Memory in Normal Aging

An edited collection of articles and news reports from the Mempowered website

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Memory in normal aging

People are poor at assessing their own memory

One thing research seems to show rather consistently is that, for older adults in particular, beliefs about one's own memory performance have little to do with one's actual memory performance[1]. People who believe they have a poor memory are usually no worse at remembering than those who believe they have a good memory.

One theory for why this might be, is that people may be influenced by their general beliefs about how memory changes with age. If you believe that your memory will get progressively and noticeably worse as you get older, then you will pay more attention to your memory failures, and each one will reinforce your belief that your memory is indeed (as expected) getting worse.

Memory decline can be a self-fulfilling prophecy

Research has also shown that common, everyday memory failures tend to be judged more harshly when the failure belongs to an older adult[2]. What is laughed off in a younger adult is treated as an indication of cognitive decline in an older person.

There are ways in which cognitive function (memory, reasoning, problem-solving, etc) declines with age, but it would be fair to say that general belief over-estimates the extent of this. It is, to a large extent, a self-fulfilling prophecy. If you believe deterioration is inevitable, you are not likely to make any effort to halt it.

Memory decline is associated with physical factors

A large-scale study that tracked seniors over a ten-year period found that cognitive decline is not a normal part of aging for most elderly people: 70% of the nearly 6000 seniors in the study showed no significant decline in cognitive function over the ten-year period. These people had two factors in common: they did not carry any of the apolipoprotein E4 genes (often associated with Alzheimer's disease), and they had little or no signs of diabetes or atherosclerosis[3]. Other factors that

have also been implicated in age-related cognitive decline are obesity, smoking, and high blood pressure. Indeed, researchers have suggested that risk factors for cardiovascular disease are also risk factors for cognitive decline: what's bad for the heart is also bad for the brain.

References

News reports

Memory gets worse with age if you think about it

Confirming earlier research (and what I've been saying for ten years), thinking that memory diminishes with age is sufficient for some elderly people to score lower on cognitive tests. Moreover, and confirming other research relating to gender and race, the study also found that a senior's ability to remember something was heavily influenced by the activation or inactivation of negative stereotypes (for example, by being told before the test that older people perform more poorly on that type of memory test). The effects of negative stereotypes were experienced more by those in their sixties than older (but those in their seventies performed worse when they felt stigmatized), and more by the very well-educated. There was some indication that these effects occur through their effect on motivation. [1]

Confidence in memory performance helps older adults remember

A study involving 335 adults aged 21 to 83 found that control beliefs were related to memory performance on a word list recall task for middle-aged and older adults, but not for younger adults. This was partly because middle-aged and older adults who perceived greater control over cognitive functioning were more likely to use strategies to help their memory. In other words, the more you believe there are things you can do to remember information, the more likely you are to make an effort to remember. [2]

Effect of expectations on older adults' memory performance

A study involving 193 participants and two experiments, each with a younger (17 – 35 years old) and older (57 – 82 years old) group of adults, has investigated how negative stereotypes about aging influences older adults' memory. Participants

were exposed to stereotype-related words in the context of another task (scrambled sentence, word judgment) in order to prime positive and negative stereotypes of aging. Results show memory performance in older adults was lower when they were primed with negative stereotypes than when they were primed with positive stereotypes. Age differences in memory between young and older adults were significantly reduced following a positive stereotype prime, with young and older adults performing at almost identical levels in some situations. [3]

Senior's memory complaints should be taken seriously

A study involving 120 people over 60 found those who complained of significant memory problems who still performed normally on memory tests had a 3% reduction in gray matter density in their brains. This compares to 4% in those diagnosed with mild cognitive impairment. This suggests that significant memory loss complaints may indicate a very early "pre-MCI" stage of dementia for some people. [4]

The Seattle Longitudinal Study of Adult Intelligence

Another study that has looked at age-related cognitive decline is the Seattle Longitudinal Study of Adult Intelligence. This study has followed a group of more than 5000 people for well over four decades. The program began in 1956 and participants have been tested across a whole gamut of mental and physical abilities at seven year intervals since that date.

The study has found no uniform pattern of age-related change across all intellectual abilities, but some support for the idea that abilities that are primarily genetically determined tend to decline earlier than abilities that are primarily acquired through schooling or experience (although there may be gender differences here).

For example, the change in perceptual speed begins in young adulthood and declines in a linear fashion - that is, the rate of decline is constant from young adulthood on; there is no sudden drop at any point.

On the other hand, a decline in cognitive abilities (word fluency, verbal memory, inductive reasoning, number skills, spatial orientation) is not reliably observed before age 60, but is reliably observed by age 74. Abilities acquired through training / experience decline more steeply after late 70s. However, even by 81, fewer than half showed reliable decrements in cognitive function over the past seven years.

Moreover, the size of this decline is significantly reduced when age changes in perceptual speed are taken into account.

Substantial cohort / generational differences have also been observed. Later-born groups have attained successively higher scores at the same ages for inductive reasoning, verbal meaning, and spatial orientation; however, they've scored successively lower in number skill and word fluency (number skill peaked with the 1924 cohort). These changes presumably reflect educational changes.

The rate and magnitude changes in intelligence seen in those entering old age showed greater decline in the 1st 3 cycles (till 1970) - that is, decline among the elderly is now slower than it used to be. At the same time, younger members are scoring lower on tests at the same age. It seems likely that the former reflects improved health and lifestyle changes, including greater mental stimulation, while the latter presumably reflects educational changes (but perhaps also health and lifestyle changes).

The role of genes is shown in the substantial similarity between parents and their adult children and between siblings that has been found for virtually all mental abilities and measures of flexibility (the exceptions are the attitude measure of social responsibility, and one measure of perceptual speed). The magnitude of similarity varied for different abilities, and was closer between parent and child than between siblings.

The following variables may reduce the risk of cognitive decline in old age:

- absence of chronic diseases
- a complex and intellectually stimulating environment
- a flexible personality style at mid-life

- high intellectual status of spouse
- maintenance of high levels of perceptual processing speed

Cognitive training studies suggested that the observed decline in many community-dwelling older people is probably a function of disuse and is often reversible. Some 2/3 of participants in a cognitive training program showed significant improvement, and 40% of those who had declined significantly were indeed returned to their earlier (pre-decline) level of cognitive functioning. These training gains were retained over seven years.

Reference

News reports

Does IQ drop with age or does something else impact intelligence?

As people grow older, their IQ scores drop. But is it really that they lose intelligence? A study has found that if college students had to perform under conditions that mimic the perception deficits many older people have, their IQ scores would also take a drop. [5]

Factors helping you maintain cognitive function in old age

An 8-year study of over 2,500 seniors in their 70s, has found that 53% showed normal age-related decline, 16% showed major cognitive decline, and an encouraging 30% had no change or improved on the tests over the years. The most important factors in determining whether a person maintained their cognitive health was education and literacy: those with a ninth grade literacy level or higher were nearly five times as likely to stay sharp than those with lower literacy levels; those with at least a high school education were nearly three times as likely to stay sharp as those who have less education. Lifestyle factors were also significant: non-smokers were nearly twice as likely to stay sharp as smokers; those who exercised moderately to vigorously at least once a week were 30% more likely to maintain their cognitive function than those who do not exercise that often; people working or volunteering and people who report living with someone were 24% more likely to maintain cognitive function. [6]

Better cognitive performance from US seniors compared to British

A study involving over 8,000 older Americans and over 5,000 British seniors has found a significant difference in cognitive performance between the two nationalities, with the Americans scoring on average as if they were ten years younger than the British. The U.S. advantage in "brain health" was greatest for the oldest old---those aged 85 and older. Part of the difference can be accounted for by higher levels of education and net worth in the United States, and part by significantly lower levels of depressive symptoms (possibly attributable to the much greater degree of medication in the US for depression). It was also found that dramatically more U.S. seniors reported no alcohol use (over 50%), compared to the British (15.5%). It is also speculated that the earlier retirement in Britain may be a factor, and also the greater prevalence of untreated hypertension. [7]

Why do some cognitive processes decline with age?

- Most basic cognitive processes decline with advanced age at higher levels of difficulty
- Part of this reflects the slowing down that occurs with age
- It does seem likely however that there is a reduction in processing capacity with age
- Strategies that reduce the memory load of a task are therefore likely to be of help to older adults, for example:
    - Use of pictures as memory aids
    - Text that is clear and explicit
- Practicing new skills and habit until they become automatic is also likely to be of even more help to older adults than younger adults (because it reduces memory load)
- Irrelevant detail can be more distracting for older adults, and this may also play a part in cognitive decline

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Most cognitive processes decline with age

It does appear that most component processes of cognition decline with advanced age if the difficulty level is sufficiently high. For example, the following processes have all shown age effects:

- processes involving attention
- working memory capabilities (the amount of information you can work with without losing track of any)
- understanding text
- making inferences
- encoding (putting information into memory) and retrieval (finding information in memory)

Other processes however, show little or no decline with age. For example:

- picture recognition
- implicit memory (information that can't be brought to mind but can be seen to affect behavior)
- prospective memory (remembering things you need to do)

Additionally, older adults' performance on highly practiced expert skills can match that of young adults (e.g., typing, bridge playing, chess).

Cognitive decline in normal aging mainly due to a reduced working memory capacity?

It would seem from this that cognitive decline in old age may be primarily due to the reduction in processing capacity - understanding text, making inferences, and paying attention are all processes that depend heavily on your working memory capability. Accordingly, it has been theorized that cognitive aids that minimize the use of processing resources might be effective in helping older adults.

Since picture recognition is one of those cognitive processes that don't appear to be affected by age, **pictures may well provide effective memory support for older**

adults. For text, instructions that **explicitly** present material rather than requiring subtle inferences (which requires more processing), would be better.

