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Chapter 12: Across the Life Span

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Summary

Risk communication messages bombard people, from cartoon characters promoting cigarettes to direct-to-consumer drug advertisements. Messages that have an impact are processed and remembered — cognitive abilities that change dramatically from childhood to old age. Overall, these abilities improve early in life, but then gradually decline. However, the ability to remember the *gist* (meaning) of information grows in childhood and remains strong in the healthy brain. Remembering the gist of information is important because it lasts longer and is relied on to make most decisions. Instilling the gist of a message should be the goal of risk communication, which can be assessed using tests of recall, recognition, and comprehension.

Introduction

The audience for risk communications ranges from children to older adults. One might assume that, at the younger end of the age spectrum, children do not make risk–benefit decisions; adults make decisions for them. However, this assumption would be false. Minors make risky decisions with enormous consequences for public health, including decisions to consume products regulated by the FDA.

For example, the FDA recently issued warnings to 25 Mississippi convenience stores to stop selling cigarettes to minors. Children influence family food purchases and make food choices at school (and those who buy, rather than bring, lunch are more likely to be obese).[1] Adolescents buy food for themselves and shop for their families, too. Children and adolescents also make decisions about drugs and about adherence to medical regimens. They may have to self-administer drugs (e.g., inject insulin) or adhere to dietary restrictions (e.g., refuse foods with peanuts or other allergens).

Moreover, many adult attitudes about risks and benefits take root in childhood or adolescence (e.g., eating disorders, alcohol and drug use, and other risky behaviors).[2,3] Risk communication begins early in life: 91% of six-year-olds recognized Old Joe, a cartoon character promoting cigarettes.[4] In another study, four-year-olds preferred foods if they thought they were from a highly advertised fast-food chain.[5] Children and youth are among the most vulnerable recipients of persuasive messages, despite efforts to limit their access to risky substances.[6]

At the opposite end of the lifespan, older adults face a bewildering array of risky decisions. Older adults make risk–benefit decisions about diagnostic tests, medications, and surgical procedures, as well as retirement-related and other important financial decisions. National surveys suggest that older adults are less likely than other age groups to understand risk.[7] Older adults are also more likely to be cognitively impaired, further compromising their comprehension of complex risks.[8-10] To have an impact, risk communication must change what is being processed and remembered.

Here, I briefly review age changes in memory and information processing relevant to risk communication. Those changes include variation in the speed of information processing; the capacity to bring information into temporary memory and maintain it (to encode it into working memory so that it can be thought about and acted on); and the ability to store and retain information in long-term memory for later use.[11] I also discuss recent work distinguishing verbatim (exact memory for details) from gist (essential meaning) memories.[12] Remembering gist is important for risk communication because it lasts longer and forms the basis for decision making.

What does the science say about these aspects of communication?

People process information faster as they age from childhood through young adulthood, but then more slowly from young adulthood to old age.[13,14] Children are less able to keep up with the pace of rapidly presented information than young adults are, and they take away less. Initial increases in speed of processing during childhood are ascribed to the development of myelination in the brain. Myelin is a fatty sheath that surrounds and insulates nerves, improving the conduction of nerve signals. In old age, conversely, demyelination occurs, along with other abnormities in white matter resulting from trauma and disease, which contributes to general slowing of processing.

Sensory changes beginning in middle age, such as loss of hearing or visual acuity, can also contribute to slow motor response. Thus, the *hardware* of the brain changes across the lifespan in ways that affect information-processing speed, but not always the quality of responses (i.e., some responses can be slow but accurate). Speed affects accuracy when it limits the capacity of the temporary memory store or working memory.

Like processing speed, analogous increases in childhood and decreases in adulthood are posited for working memory capacity. *Working memory* refers to the ability to maintain and manipulate information, as well as to selectively inhibit irrelevant information (also referred to as *executive processes*). Capacity per se is relatively constant during childhood, but speed of processing, resistance to interference, and chunking information into meaningful units increases, augmenting functional capacity — the ability to hold and operate on information.

Thus, children have difficulty maintaining information long enough to act on it by extracting meaning, solving problems, or drawing inferences. Younger children require more repetition of information (more opportunities to study) to achieve the same level of learning compared to older children or adults. Their rate of learning is slower: They learn less than older children do from the same presentations of information.

