Perception

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Glossary

Perceptual Span (also called Iconic Memory) – The amount of information that can be captured at a glance and held shortly in a sensory store.

Stimulus Persistence – The afterimage that stays in our mind after having perceived an object.

Introduction

As we know from everyday experience, the use of reading glasses or hearing aids is much more common among older adults than among young adults, adolescents, or children. From early to late adulthood and into advanced old age, sensory functions and perceptual abilities show marked and accelerating decline. Perceptual declines are observed across all modalities, such as vision, hearing, touch, smell, and taste, and they progress in close interaction with age-associated changes in cognition. In light of the steady increase in life expectancy in most developed countries, a thorough understanding of senescent changes in perception is needed in order to prepare for interventions aiming at postponing or at least at attenuating their adverse effects on everyday competence.

Aging is not a unitary process but is systemic and differential in nature. Variations between and within individuals reflect interactions among factors that are biological (e.g., genetic and neuronal), environmental (e.g., support structures), and experiential (e.g., compensatory strategies and expertise). Perceptual processes connect the faculties of the mind with the external world by representing environmental stimulations transmitted through the sensory systems (e.g., bottom-up processes) in the context of higher-order cognitive operations that involve attentional control and working memory (e.g., top-down processes). Thus, the aging of perception is a complex product of age-related negative changes in both sensory and cognitive mechanisms. Accordingly, research on perception in old age requires the empirical and conceptual integration of bottom-up and top-down processes at different levels of analysis (e.g., behavioral and neuronal; sensory, perceptual, and cognitive).

This article begins by summarizing findings on sensory decline, with an emphasis on vision, hearing, and balance control. Next, it reviews the ways in which sensory changes relate to cognitive functioning in the elderly. Finally, it discusses possible mechanisms that contribute to couplings among sensory, perceptual, and cognitive declines.

Perceptual Changes in Adulthood and Old Age: A Summary

Age-related alterations are found for all senses and at all levels of processing, from changes in the retina of the eye or the cochlea of the inner ear to changes in higher cortical sensory processing areas and related perceptual phenomena. This section selectively focuses on two primary modalities – vision and hearing – and modally complex sensorimotor functions (e.g., postural control and gait).

Vision

Various aspects of the visual system deteriorate throughout the adult life span, and numerous factors contribute to this decline. The lenses, for example, become harder, denser, and more opaque, thereby increasing the scattering of light and blurring retinal images. The iris becomes less motile so that the pupil becomes smaller. In addition, the number of receptor cells on the retina also declines. This loss is more pronounced for rods than for cones, contributing to greater age-related decline in peripheral than in central vision.

At a more perceptual level of analysis, aging has negative effects on basically any aspect of visual processing. Close and distant visual acuities, for example, decline with age. After approximately age 30, the ability to resolve images into their smallest details decreases. This loss in acuity is less pronounced for large, bright, and high-contrast stimuli, and it can be corrected, to some extent, by wearing glasses or other corrective lenses. However, even with optimal optical correction, older adults continue to resolve less detail than young adults. Depth perception decreases with age, and cases of stereoblindness increase after age 75. Accommodation and light sensitivity also change with age. Young adults adapt faster to darkness and perceive stimuli much more precisely in situations of little luminance. Young adults can, for example, continue reading a book during dusk, when older adults would need to switch on a light.

Peripheral vision, or the ability to detect objects in the periphery of the visual field, deteriorates with

age, in part reflecting reductions in photoreceptor density. The scotopic rods on the periphery degenerate earlier than the photopic cones in the fovea. The resulting reductions in peripheral vision compromise everyday activities such as driving, for which stimuli in the periphery, such as a car approaching a street crossing, need to be detected in time. Motion discrimination is reduced in old age, especially among women, again with marked consequences for everyday life. For example, one must be able to estimate how long it will take an approaching car to come closer in order to decide whether to cross the street or to let the car drive by first.