This theory that age-related cognitive decline is due to decreased processing resources also suggests that **automatizing components of complex behaviors** would be an effective strategy for older adults.

Any skill that is practiced sufficiently becomes "automatized" (think of driving a car or playing the piano). A skill or habit that has been practiced to sufficient level to become automatic will never be completely lost. Unfortunately, research does suggest that older adults require a lot more practice than younger adults to achieve automatization - but the benefit to them may well be greater.

Other theories for age-related cognitive decline

It has also been theorized that age-related cognitive decline may result primarily from the **slowing down** that occurs with age. There is certainly little doubt about the fact of age-related slowing. But it seems likely that there is more involved than simply this, as age differences are still found on many tasks even when there is unlimited time to do them. It may well be that there is an interaction between slower processing and decreased capacity, causing timing to be more critical in complex situations (e.g., approaching a complex traffic interchange on a freeway at relatively high speed). Practice does improve speed in older adults (although not to the level that it does in younger adults).

Another theory is that older adults develop problems with the inhibitory mechanisms in working memory (the part of our brain that enables us to ignore irrelevancies), and it is this that gives the impression that there has been a decrease in processing resources. A faulty inhibitory mechanism would cause older adults to pay more attention to irrelevant detail and encourage incorrect interpretations of context. There is some evidence that **older adults find irrelevant information more distracting** than do young adults.

How cognitive function declines

- Older adults commonly need to practice more than younger adults to achieve the same level of performance. Such age deficits at least partly due to poorer monitoring of their learning.
- Failing to immediately retrieve well-known information does become more common with age, with an increase in "tips of the tongue" evident as early as the mid-thirties. Older people tend to be less likely than younger people to actively pursue a missing word.
- Older adults are less likely than younger ones to use the appropriate brain regions when performing a memory task, and more likely to use cortical regions that are not as useful. But this can be at least partly overcome if the seniors are given specific strategy instructions.
- Older adults appear to be particularly impaired in context processing - particularly seen in an inability to remember where they heard (or read, or saw) something. Because context is involved in many memory processes, this may have far-reaching implications. An impaired ability to remember context may reflect frontal-lobe inefficiency rather than aging *per se*.
- Older adults may compensate for cognitive decline by using additional brain regions. However, the downside is that these brain regions are then not available when a task requires them specifically. This may explain older adults' poorer performance on complex short-term memory tasks.

News reports

Sleep, circadian rhythm, & GABA

Circadian clock may be critical for remembering what you learn

We know circadian rhythm affects learning and memory in that we find it easier to learn at certain times of day than others, but now a study involving Siberian hamsters has revealed that having a functioning circadian system is in itself critical to being able to remember. The finding has implications for disorders such as Down syndrome and Alzheimer's disease, and may also have implications for general age-related cognitive decline, because age brings about a degradation in the circadian system. The critical factor appears to be the amount of the neurotransmitter GABA, which acts to inhibit brain activity. The circadian clock

controls the daily cycle of sleep and wakefulness by inhibiting different parts of the brain by releasing GABA. It seems that if it's not working right, if the hippocampus is overly inhibited by too much GABA, then the circuits responsible for memory storage don't function properly. The effect could be fixed by giving a GABA antagonist, which blocks GABA from binding to synapses. Recent mouse studies have also demonstrated that mice with symptoms of Down syndrome and Alzheimer's also show improved learning and memory when given the same GABA antagonist. It's worth noting that the hamsters' circadian systems were put out of commission by manipulating the hamsters' exposure to light, in a technique that was compared to "sending them west three time zones." The effect was independent of sleep duration. [8]

Aging impairs the 'replay' of memories during sleep

During sleep, the hippocampus repeatedly "replays" brain activity from recent experiences, in a process believed to be important for memory consolidation. A new rat study has found reduced replay activity during sleep in old compared to young rats, and rats with the least replay activity performed the worst in tests of spatial memory. The best old rats were also the ones that showed the best sleep replay. Indeed, the animals who more faithfully replayed the sequence of neural activity recorded during their earlier learning experience were the ones who performed better on the spatial memory task, regardless of age. The replay activity occurs during slow-wave sleep. [9]

Is a dwindling brain chemical responsible for age-related cognitive decline?

A study of what are probably the world's oldest monkeys may explain age-related mental decline. The study found that the very old monkeys' nerves in the visual cortex lose their ability to discriminate between one signal and another and that this loss was directly related to the presence of a chemical called gamma-aminobutyric acid (Gaba), a neurotransmitter that appears to dwindle in old age. If a lack of GABA is indeed responsible for the old neurons' indiscriminate firing, this problem may be simple enough to treat. There already exist drugs that increase GABA production, although these drugs have yet to be carefully tested on the elderly. [10]

Brain atrophy, white matter lesions, & coordination

Occasional memory loss tied to lower brain volume

A study of 503 seniors (aged 50-85) with no dementia found that 453 of them (90%) reported having occasional memory problems such as having trouble thinking of the right word or forgetting things that happened in the last day or two, or thinking problems such as having trouble concentrating or thinking more slowly than they used to. Such problems have been attributed to white matter lesions, which are very common in older adults, but all of the participants in the study had white matter lesions in their brains, and the amount of lesions was not tied to occasional memory problems. However it was found that those who reported having such problems had a smaller hippocampus than those who had no cognitive problems. This was most noteworthy in subjects with good objective cognitive performance. [11]

Magnetic resonance imaging may help predict future memory decline

A six-year imaging study of 45 healthy seniors assessed changes in brain scans against cognitive decline. They found that progressive atrophy in the medial temporal lobe was the most significant predictor of cognitive decline, which occurred in 29% of the subjects. [12]

White-matter changes linked to gait and balance problems

A three-year study involving 639 adults between the ages of 65 and 84 has found that people with severe white matter changes (leukoaraiosis) were twice as likely to score poorly on walking and balance tests as those people with mild white matter changes. The study also found people with severe changes were twice as likely as the mild group to have a history of falls. The moderate group was one-and-a-half times as likely as the mild group to have a history of falls. Further research will explore the effect of exercise. [13]

Walking in older people is related to cognitive skills

A study of 186 adults aged 70 and older tested gait speed with and without interference (walking while reciting alternate letters of the alphabet). Walking speed was predictable from performance on cognitive tests of executive control and memory, particularly when the participant was required to recite at the same time. The findings suggest that in old age, walking involves higher-order executive-control processes, suggesting that cognitive tests could help doctors assess risk for falls. Conversely, slow gait could alert them to check for cognitive impairment. [14]

Brain systems become less coordinated with age, even in the absence of disease

An imaging study of the brain function of 93 healthy individuals from 18 to 93 years old has revealed that normal aging disrupts communication between different regions of the brain. The finding is consistent with previous research showing that normal aging slowly degrades white matter. The study focused on the links within two critical networks, one responsible for processing information from the outside world and one, known as the default network, which is more internal and kicks in when we muse to ourselves. "We found that in young adults, the front of the brain was pretty well in sync with the back of the brain [but] in older adults this was not the case. The regions became out of sync and they were less correlated with each other." However, older adults with normal, high correlations performed better on cognitive tests. Among older individuals whose brain systems did not correlate, all of the systems were not affected in the same way. The default system was most severely disrupted with age. The visual system was very well preserved. [15]

Signs

Lack of imagination in older adults linked to declining memory

In a study in which older and younger adults were asked to think of past and future events, older adults were found to generate fewer details about past events — and this correlated with an impaired ability to imagine future events. The number of details remembered by older adults was also linked to their relational memory abilities. The findings suggest that our ability to imagine future events is based on our ability to remember the details of previously experienced ones, extract relevant details and put them together to create an imaginary event. [16]

Decline of mental skills in years before death

A long-running study of 288 people with no dementia, who were followed from age 70 to death, has found that there was substantial acceleration in cognitive decline many years prior to death. Time of onset and rate of terminal decline varied considerably across cognitive abilities, with verbal ability beginning its terminal decline 6.6 years prior to death, spatial ability 7.8 years before death, and perceptual speed 14.8 years before death. With verbal ability, it appeared that the decline was not due to age only, but due to health issues. [17]

Gene expression, neurogenesis, brain chemicals

Immune function important for cognition

New research overturns previous beliefs that immune cells play no part in — and may indeed constitute a danger to — the brain. Following on from an earlier study that suggested that T cells — immune cells that recognize brain proteins — have the potential to fight off neurodegenerative conditions such as Alzheimer's, researchers have found that neurogenesis in adult rats kept in stimulating environments requires these immune cells. A further study found that mice with these T cells performed better at some tasks than mice lacking the cells. The researchers suggest that age-related cognitive decline may be related to this, as aging is associated with a decrease in immune system function, suggesting that boosting the immune system may also benefit cognitive function in older adults. [18]

Why neurogenesis is so much less in older brains

A rat study has revealed that the aging brain produces progressively fewer new nerve cells in the hippocampus (neurogenesis) not because there are fewer of the immature cells (neural stem cells) that can give rise to new neurons, but because they divide much less often. In young rats, around a quarter of the neural stem cells were actively dividing, but only 8% of cells in middle-aged rats and 4% in old rats were. This suggests a new approach to improving learning and memory function in the elderly. [19]

Early life stress can lead to memory loss and cognitive decline in middle age

Age-related cognitive decline is probably a result of both genetic and environmental factors. A rat study has demonstrated that some of these environmental factors may occur in early life. Among the rats, emotional stress in infancy showed no ill effects by the time the rats reached adulthood, but as the rats reached middle age, cognitive deficits started to appear in those rats who had had stressful infancies, and progressed much more rapidly with age than among those who had had nurturing infancies. Middle-aged rats who had been exposed to early life emotional stress showed deterioration in brain-cell communication in the hippocampus. [20]

