11
Age and Functioning in the Legal System: Victims, Witnesses, and Jurors

11.1 Objectives and Organization of the Chapter ..........11-1
11.2 Sources of Age-Related Declines in Cognitive Functioning .................................................11-2
   The Aging Brain • Perception and the Aging Senses • Working Memory • Inhibitory Functions • Stereotype Vulnerability, Stereotype Threat, and Enactment of Age-Stereotyped Behaviors
11.3 Applications to Aging Victims and Witnesses ..........11-16
   Problems of Perception • Problems of Attention and Encoding • Bias in Interpretation • Failure of Retention • Accuracy of Retrieval
11.4 Age-Related Judgment and Decision-Making Processes in Jurors .............................................11-28
   Age-Related Differences in Information Processing • Age-Related Differences in Judgment/Decision Processes • Summary
11.5 Overall Conclusions .................................................11-35
11.6 Checklist: Relationship among Underlying Causes, Effects on Cognitive Processing, and Consequences for Victims, Witnesses, and Jurors .................11-35

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11.1 Objectives and Organization of the Chapter

As the population of elderly citizens continues to increase in the United States, greater numbers of older adults will become victims of crimes and later report their experiences to police, attorneys, and juries, and perhaps attempt to identify the perpetrators (National Institute on Aging, 1996). In fact, already we know that roughly 2 million elderly individuals become victims of crime each year (U.S. Bureau of Justice Statistics, 2002). Likewise, older Americans will become disproportionately represented among accident victims, witnesses in civil and criminal trials, and juries. Thus, aging has an impact upon the legal system
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in myriad ways, from its role in generating situations subsequently litigated in the courts, to the vagaries of memory among aging witnesses, to the role of age in juror judgments.

To provide context for understanding age-related declines in cognitive functioning, we begin this chapter with a brief review of changes in the brain and their consequences for basic mechanisms of cognitive processing. Subsequently, we consider specific age-related deficits in cognitive functioning that (1) cause or contribute to incidents generating torts; (2) impair accuracy of testimony regarding these incidents; and (3) affect jurors' processing of evidence and, thus, verdicts.

### 11.2 Sources of Age-Related Declines in Cognitive Functioning

#### The Aging Brain

Modern cognitive neuroscience has begun to identify changes in the brain that in turn appear to cause changes in fundamental cognitive processes such as information processing, memory, performance, and judgment (for reviews of the following, see Glisky, 2001; Grady, 2001; Raz, 2000; Reuter-Lorenz, 2000; Schacter, 1996; and the special 2002 issue of *Neuroscience & Biobehavioral Reviews* Vol. 6, Issue 7, on the aging brain). Structurally, for example, there is widespread shrinkage of brain matter volume (and thus enhanced volume of cerebrospinal fluid) stemming from such underlying causes as shrinkage of the brain tissue, cell loss in some regions, and reduced dendritic branching. Enhanced atrophy is one of the hallmarks of Alzheimer's disease, but is also characteristic of older adults without such a diagnosis. Atrophy is also greater in those with high blood pressure or declining diastolic blood pressure (de Heijer et al., 2003).

Brain mass steadily shrinks after the 50s at the rate of roughly 5 to 10% per decade, and brain volume is related to cognitive performance and dementia (Anstey and Maller, 2003; Mingus et al., 2002; Pantel et al., 2003; Scailhill et al., 2003; Sullivan and Ruffinan, 2004). Indeed, those who begin with smaller volume (i.e., smaller head circumference) and have less education are four times as likely to suffer dementia as others (Mortimer et al., 2003). Perhaps related to atrophy of tissues and cell volume, brain metabolism also changes so that cerebral blood volume and flow and cerebral metabolic rate of oxygen utilization decline. Age is negatively related to cerebral blood flow, which in turn predicts memory performance (Santens et al., 2003).

Neuropathology also tends to escalate with age. A yellowish-brown lipid lipofuscin, called "wear and tear pigment," accumulates in cells throughout the cerebellum and cerebral cortex, typically accompanied by decrease in myelination of nerve axons and increased numbers of vascular lesions. In Alzheimer's patients, the brain accumulates neuritic amyloid plaques and tau protein tangles, which hamper neuronal function and eventually kill the cells. The extent of these plaques and tangles in neural tissue (although the extent of tau tangles is more predictive), combined with the number of areas of the brain in which they are present and the presence of stroke damage, directly predicts cognitive symptoms (Schneider et al., 2003; Snowdon, 2001; Guillotzet et al., 2003).

Neuronal communication is impaired by reduced dendritic branching and demyelination of axons (Bartozikos, 2004), as well as decline in neurotransmitters such as dopamine (which contributes to frontal lobe functions) and acetylcholine (which plays a role in learning and memory). One of the most prominent changes in the white matter of the brain (myelinated axons connecting nerve cells) is known as *white matter hyperintensities* (WMHs), which can be observed in MR images (or called *leukoaraiosis* when seen on CT scans). These WMH changes are assumed to reflect damage from vascular as well as neuronal causes and, particularly in some regions, they predict cognitive impairment (Bigler et al., 2003; Deary et al., 2003; de Groot et al., 2000). The effects of these abnormalities can be attenuated in those with greater education, however (Dufouil et al., 2003).

The preceding changes in brain structure and pathology are not uniformly distributed throughout the brain. Some structures atrophy at greater rates, such as the hippocampal formation; the frontal, temporal, and parietal convolutions; and the parasagittal region, whereas others, such as the occipital lobe, remain relatively spared. Changes in neuropathology are also somewhat region specific. Given this situation, it is not surprising that consensus exists among cognitive-aging researchers that although mental processes...
generally slow and become less efficient — and thereby become, in some cases, less accurate — arenas exist in which performance is age invariant or even positively related to age (see reviews of age-related changes in a variety of cognitive processes in Craik and Salthouse, 2000; Salthouse, 2004; Verhaeghen and Salthouse, 1997).

Generally, memory researchers have found greater declines in memory tasks that require a great deal of self-initiated or effortful processing (such as complex reasoning) but age invariance on memory tasks that require less effortful processing (such as word recognition) (see reviews in Craik and Salthouse, 2000; Light, 1991; Park and Schwartz, 2000). Generally, speed of processing, reasoning, and episodic memory (memory for events) appear to decline most rapidly (Salthouse, 2004; Verhaeghen and Salthouse, 1997).

Selective decline in cognitive functioning appears to be related to selective decline in the brain. Unfortunately, some of the most vulnerable structures are also those most important for cognitive functioning. For example, the hippocampus (which contributes to formation and maintenance of memories) and the amygdala (considered particularly important for emotional memories) exhibit loss of number and volume of neurons, as well as synaptic loss. Medial-temporal dysfunction has been related to losses in long-term memory.

Furthermore, the frontal lobes, and particularly the prefrontal cortex, are widely thought to suffer decline sooner and more extensively than other regions. Losses in volume, cells, and blood flow are greater in frontal regions, and some evidence indicates selectively greater decline in neurotransmitters and myelin (see the review in Rabbitt et al., 2001). Frontal lobe function has been shown to predict performance on a variety of tests of memory, cognitive functioning, and executive functions such as planning, initiating, and carrying out goal-directed behaviors — and inhibition of inappropriate behaviors. Age-related deficits in frontal functioning are related to a variety of failures of perception, memory, and decision making in forensic contexts. These will be reviewed in subsequent sections.

Finally, the corpus callosum, which connects the various regions of the brain, suffers enhanced atrophy relative to some other regions of the brain, thus suggesting that it may be particularly susceptible to the effects of aging. Because a variety of processing and memory functions require communication between regions, dysfunction of the corpus callosum will contribute to age-related cognitive deficits. Indeed, age-related differences in processing efficiency have been shown to be greater for tasks requiring communication through the corpus callosum (see the review in Reuter-Lorenz, 2000). Indeed, some have argued that neural networks and larger systems of interconnected brain regions and the functional activity in these circuits may be generally more important than specific cortical regions in predicting cognitive functioning (Tisserand and Jolles, 2003) and that the frontal cortex may exert its effect upon executive functioning in combination with processes involving links between different brain regions (Andres, 2003).

Raz (2000) noted that the magnitude of dysfunction is related to the order of appearance of structures in mammalian history such that “last in is first out” (p. 37). Those that evolved in more ancient species and those that appear earlier in human development are less affected by age than those that evolved or appear later. Thus, structures such as the prefrontal cortex, which evolved last and is presumed to be the seat of the intelligence that separates humans from lower animals, suffers the earliest and greatest decline with age. Structures that evolved earlier, such as the pons or occipital cortex, suffer much less damage with age. It should be noted, however, that even though these regions maintain greater structural integrity, functioning may decline. For example, the primary visual cortex exhibits decline in sensitivity and increases in response time (Crognale et al., 2001).

In apparent response to increasing decline in structure and function, the brains of older adults appear to accomplish cognitive functions somewhat differently than those of younger adults, as indicated by brain imaging during task performance. Thus, the aging brain appears to compensate for changing physiology and structure by rerouting or reorganizing functions, sometimes recruiting more of the brain to accomplish tasks that, in younger years, required fewer regions.

The multitude of changes in the underlying structure, neuropathology, and function of the brain are presumed to cause changes in four general cognitive mechanisms widely considered responsible for age-related declines in a wide range of specific cognitive tasks. These are (1) sensory function, (2) speed of information processing, (3) working memory functioning, and (4) inhibitory processes. Each of these
is conceptualized as a form of “cognitive resource” or “processing resource,” with the combination viewed by some as the best index of overall cognitive resources (Salthouse, 1991). The nature of these changes is reviewed in the following sections.

**Perception and the Aging Senses**

As the preceding section made clear, age-related changes in cognitive functioning are clearly linked to underlying changes in brain physiology. Among the most fundamental of these functions is sensory perception. External information can only enter the brain for further processing through the gateway of the senses. When these senses fail, so will the accuracy of perception and, in turn, that of memories and judgments based on the flawed perceptions. To the extent that information is encoded poorly or incorrectly, it cannot later be remembered completely and accurately or used appropriately. In this sense, then, perception may be regarded as the most fundamental sense in which cognitive processing fails with age.

Clinically significant and subclinical reductions in hearing and vision increase markedly with age, beginning in the 40s (see reviews in Kline and Scialfa, 1996; Schneider and Pichora-Fuller, 2000). Of particular importance, whereas loss in **visual acuity** can often be compensated for through corrective lenses, in most cases hearing aids are limited in effectiveness for correction of hearing loss (Lubinski and Higginbotham, 1997). Even so, uncorrectable losses in vision and hearing become more common with increasing age.

Some have argued that sensory functioning is a crude proxy for brain integrity and suggested that sensory function should therefore mediate all remaining cognitive abilities (Lindenberger and Baltes, 1994, 1997). In two studies, the authors tested subjects ranging from 25 to 103 years of age. Simple tests of auditory and visual acuity were strongly correlated with a wide range of other cognitive abilities, such as speed of processing, reasoning, memory, world knowledge, and verbal fluency. Furthermore, sensory functioning appeared to function as a more fundamental cognitive resource, and/or as a better indicator of underlying brain functioning, than the other cognitive mechanisms to be discussed later, in that the sensory tests mediated age-related variance in the other measures of cognitive function. Taken together, vision and hearing accounted for 49.2% of the total variance in the overall index of cognitive functioning and 93.1% of the age-related variance.