Stimulus persistence, which refers to the afterimage that stays in our mind after having perceived an object, is increased in the elderly. Shorter afterimages permit faster perception of new stimuli. Stimulus persistence is assessed by the critical flicker fusion threshold, which refers to the stimulus frequencies above which flickering lights are perceived as a persistent light. This threshold decreases with advancing age, indicating reductions in the temporal resolution of visual processing. Bright and high-contrast stimuli leave a shorter afterimage and result in smaller adult age differences in stimulus persistence than less-bright and low-contrast stimuli.

Perceptual span, or iconic memory, refers to the amount of information that can be captured at a glance and held shortly in a sensory store. Young adults typically capture about nine letters of an array, and this number decreases with age. Relatedly, the area of the visual field that individuals can capture accurately at one glance, the useful field of view (UFOV), is about three times larger in young adults than in older adults. Because older adults perceive smaller chunks of an image than young adults, they also have greater difficulties in recognizing ambiguous figures.

This description of age changes in visual perception is exemplary rather than exhaustive. For instance, color discrimination and the accuracy of eye movements (e.g., saccadic accuracy) also deteriorate with age, whereas color constancy, or the ability to identify colors under different lighting conditions, remains relatively intact (*see* Vision). As a result of all these interacting sensory and perceptual changes, less and noisier information reaches the visual cortex. In conjunction with other neuroanatomical and neurochemical changes, this altered input is associated with marked age differences in brain activation patterns during visual processing. There are two main visual pathways: the ventral pathway follows occipitotemporal connections and codes for object information, whereas the dorsal pathway proceeds via occipitoparietal connections and primarily codes for information about the location or specific nature of objects. Probably in part due to aging losses in sensory and low-level perceptual aspects of vision, the specificity of brain activation in the ventral pathway coding different categories of object stimuli (e.g., faces or objects) is reduced, and task-related differences between ventral and dorsal visual processing pathways are less pronounced.

Age-related changes in visual sensation and perception impinge upon older adults' performance in perceptual and cognitive tasks that depend on processing of visual information. Some of the relevant processes include visual search, feature detection, identification of individual characters (e.g., letters or digits), and object recognition. On the one hand, declines in these basic perceptual-cognitive processes limit higher-order cognition such as perceptual and semantic binding of episodic memory traces, decision making, and response selection. On the other hand, decrements in cognitive mechanisms, such as working memory and selective attention, also influence early stages of visual processing. Perceptual processing in the elderly is particularly compromised when prior knowledge of the task environment is low, be it in everyday life or during experimentally controlled laboratory conditions.

Compromised visual abilities have negative effects on everyday competence. For instance, visual deficits increase the likelihood of risky driving behaviors. Reading and writing abilities can also be affected, which may increase the need for the help of others in filling out forms, reading street signs, and the like. Age-related visual decline also narrows the range of options for entertainment (e.g., watching a movie) and information gathering (e.g., reading a newspaper). To some extent, these negative effects of visual aging can be attenuated by wearing corrective lenses (e.g., glasses) or compensated for by relying more heavily on other senses, such as hearing, and the help of others. Note, however, that very old individuals tend to have multiple sensory impairments, which restricts the opportunity for cross-modal integration.

On the positive side, the ontogeny of the visual system is not just a story of losses, primarily because older individuals have acquired and stored a vast amount of experience with visual perceptual tasks in the course of their lives. This general experience with the visual world, as well as individuals' idiosyncratic, person-specific expertise in processing visual patterns, modulates and sometimes attenuates declines in processing. For instance, young and older adults have been found to be equally proficient in searching for traffic signs in digitized images of real-world traffic scenes, which is remarkable in light of the losses summarized previously. Most likely, everyday life situations often provide cues such as texture and other contextual information that help older adults identify images that they would find difficult to identify without such context.

In everyday life, then, the behavioral consequences of senescent changes in visual processing at sensory, perceptual, and cognitive levels can be attenuated by the accumulation of task-relevant experience and general visual world knowledge, pointing to the need to consider interactions among top-down experiential factors (e.g., professional expertise), top-down cognitive mechanisms (e.g., selective attention), and bottom-up sensory processes (e.g., contrast sensitivity). It follows that age trends in visual processing observed with decontextualized materials in experimental settings may overestimate the extent of functional decline observed under more naturalistic task conditions. At the same time, careful assessment and possibly control of age differences in visual sensory processing are required to capture and examine the additive and interactive contributions of sensory and cognitive mechanisms to the aging of visual perception. Furthermore, in geriatric assessment, for example, when screening for Alzheimer's disease, one should be aware that decline in visual processing as well as in other sensory systems may affect the specificity and sensitivity of diagnostic procedures.