Some brains age more rapidly than others

Investigation of the patterns of gene expression in post-mortem brain tissue has revealed two groups of genes with significantly altered expression levels in the brains of older individuals. The most significantly affected are mostly those related to learning and memory. One of the most interesting, and potentially useful, findings, is that patterns of gene expression are quite similar in the brains of younger adults. Very old adults also show similar patterns, although the similarity is less. But the greatest degree of individual variation occurs in those aged between 40 and 70. Some of these adults show gene patterns that look more like the young group, whereas others show gene patterns that look more like the old group. It appears that gene changes start around 40 in some people, but not in others. It also appears that those genes that are affected by age are unusually vulnerable to damage from agents such as free radicals and toxins in the environment, suggesting that lifestyle in young adults may play a part in deciding rate and degree of cognitive decline in later years. [21]

Rat study offers more complex model of brain aging

A study of young, middle-aged, and aged rats, trained on two memory tasks, has revealed 146 genes connected with brain aging and cognitive impairment. Importantly, the changes in gene activity had mostly begun in mid-life, suggesting that changes in gene activity in the brain in early adulthood might set off cellular or biological changes that could affect how the brain works later in life. The study

provides more information on genes already linked to aging, including some involved in inflammation and oxidative stress, and also describes additional areas in which gene activity might play a role in brain aging, including declines in energy metabolism in cells and changes in the activity of neurons (nerve cells) in the brain and their ability to make new connections with each other, increases in cellular calcium levels which could trigger cell death, cholesterol synthesis, iron metabolism and the breakdown of the insulating myelin sheaths that when intact facilitate efficient communication among neurons. [22]

Mouse study suggests new approach to reducing age-related cognitive decline

Young and old mice learned that a particular tone was associated with a mild electric footshock. When the tone was immediately followed by a shock, both young and aged mice easily remembered the association on the following day. When the tone was separated from the shock by several seconds, the old mice were strongly impaired in comparison to the young mice. The researchers found highly elevated levels of a calcium-activated potassium channel, the so-called SK3 channel, in the hippocampus of old, but not of young mice. When the researchers selectively downregulated SK3 channels in the hippocampus of aged mice, the impairment in learning and memory was prevented. This suggests a new approach to treating age-related memory decline. [23]

Rat studies provide more evidence on why aging can impair memory

Among aging rats, those that have difficulty navigating water mazes have no more signs of neuron damage or cell death in the hippocampus, a brain region important in memory, than do rats that navigate with little difficulty. Nor does the extent of neurogenesis (birth of new cells in an adult brain) seem to predict poorer performance. Although the researchers have found no differences in a variety of markers for postsynaptic signals between elderly rats with cognitive impairment and those without, decreases in a presynaptic signal are correlated with worse cognitive impairment. That suggests that neurons in the impaired rat brains may not be sending signals correctly. [24]

An enzyme that helps us to forget

A series of experiments on genetically altered laboratory mice showed those with low levels of the enzyme protein phosphatase-1 (PP1), were less likely to forget what they had learned. This enzyme appears to be critical in helping us forget unwanted information, but it may also be partly responsible for an increase in forgetting in older adults. It was found that as the mice aged, the level of PP1 increased. When the action of PP1 was blocked, the mice recovered their full learning and memory abilities. [25]

Age-related changes in brain dopamine may underpin the normal cognitive problems of aging

A new model suggests why and how many cognitive abilities decline with age, and offers hope for prevention. Research in the past few years has clarified and refined our ideas about the ways in which cognitive abilities decline with age, and one of these ways is in a reduced ability to recall the context of memories. Thus, for example, an older person is less likely to be able to remember where she has heard something. According to this new model, context processing is involved in many cognitive functions — including some once thought to be independent — and therefore a reduction in the ability to remember contextual information can have wide-reaching implications for many aspects of cognition. The model suggests that context processing occurs in the prefrontal cortex and requires a certain level of the brain chemical dopamine. It may be that in normal aging, dopamine levels become low or erratic. Changes in dopamine have also been implicated in Alzheimer's, as well as other brain-based diseases. [26]

Memory improvement drugs

Memory-enhancing drugs for elderly may impair working memory and other executive functions

Drugs that increase the activity of an enzyme called protein kinase A improve long-term memory in aged mice and have been proposed as memory-enhancing drugs for elderly humans. However, the type of memory improved by this activity occurs principally in the hippocampus. A new study suggests that increased activity of this enzyme has a deleterious effect on working memory (which principally involves the prefrontal cortex). In other words, a drug that helps you

remember a recent event may worsen your ability to remember what you're about to do (to take an example). [27]

Drugs to improve memory may worsen memory in some

A number of pharmaceutical companies are working on developing memory-enhancing drugs not only for patients with clinical memory impairment, but also for perfectly healthy people. Although some drugs have been found that can improve cognitive function in those suffering from impairment, the side effects preclude their use among healthy people. However, a recent study has found evidence that a well-established drug used for narcolepsy (excessive daytime sleepiness) may improve cognition in normal people, without side effects. The drug seems to particularly affect some tasks requiring planning and working memory (and in a further, as yet unpublished study, appears helpful for adults with ADHD). Whether the drug (modafinil) has anything over caffeine in terms of the cognitive benefits it brings is still debated. More interestingly, and in line with the sometimes conflicting results of these kinds of drugs on different people, the researchers suggest that the effect of drugs on cognitive function depends on the level at which the individual cognitive system is operating: if your system is mildly below par, the right brain chemical could improve performance; if it's well below par, the same dose will have a much smaller effect; if (and this is the interesting one) it's already operating at peak, the chemical could in fact degrade performance. [28]

Rate of cognitive decline

- White matter, the fatty material that insulates the long extending branches of the nerve cells and makes nerve signals move faster, appears to decrease faster than grey matter (the cell bodies of nerve cells), but doesn't begin to decline until the forties. Presumably this relates to the decline in processing speed that is the most evident characteristic of age-related decline.
- Grey matter on the other hand, declines at a fairly constant rate from adolescence, mirroring a decline in processing ability that seems to start as early as the twenties.

- Regions of the prefrontal cortex appear to be particularly sensitive to the effects of aging. These regions are associated with the so-called "executive" functions, such as decision-making, planning, and working memory.
- Women seem to have a greater density of brain cells in this area, but also show a steeper rate of decline, so that in old age the density is similar between the genders.
- Education and a greater head size both help stave off age-related cognitive decline by providing a cognitive reserve.

News reports

Age of decline

Evidence cognitive decline begins in late 20s

A seven-year study involving 2,000 healthy participants between the ages of 18 and 60 has revealed that in 9 of 12 tests the average age at which the top scores were achieved was 22. A notable decline in certain measures of abstract reasoning, processing speed and spatial visualisation became apparent at 27. Average memory declines could be detected by about age 37. However, accumulated knowledge skills, such as improvement of vocabulary and general knowledge, actually increase at least until the age of 60. It must be remembered however that there is considerable variance from person to person. [29]

Brain slows at 40, starts body decline

We get slower as we age, we all know that. This slowness reflects damage to the myelin sheathing (“white matter”) that coats nerve fibers and is vital for speedy conduction of electrical impulses. A study involving 72 healthy men aged 23 to 80 has found that the speed with which they could tap an index finger, and the health of the myelin in the region that orders the finger to tap, both peaked at age 39, then gradually declined with increasing age. This explains why you don’t get many world-class athletes after 40. Luckily, it probably takes a little longer before the myelin in cognitive areas starts to fray (a decade or so, it’s thought). The finding is consistent with a recent report that the system that’s supposed to repair myelin becomes less efficient with age. More research is looking at what you can do to

help your myelin, but in the meantime, it's suggested that mental and physical activity may help stimulate myelin repair, and stress may damage it. [30]

Memory starts to decline in our mid-twenties

Studies of more than 350 men and women between the ages of 20 and 90 have found that cognitive decline starts as early as the twenties, and this decline in cognitive processing power appears to be constant - that is, the rate of decline is the same when you are in your twenties as when you are in your sixties. However young adults don't notice this decline because the loss hasn't yet become great enough to affect everyday activities. [31]

Gray matter may decline from adolescence, but white matter keeps growing until our late forties

Brain scans of 70 men, ages 19 to 76 confirms that the brain's gray matter, the cell bodies of nerve cells, declines steadily from adolescence. But surprisingly, the white matter, the fatty material that insulates the long extending branches of the nerve cells and makes nerve signals move faster, in the frontal parts of the brain appears to grow at least until the late 40's, before beginning to decline. The growth of white matter may improve the brain's ability to process information. [32]

Mental faculties unchanged until the mid-40s

A large-scale study of mental abilities in adults found that mental faculties were unchanged until the mid-40s, when a marked decline began and continued at a constant rate. The ability to remember words after a delay was especially affected. Accuracy did not seem to be affected, only speed. [33]

Factors affecting rate of decline

Memory loss becoming less common in older Americans

A new nationally representative study involving 11,000 people shows a downward trend in the rate of cognitive impairment among people aged 70 and older, from 12.2% to 8.7% between 1993 and 2002. It's speculated that factors behind this decline may be that today's older people are much likelier to have had more formal

education, higher economic status, and better care for risk factors such as high blood pressure, high cholesterol and smoking that can jeopardize their brains. In fact the data suggest that about 40% of the decrease in cognitive impairment over the decade was likely due to the increase in education levels and personal wealth between the two groups of seniors studied at the two time points. The trend is consistent with a dramatic decline in chronic disability among older Americans over the past two decades. [34]

Marital status and gender affects rate of age-related cognitive decline; education doesn't