Other researchers (Mariske et al., 1997; Salthouse et al., 1996) have since obtained similar findings (see the review in Schneider and Pichora-Fuller, 2000). Duyan and Murphy (2002) argued that such effects should obtain for all senses if the common cause hypothesis is valid. Consistent with this supposition, brain reactivity to olfactory stimuli declines (Cerf-Ducastel and Murphy, 2003), olfactory threshold rises, and odor detection and identification and odor memory decline across the lifespan (Lehrner et al., 1999; Larsson et al., 2000), and the quality of olfactory functioning predicts general cognitive decline (Duyan and Murphy, 2002).

Although such correlational results do not indicate that decrements in cognitive functioning are caused by losses in sensory function, they do indicate that decrements in sensory functioning are powerfully predictive of decrements in other cognitive functions — most likely, as Lindenberger and Baltes (1994) suggested, because sensory function is a better proxy for underlying brain function than the other measures.

Not surprisingly, other variables related to physical (and thus brain) decline have been related to cognitive performance. Interestingly, balance-gait accounted for as much variance in cognitive functioning as hearing/vision in the Lindenberger and Baltes studies and may be thus taken as another excellent predictor of cognitive function. Other studies have found a link between grip and lower-limb strength and cognitive performance (see Schneider and Pichora-Fuller, 2000, for review). Recent evidence has also begun to link metabolic processes such as glucoregulation (Messier et al., 2003) to cognitive performance.

**Hearing**

Older listeners tend to suffer decline in processing of auditory information (labeled “**presbycusis**”), the hallmark of which is elevated thresholds for detection of high-frequency (higher-pitched) sounds, due
to damage to hair cells at the base of the cochlea (cells on the basilar membrane in the inner ear where high-frequency sounds are coded). In addition, the elderly tend to suffer difficulties in detection of simple, high- and low-intensity stimuli, discrimination of small changes in frequency (pitch) or intensity (loudness), temporal resolution abilities (detecting when one sound stops and another begins), filtering out of background noise, and precision in location of the source of sounds — and thereby to suffer deficits in correct encoding of auditory information in many everyday situations (see Pichora-Fuller and Carson, 2001, for review of physical causes of these declines).

In practical terms, perhaps the greatest deficit resulting from hearing loss is accuracy in speech perception. Discrimination between consonants becomes difficult for the elderly, particularly the higher frequency consonants such as "f," "v," "s," "t," and "z" (Sataloff and Vassallo, 1966). Generally, speech begins to sound "fuzzy," with words appearing to run together even when the speech is loud enough to hear. These problems are exacerbated by general decline in cognitive processing efficiency that slows processing of speech, sometimes to the point that earlier words or sentences have dropped from working memory before the rest are fully understood (see Nusbaum et al., 2000). Speech processing also becomes more difficult when others speak at a fast rate; when there is external noise, distortion, or reverberation in the target speech; and when the listener is under stress (see Kline and Scialfa, 1996, for review).

Problems with hearing in conversation require a louder and slower conversational style and can result in such poor outcomes as inaccuracy and misunderstanding, stress in both parties, inefficiency, slowness and repetition, and avoidance of further conversation on the part of both parties. Finally, because we also rely on hearing to produce our own speech sounds, hearing loss can result in declining clarity in production of speech (Nusbaum et al., 2000).

Despite these problems, three quarters of those who might benefit from hearing aids fail to use them, and among those who do, many problems remain unsolved. Hearing aids function to aid in hearing low-intensity sounds, such as consonants in speech, but also tend to amplify irrelevant and unwanted background sounds that interfere with hearing of the target sounds. This leads users to experience difficulties processing specific sounds — such as speech — in auditorily complex situations involving multiple simultaneous sources of sound (see the review in Schneider and Pichora-Fuller, 2000). Even those who show hearing sensitivity within normal limits and hear well in quiet conditions may suffer age-related inability to hear well in noisier circumstances (see reviews in CHBB, 1988; Willott, 1991). Individuals suffering from cochlear pathologies may also find speech discrimination difficult even in quiet circumstances (see Humes, 1996, for a review); in addition, they have enhanced difficulties with frequency selectivity (ability to detect smaller differences in pitch) and abnormal growth of loudness as signal intensity increases (see reviews in Moore, 1989; Pickles, 1988; Schneider, 1997).

Of particular importance, even when speech is understood under noisy or other perceptually difficult conditions, it is remembered less well (see Schneider and Pichora-Fuller, 2000, for review) by older as well as younger adults. Thus, it is important to consider the external context in which conversation was heard, along with the internal processing difficulties created by the age of the listener, when attempting to assess accuracy of processing of, and memory for, speech. As suggested by Rabbit (1991), difficulty in hearing may affect memory because the more resources one must devote to decoding the speech signals, the fewer are available to think about what is heard — i.e., to rehearse the material or to process it deeply and elaboratively — which would otherwise facilitate memory (see below).

Specific hearing deficits may derive from degeneration of the ear (such as losses in threshold sensitivity to various frequencies and the cochlear pathologies noted earlier) or brain functioning. Even when a person has a normal audiogram assessing threshold sensitivities primarily determined by the ear, age-related deficits detected by auditory brainstem responses (ABRs) may independently cause decline in auditory functioning under more difficult circumstances. For example, deficits of synchrony in neural firing may cause problems with frequency discrimination, temporal discrimination, localization, binaural unmasking (ability to focus on a particular sound when multiple sounds enter each ear from multiple but different origins), or speech perception (see Hellstrom and Schmiedt, 1990) Again, such losses may be independent of threshold sensitivity. For example, difficulty in temporal discrimination (e.g., detecting when a sound has stopped and another begun) may cause difficulties in speech perception, even though
the person hears loudness adequately. Older adults experience greater difficulty with gap detection and with detection of differences in duration of sounds (see Fozard and Gordon-Salant, 2001; Schneider, 1997; Schneider and Pichora-Fuller, 2000; Strouse et al., 1998).

Finally, difficulties in speech perception can be compensated for in some degree by lip-reading and general use of nonverbal cues to clarify meaning. However, because vision also tends to decline with age, the older person is often further hampered by inability to read and employ nonverbal information effectively (Nussbaum et al., 2000).

Some have argued that difficulties in comprehension of speech and conversation are caused by the increased load imposed on working memory by the enhanced effort that older listeners must devote to accurate hearing (Rabbitt, 1991). The more working memory resources must be devoted to detection and identification of the sounds, the less working memory capacity is available for processing and storage of meaning. If so, removing the burden of sound detection and identification should improve cognitive processing of the speech.

Therefore, several researchers have addressed the question of whether age-related declines in word recognition, immediate recall of verbal materials, and discourse comprehension can be eliminated or reduced by improvements in hearing. These studies addressed this issue by adjusting volume to exceed the threshold sensitivities of young and old adults by a constant amount — in quiet and noisy conditions — so that each person could recognize the words accurately, or by hampering the hearing of younger adults to simulate the sensory difficulty of older adults. Generally, these results indicate that when the sheer difficulty of hearing the words adequately is equated between young and old, age-related differences in comprehension and memory are minimized or eliminated (see the review in Schneider and Pichora-Fuller, 2000).

Summary
Clearly, age is associated with a variety of hearing-related losses. Perhaps most important for the forensic arena are losses in accuracy of speech perception, elevation of thresholds for sound detection, and increasing difficulty in sound localization. However, when the possible role of hearing in forensic circumstances is considered, it is vital to remember that the specific deficit of interest must be directly tested. As shown by a host of studies (see reviews in Moore, 1989; Pickles, 1988; Schneider, 1997; Schneider and Pichora-Fuller, 2000; Hellstrom and Schmiedt, 1990; Humes, 1996), a person may have normal or reasonably normal threshold sensitivity as measured by standard hearing tests while suffering several serious losses in other auditory functions or, indeed, in threshold sensitivity under circumstances more complex than those presented by a standard hearing test.

Of particular interest would be the effects of aging on speech perception. Although the person possessing normal threshold sensitivity may hear the speech as loud enough, some of the fine detail encoded at higher frequencies would be lost even in quiet circumstances. In louder circumstances, low frequencies tend to be masked by the background noise, and gap perception becomes more difficult, thereby blurring distinctions between words. Gap perception also becomes more difficult for older listeners with faster speakers. Difficulties with binaural processing can impair ability to localize the source of sound and to focus clearly on one speaker amid a crowded noisy room. Thus, for any given older person of normal threshold sensitivity or not, specific deficits of relevance to the situation in question must be individually established.

Vision
Correctable refractive errors constitute the most commonly recognized age-related form of decline in visual functioning. However, even with such correction and among those with both good and bad general health of the eyes, visual acuity (per the "Snellen" measure in which subjects must identify letters of varying size at a specified distance) begins to decline after 45 years of age. Moreover, declines occur in other aspects of visual functioning, such as contrast sensitivity (ability to discern luminance differences for targets of various sizes) and contrast discrimination (ability to discern differences between objects in amount of contrast to background). Older adults may need two to three times more contrast to be able to see small- or medium-sized targets (such as the characters that comprise most text).
Other aspects of visual functioning decline as well, including dark adaptation (speed with which rod-based black-and-white vision functions clearly after light is reduced or eliminated), perimetric fields (gradient of differential ability to see (threshold sensitivity) in the foveal vs. peripheral regions of the retina), color vision, and stereopsis (use of both eyes for depth perception). Pathologies of the eye also increase with age, including cataracts, glaucoma, and macular degeneration (see Michaels, 1993, for a review). Overall, visual representations tend to become less precise or accurate — more so under conditions of poor lighting or poor stimulus contrast (for a review, see Faubert, 2002; Schneider and Pichora-Fuller, 2000; Pichora-Fuller and Carson, 2001; also see Enoch et al., 1999, for discussion of some visual functions that do not decline with age). Visual perception also becomes slower, so longer viewing times are necessary for older adults to perceive and recognize a visual image (Jacoby and Debner [2001], discussed in Jacoby et al., 2001).

As with hearing, some age-related changes in vision are the result of changes in the eye:

• Retinal image quality (visual acuity) is reduced and hence vision is blurred by changes in light diffraction through the cornea.
• Thresholds for rod (low light level) and cone (high light level) vision are raised as less light passes through yellowed and more opaque lenses and narrowed pupils.
• Poorer rod vision (including poorer vision under low illumination and restricted effective field of view) results from decreasing numbers of rods (Curcio, 2001).
• Poorer cone (high light level) vision results from decreased sensitivity of the cones to the light that does pass through to the retina (Werner, 1998).
• Presbyopic difficulties in adjusting focus to accommodate distance follow from increases in stiffness of the lenses.
• Inefficient transduction of light to neural impulses results from narrowing of the arteries of the retina.
• Decrease in retinal contrast is caused by increased light scatter by the cornea (resulting in decreased ability to detect and recognize common objects, including traffic signs).
• Blue–yellow color confusions are caused by greater absorption of and therefore reduced sensitivity to shorter (blue) wavelengths (and discrimination of colors of the same hue and desaturated colors such as pastels becomes more difficult).