Hearing

Auditory perception also declines with advancing age. Hearing losses become noticeable at around age 30 for men and age 50 for women, possibly as a result of differential exposure to environmental noise, such as noise associated with the operation of heavy equipment. Losses are most pronounced for high-frequency tones and accelerate with age. Similar to visual perception, age-related changes in the auditory system occur at all levels of processing. In the cochlea, loss of basilar membrane hair cells and reduced neural transmission are observed. Furthermore, the cochlear wall becomes thinner. The number of neurons in the auditory nerve decreases, along with structural, functional, and chemical alterations of early auditory processing pathways. In part as a consequence of these sensory changes, the representation of sounds in the auditory cortex differs markedly by age.

Many aspects of hearing are affected by age. Hearing thresholds show a marked increase with age. Reduced hearing sensitivity at high frequencies is a good predictor for general hearing loss. Hearing loss affects psychoacoustic dimensions such as frequency discrimination (e.g., deciding whether two tones have the same pitch or not), intensity discrimination (e.g., discriminating loudness), and temporal processing. One way to measure temporal aspects of auditory processing is to assess the ability to detect gaps in a stream of auditory stimuli. Similar to critical flicker fusion in the visual modality, older adults are unable to detect short gaps between auditory stimuli that young adults notice easily, especially when the stimuli are complex. Another aspect of temporal auditory processing refers to duration discrimination, or the ability to notice differences between the lengths of two tones. Again, this ability is compromised in old age, especially with complex auditory stimuli. Finally, temporal processing also includes the ability to encode and represent the order of a tone sequence. Older adults show more difficulty than young adults in making such order discriminations. Many other aspects of hearing are also affected by age. One important example is spatial hearing or the sound localization from binaural cues (*see* Hearing).

In concert with other changes in auditory perception, age-based changes in temporal aspects of auditory processing have profound effects on speech comprehension. The increasing inability of elderly people to understand speech is by far the most important everyday implication of age-related auditory decline. Whereas speech perception is at least mildly impaired in half of the 70-to-80-year-olds, two-thirds of 80- to 90-year-olds are moderately to severely impaired, and two-thirds of individuals older than 90 years of age have moderate to severe problems in understanding speech. Difficulties in speech perception are exaggerated when background noise is high, when speech is speeded up, when many people take part in the conversation, or when the topic of conversation is complex. Again, declines in speech perception are best understood as an interaction of sensory changes (e.g., basilar membrane hair cell loss) and cognitive changes (e.g., decreasing working memory capacity). Speech is important for maintaining social contact with others. Hence, problems in understanding speech caused by declines of the auditory system can have far-reaching effects on participation in social life and psychological well-being (*see* Social Cognition). In terms of remediation in applied settings, older people's deficits in speech perception can be attenuated by providing contextual cues (e.g., explicitly naming and introducing the topic to be talked about), lowering the speed of speech production, and using well-adjusted hearing aids.

Posture Control and Gait

As a hybrid, multimodal sensorimotor function, keeping balance while standing or walking requires online dynamic integrations of the visual, auditory, vestibular, and proprioceptive senses. All of these senses decline with advancing adult age. The standard apparatus used for assessing individuals' postural control ability is the force platform, which measures ground reaction forces and momentums of the displacements of the body's center of balance. In general, older adults sway more than young adults, particularly when the conditions of keeping balance are made more challenging (e.g., standing on a non-stable surface, receiving conflicting visual and proprioceptive sensory information, or performing a difficult concurrent cognitive task). Age-related loss of postural stability also affects gait. Walking requires not only the integration and updating of sensory and proprioceptive information, but also the execution of motor commands that are being sent to the trunk and leg muscles. Aging adversely affects all these stages of the postural control and gait system, which leads to increased demands of cognitive control for gait in the elderly.