Analysis of data from 6,476 adults born prior to 1924 (taken from the AHEAD study), who were given five rounds of cognitive testing between 1993 and 2002, has found marital status is a significant factor in rate of cognitive decline, with widows and widowers and those who never married declining faster than married individuals. This is consistent with findings of the benefits of social stimulation and support for aging cognition. Confirming earlier indications, it was also found that women declined faster than men. Level of education did not affect rate of decline. There was an effect of socioeconomic status, in that those in the bottom quintile declined more slowly than those in the highest quintile, and non-Hispanic blacks declined more slowly than non-Hispanic whites, but the chief difference was at baseline — that is, socioeconomic status and race were a far more significant factor in the level of cognitive performance at the start of the study, compared to the rate of decline with age. [35]

Education may not affect how fast you will lose your memory

A study involving some 6,500 older Chicago residents being interviewed 3-yearly for up to 14 years (average 6.5 years), has found that while at the beginning of the study, those with more education had better memory and thinking skills than those with less education, education was not related to how rapidly these skills declined during the course of the study. The result suggests that the benefit of more education in reducing dementia risk results simply from the difference in level of cognitive function. [36]

Risk of mild cognitive impairment increases with less education

A study of 3,957 people from the general population of Olmsted County, Minnesota is currently in train to find how many of those who did not have dementia might have mild cognitive impairment. A report on the findings so far suggests 9% of those aged 70 to 79 and nearly 18% of those 80 to 89 have MCI. Prevalence varied not only with age but also years of education: 25% in those with up to eight years of education, 14% in those with nine to 12 years, 9% in those with 13 to 16 years, and 8.5% in those with greater than 16 years. [37]

Childhood environment important in staving off cognitive decline

Confirming earlier studies, a British study of 215 men and women aged between 66 and 75, has found that the larger a person's head, the less likely their cognitive abilities are to decline in later years. Those with the smallest heads had a fivefold increased risk of suffering cognitive decline compared with those with the largest heads. Encouragingly, however, this doesn't mean you're doomed at birth — the researchers found that it wasn't head circumference at birth that was important, but head size in adulthood. During the first year of life, babies' brains double in size, and by the time they are six, their brain weight has tripled. These, it appears, are the crucial years for laying down brain cells and neural connections — pointing to the importance of providing both proper nourishment and intellectual stimulation in these early years. [38]

Genes

Alzheimer's pathology related to episodic memory loss in those without dementia

A study of 134 participants from the Religious Orders Study or the Memory and Aging Project has found that, although they didn't have cognitive impairment at the time of their death, more than a third of the participants (50) met criteria for a pathologic diagnosis of Alzheimer's disease. This group also scored significantly lower on tests for episodic memory, such as recalling stories and word lists. The results provide further support for the idea that a 'cognitive reserve' can allow people to tolerate a significant amount of Alzheimer's pathology without manifesting obvious dementia. It also raises the question whether we should accept any minor episodic memory loss in older adults as 'normal'. [39]

Older people with the 'Alzheimer's gene' find it harder to remember intentions

It has been established that those with a certain allele of a gene called ApoE have a much greater risk of developing Alzheimer's (those with this allele on both genes have 8 times the risk; those with the allele on one gene have 3 times the risk). Recent studies also suggest that such carriers are also more likely to show signs of deficits in episodic memory – but that these deficits are quite subtle. In the first study to look at prospective memory in seniors with the "Alzheimer's gene", involving 32 healthy, dementia-free adults between ages of 60 and 87, researchers found a marked difference in performance between those who had the allele and those who did not. The results suggest an exception to the thinking that ApoE status has only a subtle effect on cognition. [40]

People at genetic risk for Alzheimer's age mentally just like noncarriers

A long-running study involving 6,560 people has found that carriers of the so-called 'Alzheimer's gene'— the APOE4 allele — does not contribute to cognitive change during most of adulthood. There was no difference in cognitive performance between carriers and non-carriers prior to the development of dementia symptoms. 41]

Longevity gene also helps retain cognitive function

The Longevity Genes Project has studied 158 people of Ashkenazi, or Eastern European Jewish, descent who were 95 years of age or older. Those who passed a common test of mental function were two to three times more likely to have a common variant of a gene associated with longevity (the CETP gene) than those who did not. When the researchers studied another 124 Ashkenazi Jews between 75 and 85 years of age, those subjects who passed the test of mental function were five times more likely to have this gene variant than their counterparts. The gene variant makes cholesterol particles in the blood larger than normal. [42]

Physical changes to the brain

Human cerebellum and cortex age in very different ways

Analysis of gene expression in five different regions of the brain's cortex has found that brain changes with aging were pronounced and consistent across the cortex, but changes in gene expression in the cerebellum were smaller and less coordinated. Researchers were surprised both by the homogeneity of aging within the cortex and by the dramatic differences between cortex and cerebellum. They also found that chimpanzees' brains age very differently from human brains; the findings cast doubt on the effectiveness of using rodents to model various types of neurodegenerative disease. [43]

Physical brain changes with advancing age

Many of the cognitive deficits associated with advancing age are related to functions of the prefrontal cortex such as working memory, decision-making, planning and judgement. Postmortem examination of 20 brains ranging in age from 25 to 83 years, confirm that prefrontal regions may be particularly sensitive to the effects of aging. It also appears that white matter decreases at a faster rate than grey matter with age. [44]

Gender differences

Gender differences in frontal lobe neuron density

A recent study has found that women have up to 15% more brain cell density in the frontal lobe, which controls so-called higher mental processes, such as judgement, personality, planning and working memory. However, as they get older, women appear to shed cells more rapidly from this area than men. By old age, the density is similar for both sexes. It is not yet clear what impact, if any, this difference has on performance. [45]

Extent of cognitive decline

- Large-scale population surveys of mild cognitive impairment in the elderly have found levels of prevalence ranging from 10% to 26%, with the likelihood of impairment increasing significantly with every decade after 65.

- A large-scale Dutch survey of those aged 85 and older found more women than men had good memory and mental speed, despite the fact that more women than men had a limited education.
- Severe memory problems in the elderly have become more rare, perhaps because of greater physical fitness.

News reports

Most older people with mild cognitive impairment have Alzheimer's or cerebral vascular disease

Another finding from the Religious Orders Study. It seems that mild cognitive impairment is often the earliest clinical manifestation of Alzheimer's or vascular dementia. By studying the brains of study participants after death, researchers could ascertain that, of the 37 individuals with mild cognitive impairment, 23 met pathologic criteria for Alzheimer's disease, and 12 had cerebral infarcts (5 had both). Only 9 did not have either pathology. The researchers conclude that even mild loss of cognitive function in older people should not, therefore, be viewed as normal, but as an indication of a disease process. [46]

Failing recall not an inevitable consequence of aging

New research suggests age-related cognitive decay may not be inevitable. Tests of 36 adults with an average age of 75 years found that about one out of four had managed to avoid memory decline. Those adults who still had high frontal lobe function had memory skills "every bit as sharp as a group of college students in their early 20s." (But note that most of those older adults who participated were highly educated – some were retired academics). The study also found that this frontal lobe decline so common in older adults is associated with an increased susceptibility to false memories – hence the difficulty often experienced by older people in recalling whether they took a scheduled dose of medication. [47]

Population level of frontotemporal dementia

A large-scale epidemiological study in the Netherlands has found an incidence of frontotemporal dementia that equates to a population level of 1.1 per 100,000. The

prevalence was highest among those ages 60 to 69, at 9.4 per 100,000. The prevalence among people ages 45 to 64 was estimated to be 6.7 per 100,000. Symptoms began after age 65 in 22% of patients. Whites accounted for 99% of all cases despite an ample nonwhite population. A family history of dementia was present in 43% of patients. [48]

Cognitive impairment high among older people

In the first population-based study of cognitive impairment in the United States, nearly one in four older African Americans in Indianapolis were found to have measurable cognitive problems (short of dementia or Alzheimer's). The prevalence of cognitive impairment grew significantly with age, with rates increasing by about 10 percent for every 10 years of age after age 65. Of those aged 85 and older, 38% had some degree of cognitive impairment. Surveys in other countries (which cannot be directly compared due to differences in methodology, diagnostic criteria, etc) have reported results ranging from 10.7% in Italy to 26.6% in Finland. [49]

Severe memory problems in older adults have become more rare

Severe memory problems in older adults have become more rare, probably because of better treatments for dementia, depression and strokes. Researchers from the University of Michigan interviewed more than 10,000 people ages 70 and older from 1993 to 1998. People tested in 1998 did significantly better on the memory tests than those tested earlier. In 1998 less than 4% of those 70 and older showed severe memory problems, and only 8% of those 85 and older. Surprisingly, the greatest improvement was seen among those in their 80s and those with less than a high school education. The decline in memory problems is believed to be associated with the improvement in physical fitness seen among the elderly. It is speculated that the increase in number of women on hormone replacement therapy may also play a part. [50]

More women than men do well on memory tests in old age

Researchers from Leiden University tested the mental functioning of 599 Dutch men and women aged 85 years. Good mental speed on word and number recognition tests was found in 33% of the women and 28% of the men. Forty one

per cent of the women and 29% of the men had a good memory. This despite the fact that significantly more of the women had limited formal education compared to the men (not surprising given the time in which they grew up). The authors suggested that biological differences - such as the relative absence of cardiovascular disease in elderly women compared with men of the same age - could account for these sex differences in mental decline. [51]

Specific failures

Word-finding problems

- It is normal for word-finding problems to increase as we age
- It is normal for us to be slower in processing information as we age
- Difficulty in retrieving words does not mean the words are lost; there is no evidence that we lose vocabulary in normal aging
- There is little evidence for any change in semantic structure (the organization of words in memory) with age
- Older adults probably have more trouble dealing with large amounts of information
- Older adults may develop different strategies as they age, probably to accommodate their decline in processing speed and processing capacity

What do we mean by word-finding problems?