Working memory is used immediately, but long-term memory stores information over days, weeks, or even years. Long-term recall (what were the side effects the doctor told me about?; which foods have calcium in them?) improves from childhood to adulthood and declines in adulthood. Recognition (was fever a side effect?; does spinach have calcium?) shows a similar trajectory, but is a less sensitive measure because questions provide items, resulting in better performance. The rate of change in long-term memory slows as children get older, so that differences between adolescents and young adults are subtle.[15] Again, the upside-down U-shaped developmental curve is observed, with improvement in childhood followed by noticeable decline in old age. There are also individual differences in the decline of long-term memory: Education is a major protective factor for cognitive impairment. However, people with genetic markers, such as the ε4 allele of the APOE gene that predisposes some to Alzheimer's disease, show declines in memory prior to disease onset, often in late middle age.

The information-processing model of *computer as mind* stresses rote memory, including capacity of short-term buffers and accuracy of long-term stores. Although the computer metaphor of mind has been very useful, newer approaches, such as fuzzy-trace theory, emphasize the meaning of information, not just memorization of rote facts.[16] Understanding information, as opposed to merely memorizing it, helps people retain and apply learning to new problems or situations.

For example, Bransford and Franks found that new sentences that combined information — sentences that "connected the dots"— were "recognized" more often than presented sentences that did not integrate information.[17] Presented with sentences such as "The bird is in the cage" and "The cage is under the table," people falsely recognize having heard the sentence "The bird is under the table." Despite crucial constraints on this effect (instructions must specify that true but unpresented sentences should be rejected), the finding that memory emphasizes meaning has been upheld.[18] That is, children and adults misremember the gist of presented information as having been presented (although they also retain verbatim memories to a surprising degree, contrary to Bransford & Franks,[17] and other older studies). Told that the risk of dying during surgery is 2%, for instance, patients misremember the risk as zero if the meaning they infer is "no risk."[19]

Older adults rely on gist (meaning-based memories) more than young adults do.[20] Similarly, semantic knowledge, such as vocabulary, characterized as crystallized rather than fluid intelligence, remains stable during old age. As the labels "crystallized" and "fluid" imply, world knowledge may remain stable and even improve after about age 30.[14]

It is important to separate effects of verbatim memory (which can be used to reject meaning-based lures* on a recognition test) from effects of gist memory (which can be used to wrongly accept meaning-based lures on a recognition test). Thus, increases in gist-based responding can be due to either decreases in verbatim memory or increased reliance on gist memory. The net effect of these two, independent parts of memory determine memory performance in the laboratory and in real life.

Both verbatim and gist memories improve in childhood, with gist often improving more rapidly than verbatim memory.[15] This pattern leads to greater meaning-based recognition and recall as children get older and, paradoxically, greater meaning-based memory errors (net lower accuracy, once guessing and other response biases are eliminated). Figure 1 illustrates this paradoxical pattern for recall of semantically related lists of words: Recall of presented words and intrusions of semantically related (but non-presented) words both increase in childhood and adolescence, but the latter gist-based intrusions *increase more.* (During adolescence, the ability to use gist effectively — to judge reconstructed gist to be familiar — goes up; Figure 2.) Hence, net accuracy actually goes down from childhood to adulthood, as shown by the convergence of the true and *false* recall lines in Figure 1. Discovered in 2002, this effect has been replicated in more than 50 studies.[21,22]

Verbatim and gist memory decline reliably in old age, but verbatim memory declines more than gist. Memory for gist carries most of the load of remembering during old age, sustaining performance. Therefore, understand meaning is crucial for older adults. Transitions from healthy aging to memory impairment are marked by a decline in this *backup* system of gist-based memory.[10]

Recall of word lists is the most often used neuropsychological assessment of memory impairment, and the most predictive single test of conversion from impairment to Alzheimer's disease. Memory for word lists predicts memory for more complex and ecologically valid stimuli, too, such as narratives. Models that fit data for word lists also fit data for narratives, using the same concepts of verbatim and gist memory. Gist applies to the level of individual words or sentences as well as to semantic integrations across words or sentences, such as the theme of related words or inferences that integrate related sentences,

*Tempting, but wrong, answers.

as well as to numbers and other kinds of meaningful information. Small numbers are understood early in life, but it is difficult to get the gist of ratio concepts such as probability or risk (e.g., 1 out of 8 women will develop breast cancer) even for many adults.[23]

Many of the group differences that have been discussed in this chapter are summarized in Figure 2: Verbatim memory and both types of gist memory increase from childhood to young adulthood, and then they decline. Gist-based familiarity judgment increases sharply from adolescence to adulthood. When gist memory estimates are combined, the paradoxical pattern from childhood to adulthood of greater growth in gist (compared to verbatim memory) is evident, as is the greater decline in verbatim memory (compared to gist) for Alzheimer's patients.