In part, aging-related declines in postural and gait control are attributable to declines in vestibular, peripheral sensory, and muscular systems. In addition, senescent changes in several brain areas such as the cerebellum, basal ganglia, sensory motor cortex, and brain stem, as well as the parietal cortex, a brain region involved in the neural representation of the body in space, and preparatory motor attention play a role.

Similar to vision and hearing, declines in balance and gait have profound effects on older adults' everyday competence. Losing balance increases the risk for falls, which often lead to physical injuries (e.g., femur and hip fractures), with long-lasting and often irreversible effects on mobility, health, social participation, and personal well-being. Compromised balance and gait also hinder participation in social activities such as visiting relatives and friends or participating in reading clubs, thereby increasing the risk of feeling lonely and isolated. Also, the fear of falling may foster more generalized feelings of insecurity.

Various strands of research explore ways of attenuating age-related declines in balance and gait. In addition to the use of walking aids, applied bioengineering research has made use of the phenomenon of stochastic resonance, which refers to the improved detection of subthreshold signals through admixture of optimal levels of input noise to the sensory and perceptual systems. For instance, it has been shown that older adults' postural control can be improved by vibrating insoles that provide appropriate levels of subliminal proprioceptive stimulation. Related research aims at strengthening the small muscles of the joints, which are particularly relevant for maintaining balance.

Most research on perceptual aging has examined visual or auditory modalities, but performance in other sensory modalities is known to decline as well. As pointed out earlier, sensorimotor functions such as postural control and gait are among them. Other examples are olfactory and tactile information processing, with noticeable decline in middle adulthood. Furthermore, multivariate research on individual differences in perceptual aging has found that perceptual declines tend to correlate across modalities. For instance, declines in visual processing contribute to difficulties in maintaining an upright stance under challenging conditions. In addition to direct causal relations among declines in different perceptual or sensory functions, available evidence suggests that decline in top-down cognitive functions acts as a third variable that contributes to perceptual and sensory decline across a wide range of modalities.

The Link between Perception and Cognition in Old Age

The aging of perceptual abilities is embedded into sensory and cognitive changes (see **Figure 1**). Even though some aspects of intellectual functioning, such as practical and professional knowledge, are maintained or even show gains throughout adulthood and early old age, other intellectual abilities, especially those related to the fluid mechanics (e.g., processing speed, working memory, episodic memory, and reasoning), start to decline in young or middle adulthood and accelerate their decline in old and very old age.

Converging evidence from correlational and experimental studies points to an increasingly strong connection between sensory and cognitive functioning with advancing adult age. Correlations between measures of sensory functions and measures of intelligence are stronger in samples of older adults than in samples of younger adults. For instance, in one cross-sectional age-comparative study, it was found that the variance in cognitive performance shared with vision, hearing, or both was considerably larger in the older age group (see **Figure 2**). This strengthening of the connection between sensory and cognitive domains of functioning is not restricted to vision and hearing. Posture control and gait, tactile information processing, and indicators of general somatic health also are more strongly associated with measures of intellectual functioning in old age than in adulthood.

Initially, multivariate empirical evidence on cognitive-sensory correlations was based primarily on