Here are some examples:

- increasing use of circumlocutions rather than specific terms (e.g., "I wonder where the thing that goes here is")
- use of empty phrases, indefinite terms, and pronouns without antecedents (i.e., referring to something or someone as "it" or "him / her" without first identifying them by name)
- increased frequency of pauses

These problems are all characteristic of Alzheimer's, but also, to a much lesser extent, of normal aging.

Verbal fluency declines with age

Verbal fluency is measured by how many words fitting a specific criteria you can generate in a fixed time (for example, how many types of fruit you can list in a minute).

Verbal fluency often (but not always) declines as we age. This may be partly because older adults are slower to access information.

Tip-of-the-tongue experiences increase with age

There is no evidence that normal older adults actually lose the meanings of words they know.

Older adults do however have more word-finding problems than younger adults. In particular, as we get older we tend to experience more experiences when the word we are searching for is "on the tip of my tongue"[1].

Picture-naming errors also increase, though not perhaps until the eighties[2].

Some studies have found a decline in older adults' ability to produce words when given their definitions, but others haven't. This may relate to strategy differences.

No structural changes to memory in normal aging

So, older adults do show some of the same type of word-finding problems as Alzheimer's patients do, but to a considerably smaller degree. There is little evidence however that this decline is due to any structural changes in semantic memory with age. Normal younger and older adults give the same sort of responses. (Alzheimer's patients on the other hand, become more eccentric in their word associations).

Older adults may use different memory strategies than younger adults

While older adults are slower to make category judgments (e.g., "Is a tomato a fruit? True or false"), they do not give responses different from those of younger adults, supporting the view that semantic organization hasn't changed. However,

there is some evidence that young and old differ in the way they judge similarity (older adults seem to rely more on distinctive features; younger adults use both common and distinctive features). This may however be due to strategy differences.

There is no evidence for any decline in prose comprehension with age. However, when there is a large load on memory (when the text is complex, for example), older adults find retrieving general knowledge more difficult.

It appears that encoding of new information might become less context-specific with age, but this may only relate to particular types of context information. It might only be that older adults are less inclined to attend to such (largely irrelevant) details as: whether something was printed in upper or lower case; the sex of a speaker; the color in which a word is printed. The temporal and spatial contexts are also likely to be less important. In other words, older adults seem to encode less information about the source of new information (the circumstances in which the information was acquired) than younger adults.

References

Tip-of-the-tongue experiences

- In a tip-of-the-tongue experience, you typically know quite a lot of information about the target word without being able to remember the word itself.
- Remembering often occurs sometime later, when you have stopped searching for the word.
- Often a similar sounding word seems to block your recall, but these probably don't cause your difficulty in remembering.
- TOTs probably occur because of there is a weak connection between the meaning and the sound of a word.
- Connections are weak when they haven't been used frequently or recently
- Aging may also weaken connections.
- TOTs do occur more frequently as we age.

- In general, this increase in TOTs with age is seen in poorer recall of names (proper names and names of things). Abstract words do not become harder to recall with age.
- Keeping your experience of language diverse (e.g., playing scrabble, doing crosswords) may help reduce TOTs.

What is a tip-of-the-tongue experience?

The tip-of-the-tongue experience (TOT) is characterized by being able to retrieve quite a lot of information about the target word without being able to retrieve the word itself. You know the meaning of the word. You may know how many syllables the word has, or its initial sound or letter. But you can't retrieve it all. The experience is coupled with a strong feeling (this is the frustrating part) that you know the word, and that it is hovering on the edges of your thought.

When you do eventually remember it, the experience is often as erratic and abrupt as the initial failure — typically it pops up sometime later, when you have stopped searching for it.

Another characteristic of TOTs is that a similar sounding word keeps blocking the way. There you are, trying to remember *Velcro*, and all you can think of is *helmet*. You feel strongly that if you could just stop thinking of *helmet*, then you'd find the word you're looking for, but *helmet* won't budge.

What causes TOTs?

It has been thought that these interfering words cause the TOTs, but some researchers now believe they're a consequence rather than a cause. Because you have part of the sounds of the word you're searching for, your hard-working brain, searching for words that have those sounds, keeps coming up with the same, wrong, words.

A recent study by Dr Lori James of the University of California and Dr Deborah Burke of Pomona College suggests a different cause.

How are words held in memory? A lot of emphasis has been placed on the importance of semantic information — the meaning of words. But it may be that the sound of a word is as important as its meaning.

Words contain several types of information, including:

- semantic information (meaning),
- lexical information (letters), and
- phonological information (sound).

These types of information are held in separate parts of memory. They are connected of course, so that when, for example, you read *Velcro*, the letter information triggers the connected sound information and the connected meaning information, telling you how to pronounce the word and what it means.

When you try to think of a word, as opposed to being given it, you generally start with the meaning ("that sticky stuff that has fuzz on one side and tiny hooks on the other"). If the connection between that meaning and the sound information is not strong enough, the sound information won't be activated strongly enough to allow you to retrieve all of it.

Drs James and Burke think that TOTs occur because of weak connections between the meaning and the sound of a word.

Connections are strengthened when they're used a lot. They are also stronger when they've just been used. If you haven't used a connection for a while, it will weaken. It may also be that aging weakens connections.

This may explain why the errant word suddenly "pops up". It may be that you have experienced a similar sound to the target word.

Are TOTs worth worrying about?

TOTs are ranked by older adults as their most annoying memory failure. They do happen more often as you age, and this increase starts as early as the mid-thirties.

While everyone has TOTs, there are some differences in the TOTs experienced by older adults. For example, the most common type of word involved in TOTs at all ages is proper names. But while forgetting proper names and object names becomes more common as we get older, abstract words are actually forgotten less.

The length of time before the missing word is recalled also increases with age. This may be because older people are less likely to actively pursue a missing word, and more inclined to simply relax and think about something else. Older adults are also more likely than younger adults to go completely blank (unable to recall any part of the word's sound or letters).

Alzheimer's disease *is* characterized by word failures. However, normal TOTs tend to involve rarely used words. In Alzheimer's, people lose very high frequency words, such as *fork* and *spoon*.

Why do TOTs increase as we age? Part of the reason may be that most of us experience fewer new and rare words as we get older and stuck in our own particular ruts. It seems that we need a lot of activation of the sound connections to keep them alive. The more we limit our experience to the tried and true, the less opportunity to keep these rarer connections active.

Dr James suggests: "People should keep using language, keep reading, keep doing crosswords. The more you use your language and encounter new words, the better your chances are going to be of maintaining those words, both in comprehension and in production, as you get older."

References

Research report

Burke, D.M., MacKay, D.G., Worthley, J.S. & Wade, E. (1991). On the tip of the tongue: What causes word finding failures in young and older adults. *Journal of Memory and Language, 30*, 542-579.

- Failing to immediately retrieve well-known information does become more common with age.
- An increase in "tips of the tongue" is evident as early as the mid-thirties.

- The increase in memory failures applies to names of people and things; abstract words do not get harder to recall.
- The length of time before the missing word is recalled also increases with age.
- Older people tend to be less likely than younger people to actively pursue a missing word.

It is common for people to feel as they get older that they more frequently experience occasions when they cannot immediately retrieve a word they know perfectly well ("it's on the tip of my tongue").

Tips of the tongue (TOTs) do indeed increase with age, and this increase is evident as early as the mid-thirties. There are other differences however, in the TOT experiences as people age. For example, older adults are much more likely to "go blank" than either young or mid-age (35-45) adults. That is, younger adults are more likely to be able to retrieve some information about the target word.

At all ages, the most common type of word involved in TOTs is proper names. But while forgetting proper names and object names becomes more common as we get older, interestingly, abstract words are forgotten less.

The most common means of resolution at all ages is that the forgotten word simply "pops up", but as we get older, it takes longer before this happens. "Pop-ups" are relatively more common for older adults. It is suggested that this may be because they are less likely to actively attempt to retrieve the information. According to a questionnaire, older adults are more likely to simply relax and think about something else.

News reports

Dealing with memory failures in which you feel the information you want is "on the tip of my tongue"

Memory failures in which you feel the information you want is "on the tip of my tongue" appear to occur because the memory trails to those items have become faint, either because the items haven't been used regularly or because of age.

Similar sounding items can help recall. To keep your memory trails strong, you need to use them - by reading, doing crosswords, anything that uses language and keeps you meeting new words. [52]

Forgetting to do things

- Forgetting future tasks and events is the most common type of memory failure
- Older adults are in general no worse at this type of remembering than younger adults
- Older adults may have more difficulty at remembering to do actions at particular times
- Older adults also need to make more effort in situations when an action cannot be performed immediately, but must be held in memory for a brief period.

The other day I was sitting in the sunshine in my living room going through some journal articles I'd photocopied. I realized I needed to staple the pages together and went down to my study to get the stapler. Approaching my desk, I decided to check my email while I was there. And then, I decided to check my library account online to see whether a book I had requested had turned up. When I'd done that, I went back upstairs to my papers. Where I realized, of course, that I'd forgotten the stapler.

This type of memory failure -- going to do something, getting sidetracked, doing something else and forgetting the original task -- is familiar to all of us. As are everyday memory failures like forgetting to put the garbage out; forgetting to take medication at the right time; forgetting a dentist appointment (although there's more than one reason for that!).

This type of memory failure -- forgetting the future, as it were -- is a failure of a type of memory called prospective memory, and it is probably the most common type of memory failure older adults suffer from. And probably the biggest concern.

It's a concern because it's a failure of memory that has consequences, and those consequences are often not only obvious to ourselves, but also to others. Which makes us feel worse, of course.

