adults credit for what they know—intelligence is well preserved into late life.

SEE ALSO: Attention; Cognitive Plasticity; Cross-lagged Panel Analysis; Cross-sectional Designs; Expertise; Intelligence, Crystallized; Intelligence, Fluid; Longitudinal/Panel Designs; Working Memory

References

Ackerman, P. L. (1996). A theory of adult intellectual development: Process, personality, interests, and knowledge. *Intelligence, 22,* 229–259.

Ackerman, P. L. (2008). Knowledge and cognitive aging. In F. I. M. Craik & T. A. Salthouse (Eds.), *The handbook of aging and cognition* (3rd ed., pp. 445–489). New York, NY: Psychology Press.

Beier, M. E., & Ackerman, P. L. (2005). Age, ability and the role of prior knowledge on the acquisition of new domain knowledge. *Psychology and Aging, 20,* 341–355. doi: 10.1037/0882-7974.20.2.341

Carroll, J. B. (1993). *Human cognitive abilities: A survey of factor-analytic studies.* New York, NY: Cambridge University Press.

Hertzog, C., Kramer, A. F., Wilson, R. S., & Lindenberger, U. (2008). Enrichment effects on adult cognitive development: Can the functional capacity of older adults be preserved and enhanced? *Psychological Science in the Public Interest, 9,* 1–65.

Horn, J. L., & Cattell, R. B. (1966). Refinement and test of the theory of fluid and crystallized general intelligences. *Journal of Educational Psychology, 57,* 253–270. doi: 10.1037/h0023816

Schaie, K. W. (2005). *Developmental influence on adult intelligence: The Seattle Longitudinal Study.* New York, NY: Oxford University Press.

Spearman, C. (1927). *The nature of "intelligence" and the principles of cognition.* New York, NY: Macmillan.

Sternberg, R. J., & Jordan, J. (2005). *A handbook of wisdom: Psychological perspectives.* New York, NY: Cambridge University Press.

Further Reading

Hertzog, C. (2011). Intelligence in adulthood. In R. J. Sternberg & S. B. Kaufman (Eds.), *The Cambridge handbook of intelligence* (pp. 174–190). New York, NY: Cambridge University Press.

Interference

M. Karl Healey
University of Pennsylvania, USA

In any task, only a fraction of the information a person could consider is actually relevant. Interference refers to the disruptive effect of considering irrelevant information. Irrelevant information can take the form of distracting stimuli in the environment, inappropriate response tendencies, and task-irrelevant memories and thoughts. Interference from these sources generally leads to slower and, depending on the task, less accurate performance, but the negative effects tend to be larger for older adults (Hasher, Lustig, & Zacks, 2007).

Interference From Distracting Stimuli

Age differences in susceptibility to distracting stimuli are observed even on simple visual tasks. For example, in a task that requires focusing on a fixation cross and then directing your gaze to a target (e.g., an "o") and ignoring a distractor (e.g., an "x") that appears in another location, younger adults' eye movements show an initial deviation toward the distractor that is quickly corrected. Older adults' eye movements are slower to correct this initial deviation toward the distractor (Campbell, Al-Aidroos, Pratt, & Hasher, 2009). When searching for a target among multiple distractors, older and younger adults show little difference in locating targets if the number of distractors is small, but older adults begin to show deficits as the number of distractors increases (for a review and discussion of mediating factors see Porter, Wright, Tales, & Gilchrist, 2012).

Older adults are also more vulnerable to environmental distractors on more complex tasks. Age differences in reading speed are generally small. But if irrelevant words are interspersed in the text (e.g., words in a different font), older adults' reading speed is disproportionately slowed (Connelly, Hasher, & Zacks, 1991; Duchek, Balota, & Thessing,

1998). Distraction also impacts problem solving. The remote associates task requires finding the link between three distantly related words (e.g., "space" for *ship*, *outer*, and *crawl*). Along with the three words, May (1999) presented ostensibly irrelevant words as distractors. However, the distractors actually suggested meanings inconsistent with the relevant meanings of the words (e.g., for *ship*, *outer*, and *crawl* distractors would be *ocean*, *inner*, and *floor*). Younger adults were able to ignore the distractors and successfully solve the problems, but older adults experienced interference from the distractors and solved fewer problems.