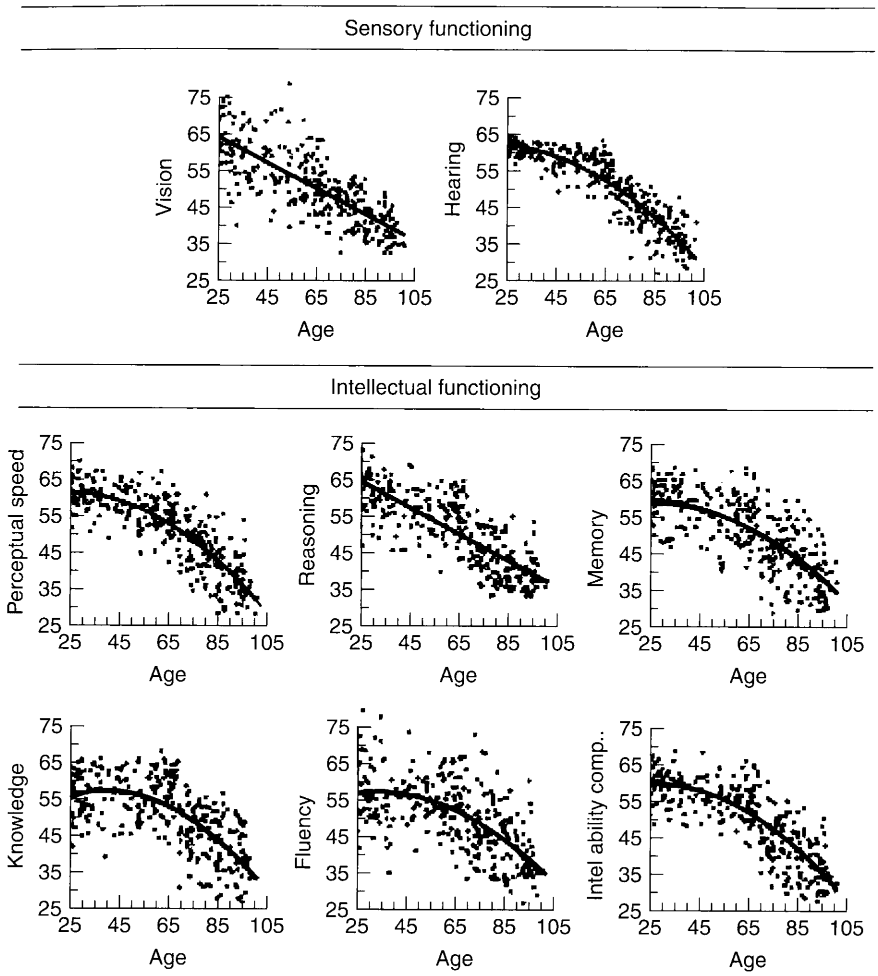

Figure 1 Cross-sectional age gradients for vision, hearing, five intellectual abilities, and the intellectual ability composite ($N = 315$, age range = 25–101 years). With respect to vision and reasoning, quadratic age trends did not differ significantly from zero ($P > 0.01$). Intel. Ability Comp., intellectual ability composite. Reproduced with permission from Baltes PB and Lindenberger U (1997) *Psychology and Aging* 12: 12–21, American Psychological Association.

age-comparative cross-sectional data, which have a number of methodological shortcomings. More recent longitudinal studies report similar, though less extreme, increments in correlations between sensory and intellectual measures. Recent analyses of longitudinal data provide more direct support for dynamic couplings between sensory and cognitive changes in old age. Applying the multivariate dual-change score models (DCSMs) developed by McArdle and colleagues to 8-year, four-occasion longitudinal change data from the Berlin Aging Study, Ghisletta and Lindenberger found that changes in vision and changes in cognition are linked to each other over time by directed effects in either direction. However, other recent analyses of multivariate longitudinal data fail to support dedifferentiation. These discrepancies may be due to measurement issues, the contribution of short-term fluctuations to longitudinal change, and sample heterogeneity. With respect to the latter, sensory/perceptual and cognitive functions may dedifferentiate in some but not all older adults.

Experimental evidence suggests that cognitive involvement in sensory and sensorimotor functions increases with adult age. A common methodological approach is a variant of the dual-task paradigm in which individuals are asked to perform a sensorimotor task (e.g., balancing, walking, or spatial navigation) while performing a cognitive task (memorizing, speech perception or production, or simple decision making) at the same time. Typically, sensorimotor-cognitive dual-task costs increase from early to late adulthood, pointing to greater online interdependence between sensorimotor and cognitive domains of functioning. For instance, in one study, young, middle-aged, and older adults were asked to memorize words while walking on a narrow track. In both task domains, dual-task costs increased with age (for memory performance, see **Figure** 3). Follow-up studies