But it's not just a matter of being embarrassed. Older adults are particularly vulnerable to thoughts that they are "losing" their memory -- and the fear of Alzheimer's lurks in all of us.

So, should you be worried if you forget what you're doing?

Like other types of forgetting or absent-mindedness, it depends on the degree of your forgetfulness. But prospective memory failure is common among older adults for a very good reason. Not because it's a precursor of cognitive impairment, but because it's the most common type of memory failure for everyone.

In fact, older adults in general are no worse than anyone else in this particular memory domain, although they may worry about it more (because they worry about any memory failure more).

In some aspects of prospective memory, older adults are actually better than younger adults! One reason for this is that they are more likely to use memory aids -- like writing down reminders, or putting reminder objects in strategic places -- to help them remember.

However, it does seem that older adults may do less well at remembering things that have to be done at particular times, and one reason for this seems to be that they tend to be poorer at monitoring time. In these cases, it's therefore a good idea to use timers as reminders.

Older adults also seem to have more trouble in the situation when a remembered intention cannot be performed immediately, but must be held in memory for a brief period. Even 5-10 seconds is too long! Tasks that you are "just about" to perform, but in fact are not doing that very second (because you have some other intervening task to do first) are probably particularly dangerous because you don't feel a need to make an effort to remember them (because you are "just about" to do it). But without rehearsal, information falls out of working memory (the stuff we're

holding in the conscious "forefront" of our mind) in seconds. So you do need to make an effort. And often, that's all it needs.

You can read more about planning memory strategies in my ebook on planning memory. The book is in pdf format. You can find a free extract at: http://www.memory-key.com/excerpt_intention.pdf.

I have also extracted the 20-item questionnaire about performance on remembering particular types of intention, designed to help you get a better idea of your present performance on intention memory tasks, and to establish those specific tasks you most wish to improve. The quiz is in printable format at: http://www.memory-key.com/quiz_intention.htm

News reports

Vulnerability to distraction

More evidence the aging brain is easily distracted

Here's another study demonstrating that older adults aren't able to filter out distracting information as well as younger adults. The imaging study compared face recognition performance in younger adults (average age 26) and older (average age 70). It was found that, for both groups, difficulties encoding a new face were marked by decreased activity in the hippocampus. But older brains also showed increased activation in the auditory cortex, left prefrontal cortex and medial parietal cortex, showing that they were processing too much irrelevant information from their external environment – the notoriously loud noise of the scanner. Apart from confirming the distractibility of the older brain, the finding also raises questions about imaging studies in general, for older adults. It's likely that older adults' cognitive performance have been systematically underestimated. [53]

Age-related memory loss tied to slip in filtering information quickly

Increasing research in recent years has concluded that one of the problems for the aging brain is a diminished ability to ignore irrelevant information. In fact, many

believe it is the major problem for the healthy aging brain. Others believe, more traditionally, that the main problem is a decline in processing speed. A new study shows that both of these happen — in tandem. The difficulty in suppressing irrelevant information occurs because the processing of that irrelevant information has slowed down. This slowdown, at least in visual memory, seems to occur only in the first 200 milliseconds of visual processing, and the difficulty in suppressing irrelevant information occurs only during this period. This suppression failure is thought to impact on working memory. [54]

More on why older adults are more distractible

A number of recent studies have made it clear that as we age, we find it harder to block out unwanted distractions. A new study used a new brain imaging technique known as EROS to determine whether this is due to faster sensory memory decay or to inefficient filtering of irrelevant sensory information. The study involved 16 young and 16 older participants who read a book of their choice while distracting tones played in the background. The volume of the tones was adjusted so that all the participants heard them at the same level, and the tones were emitted in groups of fives. The young participants showed brain activity in the auditory cortex in response to the first tone in each sequence only, but the older adults' brains responded to all five. The finding supports the view that the growing difficulty at blocking out distractions is due to inefficient filtering of irrelevant sensory information , not faster sensory memory decay. [55]

Why older adults more vulnerable to distraction from irrelevant information

We know older adults find it harder to filter out irrelevant information. Now a study looking at brain function in young, middle-aged and older adults has identified changes in brain activity that begin gradually in middle age which may explain why. In younger adults, activity in the dorsolateral prefrontal cortex (associated with tasks that require concentration, such as reading) normally increases during the task, while activity in the medial frontal and parietal regions (associated with non-task related activity in a resting state, such as thinking about yourself, what you did last night, monitoring what's going on around you) normally decreases. In middle age (40-60 years), this pattern begins to break down during

performance of memory tasks, although performance is not affected (but most of the participants were fairly well educated, so the finding of brain changes without accompanying behavioural changes in the middle-aged group may reflect the "protective effect" of education). Activity in the medial frontal and parietal regions stays turned on while activity in the dorsolateral prefrontal cortex decreases. The imbalance becomes more pronounced in older adults (65+), suggesting there is a gradual, age-related reduction in the ability to suspend non-task-related or "default-mode" activity and engage areas for carrying out memory tasks. [56]

Changes in brain, not age, determine one's ability to focus on task

It's been established that one of the reasons why older adults may do less well on cognitive tasks is because they have greater difficulty in ignoring distractions, which impairs their concentration. But not all older people are afflicted by this. Some are as focused as young adults. An imaging study has now revealed a difference between the brains of those people who are good at focusing, and those who are poor. Those who have difficulty screening out distractions have less white matter in the frontal lobes. They activated neurons in the left frontal lobe as well as the right. Young people and high-functioning older adults tended to use only the right frontal lobe. [57]

Memory loss in older adults due to distractions, not inability to focus

We know that older adults often have short-term memory problems, and this has been linked to problems with attention. An imaging study now provides evidence that these short-term memory problems are associated with an inability to filter out surrounding distractions, rather than problems with focusing attention. It's been suggested that an inability to ignore distracting information may indeed be at the heart of many of the cognitive problems that accompany aging. It should be noted that this is not an inevitable effect of age — in the study, 6 of the 16 older adults involved had no problems with short-term memory or attention. [58]

Source memory failures

Older adults more likely to "remember" misinformation

In a study involving older adults (average age 75) and younger adults (average age 19), participants studied lists of paired related words, then viewed new lists of paired words, some the same as before, some different, and some with only one of the two words the same. In those cases, the "prime" word, which was presented immediately prior to the test, was plausible but incorrect. The older adults were 10 times more likely than young adults to accept the wrong word and falsely "remember" earlier studying that word. This was true even though older adults had more time to study the list of word pairs and attained a performance level equal to that of the young adults. Additionally, when told they had the option to "pass" when unsure of an answer, older adults rarely used the option. Younger adults did, greatly reducing their false recall. The findings reflect real-world reports of a rising incidence of scams perpetrated on the elderly, which rely on the victim's poor memory and vulnerability to the power of suggestion. [59]

Repeated product warnings are remembered as product recommendations

Warnings about particular products may have quite the opposite effect than intended. Because we retain a familiarity with encountered items far longer than details, the more often we are told a claim about a consumer item is false, the more likely we are to accept it as true a little further down the track. Research also reveals that older adults are more susceptible to this error. It is relevant to note that in the U.S. at least, some 80% of consumer fraud victims are over 65. [60]

Source-memory problems not an inevitable consequence of aging, but a function of frontal-lobe efficiency

Source memory is memory for the broad contextual aspects surrounding an event, such as who was speaking, or whether you learned something from a book or TV. Previous research has found that it is in this aspect of memory that older people tend to be particularly poor. In a study that compared older individuals with undergraduates, it was found that those who performed above average on frontal-lobe tests, showed no significant impairment of source memory, regardless of age. Those with below-average performance, tended to have impaired source memory (as a group). In other words, source-memory problems are not an inevitable consequence of aging, as has been widely thought, but rather are a function of

frontal-lobe efficiency. The proportion of older adults who experience frontal-lobe decline, at what ages, and to what degree, is unknown at this time.
What's more, when researchers required people to consider the relation between an item and its context (source), age differences in memory performance completely disappeared, suggesting older adults can learn strategies to remember the context better. [61]

The positive side of age-related cognitive change

The brain changes as we age, but it's not all bad! Experience changes our brains in a good way.

News reports

Older brains make good use of 'useless' information

It's now well established that older brains tend to find it harder to filter out irrelevant information. But now a new study suggests that that isn't all bad. The study compared the performance of 24 younger adults (17-29) and 24 older adults (60-73) on two memory tasks separated by a 10-minute break. In the first task, they were shown pictures overlapped by irrelevant words, told to ignore the words and concentrate on the pictures only, and to respond every time the same picture appeared twice in a row. The second task required them to remember how the pictures and words were paired together in the first task. The older adults showed a 30% advantage over younger adults in their memory for the preserved pairs. It's suggested that older adults encode extraneous co-occurrences in the environment and transfer this knowledge to subsequent tasks, improving their ability to make decisions. [62]

Experienced air traffic controllers work smarter, not harder, making up for normal mental aging

A study involving 36 air traffic controllers and 36 age- and education-matched non-controllers, with 18 older (average age 57) and 18 younger adults (average age

24) per group has found that although predictable age-related declines were observed in most of the standard tests of cognitive function, in the simulated air traffic control task, experience helped the older controllers to compensate to a significant degree for age-related declines, especially in their performance of the more complex simulations. [63]

When emotions involved, older adults may perform memory tasks better than young adults

A study involving 72 young adults (20-30 years old) and 72 older adults (60-75) has found that regulating emotions – such as reducing negative emotions or inhibiting unwanted thoughts – is a resource-demanding process that disrupts the ability of young adults to simultaneously or subsequently perform tasks, but doesn't affect older adults. In the study, most of the participants watched a two-minute video designed to induce disgust, while the rest watched a neutral two-minute clip. Participants then played a computer memory game. Before playing 2 further memory games, those who had watched the disgusting video were instructed either to change their negative reaction into positive feelings as quickly as possible or to maintain the intensity of their negative reaction, or given no instructions. Those young adults who had been told to turn their disgust into positive feelings, performed significantly worse on the subsequent memory tasks, but older adults were not affected. The feelings of disgust in themselves did not affect performance in either group. It's speculated that older adults' greater experience allows them to regulate their emotions without cognitive effort. [64]

Aging brains allow negative memories to fade

Another study has found that older adults (average age 70) remember fewer negative images than younger adults (average age 24), and that this has to do with differences in brain activity. When shown negative images, the older participants had reduced interactions between the amygdala and the hippocampus, and increased interactions between the amygdala and the dorsolateral frontal cortex. It seems that the older participants were using thinking rather than feeling processes to store these emotional memories, sacrificing information for emotional stability.