Generally, less efficiency and precision in processing visual input results. (See Faubert, 2002; Fozard and Gordon-Salant, 2001; Kline and Scialfa, 1996, 1997; Schneider and Pichora-Fuller, 2000; Scialfa, 2002; Spear, 1993.)

Essentially every structure in the primary visual pathway changes with age. Density in the retinal ganglion cell layer decreases, particularly outside the macular region. Similarly, cell and synapse density, number of synapses, and myelin sheath integrity decrease in the visual cortex. Similar changes occur throughout the brain and predict a variety of specific indices of cognitive decline (Faubert, 2002; Peters et al., 1996, 2000; Nielsen and Peters, 2000; Scialfa, 2002). Great individual differences exist within age groups, with poorer vision associated with greater exposure to sunlight, which is associated with aging of the lens and the retina (see Werner, 1998, for review).

There is substantial evidence of the practical effects of declining visual functioning of the eye on activities of daily living. Difficulties with visual acuity, depth perception, motion perception, and vision in low illumination or shadowed areas cause difficulty in managing daily routines. We illustrate a number of these effects in the context of driving.

**Visual Acuity**

Visual acuity (the clarity of an image) is especially important for night driving (Eby et al., 1998; Panek et al., 1977), but declines substantially with age, particularly in conditions of low illumination. Thus, visual acuity — at least for drivers (and especially older drivers) — tends to be worst when it is most needed.

The previously referenced changes in lens color and opaqueness, combined with narrowing of the iris and often cataracts on the corneas, reduce the amount of light entering the eye. Because the sharpness
of an image is dependent upon illumination and, to some degree, on color and because color vision drops out with sufficient drop in illumination, overall visual acuity will decline with decline in illumination entering the eye. Furthermore, neural processing mechanisms adapt to lower illumination by, in essence, trading temporal and spatial acuity for sensitivity.

The aging eye causes some degree of reduction in illumination under all circumstances. However, this essential reduction makes the aging person more vulnerable to loss of acuity in external conditions of low illumination, such as nighttime. Indeed, older persons have substantially greater difficulty with night vision (and night driving), as well as more difficulty (time needed) in recovering from glare (see Klavora and Heslegrave, 2002).

**Motion Perception**

Motion perception is dependent upon a variety of visual factors, including

- Ocular musculature adequate to track objects smoothly
- Contrast sensitivity (ability to see differences in luminance between target and background)
- Stereopsis (use of both eyes for depth perception)
- Temporal contrast sensitivity (ability of the eye to see changes occurring over time at different rates, such as fast vs. slow flickering patterns)
- Backward masking (the ability of new stimuli to obscure the afterimage of previously seen objects)

These factors, as well as others, decline with age. Thus, not surprisingly, motion perception (dynamic vision) tends to be impaired in the elderly (Tran et al., 1998; Willis and Anderson, 2000; Wist et al., 2000, Wojciechowski et al., 1995) in foveal and peripheral vision, although more so in the foveal area (see reviews in Schneider and Pichora-Fuller, 2000; Faubert, 2002; Scialfa, 2002).

Because the oculomotor system (eye movement) is slowed with age, older adults suffer impairments of tracking speed — i.e., greater difficulty tracking objects moving at high speeds and when there is a high degree of relative motion between the target and observer (Scialfa et al., 1988). Furthermore, older adults suffer deficits in visual marking for moving stimuli. Visual marking refers to the top-down inhibition of attention to or processing of old stimuli already in the visual field (such as cars already in the stream of traffic) so that processing of new visual information (such as a car entering the traffic stream) can be facilitated (Watson and Humphreys, 1997). This visual marking is assumed to be advantageous, in that it facilitates the observer’s ability to maintain an up-to-date representation of the world, which in turn would provide the most useful basis for action decisions.

As we shortly review, older adults suffer deficits in attentional control, particularly in controlled inhibition of attention to undesirable or irrelevant stimuli. Consistent with this general deficit, older adults manifest deficits in visual marking for moving stimuli (although they do so less consistently for stationary stimuli; see Kramer and Atchley, 2000; Watson and Maylor, 2002). That is, they show greater difficulty locating new stimuli amid a constellation of already present stimuli. Age-related declines in marking ability are relevant for a variety of everyday human factors issues (see Rogers and Fisk, 2000), such as driving, instrument monitoring, air traffic control, and so on.

In practical terms, deficits in motion perception play a substantial role in automobile accidents among the elderly (Staplin and Lyles, 1991). Difficulties in motion perception render the elderly subject to errors in speed, distance, time-to-collision, and gap-acceptability judgments, which tend to result in misjudgments in complex traffic situations, including failure to yield the right of way. Such failures, in combination with generally slower responses, are responsible, for example, for the tendency of the elderly to be involved in accidents in which they turn left in front of an oncoming vehicle (see Klavora and Heslegrave, 2002, for review). Older persons also become less sensitive to (less likely to notice changes in) temporally modulated (changing across time) stationary patterns such as flickering lights, as well as to spatial movement of objects (see Schneider and Pichora-Fuller, 2000). While a person is driving, for example, this insensitivity can result in failure to notice a vehicle begin to move, changes in traffic lights, or other important changes in position.
Visual Search

Visual search refers to the ability to identify a target object or objects in a field of distractors. Depending upon the complexity of the scene, the number of distractors, the nature of features distinguishing the target from distractors, and features of the context such as fog, mist, or poor illumination, accuracy and speed with which the target is located can be compromised. Correct discrimination between stimuli requires comparing a given stimulus with internal models of correctness and incorrectness. Reduction in short-term visual memory capacity will limit ability to discriminate accurately and rapidly.

Generally, age is associated with poorer overall performance and greater reactivity to features that tend to compromise performance (Burton-Danner et al., 2001; Scialfa and Jaffe, 1997; Madden et al., 2002; Speranza et al., 2001). Indeed, older adults report difficulties with everyday activities relying on visual search, including such problems as distracting objects and events, cluttered visual scenes, and insufficient time to find target objects (Kosnik et al., 1988; Kline et al., 1992).

Safe driving often requires the ability to search complex traffic scenes rapidly in order to locate critical objects — such as signs, traffic lights, pedestrians, turnoffs, and address markers — and respond appropriately. Therefore, age-related slowing and increased susceptibility to distractors render older drivers less able to locate critical objects. For example, older drivers are less able to locate traffic signs successfully, particularly in visually cluttered scenes (Ho et al., 2001; Schieber and Goodspeed, 1997) and less able to read them successfully, particularly at night (Sivak et al., 1981). Older adults tend to scan traffic scenes differently, using more fixations, less evenly distributed fixations, and more repeat fixations to a specific target (Maltz and Shinar, 1999) and require more eye movements to find a target such as a sign (Ho et al., 2001). Thus, older adults are less efficient and less accurate in traffic-related visual searches.

Peripheral Vision

Peripheral vision declines with age, resulting in less likelihood of detection of objects in the peripheral field, less accurate discrimination between objects in the peripheral field, and less accurate motion detection. One study (Johnson, 1986; see also Panek et al., 1977) showed that the range of the visual field declined from 180° among younger adults to 140° beyond age 70. A related index of peripheral vision, the "useful field of view," or UFV, comprises the limits at which the observer can no longer locate or identify objects or targets in the visual field (tested under conditions in which eye movement is prohibited). (Coeckelbergh and colleagues [2004] discuss age differences for an alternate measure, AFOV, or attended field of view, which tests for target search in circumstances permitting eye movement.)

UFV has become popular among many investigators, particularly those concerned with predicting driving performance and accidents (Owlesly et al., 1991; Sekuler et al., 2000). Useful field of view is assumed to decrease with age as a function of the three underlying cognitive processes of decreased ability to divide attention, decreased ability to ignore distractors, and reduced processing speed (Ball et al., 1990). UFV has proven to be a strong predictor of accident involvement. Those with poor peripheral vision are believed to have two to six times the accident rate of those with normal peripheral vision (Morgan and King, 1995; Ball et al., 1993; see reviews in De Raedt and Ponjaert-Kristoffersen, 2001; Klavora and Heslegrave, 2002; Park and Gutchess, 2000). However, this predictive value appears to be due to the divided attention component and is unrelated to the other two (Owlesly et al., 1998).

In light of the role of capacity for divided attention in determining UFV, it is not surprising that the presence of distractors effectively reduces UFV (Sekuler et al., 2000), particularly for older adults in whom capacity for divided attention is reduced (see below). Such distractors can include irrelevant objects in the peripheral field, greater similarity between relevant and irrelevant objects, and engagement in multitasking (such as eating or talking on the phone while driving). Depending upon circumstances, older adults’ UFV can become restricted to only one third of that of younger adults in similar circumstances (see Schneider and Pichora-Fuller, 2000, for review), with obvious consequences for detection of pertinent traffic signs, obstructions, and approaching vehicles.
Fortunately, declines in UPV can be successfully decreased with normal elderly clients and stroke victims with a program called "visual–motor useful field of view" (VM-UFOV) using the "Dynavision" apparatus (a device used for training athletes and others to enhance dynamic vision, reaction time, movement time, hand–eye coordination, peripheral vision, and the ability to divide attention and make decisions under stress). The device is in use in a number of rehabilitation and medical centers across the country (see the review in Klavora and Heslegrave, 2002).

Summary
As with hearing, a number of age-related declines occur in the visual system. Also, as with hearing, in forensic contexts it is vital to test the specific suspected deficits relevant to the situation at hand. The most common vision test is the Snellen test of visual acuity (identification of letters of varying sizes from fixed distances). However, Snellen acuity is measured in conditions involving no motion but full illumination. For this reason, it is a poor predictor of other aspects of processing, including impaired processing of motion, tracking of high-speed objects, vision in low illumination, and the UPV index that is so predictive of peripheral vision performance and automobile crashes.

For traffic accidents involving the elderly, impairment in one or more visual skills may well play a causal role. The elderly appear to be aware of visual deficits to some degree. They drive shorter distances; drive more slowly; and decrease their night, highway, and rush-hour driving. However, they are still at greater risk of accidents, per mile driven, at a level comparable to that of 15- to 25-year-olds (see Klavora and Heslegrave, 2002; De Raedt and Ponjaert-Kristoffersen, 2001).

Although thus far we have illustrated with examples regarding driving, impairments in vision contribute widely to a variety of accidents and are relevant for ergonomic design in a number of situations (see Echt, 2002, for an excellent review of the effects of age-related declines in vision on reading and the use of computer screens) and to issues of perception and memory in forensic contexts involving witnesses and jurors (explored later).

Processing Speed
Substantial evidence exists in support of the proposition that decreased speed of processing accounts for age-related decline in performance of all cognitive tasks. Salthouse (1991, 1996) proposed that two general mechanisms underlie the relationship between speed of processing and cognitive performance. First, Salthouse suggested that "the time to perform later operations is greatly restricted when a large proportion of the available time is occupied by the execution of earlier operations" (p. 404), which he referred to as "the limited time mechanism." Second, he suggested that "the products of earlier processing may be lost by the time that later processing is completed" (p. 405); he referred to this as the "simultaneity mechanism."