Interference From Inappropriate Response Tendencies

Interference does not always come directly from stimuli in the environment. Many tasks require withholding a strong tendency to make one response in favor of a weaker, but more appropriate, response. In the Stroop task individuals must name the color in which a word is printed. There are three types of trials. On congruent trials, the words are color names printed in the corresponding (i.e., congruent) color (e.g., the word "red" printed in red font). On incongruent trials, the words are color words printed in a conflicting font color (e.g., the word "blue" printed in green font). On neutral trials, the words are noncolor words (e.g., "chair"). On both congruent and incongruent trials there is a very strong tendency to read the word rather than name its print color. For incongruent trials this tendency interferes with making the appropriate response and results in slowed responding. The interference effect can be quantified as the difference in response time between neutral and incongruent trials. Even younger adults show interference-related slowing, but the slowing effect is larger for older adults (Davidson, Zacks, & Williams, 2003; Ludwig, Borella, Tettamanti, & De Ribaupierre, 2010; for evidence to the contrary see Verhaeghen & De Meersman, 1998). For most older adults, reading a word is an automatic response reinforced by a lifetime of experience, but older adults also experience interference from less ingrained response tendencies. Both the go/no-go and the stop-signal tasks present a series of stimuli. Participants must respond to most stimuli, which creates a strong tendency to respond whenever a stimulus appears. But on rare trials, participants have to withhold their response (e.g., when a "stop signal" is given). On these critical trials, older adults have difficulty ignoring the tendency to respond and are slower and more error-prone than younger adults (May & Hasher, 1998; Vallesi, 2011).

Interference From Task-Irrelevant Memories

Declining episodic memory performance is one of the most troubling aspects of aging (Kausler, 1994; Newson & Kemps, 2006). Interference is a powerful cause of memory failure in young adults (Underwood & Postman, 1960). Many studies have compared older and younger adults on classic tests of memory interference and while there are some subtleties (for a review see Kane & Hasher, 1995), the general conclusion is that older adults are more susceptible to memory interference. Recent work has verified a causal link between interference and impaired memory in older adults by showing that reducing the amount of interference in a memory task also reduces age differences in memory performance (e.g., May, Hasher, & Kane, 1999; Rowe, Hasher, & Turcotte, 2008; Winocur & Moscovitch, 1983). For example, span tasks present lists of stimuli (e.g., words) for immediate recall. The lists vary in length from two to approximately five items. A person's span score is a function of the total number of items they recall across lists. The lists with the most items, and therefore the most influence on the final span score, are often presented last where they are vulnerable to interference from prior lists. Age differences are large on this version of the task. But if the longest lists are presented first, before much interference has built up, age differences are

reduced and even eliminated (May et al., 1999; Rowe et al., 2008).

Most laboratory memory tasks are *explicit* memory tests that ask participants to deliberately search their memories for studied items. But interference also occurs on *implicit* memory tests, which are designed to test memory without participants' awareness. For example, in Ikier, Yang, and Hasher (2008) the first phase involved counting the vowels in a series of words that included some critical words (e.g., "allergy"). The second phase was a word-fragment completion task in which some fragments could be completed by the critical words (e.g., "a_l__gy" can be completed by "allergy"). Both younger and older adults solved more of these critical fragments compared to control fragments that did not have their solutions presented in the first phase. If, however, the initial phase introduces the potential for interference, for example by presenting both the correct solution and another word that is orthographically similar, but not a valid solution (e.g., both "allergy" and "analogy"), the benefit of preexposure was reduced, especially for older adults.

Laboratory memory tests generally use controlled stimuli like words or pictures, but there is evidence that older adults also have difficulty recalling specific real-life episodes. Autobiographical memory tasks require recalling a specific episode from one's past (e.g., remembering one's last vacation). Older adults' autobiographical memory tends to exhibit intact recall of "semantic" details (e.g., the fact that I took a vacation at the beach last summer) but impaired recall of episodic details (e.g., the fact that I sat on the beach sipping a drink and listening to the waves; Levine, Svoboda, Hay, Winocur, & Moscovitch, 2002; St. Jacques, Rubin, & Cabeza, 2012). One interpretation of these findings is that older adults have difficulty accessing specific details of a particular episode due to interference from similar episodes.

A Possible Advantage of Being Susceptible to Interference

Older adults' tendency to consider seemingly irrelevant stimuli, response tendencies, and memories is often detrimental. But it can occasionally be beneficial if what seems like distraction turns out to be relevant to the task (for a review see Healey, Campbell, & Hasher, 2008). For example, participants in a study by Biss, Ngo, Hasher, Campbell, and Rowe (2013) examined a list of words, recalled the words, and then moved on to an ostensibly unrelated task in which some of the words from the initial recall task were presented as distractors. They then had a surprise second test of their memory for the original list. Presenting list items as distractors had little influence on the performance of younger adults, suggesting they treated them as irrelevant and a potential source of interference. But older adults showed better recall for the represented words, suggesting a possible upside to failing to ignore distraction.