The findings are consistent with earlier research showing that healthy seniors are able to regulate emotion better than younger people. [65]

'Super-aged' brains reveal secrets of sharp memory in old age

While we take for granted that we'll lose some cognitive ability as we get older, it's also true that some very old people have brains just as quick as they always were. Now a post-mortem study of the brains of five of these "super aged" has revealed that these brains do indeed differ from normal elderly brains; specifically, by having much fewer tau tangles. Tau tangles are characteristic of Alzheimer's patients, but they are not restricted to them; until now, it's been assumed that aging brings about the accumulation of these tangles. However, amyloid plaques, also characteristic of Alzheimer's and found in smaller quantities in aging brains, were found in "normal" quantities, pointing to the tangles as the critical factor. [66]

An advantage of age

A study comparing the ability of young and older adults to indicate which direction a set of bars moved across a computer screen has found that although younger participants were faster when the bars were small or low in contrast, when the bars were large and high in contrast, the older people were faster. The results suggest that the ability of one neuron to inhibit another is reduced as we age (inhibition helps us find objects within clutter, but makes it hard to see the clutter itself). The loss of inhibition as we age has previously been seen in connection with cognition and speech studies, and is reflected in our greater inability to tune out distraction as we age. Now we see the same process in vision. [67]

Cognitive abilities are fairly stable and may be correlated with longevity

The Scottish Mental Survey assessed 87,498 eleven-year-olds in 1932, and another 70,805 in 1947. In a fascinating follow-up to this study, over 1000 of these students have been contacted and re-assessed, on the exact same tests. It was found that, first of all, the seniors did rather better than they had at age 11, and that differences in mental ability remained fairly stable with age. Mental ability at 11 was also found to be significantly correlated with survival — those who scored highly were more likely to have survived, with the exception that men with high

ability were more likely to die in active service in World War II. People of lower ability had a greater tendency to lung and stomach cancer. More results from this landmark study are expected.. [68]

'Sharp' older brains are not the same as younger brains

We know that many older adults still retain the mental sharpness of younger people, but studies comparing brain activity in older and younger adults suggests they perform differently. A rat study has now found the first solid evidence that still "sharp" older brains do indeed store and encode memories differently than younger brains. Comparison of those older rats who had retained their cognitive abilities with those who had not, also revealed that those with impaired cognition had lost the ability to modify the strength of the communications between synapses (synaptic communication is the means by which memories are encoded and stored). But the competent seniors also differed from the younger rats in the mechanism most used to bring about synaptic change. [69]

Compensating strategies for aging memories

PET scans of the prefrontal cortex reveal that older adults who perform better on a simple memory task display more activity on both sides of the brain, compared to both older adults who do less well, and younger adults. Although this seems counter-intuitive – the older adults who perform less well show activity patterns more similar to that of younger adults, this supports recent theory that the brain may change tactics as it ages, and that older people whose brain is more flexible can compensate for some aspects of memory decline. Whether this flexibility is neurological, or something that can be taught, is still unknown. [70]

Training can improve age-related memory decline in elderly

Older adults show two kinds of cognitive-processing deficits: under-recruitment, where appropriate areas of the brain are less likely to be utilised without specific instruction, and non-selective recruitment, where non-relevant regions of the brain are more likely to be used. A recent imaging study confirmed that older adults were less likely than younger ones to use the critical frontal regions when performing a memory task, and more likely to use cortical regions that are not as

useful. However, when subjects were given specific strategy instructions, the older adults showed increased activity in the frontal regions, and their remembering improved. Even with this support however, older adults still showed a greater tendency to use brain regions that were not useful. [71]

How aging brains compensate for cognitive decline

Evidence from a series of studies using functional positron emission tomography (PET) images suggests that one way older adults may compensate for age-related cognitive decline is by using additional regions of the brain to perform memory and information processing tasks. For example, simple short-term memory tasks involve the same brain regions in both older and younger adults, but older adults also activate a frontal cortex region that young adults use only when performing complex short-term memory tasks. This may explain why performance of older adults on complex memory tasks is usually significantly poorer than that of younger adults - the frontal cortex region that young adults will activate to help with complex short-term memory tasks is already preoccupied in older adults, and is less available to help when the task becomes more complex. [72]

Glossary

amygdala : means "almond", so-named because of its shape and size. The amygdala is part of the basal ganglia, and is situated in the temporal lobe. It has many connections with other parts of the brain, most particularly with the limbic system, for which reason it is considered part of the limbic system (although not part of the limbic lobe itself). The amygdala is critically involved in computing the emotional significance of events, and recent research indicates it is responsible for the influence of emotion on perception, through its connections with those brain regions that process sensory experiences, thus "allowing perception of emotionally significant events to occur despite inattention." Rat studies also suggest that the amygdala, in tandem with the orbitofrontal cortex, is involved in the forming of new associations between cues and outcomes - in other words, it is the work of the amygdala to teach us what happens to us when we do something.

amyloid beta peptides : peptides derived from amyloid precursor protein, these fragments of amyloid beta are the main protein component of plaques, and probably a major cause for the their toxicity. They are thought to bind to a receptor in the brain, blocking the signals needed for learning and memory. The peptides come in two forms: A-beta 42 and A-beta 40. Amyloid beta peptides routinely circulate in the human bloodstream, where they are harmless. Early beta amyloid accumulation within neurons is the trigger for the onset of memory decline in Alzheimer's.

amyloid precursor protein (APP): is found in many tissues besides brain, but its functions are largely unknown. It is anchored across the cell membrane, so part of it is inside and part of it is outside the cell. Enzymes snip it apart into three protein fragments, two of which are released outside the cell and one inside. One of those which is found outside the cell is made of amyloid beta peptides. It's speculated that the creation of amyloid plaque is a byproduct of a misregulation in normal APP processing. Mutation in the APP is thought to be involved in early-onset Alzheimer's; the APP gene is located on chromosome 21, at 21q21.

auditory cortex: Heschl's gyrus -- the primary auditory cortex, located in the superior temporal gyrus, in the temporal lobe. Part of a language and music processing network.

axon: a long projection extending from the cell body, that carries the output of the neuron away from it

basal ganglia: are large "knots" (ganglion means knot) of nerve cells deep in the cerebrum. They are thought to be involved in various aspects of motor behavior (Parkinson's disease, for example, is an affliction of the basal ganglia).

beta-amyloid plaques: are considered one of the hallmarks of Alzheimer's disease. The plaques are hard, insoluble aggregations of various peptides and proteins, chiefly and most important amyloid-beta peptides. Recent research suggests plaques attach primarily to blood vessels, damaging them.

cerebral cortex: the gray matter outer layer of the cerebrum. The newest part of the brain in evolutionary terms; responsible for primary sensory functions, motor

coordination and control, and most particularly, the "higher-order" functions of language and thinking.

cerebrum: the largest structure of the brain; containing the cerebral cortex (the outer layer), which is made of gray matter, and an inner core composed of white matter (myelinated nerve fibers and gray basal ganglia); divided into a number of regions known as lobes.

consolidation: new memories are initially 'labile' and sensitive to disruption before undergoing a series of processes (e.g., glutamate release, protein synthesis, neural growth and rearrangement) that render the memory representations progressively more stable. It is these processes that are generally referred to as “consolidation”.

corpus callosum : the main "bridge" between the left and right cerebral hemispheres; a broad bundle of myelinated fibers (white matter) carrying information from regions in one lobe to similarly placed regions in the opposing lobe. There are some 300 million fibers in the average corpus callosum. Cutting the corpus callosum prevents communication between the hemispheres (creating the well-known "split-brain" cases), and is used in severe cases of epilepsy.

dorsolateral prefrontal cortex : part of the prefrontal cortex, associated with tasks that require concentration, such as reading

enzymes : are a type of protein; they are responsible for catalyzing the chemical reactions in a living cell -- that is, they accelerate the rates of reactions.

frontal lobe : the frontal lobes (left and right) are situated at the "front" of the cortex, i.e. behind the forehead. They are the largest of the lobes in the cerebrum, and may be thought of as the "highest" part of our brain. The frontal lobes are critical for those faculties that humans regard as special to our species - reasoning, planning, attention, some aspects of language. Women have up to 15% more brain cell density in the frontal lobe, but with age, appear to shed cells more rapidly from this area than men. By old age, the density is similar for both sexes. The effect of this on performance is unknown.

gamma-aminobutyric acid (GABA) : an amino acid synthesized from glutamate, it's the major inhibitory neurotransmitter in the adult brain, that is, one that dampens neuronal activity. It appears to dwindle in old age.

glutamate : an amino acid, it's the most prevalent excitatory neurotransmitter in the adult brain

gray matter : brain tissue is divided into two types: gray matter and white matter. Gray matter is made up of the cell bodies of nerve cells. The volume of gray matter tissue is a measure of the density of brain cells in a particular region.