These two mechanisms can together result in slower, but still accurate, performance or performance failures. Earlier stages of processing may be slowed but accurate, but can result in performance failure if this slowing causes the person to fail to reach later stages. Salthouse (1991, 1996) believed the effects of slow processing to affect all cognitive tasks, including those with no obvious speed component.

Salthouse (1996) reviewed an impressive array of evidence that performance on "perceptual speed tasks" is an excellent predictor of performance on a wide range of other specific cognitive tasks. Perceptual speed tasks require the person to make rapid perceptual same–different judgments about pairs of digits or letter strings, or two similar symbols. Speed of processing is measured by the number of correct same–different comparisons made in a fixed period of time. Generally, Salthouse (1996) demonstrated that age-related variance on other specific cognitive tasks is reduced or eliminated when controlling for variance in processing speed.

Despite the success of perceptual speed tasks as predictors of performance on other, even apparently non-speed-related, cognitive tasks, the processing speed theory of age-related decline has not been universally accepted, as suggested by Bashore et al. (1997), Fisk and Fisher (1994), Hartley (1992), and Perfect (1994). These authors suggest that no strong tests have been conducted regarding the issue of whether age differences on the wide range of specific tasks are attributable to the general factor of processing speed vs. process- or task-specific factors and no agreement on how best to test the relative
influences of general vs. specific factors has been reached. Notwithstanding such unresolved issues, however, it is clear that speed of processing does decline with age (Salthouse, 1996).

**Processing Speed and Older Drivers**
A person trying to follow directions or a map can often be required to make quick choices and execute them in a complex and rapidly moving traffic situation — frequently in the midst of complex and rapidly changing contexts such as shopping districts replete with shops, pedestrians, and cyclists. Thus, impairments of processing and response speed can seriously compromise the driving safety of older adults, who tend to perform best under simple conditions, when not rushed. Increased difficulties of older adults in perception, choosing responses, preparing and executing responses, and so on tend to result in slower reaction times that, in turn, can cause accidents.

Stelmach and Nahom (1992) reviewed changes in all aspects of motor performance, including selection, preparation, and execution of responses, among others. Consistent with a large body of research showing stronger age-related declines of all kinds under more complex or demanding conditions, decrements in speed were particularly strong under conditions of task complexity and complex arrays of stimuli — for example, during complex driving situations or responding to pending collisions. Increased decrements under demanding conditions are presumably due to increased demands upon working memory (see below). In this light, not surprisingly, response selection (which presumably places the greatest demands upon working memory) was the most age-sensitive factor studied.

In addition to slowing of cognitive processing with age, physical behaviors and reactions are slowed as well. Older drivers exhibit slower movements, due in part to reduced joint flexibility, joint deterioration, arthritis, etc. The U.S. Department of Transportation maintains a web site with a variety of materials related to how physical condition and cognitive functioning are related to driving safety (http://www.nhtsa.dot.gov/people/injury/olddrive/), which includes an excellent research report (April, 1999) of the data documenting these relationships (http://www.nhtsa.dot.gov/people/injury/olddrive/safe/). Also see a recent meta-analysis of the relationship between neuropsychological functioning and driving ability by Reger and colleagues (2004).

**Working Memory**

Craik and Byrd (1982) suggested that age-related deficits in processing resources are best measured by working memory tasks, rather than perceptual speed tasks. Working memory is conceptualized as the total processing resources available at any given moment to perform online cognitive operations (Baddeley, 1986) and is measured through tasks in which the subject must store and process information simultaneously. For example, a person might be asked to perform a computational span task, in which he or she must solve a series of equations while remembering the second number in each equation. Working memory is measured by how many equations the subject solves correctly while accurately remembering the target number.

Well-documented age-related declines in working memory reflect decreasing ability to hold multiple items of information in mind while performing one or more cognitive tasks (see a recent meta-analysis by Verhaeghen et al., 2003) Age-related deficits appear most strongly in cognitive tasks imposing stronger processing demands on working memory, such as tasks requiring simultaneous consideration of multiple items of information, difficult manipulation of information (e.g., reasoning, problem-solving, mathematics), multitasking requiring divided attention, or working in distracting conditions that require filtering of irrelevant information. These deficits are negligible for those requiring less effortful processing (Craik and Jennings, 1992; Light, 1991). Furthermore, effective processing load or capacity is affected by age-related physical conditions. For example, chronic pain (e.g., Grigsby et al., 1995) is related to deficits in information processing, as are such conditions as hypertension, diabetes, impaired thyroid function, and others (see the review in Nilsson and Soderlund, 2001).

In practical terms, declining capacity of working memory is reflected in age-related declines in performance of more processing-intensive tasks, in multitasking (see the review in Kemper et al., 2003),
and in memory for information encountered during processing-intensive tasks or in complex or distracting circumstances. Of particular pertinence in legal settings, deficits in working memory are widely considered to result in failures of “associative learning” or “binding” (learning associations between items such as between word pairs or, more practically, between a person’s face and the context in which that person was encountered). Failures of this kind are considered to contribute to such dramatic memory errors as mistaken eyewitness identifications (Wells et al., 1998) or development of false memories of sexual abuse (Loftus and Ketcham, 1994). Furthermore, failures of working memory can compromise the ability of older jurors to process trial input and to remember it and reason adequately to arrive at an appropriate verdict.

Fortunately, declining working memory can be compensated for through “environmental supports” (Cherry et al., 1996; Craik and Byrd, 1982; Park et al., 1990). Essentially, such supports reduce the load on working memory by providing external cues (such as pictures or lists) to make it unnecessary to hold all information in working memory in order to use it for processing or judgment.

**Working Memory and Older Drivers**

Decline in working memory capacity is widely considered to contribute substantially to age-related accidents. As working memory declines, the person cannot manage the demands for divided attention and complex decision making that tend to characterize complex driving situations. Therefore, as noted earlier, speed of response slows most dramatically for the elderly under complex, stimulus-intensive driving conditions. In these conditions, many distractors place demands on allocation of attention, and rapid responses to multiple moving stimuli must be selected, planned, and executed rapidly.

Older drivers are prone to experiencing cognitive overload on the road and fail to divide attention successfully in order to process the full range of relevant stimuli such as other vehicles, pedestrians, traffic lights and signs, road hazards, and so on. They encounter problems in discriminating between relevant and irrelevant stimuli in complex situations and have difficulty ignoring irrelevant or meaningless information in favor of focus on relevant and important objects. Thus, older drivers have difficulty changing lanes, turning, passing, driving in reverse, and comprehending traffic sign symbols. They tend to commit such attention-related errors as running red lights or stop signs, failure to yield right-of-way, and committing traffic violations during turning maneuvers.

Perhaps because the driving situation is more complex at intersections, older drivers are more likely to experience multivehicle, side-impact collisions at intersections, particularly when turning left. They also experience accidents due to tendencies to turn mistakenly prior to the intersection, commit illegal turns, disregard traffic signals, and rear-end others, due to failure to notice change in motion (Stamatiadis et al., 1991). Finally, all of the consequences of limitations in working memory are enhanced by anxiety and stress, which further limit working memory capacity, narrow the focus of attention, and thereby enhance accident potential (see De Raedt and Ponjaert-Kristoffersen, 2001; Klavora and Heslegrave, 2002; Preussler et al., 1998). Generally, Hakamies-Blomqvist (1994) found errors of attention to be the most important cause of fatal accidents involving older drivers. Reflecting failures of attention and processing, 44% of older drivers in another of this author’s studies (Hakamies-Blomqvist, 1993) had not noticed any danger prior to their accident, whereas only 26% of younger drivers failed to notice danger.

**Inhibitory Functions**

A particularly interesting proposition was introduced by Hasher and Zacks (1988; see also Lustig et al., 2001; Persad et al., 2002), who argued that optimal performance requires control over attention to irrelevant information. Furthermore, they provided evidence that age is associated with declining ability to focus on target information while inhibiting attention to irrelevant information. Others have since provided neuroimaging and neuropsychological evidence to suggest that age-related declines in attentional control may be the result of age-related changes in the frontal lobes of the brain (Moscovitch and Winocur, 1995; Shimamura and Jurica, 1994; West, 2000). Successful inhibition in older adults is associated with activation of areas of the brain beyond those activated by younger adults, suggesting that
older adults must compensate for age-related difficulties in inhibition with supplementary recruitment of brain resources (Nielson et al., 2002).

In contrast to theorists emphasizing age-related reductions in speed of processing, the inhibitory control framework emphasizes changes in efficiency of processing. Efficient processing is presumed to require strong attentional control so that attention is occupied only by goal-relevant information. Inefficient inhibitory processes are assumed to permit goal-irrelevant information to command attention and enter working memory, thereby detracting from processing of goal-relevant information. Moreover, impaired inhibitory processes allow the irrelevant information to persist in inhabiting working memory, thereby affecting cognitive performance for some time after exposure. As the attentional draw of the irrelevant information becomes stronger, so does impairment of the focal task (Zacks and Hasher, 1997), particularly when inhibitory processes are compromised by age or other factors.

Hasher and colleagues suggest that failures of inhibitory control affect present performance and future memory. Present performance depends upon the ability to concentrate attention on task-relevant information and to ignore irrelevant distractions. Furthermore, memory is dependent upon attention (Schacter, 2001). Memory follows the focus of attention and depends upon the amount and quality of attention. Thus, to the extent that failing inhibitory processes alter the nature of attentional processes, they will alter performance and memory.

Proponents of the inhibitory deficit framework view a wide variety of age-related declines in cognitive processing as the result of failing inhibitory processes. Although substantial debate exists regarding whether these deficits are the result of generalized age-related slowing vs. specific deficits in inhibitory capacity (McDowd et al., 1995; Verhaeghen and Meersman, 1998), strong evidence exists of age-related decline in ability to control attention and to engage more generally in controlled rather than automatic processing strategies (see reviews by McDowd and Shaw, 2000; Rogers, 2000).

Older adults are less able to sustain attention or maintain focus on relevant information. Problems of this nature are reflected in poorer performance on “vigilance tasks,” such as those of air traffic controllers, radar monitors, or product defect screeners, in which the person must sustain attention for long periods and successfully focus on relevant targets only.

Older adults are also more distracted by irrelevant information (current distractors or irrelevant information from long-term memory). This age-related susceptibility to current distractors results in poor immediate performance, as well as shallow encoding and later poorer memory. Memory and performance are further impaired by age-related failures to inhibit attention to irrelevant past information. For example, Lustig and colleagues (2001; see also Bowles and Salthouse, 2003) reviewed evidence that older adults are more susceptible to “proactive interference” effects. That is, previously learned information is more likely to interfere with learning (memory for) new information. Presumably, this difficulty in learning the new information is caused by the age-related inability to suppress activation of (and therefore interference from) the old information (see Hedden and Park, 2001, for similar age-related enhancement of “retroactive interference” effects).

Similarly, failure to inhibit attention to irrelevant information hampers problem-solving and decision making. Finally, similar inhibition deficits are reflected in age-related differences in automatic vs. controlled processing in that older adults are more susceptible to the effects of positive priming and more likely to engage in schematic and automatic processing (see reviews by McDowd and Shaw, 2000; Rogers, 2000). In later sections, we explore the implications of these processes for older witnesses and jurors.