Theories and Mechanisms

That older adults are disproportionately susceptible to interference is among the best supported findings in cognitive gerontology. Exactly why older adults experience this susceptibility, however, is an area of ongoing research. Some early theorists discussed the possibility that older adults may have difficulty regulating strong response tendencies (Brinley, 1965), selecting among competing memories (Kausler, 1970), or limiting memory search to currently relevant items (Craik, 1977). Hasher and Zacks (1988) were the first to fully articulate this position, suggesting that whereas young adults are able to resolve interference by inhibiting (i.e., suppressing) irrelevant information, older adults have an impaired ability to inhibit.

A variety of paradigms have been used to show age-related deficits in the ability to inhibit interfering information. Perhaps the most direct evidence comes from studies that use sensitive measures to show that competitors

are less accessible in memory after interference resolution (Anderson, Reinholz, Kuhl, & Mayr, 2011; Aslan & Bäuml, 2013; Healey, Hasher, & Campbell, 2013; Healey, Ngo, & Hasher, 2014; Ortega, Gómez-Ariza, Román, & Bajo, 2012; Radvansky, Zacks, & Hasher, 2005). For example, Healey et al. (2014) presented participants with a list of cue words and for each word either asked them to generate a strong associate of the cue or asked them to generate a word that had as little association to the cue as possible. Because words automatically activate their meanings, participants likely thought of strong associates in both conditions but had to suppress them when trying to generate a weaker associate. Indeed, on a later naming time test that measured how accessible words were in memory, young adults showed reduced access to the strong associates they should have suppressed. But older adults did not show this suppression effect, indicating a deficient inhibitory ability.

Theories of memory based on neural network models of the interactions between cortex and the hippocampus are beginning to provide insight into age differences in susceptibility to interference. One way to think of interference is as the result of two memories having very similar neural representations, which makes it difficult for the memory system to select among them. One could design a system that avoids interference by taking input patterns and transforming them so their representations are more distinct, creating a separation between the patterns representing the stimuli (Norman & O'Reilly, 2003). There is evidence that particular regions within the hippocampus perform just such pattern separation (for a review see Yassa & Stark, 2011). Recent work has shown that when viewing a series of stimuli of varying degrees of similarity (e.g., several similar, but not identical, pineapples), measures of younger adults' cerebral blood flow show signs of pattern separation even for highly similar stimuli. By contrast, older adults showed signs of pattern separation only for stimuli with high levels of dissimilarity, suggesting they were unable to conduct pattern separation for highly similar stimuli. Consistent with this interpretation, the level of pattern separation predicted success on memory tests (Yassa, Lacy et al., 2011; Yassa, Mattfeld, Stark, & Stark, 2011).

Conclusions

In general, older adults are more vulnerable than younger adults to interference from irrelevant environmental stimuli, inappropriate response tendencies, and irrelevant memories. This increased vulnerability can impair task performance, both in terms of speed and accuracy. A reduced ability to control interference may underlie some of the negative consequences of aging such as difficulty with episodic memory retrieval. Therefore understanding the causes of older adults' susceptibility to interference is one of the most important challenges in cognitive gerontology. Leading theories implicate an impaired ability to prevent interference by using distinct neural representations to encode similar stimuli (Yassa, Mattfeld et al., 2011) and an impaired ability to resolve interference by suppressing the competing (i.e., irrelevant) information (Healey et al., 2014).

SEE ALSO: Cognitive Processes; Inhibitory Deficit Hypothesis; Memory; Problem Solving; Vision in Mid and Late Life

References

Anderson, M. C., Reinholz, J., Kuhl, B. A., & Mayr, U. (2011). Intentional suppression of unwanted memories grows more difficult as we age. *Psychology and Aging, 26*, 397–405. doi: 10.1037/a0022505

Aslan, A., & Bäuml, K.-H. T. (2013). Listwise directed forgetting is present in young-old adults, but is absent in old-old adults. *Psychology and Aging, 28*(1), 213–218. doi: 10.1037/a0031295

Biss, R. K., Ngo, K. W. J., Hasher, L., Campbell, K. L., & Rowe, G. (2013). Distraction can reduce age-related forgetting. *Psychological Science, 24*(4), 448–455. doi: 10.1177/0956797612457386

Brinley, J. F. (1965). Cognitive sets, speed and accuracy of performance in the elderly. In A. T. Welford & J. E. Birren (Eds.), *Behavior, aging, and*

the nervous system: Biological determinants of speed of behavior and its changes with age (pp. 114–149). Springfield, IL: Charles C. Thomas.