gyrus : a fold or convolution in the cerebrum

hippocampus : means "sea horse", and is named for its shape. It is one of the oldest parts of the brain, and is buried deep inside, within the limbic lobe. The hippocampus is important for the forming, and perhaps long-term storage, of associative and episodic memories. Specifically, the hippocampus has been implicated in (among other things) the encoding of face-name associations, the retrieval of face-name associations, the encoding of events, the recall of personal memories in response to smells. It may also be involved in the processes by which memories are consolidated during sleep.

internal capsule: a collection of axons connecting the cerebral cortex and the brain stem

left prefrontal cortex: part of the prefrontal cortex; active during both procedural and declarative learning; active during encoding of unfamiliar faces.

limbic lobe: a lobe that lies deep within the cerebrum - a broad collar of cortex fringing the corpus callosum (limbic means "border"). The limbic lobe includes the hippocampus, cingulate gyrus, dentate gyrus, and the parahippocampal gyrus.

lobes : the cerebrum is highly convoluted - it is this deep and numerous folding that vastly increases the cortical area of the human brain. The deepest fissures provide somewhat arbitrary boundaries for the mapping of the brain. Following

these guidelines, the cerebrum is divided into five lobes: the frontal, temporal, parietal, occipital and limbic lobes.

myelin : the sheathing that insulates axons and facilitates speedy communication among neurons.

neurofibrillary tangles : are tangled bundles of fibers inside neurons. Like plaques, they are considered one of the hallmarks of Alzheimer's disease, although they also occur in other neurological disorders. Tangles mainly consist of tau protein. By disrupting the structure of the neuron and disabling the transport of nutrients, tangles cause neurons to die. Plaques can induce tangles, but that is only one way in which tangles can form. Nicotine is, apparently, another.

neurotransmitter : a messenger chemical in the brain; it is through neurotransmitters that neurons communicate with each other. Examples are GABA, glutamate, acetylcholine, dopamine, serotonin, norepinephrine.

occipital lobe : one of the lobes of the cerebrum, situated at the back of the skull, and above the hindbrain. It borders with the parietal lobe (from which it is not clearly demarcated) and the temporal lobe. The occipital lobe contains the primary visual cortex, where visual information is processed.

parietal lobe : one of the lobes of the cerebrum, situated at the top, behind the frontal lobe. The primary sensory area is located in the parietal lobe - this is where nerve impulses carrying sensations of pain, temperature, touch, and pressure come. Areas in the parietal lobe are also involved in spatial orientation, speech and language development, and attention.

peptide : a compound of two or more amino acids linked by a peptide bond. Peptides differ from proteins by their size; peptides are shorter. Proteins can be broken down into peptides (this occurs during digestion).

prefrontal cortex : is the area of the brain at the very front of the frontal lobes. It is involved in "executive functions", such as working memory, decision-making, planning and judgment. Prefrontal regions appear to be particularly sensitive to the effects of aging. It is thought that the reduced ability to recall the context of

memories that occurs with advancing age, is evidence that the prefrontal cortex is also critical for context processing - a process involved in many cognitive functions. A recent study has also revealed that emotional stimuli and attentional functions are integrated in a specific part of the prefrontal cortex.

prospective memory: is future memory -- your plans and goals (such as, “I must pick up the dry-cleaning today”; “I intend to finish this project within three months”; "I have an appointment at the dentist tomorrow")**.**

proteins : are essential to living organisms; they are long chains of amino acids linked together by peptide bonds. Enzymes, hormones, and antibodies are all types of protein.

superior temporal gyrus : a gyrus in the upper part of the temporal lobe. Contains the primary auditory cortex. The anterior part of this region has been implicated in generating the aha! experience of insight.

synapse : the site where one neuron makes contact with another

tau proteins : are proteins that form part of a structure called a microtubule, which helps transport nutrients and other important substances from one part of the nerve cell to another. In Alzheimer's disease, however, the tau protein is abnormal and the microtubule structures collapse, causing neuron death.

temporal lobe : one of the lobes of the cerebrum, situated below the frontal and parietal lobes, and above the hindbrain. The temporal lobe is primarily concerned with sensory experience - specifically, with hearing, and with the integration of information from multiple senses. Part of the temporal lobe also plays a role in memory processing. Patients with damaged temporal lobes appear to have impaired lexical retrieval of names of living things.

white matter : Brain tissue is divided into two types: gray matter and white matter. White matter is made up of the axons of neurons -- the long filaments that extend from the cell bodies and carry the electrical signals that carry the messages between neurons. It's the myelin sheathing that makes it look white. There are three

major white matter systems, which all connect to form one continuous system: cortical white matter; the corpus callosum; the internal capsule.

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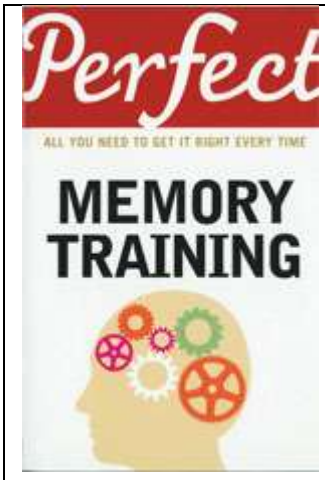	A revised edition of The Memory Key, Published 2009 by Random House UK

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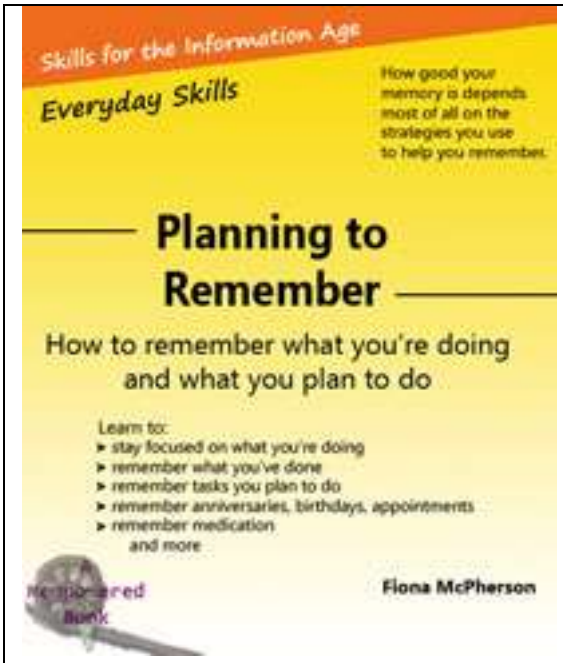
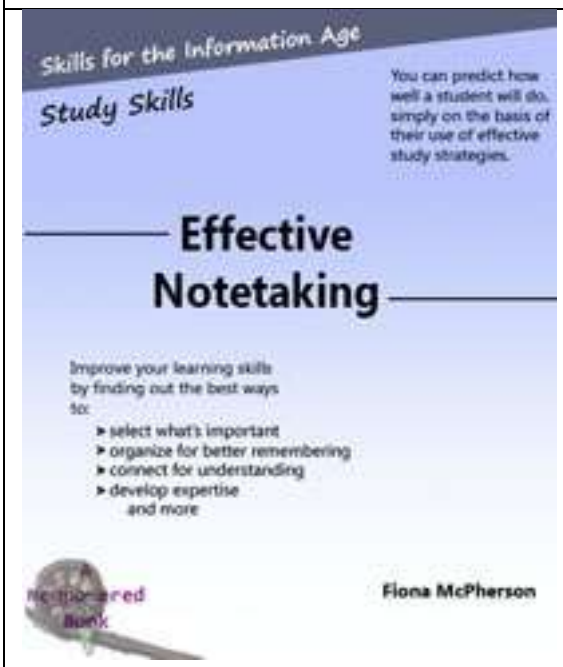
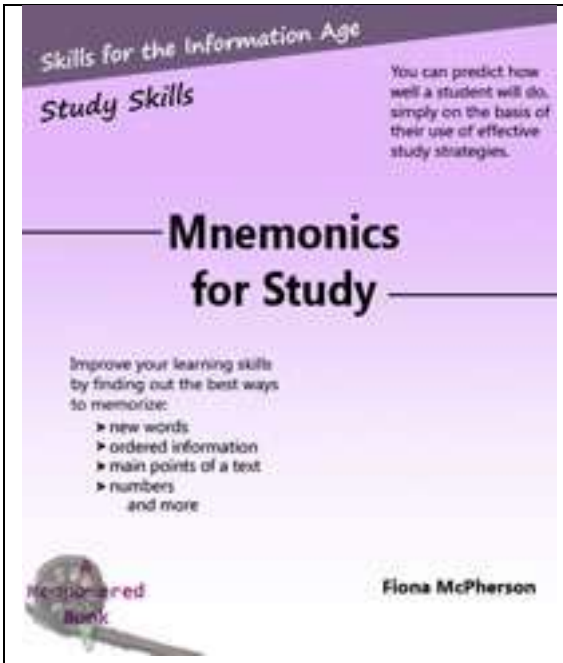
	**Planning to Remember** tells you how to improve your ability to remember appointments, important dates, things you plan to do, and also helps you with problems of short-term memory and absentmindedness. Find out more
	Being a successful student is far more about being a smart user of effective strategies than about being 'smart'. In fact it is possible to predict how well a student will do simply on the basis of their use of study strategies. **Effective notetaking** looks at the most important group of study strategies — taking notes — a broad category that encompasses not only information selection techniques, but also ways of organizing and arranging your notes to help you understand and remember. Find out more

	Whereas the book on note-taking encompasses many study skills, including those of selection, organization, and comprehension, **Mnemonics for Study** focuses solely on strategies for memorizing. Find out more
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