**Circadian Patterns and Inhibitory Capacity**

Hasher and her colleagues have shown that inhibitory abilities vary with the time of day in older and younger adults. However, whereas younger adults' abilities are lowest in the morning and peak in late afternoon, those of older adults peak in the morning and wane throughout the day (May and Hasher, 1998; May et al., 1993, Yoon et al., 2000b). May (1999), for example, showed that distractors had greater effects on performance for young and old adults who were tested at their own nonoptimal time of day, compared to those tested at their optimal time. These established differences in circadian arousal patterns
can contribute to hourly variation in accidents, performance in job-related settings, or memory and information processing in witnesses and jurors.

**Stereotype Vulnerability, Stereotype Threat, and Enactment of Age-Stereotyped Behaviors**

A final explanation for age-related decrements in memory and performance has proposed that age differences may be caused in some degree by age stereotypes. Research examining stereotypes of age has revealed positive as well as negative attitudes toward aging and the old. However, in contexts in which cognitive competence is at issue, the stereotypes tend to be overwhelmingly negative (Hertzog et al., 1999; Kite and Johnson, 1988; Levy, 2003), including expectations of declining cognitive performance and memory (see reviews in Levy and Langer, 1994; Nelson, 2002; Stone and Stone, 1997). Ryan (1992) suggested that these stereotype-based expectations of poor cognitive performance may become a self-fulfilling prophecy through indirect impact on decreased effort, lesser use of adaptive strategies, avoidance of challenging situations, or failure to seek medical help as a result of improper attribution of cognitive failures to age, rather than to underlying disease or drug side effects.

Similar processes may cause other stereotype-based self-fulfilling prophecies (see Wheeler and Petty, 2001, for review of mechanisms by which stereotypes affect performance). Indeed, research has suggested that childhood exposure to the negative images of old age present in fairy tales, television, and everyday conversations in America can influence one’s level of activity and alertness in old age (Langer et al., 1988; Rodin and Langer, 1980).

A series of subsequent studies has supported Ryan’s (1992) reasoning. Levy and Langer (1994) reasoned that age-related deficits in memory performance would be predicted by beliefs in age-related memory stereotypes. Therefore, they compared the performance of Chinese mainland participants to that of hearing and deaf Americans. Based on research indicating that those from the Chinese mainland and deaf Americans would have less exposure to negative age stereotypes, they predicted (and found) that, although younger participants from all groups performed equivalently, older American hearing participants performed more poorly than older American deaf or older Chinese participants. In China, no age differences were found on any of the four separate memory tests that commonly show age-related deficits in American participants. Overall, positive views of age also predicted better memory performance, and path analyses indicated that memory performance across cultures was mediated by views of aging.

In a subsequent conceptual replication, Yoon and colleagues (2000a) found a difference on two of four memory tasks between Anglphone Canadians and Chinese Canadians who had recently emigrated from Hong Kong. However, younger adults outperformed older adults on all tasks. This age difference was reduced for Chinese Canadians on two tasks, but not eliminated. Moreover, unlike Levy and Langer (1994), views of aging did not mediate memory performance. The authors concluded on the basis of these findings, as well as various methodological issues in their own work and the Levy and Langer work, that cultural differences in age-related stereotypes cannot yet be considered a clear contributor to age-related decline in memory.

Levy (1996) later employed a subliminal priming methodology to examine the effects of activation of age-related stereotypes on four memory tasks. Older adults consistently performed worse than younger adults. However, exposure of older participants to negative age-related stereotype primes (e.g., senile) resulted in poorer memory performance, whereas exposure to positive (e.g., wise) primes enhanced performance. This difference was not obtained with younger adults, for whom such stereotypes presumably did not seem personally relevant.

In a later conceptual replication of Levy’s priming research, Stein and colleagues (2002) found that, although priming negative stereotypes impaired performance of older adults who were unaware of the primes, priming positive age stereotypes did not enhance performance. Like Levy (1996), the authors found no priming effects in younger adults.
Levy et al. (2000) argued that exposure to negative age stereotypes can cause cardiovascular stress (which could in turn affect cognitive functioning). The authors exposed older individuals to subliminal presentations of positive or negative age stereotypes, followed by mathematical and verbal challenging tasks (stressors). Those exposed to negative primes exhibited increased physiological responses to stress—including skin conductance, systolic and diastolic blood pressure, and heart rate—compared to those exposed to positive primes; these effects persisted at a second measurement one half-hour after the interventions. Negative primes also induced poorer performance on the math test than positive primes did.

Levy and her colleagues went on to explore the effects of subliminal positive and negative age-related stereotypical primes on other age-related behaviors such as measures of walking performance of gait speed and swing time (time with one foot in the air during walking; Hausdorff et al., 1999; see also Bargh et al., 1996, for effects of negative age stereotype primes on walking speed of young adults) and handwriting (Levy, 2000). In each study, performance was shown to conform to the nature of the primes (but in varying degree).

In perhaps the most dramatic of her studies, Levy et al. (1999–2000) examined whether aging self-stereotypes could influence the will to live. The authors exposed young and old participants to positive or negative age-stereotype primes presented subliminally. They then asked participants to read a series of hypothetical medical situations involving fatal conditions and interventions that could prolong life. The scenarios included presentations of disadvantages of the treatment involving financial cost or caregiving responsibilities of family members. Older persons who were exposed to positive aging stereotypes tended to accept the life-prolonging medical interventions, regardless of financial or caregiving costs, whereas those exposed to negative aging primes tended to reject such interventions although no effects of the primes were observed among younger participants.

Levy subsequently demonstrated that positive self-stereotypes of aging measured earlier in life appear to predict the will to live and actual health and mortality in older age (Levy et al., 2002a, b).

Finally, borrowing on the stereotype threat paradigm (Steele, 1997), Rahhal and Hasher (1998) examined age-related differences in performance of tasks that participants had been led to believe were memory related (i.e., relevant to the negative age–cognitive functioning stereotypes) or memory unrelated (unrelated to negative age-related stereotypes). Presumably, older adults perform worse when they believe the task reflects abilities (i.e., memory) for which negative age-related stereotypes exist than if it reflects one for which there are no such stereotypes. Indeed, although the tasks were held constant, with memory instructions, younger adults outperformed older adults, whereas with "knowledge" instructions, there were no age differences. Similarly, Earles and Kersten (1998) found that younger adults performing a series of memory tasks tended to remember the items they found most difficult, whereas older adults tended to remember those they found relatively easy.

Unfortunately, the effects of memory-related stereotype threat appear to be strongest for older persons who place more value on their memory abilities. Hess and his colleagues (2003) had older and younger adults perform memory tasks under high or low conditions of stereotype threat. High threat affected the performance of older more than that of younger subjects, and this effect was strongest for older adults who valued memory performance the most.

In part, stereotype threat appears to impair performance through its effects upon working memory. Although this has not yet been shown with respect to age stereotypes, Schmader and Johns (2003) demonstrated that stereotype threat regarding gender and ethnicity impaired working memory capacity, and that reduction in working memory capacity mediated the effect of stereotype threat on women's math performance.

Overall, the results of these stereotyping studies suggest that older adults can react to salient age-related stereotypes by behaving in stereotype-consistent ways (see the review in Levy, 2003). Thus, negative age-related stereotypes appear to contribute to, but not to explain fully, age-related performance deficits. Although salient positive age-related stereotypes may sometimes reduce age-related performance decrements, it is clear that they cannot eliminate them. It is also clear that older adults can suffer greatly from exposure to (or belief in) negative age stereotypes.
11.3 Applications to Aging Victims and Witnesses

Age-related problems with forensic implications occur at all stages of cognitive processing. We review some of these next. We emphasize the aging witnesses but also discuss implications for generation of accidents.

Problems of Perception

In order to process and remember information accurately and therefore use it appropriately, the perceiver must first perceive it correctly. Age exerts a major influence at this stage. We have previously reviewed the nature of decline in auditory, visual, and olfactory processes with age and noted some of their effects for aging drivers. We now review several areas of perception that rely on these senses and, therefore, suffer age-related declines as well. We focus on those that are relevant in forensic contexts.

Estimating Time

Time estimation is central to everyday life. One must prospectively project time to schedule work and leisure activities such as time to arrive at a destination, cook dinner, perform tasks at work (write a chapter), see a movie, and so on. One must also prospectively estimate much shorter time intervals, such as in those involved in driving-related judgments such as time to impact, gap-acceptability judgments, and so on, correctly. Such short-interval judgments are also important for sports-related abilities such as catching a ball.

Witnesses are most often confronted with the task of estimating actual time passed — the duration of a particular sound or event (e.g., “How long were you able to observe the perpetrator?”) or the elapsed time between two events (e.g., “How long was the defendant out of the room?” or “How long between when he left and when you heard the scream?”). Generally, estimates of duration tend to be inaccurate and to overestimate actual duration, particularly when the observer is under stress (Loftus et al., 1987; see Block and Rakay for a review). Aging is associated with enhanced inaccuracy (McCormack et al., 2002) and enhanced verbal overestimation of duration (see a meta-analysis by Block et al., 1998).

Witnesses are also frequently asked to report the order in which events occurred across short and long intervals. Again, memory for order is often poor across the lifespan, but older adults suffer enhanced impairment (Schmittner-Edgecombe and Simpson, 2001), perhaps because memory for order is dependent upon frontal region functioning (Schacter, 1996).

Visuospatial Processing

Processing of visuospatial information appears to be particularly susceptible to age-related decline. Converging evidence indicates that visuospatial cognition is more age sensitive than verbal cognition (Craik, 2000; Jenkins et al., 2000; Lawrence et al., 1998; Myerson et al., 2003a, b; Park et al., 2002; Verhaeghen, 2002). Furthermore, like all aspects of information processing, visuospatial deficits are manifest more strongly as demands upon working memory increase (e.g., Chen et al., 2003), for example, in complex visual environments or when multitasking. This decline is reflected in a number of age-related deficits in driving skills, as we outlined in the earlier sections on visual decline. However, visuospatial processing is central to a wide variety of additional daily living skills, as well as in forensic contexts.

First, elderly witnesses suffer the same difficulties in processing of speed, motion, distance, time to impact, and so on as elderly drivers. Thus, whether they are the parties involved in an accident or those witnessing it, older persons are less likely to encode such information accurately or to report it accurately later as witnesses.

Second, processing of spatial information is central to object identification, including face identification, as we discuss shortly. In addition to facial identification, object identification is crucial to many professions, from military personnel attempting to distinguish friend from foe to medical personnel reading x-rays or slides. Age-related declines in visual marking, target detection, or visual matching are reflected in performance of these and other identification tasks.
For example, Dollinger and Hoyer (1996) found age-related declines between younger (mean age 26.5 years) and middle-aged (mean age 45.7 years) matched novices and medical technologists on domain-specific and general visual recognition performance. Younger participants were faster than older participants on both tasks. Moreover, those tested under dual task conditions were slower and less accurate than those tested under single task conditions — a difference that was greater for older adults. However, expertise compensated to some degree for age-related declines, in that medical technologists suffered fewer age-related deficits for the domain-specific tasks. Other studies have similarly indicated that performance differences between young and older experts are substantially smaller than those between young and older novices (Rogers and Fisk, 1996; Salthouse, 1991).