The last pair of groups on the right, of older adults and Alzheimer's patients, was presented with materials that provided greater verbatim support (materials for all other pairs were similar to one another). As can be seen from the figure, older adults' verbatim memory in that task can be as strong as younger adults' verbatim memory in a harder task, illustrating that memory performance is not a fixed quantity. Instead, performance is a function of both task and ability. I now turn to the implications of these differences in information processing for risk communication.

Figure 1. Age-Related Increases in the Proportion of True and Gist-Based "False" Recall for Semantically Related Word Lists

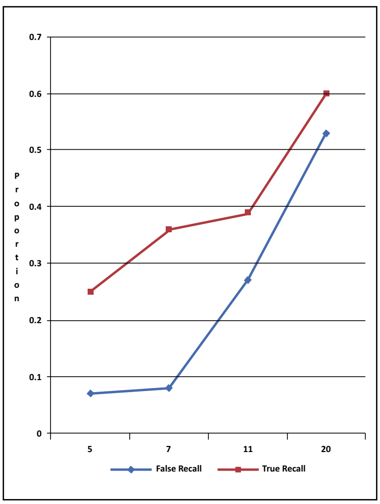

Figure 2. Estimates of Verbatim Readout, Gist Reconstruction, and Gist Familirity in Recall of word Lists across Groups

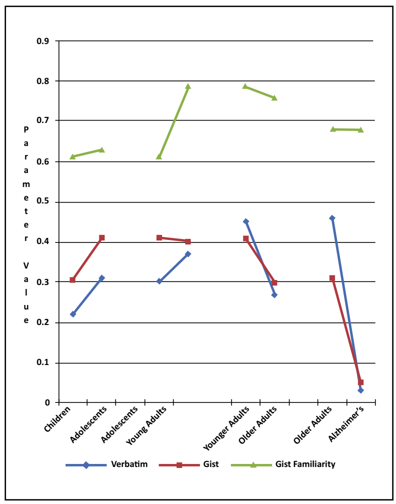

Figure 2 shows results from recall tests for a list of unrelated words across the life span, including Alzheimer's patients. Two groups are compared at a time (e.g., children to adolescents) regarding their memories for the same materials, averaging across studies (see Brainerd et al., 2009 for details).[15] Verbatim memory (exact recall of presented words) and two kinds of gist memory are depicted: The ability to reconstruct the gist meaning of presented words and the ability to judge reconstructed gist as sufficiently familiar to report it as a recalled item. Parameter values are empirical estimates of these abilities, using mathematical models tested for fit with recall data.

What general practical advice can the science support?

Messages about risks and benefits are received from family, schooling, the media (e.g., from advertising), and other cultural influences and may be explicit or implicit (e.g., role modeling). In the laboratory, boundaries are drawn between cognitive, social, and emotional factors, but, in practice, these factors are intertwined.[24] Social values and emotional reactions are often learned by processing cultural messages, and, conversely, information must be processed to elicit emotional reactions.[25] In the preceding section, evidence was presented that how information is processed differs developmentally and across individuals.

Consider the dictum to eat five or more vegetables per day, which is taught in schools and reported in the media. Elementary school-aged children can certainly count up to five and know the word vegetable. This message is more likely to be remembered by children if it is presented repeatedly, in small chunks of fewer than about five words (not long sentences) and at a slower pace: "Eat vegetables. Five *vegetables* every day. Eat five vegetables a day." Pictures accompanying words are a form of repetition and can support memory.

Note that verbatim repetition *stamps in* memories, but is unlikely to produce transfer or long-term retention of information. Cuing meaning (e.g., saying, "Vegetables make us strong. These are all vegetables" and then listing vegetables) can boost memory for gist or meaning in younger children and helps children connect the dots to new situations (raw carrots at home, cooked green beans in school lunches, etc.). Although these connections seem obvious to adults, young children can be quite literal. Also, children may be unable to carry out a series of instructions not because they are dumb, but simply because they cannot remember multiple steps. Breaking the steps down so that they can be executed one at a time, especially with repetition and reminders along the way, should improve adherence.

