.

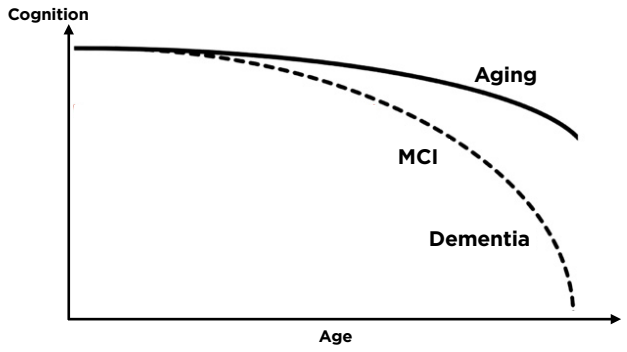
- Classification reflects the decline of multiple aspects of cognition (motor speed, attention, cognitive control, learning/memory, or language) to such an extent that the individual is no longer able to engage in activities of daily living without substantial interference.
- An individual in this stage may still be able to maintain some basic activities (bathing, dressing, personal hygiene activities), but other more intensive or complex activities such as paying bills, preparing a meal, or shopping may no longer be possible.

Classifications of
Cognitive Aging

Dementia

Age-related changes in cognition where more than one aspect of cognition is significantly impaired to the point of interfering with daily function or independence.

- Brain imaging and blood tests are typically used to ensure that brain tumors or brain lesions (wounds, damage) are not causing the cognitive impairment.
  - Brain imaging and blood tests are not actually used for the diagnosis of dementia itself — because dementia is a disease of the mind.
- Although no treatments have been found effective at resolving either mild cognitive impairment or dementia, they may help to slow the progression of these disease states to reduce further deterioration.



Subtypes of
Dementia

Despite dementia being a disease of the mind; efforts in the late 1990's and early 2000's pushed medical specialties to adopt a very brain based view.

As a result, specific subtypes of dementia are usually differentiated based upon the common symptom presentation (reflecting the issue in the mind) as well as the issue in the brain that is thought to cause the symptom presentation.

Classifications of
Cognitive Aging

- Characterized by dramatic changes in personality, relationships, and conduct (swearing, stealing, impulsive/repetitive/inappropriate behaviors)
- Usually attributed to progressive loss of brain tissue in the frontal and temporal lobes (essentially deterioration of structures involved with cognitive control).
- In some individuals this also relates to progressive lost in the ability to speak and even understand language.

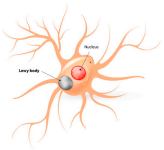
Fronto-Temporal Dementia

Classifications of
Cognitive Aging

- Characterized by visual hallucinations, highly variable levels of confusion, muscle rigidity/stiffness, and loss of coordination.
- Lewy Body dementia is a progressive disease attributed to the accumulation of lewy bodies proteins.
  - Most individual survive around eight years after symptoms begin to present.

Lewy Body Dementia

~10% of cases of Dementia



Classifications of
Cognitive Aging

- Occurs when blood vessels flowing to the brain become obstructed
  - Essentially the brain version of coronary heart disease.
- The nature of the cognitive impairment depends upon the location of the reduced blood flow.

Vascular Dementia

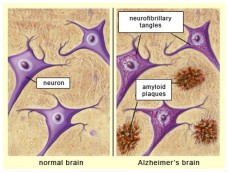
~30% of cases of Dementia

Classifications of
Cognitive Aging

- Characterized by cognitive impairments specific to language and memory.
- Usually attributed to the abnormal accumulation of beta-amyloid (plaques) and tau proteins (tangles) on the brain.

Alzheimer's Disease

~40% of cases of Dementia



- Early in the day or after waking up from a nap; the individual appears to have fully intact cognitive abilities or only minor symptoms of mild cognitive impairment/dementia.
- After a prolonged period awake the individual exhibits substantially greater severity of symptoms and impairments indicative of mild cognitive impairment/dementia.
  - Not recognized as a symptom or subtype of either mild cognitive impairment or dementia.
  - Does not occur with greater frequency in any particular type of dementia.
  - Also occurs in populations at risk for mild cognitive impairment and dementia.

Sundowning

Reductions in cognitive abilities and behavioral changes that tend to occur late in the afternoon or evening.

Sundowning

Despite being a well documented phenomenon for almost a century, the presence of sundowning has only recently became commonly accepted within the medical community.

Clinicians

Clinical assessments typically performed early in the morning when patients are willing to come in.

Patients exhibit intact cognitive abilities or only minor symptomatology.

Caregivers & Nurses

Report cognitive and behavioral impairments that occur later in the day/evening.

Reports clinically disregarded as reflecting lack of tolerance or fatigue related to extended care of an elderly individual.

Currently no formal diagnostic criteria or procedures for assessing this clinical phenomenon; simply a characterization that patients exhibit increased agitation, aggression, anxiety, wandering, disorientation, hallucinations, delusions, and/or deterioration of cognitive function that appear in the evening.

Causes of
Sundowning

A popular assertion attributes sundowning to alterations in sleep and circadian rhythms.

- Since symptoms tend to occur in the evening, the assertion was that they must therefore be associated with aspects of the suprachiasmatic nucleus (SCN) inputs into the dorsomedial hypothalamic nucleus (DMH) ultimately disrupting sleep–wake cycles.
  - Not well supported by the evidence showing no difference in sleep duration or other sleep metrics and disorders between those who experience sundowning and those who do not.
  - Does it align with fundamental understanding of circadian pathways beyond poor sleep contributing to poor cognitive abilities.

Causes of
Sundowning

- Sundowning behaviors tend to be more commonly expressed when there is very low levels of sunlight as well as in poorly lit environments, and in environments where sound is kept to very low levels.
- These populations exhibit visual and auditory sensory function.
  - The lack of an ability to see and hear in such environments contributes to a greater sense of confusion, disorientation, and fear; exacerbating underlying cognitive dysfunctions and manifesting such sundowning behaviors.

Sensory Function Theory of Cognitive Aging

Causes of
Sundowning

- Early in the morning there are ample metabolic resources to support cognitive abilities.
  - Function appears relatively normal.
- As the individual is awake for extended periods of time this pool of resources may shrink to a point at which cognitive functions may begin to suffer.
  - Emergence of sundowning behaviors.

Resource Pool Theory of Cognitive Aging

Causes of
Sundowning

- A common misconception then is that to preserve metabolic resources for cognitive abilities then we should limit physical exertions as they would diminish this resource pool.
- The reverse is actually true, as metabolic production is increased following physical activity and decreased following extended sedentary behavior.
  - Sundowning occurs more commonly within populations who exhibit prolonged sedentary behavior, inadequate nutritional and water intake, and lower aerobic fitness – all factors which relate to lower energy metabolism.

Resource Pool Theory of Cognitive Aging