Poor identification of shapes and objects is associated with poor memory for them. Thus, in addition to declines in facial identification and recognition, similar age-related declines occur in object recognition (Park et al., 2002) — which would in turn be reflected in witness failures to identify accurately such objects as vehicles, clothes, guns, and other items relevant in forensic contexts.

Older adults also experience greater difficulty with memory for the location of objects. Older persons cite difficulties in remembering object locations in everyday life among their memory concerns (Reese et al., 1999), and substantial evidence exists to support the beliefs that spatial location memory declines with age (see the review in Cherry and Jones, 1999). Caldwell and Masson (2001), for example, had subjects work with drawings of household objects and rooms of a house depicted on a computer monitor to simulate placing objects in various places. Older subjects demonstrated poorer memory for object locations. In a real-life study of memory for spatial layout, Uttl and Graf (1993) tested museum visitors of ages 15 to 74 on memory for the spatial layout of recently visited museum displays. Those over age 55 showed reduced accuracy.

Finally, even when reporting on familiar well-known spatial locations, older adults perform more poorly (see the review in Lipman and Caplan, 1992). For example, Evans and colleagues (1984) found that older adults were less able to recall, or place accurately on a map, buildings from a familiar part of their city. These results and others suggest that older witnesses may suffer a disadvantage when asked to testify regarding spatial layout or object location. Furthermore, evidence demonstrating that older adults tend to overestimate their ability to recall object location (West et al., 2002) suggests that they will not be aware of their inaccuracy, perhaps becoming very confident, but inaccurate, eyewitnesses.

Spatial processing is also important for encoding location or relative location and for navigation from one point to another, as well as for memory for that route. In a creative use of virtual environment (VE) technology, Moffat and colleagues (2001) examined the navigation skills of adults from 22 to 91 years of age. The VE included a richly textured series of interconnected maze-like hallways, complete with dead ends and others leading to the goal. Older participants took longer to solve each trial, traveled longer distances, and made significantly more spatial memory errors. More of the younger (86%) than older (24%) adults achieved error-free performance after five trials. Furthermore, performance was related to standard measures of verbal and visual processing. Similar results for place navigation have also been obtained using a virtual Morris water maze (Moffat and Resnick, 2002; see also Shukitt-Hale et al., 2004).

The navigation skills that depend upon spatial processing are reflected in everyday use of the environment. For example, Simon and colleagues (1992) examined the relationship between spatial processing and neighborhood use among older adults. Spatial memory was related to neighborhood knowledge, which in turn was predictive of neighborhood use (e.g., visits to shops, services, restaurants) and more predictive than mobility or years living in the neighborhood. Finally, such skills are also reflected in memory for routes taken, which also has been shown to decline with age (see the review in Lipman and Caplan, 1992).

Problems of Attention and Encoding

Successful encoding of information is dependent upon adequate attention (Craik and Lockhart, 1972). Memory is, in turn, dependent upon adequate encoding, such that inadequate attention and depth of
processing at encoding may cause a person later to commit errors of omission (failure to remember things that did happen) and errors of commission ("remembering" things that did not happen, or remembering inaccurately what did happen; Schacter, 1999). Age-related decline in attentional control and resources renders older adults more susceptible to both errors, such that they remember less, and less accurately, than younger adults (see reviews in Craik, 2000; Koutstaal and Schacter, 2001).

These age-related limitations also render older adults more susceptible to disruption of attentional capacities at encoding. For example, encoding is more impaired by distraction for older than younger adults. Therefore, although complex events are encoded more poorly than simpler events for those of all ages, complexity will cause greater encoding deficits in older adults. Thus, across a variety of tasks, undistracted older adults often perform similarly to distracted younger adults, and distracted older adults perform more poorly than distracted younger adults (see Zacks et al., 2000).

Bias in Interpretation

Information may be perceived accurately by the senses and nevertheless be encoded incorrectly due to failures of interpretation. One source of such failures is "schematic processing." The influence of schemas on information processing is pervasive (for reviews of the following, see Fisk and Taylor, 1991; Hastie, 1981; Kunda, 1999). They allow us to recognize and categorize objects, people, events, situations, and other features of the environment. They form the basis of expectations that tell us what to do with objects or persons, or how to behave in specific circumstances. They offer standards for evaluation for what we witness or experience, direct attention to schema-relevant features of what we witness, and direct interpretation of it.

Schemas generally direct attention and information processing so that attention is selectively focused on schema-relevant aspects of the situation. Thus, memory for schema-relevant information is generally better than for schema-irrelevant information. Schema-inconsistent information is often processed more carefully, in order to try to integrate it into the schema-driven impression and, hence, this enhanced processing leads to better memory.

Schemas exert a biasing effect on initial interpretation and later memory. Information is interpreted in light of salient schemas. Hence, interpretation is often distorted toward consistency with the schema, e.g., when activation of a racial stereotype can lead to interpretation of success as luck rather than ability. Furthermore, memory is distorted so that schema-relevant information is retained at the expense of schema-irrelevant information. In addition, schema-based "constructive" memory processes can cause a person to fill in additional schema-consistent information. Generally, memory is biased toward retention of true schema-relevant information and addition of false, but schema-consistent, information.

Older adults are more susceptible to the biasing effects of schematic processing with respect to social information (Hess, 1999) and memory for nonsocial objects (Hess and Slaughter, 1990). We discuss this in greater detail in the section on jury decision making.

Failure of Retention

Age is related to more rapid forgetting in a variety of specific domains, including spatial location (Rutledge et al., 1997). When tested for recall immediately, older adults show substantially less impairment relative to younger adults than when tested after delay (see reviews in Craik, 2000; Zacks et al., 2000). Thus, it is particularly important to interview older witnesses as soon as possible after the event in question. This differential slope of forgetting over time also has implications for the performance of older jurors, particularly in long trials in which evidence and witness testimony must be remembered for weeks or months before the jurors reach a verdict.

Accuracy of Retrieval

Generally, older adults are unable to remember events as completely or as accurately as younger adults (see reviews in Craik, 2000; Rubin, 2000). "Episodic memory," or memory for autobiographical events
that have happened comparatively recently (see reviews in Craik, 2000; Wingfield and Kahana, 2002), is among the cognitive abilities shown to decline most sharply with age. Thus, older adults will, on average, be less able to retrieve elements of events they have witnessed, whether peripheral details or the core of the event. However, a particular deficit of episodic memory — memory for the context of an event (often referred to as “source monitoring”) — has been of interest in legal settings. Therefore, we will focus our discussion on this problem.

**Age and General Problems of Source Monitoring**

Older persons experience greater difficulty in “associative learning” — that is, in forming and maintaining connections between mental events. This is referred to as a deficit in “binding,” or integration of the various elements of an event, or of the event with the context in which it occurs (see reviews in Craik, 2000; Glisky, 2001; Koustaal and Schacter, 2001). “Source memory” or “source monitoring” refers to the latter instance of associative learning (or binding), in which the memory of the core or gist of an event is bound successfully with the memory of the context in which it occurred. Substantial evidence has indicated that source or contextual memory is particularly dependent upon frontal lobe function and that the frontal lobes are preferentially affected by aging (see Glisky, 2001; Koustaal and Schacter, 2001; Raz, 2000).

Memory for context is considered to be more difficult than simple memory for the core of an event, as well as more susceptible to age-related decline, in that it requires greater attention (and divided attention) and processing of content and the spatiotemporal link between elements at encoding — capacities known to decline with age. Older adults may have problems dividing attention to encode the core event, along with the contextual cues and links between them, and therefore narrow attention to the core at the expense of context.

Schacter and his colleagues (see Koustaal and Schacter, 2001) have suggested that elderly adults tend to encode information in a less elaborative and distinct manner (such that cues that would distinguish the target information from other potentially similar information are encoded and bound with the target), which tends to render them more susceptible to source-monitoring errors. Indeed, a number of studies have shown that fact memory is substantially less affected by aging than source memory (see the review in Glisky, 2001). Furthermore, although source errors can be reduced for younger and older adults through use of more elaborative encoding strategies that increase the distinctiveness of target information, age differences still remain (see Koustaal and Schacter, 2001).

Difficulty with adequate encoding of contextual cues has been shown to result in a disadvantage for older adults in memory for, among others,

- Perceptual details such as color, case, or font of written stimuli
- Locations
- Temporal sequence
- The sex or specific identity of a speaker
- Whether an item was presented in video or photo format
- Whether something was presented auditorily or visually
- Whether the individual personally said something or actually did it
- Whether something was seen or heard vs. simply inferred on the basis of other things that were seen or heard
- Whether something was imagined or actually happened
- Why a face seems familiar (i.e., where it is known from)
- Which person did or said something
- Things one is supposed to do at a particular time or place (termed “prospective memory”)
- The source of medical information

See reviews in Glisky (2001); Zacks et al. (2000); and Koustaal and Schacter (2001).

Furthermore, older adults tend to rely more on schematic knowledge in attempts at source memory, which may enhance their source-monitoring errors when the actual source is inconsistent with their
schemas (Mather et al., 1999). In part, these deficits in source monitoring are reflected in problems we have already reviewed, such as less detail and poor memory for time and spatial features such as durations, sequence, location, layout, or route. However, of particular interest in forensic settings, problems in source memory have been implicated as the cause of inaccuracy in witness testimony.

Three general arenas of source confusion in witness testimony have been extensively studied:

- The "misinformation effect" (Loftus, 1979), in which information suggested during an interview replaces or becomes integrated with the memory of the actual event
- Confusion between ideas or "memories" developed in therapeutic procedures and actual events (Loftus and Ketcham, 1994)
- Misidentification of an innocent suspect due to misunderstanding of the source of the sense of familiarity of the face

We review research relevant to age differences in susceptibility to these three forms of source monitoring errors in the following subsections. Later, we consider the implications of age-related decline in source monitoring for jurors.

The Misinformation Effect

A popular paradigm for studying memory distortion that is applicable to the forensic arena has been the "misinformation" paradigm developed by Loftus and her colleagues (Loftus, 1979; 1992; Loftus and Hoffman, 1989; Loftus et al., 1978). Participants are exposed to pictures or films depicting objects or action sequences and, subsequently, experience misleading information regarding the contents. For example, the experimenter may ask a question that presumes the existence of a fact or object not depicted in the original materials (e.g., "Did another car pass the red Datsun while it was at the stop sign?"). When later asked whether the nonpresented object (the stop sign) was present in the original depiction, many participants will nonetheless report that it was and proceed to describe it in detail. Older subjects have reliably shown greater susceptibility to this misinformation effect (Cohen and Faulkner, 1989; Karpel et al., 2001; Loftus et al., 1992; Searcy et al., 2000; see Coxon and Valentine, 1997, for less clear differences) and greater confidence in their false memories (Cohen and Faulkner, 1989; Karpel et al., 2001; Mitchell et al., 2003).