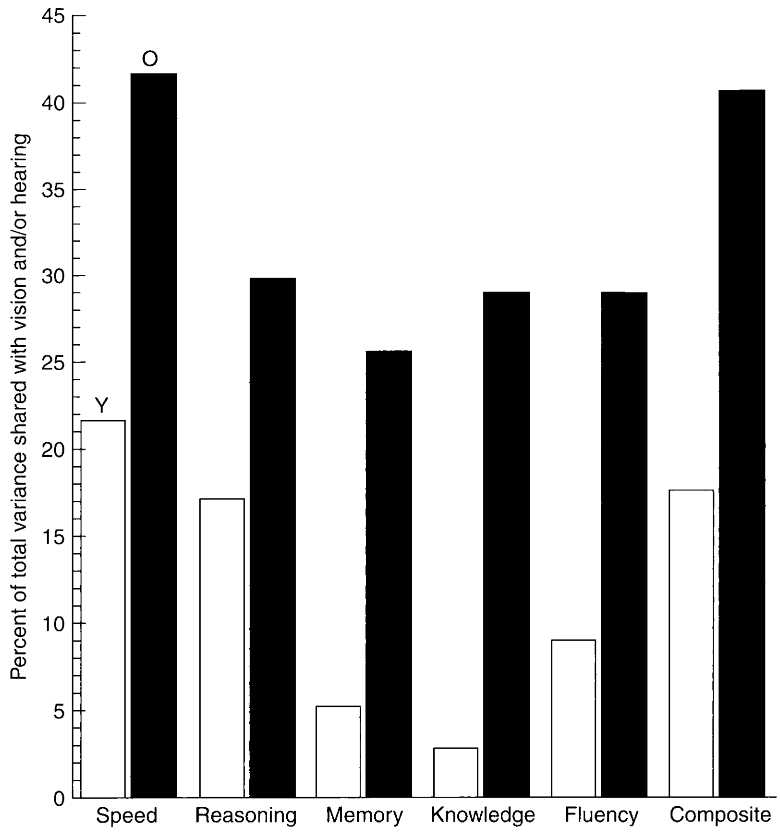

Figure 2 Amount of total variance in intellectual functioning accounted for by vision and hearing in two age groups. Bars represent the amount of total variance predicted by the main effects of vision and hearing. White bars refer to the younger (Y) sample ($N = 171$, age range = 25–69 years), and black bars to the old age (O) sample ($N = 516$, age range = 70–103 years). Except for reasoning, differences in predicted variance were significant at the 0.01 level. Reproduced with permission from Baltes PB and Lindenberger U (1997) *Psychology and Aging* 12: 12–21, American Psychological Association.

found that older individuals tend to prioritize walking as the walking tasks become increasingly difficult, presumably reflecting the adverse consequences of falling.

The finding of increasing couplings between sensory, sensorimotor, and cognitive performance has motivated researchers to design technological support structures such as hearing aids to reduce the cognitive resource load of across-domain multitasking, which is common in daily life (e.g., rehearsing a shopping list while walking on a slippery path).

Perception at the Interface of Sensory and Cognitive Aging: The Search for Systemic Explanations

Three different but not mutually exclusive explanations have been proposed for the increased coupling (dedifferentiation) of sensory and cognitive functions. First, according to the notion of sensory biomarkers, declining sensory abilities represent the first and most valid signs of behavioral and brain aging in general. Second, according to the cognitive permeation hypothesis, sensory and sensorimotor functions are increasingly in need of attentional and related cognitive resources, which themselves are declining, to attenuate the adverse consequences of sensory and sensorimotor losses. Third, according to the common-cause hypothesis, the etiologies of senescent changes overlap across sensory, sensorimotor, and cognitive domains, and this overlap in causal factors imposes increasingly severe and common constraints on sensory, sensorimotor, and cognitive aspects of behavior.

Within the sensory biomarker approach, proponents of the cascade hypothesis state that age-related losses in sensory functions temporally precede and possibly cause age-related losses in cognitive performance. More specifically, the sensory deprivation hypothesis suggests that declining sensory systems result in chronically impoverished sensory inputs, which over time alter the processing interactions between sensory and cognitive processes.