As children get older, after about 11 years of age on average, verbatim repetition can give way to emphasizing the meaning of information. Environmental support for remembering verbatim information (e.g., oral or written reminders) remains useful at all ages as verbatim memory is evanescent and vulnerable to interference. However, older children and adolescents are more likely than younger children to integrate information, noticing semantic themes and drawing inferences that go beyond literal facts. (Even adolescents are not as readily able to spontaneously connect the dots as adults, for example, between actions and probable consequences despite *knowing* the consequences.) For example, older children will get the gist of a list such as "fries, taco, Coke, burger" (fast food or junk food) versus "apple, spinach, carrots, fish" (healthy food). Recognition of healthy foods is not sufficient for behavior change, but it can facilitate such change when accompanied by retrieval of relevant values in the context of behavior.[12,26]

Communications should be presented more slowly to older than younger adults, and their responses are likely be slowed. However, slower does not mean dumber; information should not be dumbed down for older adults. Despite general slowing and an inability to retain details, vocabulary and reading ability of older adults can remain high. Unlike children, despite lower levels of verbatim memory, older adults can rely on fairly high levels of gist familiarity. Therefore, for older adults, we can expect impairments in verbatim memory for detailed dietary instructions or in prospective memory for exact dosages or exact times of day to take medications. Written instructions, as well as alerts and reminders delivered electronically (e.g., to take medication or to signal that medication has already been taken) are likely to be helpful cognitive prosthetics because they support verbatim memory.

Because of older adults' conserved gist memory, it is also essential to explain the reasons for dietary recommendations or medications to them. Comprehension, or extraction of gist, is the main mechanism through which older adults remember information. Therefore, if they do not understand the meaning of information, they cannot fall back on rote recall as easily as younger adults can. Even patients with mild to moderate Alzheimer's disease retain some ability to remember the gist of information.

How does one evaluate communications implementing this advice?

Information must first be taken into memory to influence attitudes, values, or preferences, which, in turn, influence behavior. Therefore, memory tests can assess whether messages have been received, and if so, how they have been interpreted (or mentally represented). Use recall or recognition tests, not only to measure *true* or accurate memories, but to measure distortions in recall (intrusions) or *false* recognitions that reveal how the *meaning* of messages has been understood. Immediate memory tests are not sufficient, as transfer and long-term retention are more likely to shape behavior. Immediate memory performance cannot be assumed to reflect the same factors as long-term retention because verbatim memory is tapped more often on immediate tests but gist memory is tapped more often on delayed tests.

Successful information processing should also lead to changes in attitudes, values clarification, and modification of preferences. Attitudes, values, and preferences are often assessed through verbal self-reports (or reports by others, such as family members). However, self-reports are subject to a variety of biases. In childhood, the ability to explain reasons for behaviors (i.e., to articulate attitudes or preferences) lags years behind the ability to demonstrate those attitudes or preferences. In adulthood, biases are more likely due to such factors as social desirability (e.g., underreporting weight). Thus, communications can be assessed behaviorally (e.g., by offering food choices and determining which options are chosen or weighing the amounts of particular types of food that are eaten in a controlled setting). Although behavioral measures are ideal, they are not direct windows on the mind; self-reports do correlate with behavior, just not perfectly. Both self-reports and behaviors must be interpreted via theories of underlying mechanisms. Assessments should be designed based on theories grounded in experiments in which hypotheses have been tested.

Although memory tests and attitude surveys can be administered relatively cheaply in the short term, long-term follow-up requires monetary incentives to combat attrition. Access to community samples of older adults is also expensive, and such subjects must be assessed for medical conditions (to obtain a "healthy" aged sample, isolating the effect of aging). Randomized assignment of people receiving different risk communications with pre-tests and post-tests, efforts to avoid cross-contamination, and proper statistical analysis remain the best methods for assessing effectiveness. Recall tests are more discriminating than recognition tests, but require scoring by hand (which is labor intensive, and therefore costly). Finally, assessing multiple levels of information processing, not simply acquisition of knowledge, but also extraction and transfer of meaning to situations that were not directly taught, requires extensive batteries of tests (i.e., costly multiple sessions).

Additional resources

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Endnotes

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