Underwood and Pezdek (1998) investigated relative susceptibility to misinformation provided by credible vs. incredible sources. Although misinformation from a credible source induced more errors immediately after the misinformation, 1 month later errors consistent with the misinformation were high for both high- and low-credibility sources. Presumably, as memory for the source of information decreased, discounting of information from a low-credibility source also decreased. Greater susceptibility to source forgetting in the elderly would be expected to render them relatively more susceptible to misinformation from low-credibility sources — particularly as the delay between the misinformation and retrieval increases.

Multhaup and colleagues (1999) investigated the potential of a "source-monitoring" retrieval procedure to reduce the misinformation effect in older adults. This procedure had previously been shown to eliminate the misinformation effect in younger adults (Lindsay and Johnson, 1989). Lindsay and Johnson gave half of the participants in a misinformation experiment a yes/no recognition test for items in the original event. The other half was given a source-monitoring test, in which they were asked to identify the origin of each item as the original picture, the (misleading) text, neither, or both. The authors found the standard misinformation effect with the yes/no procedure, but not for the source-monitoring procedure. Multhaup et al. (1999) replicated this design with older adults and, again, the source-monitoring test format eliminated the misinformation effect. At least in their sample, instructions requiring conscious effort to retrieve the contextual source of information were effective for the older adults.

A conceptually similar pattern of results was obtained by Multhaup (1995), who showed that the "false fame" effect was eliminated by a similar source-monitoring retrieval task. Subjects in the false-fame task pronounce a list of nonfamous names. Later, they judge as famous or nonfamous a list of names including famous names, pronounced nonfamous names, and new nonfamous names. During the fame judgment task, the pronounced nonfamous names seem familiar.
If the person fails to monitor the source of that feeling of familiarity accurately as the previous pronunciation, he may falsely conclude the name is famous. As a result, previously pronounced nonfamous names will more often be judged famous than those not previously pronounced. Multhaup's (1995) source-monitoring retrieval task led participants to indicate whether each test name was a famous name, a nonfamous name pronounced earlier, or a new nonfamous name. Although older adults were more susceptible to the false fame effect than younger adults in a standard famous/nonfamous recognition task, the false-fame effect was eliminated for both groups in the source-monitoring retrieval task.

For the misinformation and false-fame studies, the authors attributed their results to the adoption of stricter decision criteria for assigning a particular item to a particular source to perform the source-monitoring task. In the absence of such strict criteria, the person may rely on a sense of familiarity to decide whether the item was present in the picture, whereas the stricter criterion presumably requires reliance on memory for more specific perceptual and spatial details to establish context. Multhaup et al. (1999) suggested that older adults may benefit from listing possible sources when they are trying to retrieve the context of events or information. (See Zacks et al., 2000, for other factors and strategies that moderate age differences in source monitoring failures.)

A promising line of research showing that elderly people can learn to reduce source monitoring errors involves the use of a procedure known as the DRM paradigm. Here, subjects study lists of semantically related words (such as dream, tired, bed, snore) and then try to recall or to recognize what they previously heard. A central finding is that all adults, regardless of age, are prone to remember nonpresented but associated words (e.g., sleep). However, older adults are more likely than younger adults to false recall the critical nonpresented lures. This increase in false recognition has been seen in a number of paradigms (Dodson and Schacter, 2002). On a more positive note, older adults were able to learn to use a retrieval strategy called the “distinctiveness heuristic” to reduce their rate of error. If pictures accompanied the words, an especially large reduction in error rate occurred for the elderly, making their performance more comparable to that of young adults.

**Source Confusion and Therapeutic Process**

Recent years have witnessed an explosion of interest in the extent to which common therapeutic techniques such as hypnosis, guided imagery, dream interpretation, and participation in “survivor groups” might lead a patient to develop false memories — in particular, false memories of sexual abuse (see Loftus and Ketcham, 1994). A wealth of data has now accumulated to demonstrate that these techniques can, indeed, produce false memories (see reviews in Davis and Follette, 2001; Loftus and Ketcham, 1994).

Essentially, the person is exposed to suggestions from the therapist that a particular event may have happened, followed by a variety of procedures designed to uncover the memories that are at first allegedly inaccessible. These procedures involve continuing suggestion during such activities as dream interpretation, guided imagery, or hypnosis. For example, the person may be asked to imagine the event in question, try to remember it, or expose himself to situations that might trigger the memory (such as survivor group discussions). In this context, the person may develop vivid images or dreams of the presumed events, even though they never occurred. The combination of suggestion and imagery results in what feels like a “memory.” However, the person mistakenly believes the source of this memory to be an actual event, rather than the mental processes and images generated by the therapeutic process.

Empirical research has demonstrated the capacity of suggestion, guided imagery, hypnosis, and other procedures to generate false memories. However, although there is not a great deal of research on aging and the potential of such procedures to induce false memories, we did locate some work using imagination with older participants. A number of studies have shown that older adults more easily mistake events they have imagined as memories for actual events. This difference applies with respect to confusion between imagining and actually doing something, and imagining vs. seeing or hearing something done or presented by others (see reviews in Koustaal and Schacter, 2001; Zacks et al., 2000). Given these specific results in combination with the general literature showing age-related decline in accurate source monitoring, it is reasonable to hypothesize that older adults will be more susceptible to development of false memories through common therapeutic procedures.
Face Perception and Eyewitness Identification

Cognitive researchers have identified age-related declines in fundamental face perception processes, which ultimately result in greater rates of inaccurate eyewitness identification and, in particular, higher rates of false identification. We first consider age-related changes in basic face perception processes and then turn to research specifically on eyewitness identification.

Age-Related Declines in Face Perception and Face Memory. Aging is generally associated with decline in spatial/nonverbal ability (see reviews in Chalfonte and Johnson, 1996; Jenkins et al., 2000). Consistent with this general decline in visuospatial abilities, research on face recognition has documented age-related declines in recognition performance for unfamiliar (once before seen) faces (Bartlett, 1993; Bartlett and Leslie, 1986; Bartlett et al., 1989; Crook and Larrabee, 1992; Ferris et al., 1980; Smith and Winograd, 1978). Older adults exhibit greater susceptibility to false recognition of faces not actually previously seen (Koustaal et al., 2001), although consistent age differences in accurate recognition of once-seen faces has not been observed (see Searcy et al., 1999, for review). In addition, older adults report less confidence when they do correctly reject foils (Yarmey, 1984; Yarmey and Kent, 1980). Older adults seem generally more susceptible to false recognition because they exhibit greater tendency to select false information when recognizing details of a previously seen event as well.

Several processes appear to underlie age-related differences in facial recognition performance. First, many face recognition tasks rely at least in part on long term episodic memory — for example, in the standard eyewitness identification paradigm to be discussed later. Because episodic memory shows one of the steepest declines with age, age-related declines in facial memory may reflect general deterioration of long-term episodic memory. Consistent with problems with long-term episodic memory, Memon and colleagues (2003) found the effect of age on perpetrator lineup identification to be greater after 1 week than after 35 minutes.

Second, face recognition relies in part on accurate source-monitoring capabilities. The person must recognize that the face is known and retrieve the context in which it was encountered. Some have suggested that older adults rely more on heuristic strategies such as “familiarity,” “feeling of knowing,” or “availability,” in the absence of more consciously controlled processes such as contextual recollection and source monitoring (Bartlett and Fulton, 1991; Jacoby, 1991; Searcy et al., 1999, 2000). Thus, they will tend to choose faces that seem familiar, whether or not the source of familiarity is correct. Indeed, Memon et al. (2003) showed that correct perpetrator lineup identifications were related to an independent measure of source recollection ability, which in turn was negatively related to age.

Third, advancing age may result in declining face perception abilities. Indeed, evidence from the standard Benton Facial Recognition Test (Benton et al., 1994) has indicated that older adults become less able to match a target face to the correct alternative among six candidates shown immediately below (and simultaneously with) the target. This non-memory-dependent task has been shown to predict time-delayed memory-dependent witness lineup performance (Searcy et al., 1999). Therefore, age appears to be related to decline in perceptual feature matching, which is in turn related to poorer recognition performance.

Furthermore, Memon and Bartlett (2002) have offered evidence that older witnesses reported greater reliance on feature matching as a strategy for identification of culprits from a lineup and, in turn, those who reported relying on feature matching were less accurate (13%) than those who reported other strategies (44%). Interestingly, the reverse was true for younger witnesses (38 vs. 15%). Thus, it appears that older adults may be more reliant on feature matching as a strategy for recognition and less accurate in using their preferred strategy.

These and other potential mechanisms underlying decline in face perception and memory are the likely results of age-related changes in brain structure and function. For example, Schretlen and his colleagues (2001) examined the influence of age, sex, education, perceptual comparison speed, frontal lobe volume, nonfrontal volume, and ventricle-to-brain ratio (VBR) to Benton Facial Recognition Test performance. Age was the strongest negative predictor of performance. However, VBR and processing speed alone accounted for almost 34% of the variance, with age in the equation. Frontal and nonfrontal lobe volume also contributed significantly to the equation, but added only slightly more than 1% to the
explained variance. Such results are consistent with long-standing findings that lesions, injuries, or lobectomies to the frontal lobes create impairment in face processing and recognition (see the summary in Schreden et al., 2001).

Others have directly examined brain function during facial processing tasks through use of event-related brain potentials (ERP) (Grady, 2002; Pfetze et al., 2002) or PET (positron emission tomography; Grady et al., 2002, in attempts to identify the location and nature of age-related differences in brain function and their relationship to deficits in specific stages of facial processing and retrieval under varying task conditions. A detailed review of these results is beyond the scope of this chapter. However, Grady et al. (2002) and Pfetze et al. (2002) provide excellent summaries of recent relevant literature.

Generally, such studies of brain function have shown some age-invariant functions but a greater variety of age-related changes in brain functions, which can be empirically linked to face processing/recognition performance. Furthermore, they have shown that older adults appear to use different areas of the brain than younger adults for face processing under some conditions, indicating that loss of function in some areas of the brain may be compensated for by alternative processing routes. Together with studies linking structural changes in the brain to performance, the ERP and imaging studies clearly demonstrate that brain changes underlie age-related declines in face processing.

Finally, several studies have shown that older adults less accurately identify facial displays of emotion in photographs and video clips (Sullivian and Ruffman, 2004; McDowell et al., 1994). As with other visual skills, older adults appear to use different areas of the brain for emotion identification than younger adults (Gunning-Dixon et al., 2003). Although not directly relevant to eyewitness identification, these results suggest that older adults may be less accurate in reporting the emotional tone of interchanges and thus less accurate in their reports of the meaning of the exchange.

Specific Studies of Age and Eyewitness Identification. Compared to the enormous number of studies that have been done on children as eyewitnesses, there is a relative paucity of research involving older eyewitnesses. A few studies have shown that elderly eyewitnesses are more prone to inaccuracy in eyewitness identifications (List, 1986; Memon and Bartlett, 2002; Memon and Gabbett, 2003a, b; Memon et al., 2002; O’Rourke et al., 1989; Yarmey, 1985, 1993, 1996; Yarmey et al., 1984), with elderly witnesses making from 25 to 50% more identifications than their younger counterparts — most of them false. A few studies have failed to replicate this age difference (Memon et al., 2003; Wright and Stroud, 2002; Yarmey and Kent, 1980). However, Yarmey and Kent (1980) did find poorer recognition of bystanders among older participants. Also, Memon et al. (2003) found no age differences on the Benton Facial Recognition Test in their sample. Thus, the lack of differences in false identifications in their study may be explained by their relatively high-functioning older sample.