Campbell, K. L., Al-Aidroos, N., Pratt, J., & Hasher, L. (2009). Repelling the young and attracting the old: Examining age-related differences in saccade trajectory deviations. *Psychology and Aging, 24*(1), 163–168. doi: 10.1037/a0014106

Connelly, S. L., Hasher, L., & Zacks, R. T. (1991). Age and reading: The impact of distraction. *Psychology and Aging, 6*(4), 533–541. doi: 10.1037/0882-7974.6.4.533

Craik, F. I. M. (1977). Age differences in human memory. In J. E. Birren & K. W. Schaie (Eds.), *Handbook of the psychology of aging* (pp. 384–420). New York, NY: Van Nostrand-Reinhold.

Davidson, D. J., Zacks, R. T., & Williams, C. C. (2003). Stroop interference, practice, and aging. *Aging, Neuropsychology, and Cognition, 10*(2), 85–98. doi: 10.1076/anec.10.2.85.14463

Duchek, J. M., Balota, D. A., & Thessing, V. C. (1998). Inhibition of visual and conceptual information during reading in healthy aging and Alzheimer's disease. *Aging, Neuropsychology, and Cognition, 5*(3), 169–181. doi: 10.1076/anec.5.3.169.616

Hasher, L., Lustig, C., & Zacks, R. T. (2007). Inhibitory mechanisms and the control of attention. In A. Conway, C. Jarrold, M. Kane, A. Miyake, & J. Towse (Eds.), *Variation in working memory* (pp. 227–249). New York, NY: Oxford University Press.

Hasher, L., & Zacks, R. T. (1988). Working memory, comprehension, and aging: A review and a new view. In G. H. Bower (Ed.), *The psychology of learning and motivation: Advances in research and theory* (pp. 193–225). San Diego, CA: Academic Press.

Healey, M. K., Campbell, K. L., & Hasher, L. (2008). Cognitive aging and increased distractibility: Costs and potential benefits. In W. S. Sossin, J. C. Lacaille, V. F. Castellucci, & S. Belleville (Eds.), *Progress in brain research* (Vol. 169, pp. 353–363. Amsterdam, Netherlands: Elsevier

Healey, M. K., Hasher, L., & Campbell, K. L. (2013). The role of suppression in resolving interference: Evidence for an age-related deficit. *Psychology and Aging, 28*(3), 721–728. doi: 10.1037/a0033003

Healey, M. K., Ngo, K. W. J., & Hasher, L. (2014). Below-baseline suppression of competitors during interference resolution by younger but not older adults. *Psychological Science, 25*, 145–151. doi: 10.1177/0956797613501169

Ikier, S., Yang, L., & Hasher, L. (2008). Implicit proactive interference, age, and automatic versus controlled retrieval strategies. *Psychological Science, 19*(5), 456–461. doi: 10.1111/j.1467-9280.2008.02109.x

Kane, M. J., & Hasher, L. (1995). Interference. In G. Maddox (Ed.), *Encyclopedia of aging* (2nd ed., pp. 514–516). New York, NY: Springer.

Kausler, D. H. (1970). Retention–forgetting as a nomological network for developmental research. In L. R. Goulet & P. B. Baltes (Eds.), *Life-span developmental psychology: Research and theory* (pp. 305–353). New York, NY: Academic Press.

Kausler, D. H. (1994). *Learning and memory in normal aging*. San Diego, CA: Academic Press.

Levine, B., Svoboda, E., Hay, J. F., Winocur, G., & Moscovitch, M. (2002). Aging and autobiographical memory: Dissociating episodic from semantic retrieval. *Psychology and Aging, 17*(4), 677–689. doi: 10.1037/0882-7974.17.4.677

Ludwig, C., Borella, E., Tettamanti, M., & De Ribaupierre, A. (2010). Adult age differences in the color Stroop test: A comparison between an item-by-item and a blocked version. *Archives of Gerontology and Geriatrics, 51*(2), 135–142. doi: 10.1016/j.archger.2009.09.040

May, C. P. (1999). Synchrony effects in cognition: The costs and a benefit. *Psychonomic Bulletin & Review, 6*(1), 142–147. doi: 10.3758/BF03210822

May, C. P., & Hasher, L. (1998). Synchrony effects in inhibitory control over thought and action. *Journal of Experimental Psychology: Human Perception and Performance, 24*(2), 363–379.