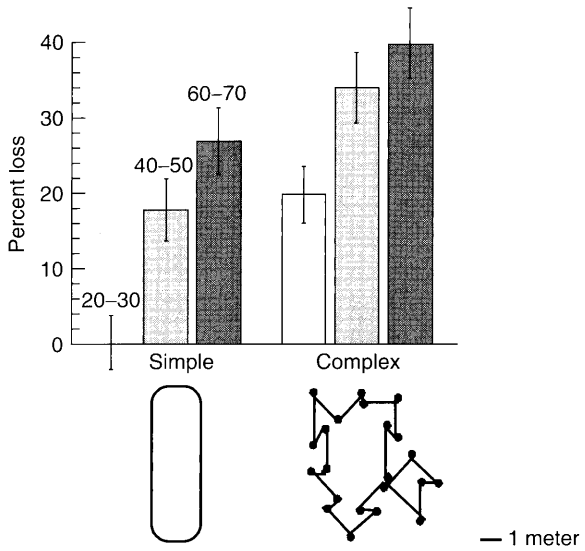

Figure 3 Dual-task costs in memory performance as a function of track and age group. Cost scores refer to the percentage of loss in serial word recall with the method of loci under walking encoding conditions (oval vs. aperiodic track) relative to the average of seated and standing encoding conditions. Middle-aged and old adults showed significantly higher costs than young adults. Error bars represent standard errors of the mean. Schematic drawings of the oval and aperiodic walking tracks are shown underneath. Error bars represent 95% confidence intervals. Adapted from Lindenberger U *et al.* (2000) *Psychology and Aging* 15: 417–436.

According to the cognitive permeation hypothesis, older adults need to invest more attentional resources into sensory and perceptual aspects of stimulus processing and sensorimotor control, which leaves less room for further cognitive processing of the same or some other concurrently executed task. Thus, sensory and sensorimotor tasks or task components that are processed in a largely automatic fashion by specialized sensory and perceptual mechanisms in younger adults are converted into cognitively demanding tasks in their own right with advancing age.

Proponents of the common-cause hypothesis underscore that the aging brain is marked by senescent changes at anatomic, chemical, and functional levels of analysis and that some of these changes have domain-general consequences that transcend the conventional boundaries between sensation, perception, and cognition. The volumes and densities of gray and white matter decline in many brain regions of the brain, though at different rates. For instance, the rate of shrinkage has been found to be larger in the prefrontal cortex and the hippocampus than in other cortical and subcortical regions. Other senescent changes include neuronal loss, loss of dendritic density, and deficient neuromodulation. Sensation, perception, and cognition depend on functional neural circuitries that overlap and interact in space and time. For instance, prefrontal circuitry is involved in attentional control during cognitive tasks and also plays an increasing role in the top-down regulation of seemingly simple sensorimotor tasks. Moreover, certain pathological alterations, such as changes in the basal ganglia and the substantia nigra in Parkinson's disease, are known to affect both cognitive (e.g., working memory) (*see* Intelligence; Memory) and sensorimotor (e.g., tremor) aspects of behavior. Milder forms of these alterations are also present in normal aging. Specifically, decrements in dopamine receptor density result in substantial changes in dopaminergic neuromodulation and related frontostriatal circuitries, with presumably widespread consequences on behavior.

Empirical support for the common-cause hypothesis can be found at different levels of analysis. The majority of findings from cross-sectional as well as longitudinal studies point to a dedifferentiation of ability structures within and across domains of functioning. Similarly, cortical activation patterns become more diffuse with advancing age, and the cortical circuitries activated during performance on different cognitive and perceptual tasks tend to show greater overlap (i.e., less specificity) in older adults than in young adults. These results can be interpreted in terms of age-associated decrements in the signal-to-noise ratio of neural processing. Li, Lindenberger, and colleagues have proposed that aging-related declines in dopaminergic neuromodulation decrease the signal-to-noise ratio of neural information processing, which in turn increases the relative contribution of random processing noise, resulting in less distinctive neurocognitive representations of environmental inputs and dedifferentiated processing pathways.

For instance, neurocomputational modeling suggests that suboptimal dopaminergic neuromodulation in simulated old neural networks reduces the activation intensity and increases stochastic activation variability in response to perceptual stimuli embedded in background sensory noise. More recent simulations of sensory detection demonstrated that both simulated young and simulated old neural networks exhibit the fundamental phenomenon of stochastic resonance, although the magnitude of the effect is smaller in old networks. Moreover, in line with recent empirical evidence, older networks actually needed more external noise to show the stochastic resonance effect.

As for the effect of dedifferentiation, computational results also indicate that suboptimal neuromodulation results in less distinctive neurocognitive representations of different stimuli or stimulus categories, as well as a greater amount of cross-process coactivation between, for instance, verbal and spatial processes. These computational effects on stimulus dedifferentiation and process coactivation are in line with at least two lines of empirical inquiry. First, with respect to stimulus dedifferentiation, Park and colleagues examined young and older adults' brain activation patterns while perceiving visual stimuli of faces, scenes, objects, and pseudo-words. Previous research with young adults has found that faces activate an area in the temporal cortex (i.e., the fusiform face area), whereas houses and scenes activate an area in the parietal cortex (i.e., the parahippocampal place area). The results of the study by Park *et al.* show that activation patterns were less category specific in older adults than in young adults, which is consistent with the assumption of more diffuse, or less distinct, neuronal representations in the aging brain. According to a rival explanation, the elderly activate more brain areas in order to compensate for age-related losses.

Second, studies on neurocognitive aging have shown that different processes such as verbal versus spatial working memory or memory encoding versus retrieval operations, both of which involve relatively distinct functional cortical regions in young adults, tend to activate more and more similar cortical regions in older adults. Again, it is unclear whether additional activation reflects the inability to suppress competing neuronal groups and to process information in distinct ways (e.g., dedifferentiation), whether additional activation reflects compensatory recruitment of neural circuitry to compensate for aging-related losses (e.g., compensation), or whether it reflects a mixture of both dedifferentiation and compensation.

In summary, normal aging alters perceptual processing through more than one developmental pathway. Some of the causes underlying sensory, perceptual, and cognitive declines are likely to be shared. Also, after critical periods of perceptual development have been completed, reduced sensory input in itself does not seem to exert immediate and widespread negative effects upon cognitive ability. For instance, middle-aged adults whose effective acuity of visual and auditory input was reduced to levels normally observed among older adults did not show generalized decrements in cognitive performance. Also, sensory-cognitive correlations observed in cross-sectional studies are not markedly lowered when individuals with very poor vision or hearing are excluded from the analysis.

Common cause, sensory deprivation, and cognitive permeation are not mutually exclusive explanations of the connections between sensory, perceptual, and cognitive aging. Rather, the mechanisms underlying these explanations may co-evolve and interact during the transition from early to late adulthood and old age. It also is worth noting that some functions such as selective attention remain relatively intact in old age. The various explanatory accounts converge upon the prediction that such functions are less complex, more dependent in acquired knowledge, or both. At a more detailed level of analysis, however, explanations may differ. For instance, according to the common-cause hypothesis, functions are likely to be spared when they are less dependent on the shared common influence. According to the cognitive permeation hypothesis, perceptual functions are more likely to be spared when they show less of an age-related increase in the dependence on top-down processing. Future research needs to discern the ontogenetic dynamics and relative importance of the relevant mechanisms associated with these different explanatory accounts.

Conclusion

Perception involves a multitude of interacting sensory and cognitive mechanisms. Normal aging affects all senses, with marked declines in visual and auditory processing. Multimodal mechanisms of posture control and gait also become less efficient with age. Empirical evidence suggests that sensation and cognition become increasingly intertwined with advancing age. Progress in understanding perceptual aging, with the goal of effectively attenuating its adverse consequences on everyday competence, requires an explicit focus on dynamic interactions between age changes in bottom-up sensory and top-down cognitive processes.

See also: Balance, Posture and Gait; Hearing; Intelligence; Memory; Social Cognition; Vision.

Further Reading

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