May, C. P., Hasher, L., & Kane, M. J. (1999). The role of interference in memory span. *Memory & Cognition, 27*, 759–767.

Newson, R. S., & Kemps, E. B. (2006). The nature of subjective cognitive complaints of older adults. *International Journal of Aging Human Development, 63*(2), 139–151. doi: 10.2190/1EAP-FE20-PDWY-M6P1

Norman, K. A., & O'Reilly, R. C. (2003). Modeling hippocampal and neocortical contributions to recognition memory: A complementary learning systems approach. *Psychological Review, 110*, 611–646. doi: 10.1037/0033-295X.110.4.611

Ortega, A., Gómez-Ariza, C. J., Román, P., & Bajo, M. T. (2012). Memory inhibition, aging, and the

executive deficit hypothesis. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 38*(1), 178–186. doi: 10.1037/a0024510

Porter, G., Wright, A., Tales, A., & Gilchrist, I. D. (2012). Stimulus onsets and distraction in younger and older adults. *Psychology and Aging, 27*(4), 1111–1119. doi: 10.1037/a0028486

Radvansky, G. A., Zacks, R. T., & Hasher, L. (2005). Age and inhibition: The retrieval of situation models. *Journals of Gerontology Series B: Psychological Sciences & Social Sciences, 60*(5), P276–P278. doi:10.1093/geronb/60.5.P276

Rowe, G., Hasher, L., & Turcotte, J. (2008). Age differences in visuospatial working memory. *Psychology and Aging, 23*(1), 79–84. doi: 10.1037/0882-7974.23.1.79

St. Jacques, P. L., Rubin, D. C., & Cabeza, R. (2012). Age-related effects on the neural correlates of autobiographical memory retrieval. *Neurobiology of Aging, 33*(7), 1298– 1310. doi: 10.1016/j.neurobiolaging.2010.11.007

Underwood, B. J., & Postman, L. (1960). Extra-experimental sources of interference in forgetting. *Psychological Review, 67*(2), 73–95. doi: 10.1037/h0041865

Vallesi, A. (2011). Targets and non-targets in the aging brain: A go/nogo event-related potential study. *Neuroscience Letters, 487*(3), 313–317. doi: 10.1016/j.neulet.2010.10.046

Verhaeghen, P., & De Meersman, L. (1998). Aging and the Stroop effect: A meta-analysis. *Psychology and Aging, 13*(1), 120–126. doi: 10.1037/0882-7974.13.1.120

Winocur, G., & Moscovitch, M. (1983). Paired-associate learning in institutionalized and noninstitutionalized old people: An analysis of interference and context effects. *Journal of Gerontology, 38*(4), 455–464. doi: 10.1093/geronj/38.4.455

Yassa, M. A., Lacy, J. W., Stark, S. M., Albert, M. S., Gallagher, M., & Stark, C. E. L. (2011). Pattern separation deficits associated with increased hippocampal ca3 and dentate gyrus activity in nondemented older adults. *Hippocampus, 21*(9), 968–979. doi: 10.1002/hipo.20808

Yassa, M. A., Mattfeld, A. T., Stark, S. M., & Stark, C. E. L. (2011). Age-related memory deficits linked to circuit-specific disruptions in the hippocampus. *Proceedings of the National Academy of Sciences of the United States of America, 108*(21), 8873–8878. doi: 10.1073/pnas.1101567108

Yassa, M. A., & Stark, C. E. L. (2011). Pattern separation in the hippocampus. *Trends In Neurosciences, 34*(10), 515–525. doi: 10.1016/j.tins.2011.06.006

Intergenerational and Family Ties of Baby Boomers

Barbara A. Mitchell
Simon Fraser University, Canada

Born between 1946 and 1965, the baby boom generation—comprising nearly 80 million people—constitutes the largest generational birth cohort in US history. Until 1946, birthrates had been steadily dropping and had declined since the turn of the century. Increased urbanization and modernization transformed American society, and American culture was increasingly characterized by individualization and the needs of a modern, industrial-based economy. Following World War II, a fertility surge coincided with rapid economic expansion and birthrates continued to increase throughout the 1950s. These rates remained high for nearly 20 years after 1945, suggesting that other causes than the end of the war were important.

The prosperous postwar economy was a major factor in creating the baby boom since it brought unprecedented growth in housing, education, transportation, and manufacturing. This produced a strong economy with high employment and allowed many families to rely on one breadwinner income and to form large, relatively stable families. Many were able to marry at relatively early ages, afford more children, and have children more tightly spaced.

The baby boomers are significant not only for their size but also for their unique characteristics. Generally, compared to their