As with basic face recognition studies, eyewitness identification studies have shown that older adults are particularly prone to false identifications of innocent foils, whereas there are often smaller or no age differences in accurate identification of the perpetrator in target-present lineups (Adams-Price, 1992a, b; Searcy et al., 1999, 2000; Memon and Bartlett, 2002; Memon et al., 2003; Memon and Gabbert, 2003a, b), although Searcy et al. (2001) found the opposite pattern and, in another study, found an age-related reduction in hit rates (Searcy et al., 1999, lineup 3). Generally, the tendency of older adults to make false identifications in target-present, as well as in target-absent, lineups is robust and widely interpreted as the result of older adults' greater use of "gist-like" encoding and failures of source memory (Koutstaal and Schacter, 1997; Schacter et al., 1998; Tun et al., 1998).

The Own-Age Effect. An unfortunate characteristic of much of the research on age and eyewitness memory is that, although witness age is varied systematically, perpetrator age is often held constant within younger age groups, thereby confounding witness age with witness–perpetrator relative age. This presents a problem of potential significance. That is, just as eyewitness researchers have documented a "cross-race" effect in eyewitness identification (Sporer, 2001), there appears to be a "cross-age" effect, such that witnesses are better able to identify targets of their own age group.

In two experiments, Wright and Stroud (2002) found that participants from two age groups (18 to 25 vs. 35 to 55), who had previously viewed videos of a car or a television theft, were more accurate at identifying the culprit when viewing culprit-present lineups of people their own age. (This effect occurred...
in those making the identification after only 1 day, but was very weak in those making the identification after 1 week and was weaker in older than in young adults.) No same-age effect was found for misidentification of innocent suspects in target-absent lineups. Similarly, an earlier study by List (1986) had 10-year-olds, college-age students, and adults 65 to 70 view shoplifting videos. Culprits were college-age or middle-age females. Older adults exhibited poorer recognition memory for the college-age culprits than either of the two other groups but better memory for the middle-age culprit.

Memon et al. (2003) investigated accuracy in identification of perpetrators who were old or young among old and young participants. Younger participants generally outperformed older participants. Older participants made more false identifications in perpetrator-present and perpetrator-absent lineups, particularly for younger perpetrators and after delays of 1 week rather than 35 minutes. Younger participants were also more prone to misidentify someone in older lineups, but were not less likely to identify the perpetrator.

Finally, own-age recognition biases have been observed outside the eyewitness identification paradigm. Several studies using standard face recognition paradigms, for example, have found superior performance for own-age targets (Bartlett and Leslie, 1986; Fulton and Bartlett, 1991; Mason, 1986). Furthermore, in their initial demonstration of the “change-blindness” phenomenon, Simons and Levin (1998) obtained what was apparently an own-age effect.

College-aged experimenters approached an unsuspecting pedestrian on campus, asking for directions to a campus building. While the pedestrian attempted to provide directions, two other confederates appeared to interrupt rudely by passing between the experimenter and pedestrian, carrying a large door. As the door passed between them, the first experimenter changed places with a second, who emerged from behind the door and continued the exchange with the pedestrian as if he had been in the conversation all along. The second experimenter wore different clothing and differed in height and voice. Yet, less than half of participants noticed the change and older adults were less likely to notice than younger adults.

Simons and Levin interpreted this age difference as an instance of the broader own-group bias in face processing. A replication of the door experiment revealed that even younger people are more likely to notice the change for members of their own social group (other college students) than for those of a different social group (the same persons, but dressed as construction workers; Simons and Levin, 1998, experiment 2), perhaps due to greater specificity in processing for in-group members.

The growing evidence of an own-age bias in face recognition suggests that the results of many earlier studies of eyewitness accuracy might be due not to age-related general decline in accuracy but rather to the particular age combinations used in the study. Further research is needed to examine the relationship between witness and culprit age that employs adults throughout the age span, including into old age. Meanwhile, the results are nonetheless useful in practice for a wide variety of witnessing situations. Because crime is much more prevalent among the young, elderly witnesses will often be in the position of attempting identification of a younger culprit.

**Interaction of Age with Conditions of Encoding or Retrieval.** To the extent that age renders the witness more susceptible to failures of encoding, storage, or retrieval, it is relevant to ask whether the aging witness will suffer enhanced impairment as a result of poor witnessing conditions, longer retention intervals, or biasing influences at retrieval. To date, however, only a few studies have addressed these issues.

Witnessing Conditions. Two studies examined the effects of “weapons focus,” violence of the crime, perpetrator disguise (O’Rourke et al., 1989), and “cross-race” targets (Brigham and Williamson, 1979) as a function of age, but found no interaction of these variables with age. Memon et al. (2003) examined the effect of duration of exposure to the perpetrator’s face, and whether the lineup was target present or target absent, on accuracy in young and old adults. They also found no interactions with age (although as noted earlier, the sample of older adults scored equivalently to the young adults on the Benton Facial Recognition Test). We were unable to locate other studies examining the interaction of age with effects of such variables as lighting, arousal, and so on, even though the documented declines in perceptual processes would suggest such age-related interactions. Thus, a number of issues remain open for future research to pursue.
Attention at Encoding. The Negative Relationship between Memory for Detail and Eyewitness Accuracy. Some previous research has indicated that memory for details of some aspects of an event is negatively associated with memory for others (Wells and Leippe, 1981). If attention is focused on some things, attention to others will suffer. To the extent that older adults suffer decrements in capacity for divided attention (as reviewed earlier), they might be expected to show enhanced negative relationships between recall of peripheral detail and identification accuracy. Indeed, Searcy et al. (2000) found that higher levels of recall of the target event and of other nonfacial features of the target were associated with higher levels of false identifications for seniors, but not for younger adults.

Lineup Procedures. Several studies have attempted to assess the differential impact of variations in identification procedures for younger and older witnesses. Eyewitness researchers have adopted the position that witness identification accuracy is enhanced through use of sequential lineups in which one potential culprit is present at a time, as opposed to simultaneous lineups in which (usually) six potential suspects are presented simultaneously (Steblay et al., 2001). More specifically, as shown by Steblay’s (Steblay et al., 2001) meta-analysis of these effects, sequential lineups appear to reduce the overall likelihood of any choice, correct or incorrect. Thus, although the procedure reduces the proportion of false identifications of innocent suspects, it also reduces true identifications of the perpetrator (hits).

Self-reports of those tested with a sequential lineup suggest they tend to use an “absolute” — as opposed to a “relative” — judgment strategy, whereby the target is judged for absolute fit to the witness’s memory of the culprit rather than for the relative fit of the target to the memory (i.e., the fit relative to other members of the lineup) (Dysart and Lindsay, 2001; Wells et al., 1998). This stricter decision criterion would naturally have the effect of reducing witness willingness to make any choice, whether correct or incorrect.

Memon and her colleagues have investigated the potential interaction of age with lineup procedure in a series of studies. Using a target-present lineup only, Memon and Bartlett (2002) investigated the effects of simultaneous vs. sequential procedures for young (18 to 30 years) vs. old (60 to 80 years) adults. Generally, older adults made more false identifications, but lineup procedure did not interact with age. Instead, sequential lineups decreased accurate identifications (hits) for both age groups.

Similar results were obtained by Memon and Gabbert (2003b) for target-present lineups. However, these researchers (2003a) did find an interaction between age and lineup procedure in target-present lineups (but not target-absent lineups), such that sequential testing reduced false alarm rates for younger but not for older adults. For target-absent lineups, the authors found main effects for both age and testing conditions, such that both groups made fewer false identifications under sequential testing conditions, but older adults made more false identifications than their younger counterparts in sequential and simultaneous target-absent lineups.

Memon and Gabbert (2003b) further investigated the effects of lineup procedure specifically for TP (target-present) lineups. However, in this study, they also varied whether the appearance (hairstyle) of the perpetrator had changed subsequent to the crime. This variation was expected to have a greater effect under conditions in which the witness adopts stricter criteria of absolute fit for identification (i.e., the sequential procedure) than under those in which he might adopt a more lenient criterion of best fit (i.e., the simultaneous procedure).

Younger (17 to 33 years) and older (58 to 80 years) adults viewed a short film depicting a female target stealing money from a car. Later, participants described the perpetrator and subsequently viewed a lineup, in either simultaneous or sequential format, in which the perpetrator’s hairstyle had or had not changed. Across conditions, younger adults recalled more details of the target’s appearance correctly and fewer incorrectly. Older adults made fewer hits and more false identifications than younger adults. Across age groups, fewer choices of all kinds were made under sequential (58%) than under simultaneous (75%) lineup procedures. This drop was due to a drop in hit rates in the sequential lineups because there was no drop in false identifications.

Interestingly, although the rate of misses increased dramatically for perpetrators whose appearance had changed, it did so particularly for sequential lineups, and particularly for younger adults. For older adults, although the pattern was similar, no significant main effects or interactions were found. Memon
and Gabbert suggested that change in appearance was particularly detrimental to younger adults, who they presumed would be relying on attempts to remember the face in context specifically, whereas it would be less detrimental to older adults, who they presumed would be more likely to rely on a context-free sense of familiarity.

Memon and Gabbert’s (2003b) results suggest that, in practical circumstances, older adults may suffer a lesser drop in hit rates when viewing sequential, as opposed to simultaneous, lineups, specifically under conditions in which the perpetrator’s appearance may have changed. Changes in clothing, hair, facial hair, the presence of a hat, removal of elements of a disguise, and so on are arguably quite common between the crime and arrest.

To summarize, for target-present lineups, age effects are somewhat inconsistent. For simultaneous lineups, some have found reduced hit rates among older adults (Searcy et al., 1999, lineup 3; 2001), and some have found no age differences (Searcy et al., 1999, lineup 1; Memon et al., 2003). Older adults have been consistently more susceptible to false alarms in target-present and target-absent lineups, whether administered simultaneously or sequentially. Sequential vs. simultaneous testing did not eliminate age-related declines in eyewitness performance. Instead, under conditions in which the perpetrator’s appearance (hairstyle) was different in the lineup than when he or she had committed the crime, the hit rate of younger adults was selectively impaired by the sequential procedure, whereas the rate of false identifications of older adults was not improved. Overall, then, there appear to be no reliable age by lineup procedure interactions.

Source Monitoring and Exposure to Mugshots. In some cases, the witness is asked to examine mug books to attempt identification of a suspect. This exposure can lead to a sense of familiarity, which forms the basis of a source-monitoring error that can produce a false identification when the witness later sees the same person in a lineup. If the witness actually identifies the innocent person in the mugbook, he may become committed to that identification in a way that further encourages him later to identify the innocent falsely in a lineup (see the review in Memon et al., 2002).

Memon and colleagues (2002) exposed participants to a videotaped car theft. Subsequently, they were asked to examine a target-absent mug book to attempt identification of the suspect (although control subjects did not inspect the book). All participants were given a target-absent lineup 48 hours later. Older adults were significantly more likely to identify someone from the mug book falsely and to choose a foil from the lineup. However, although all subjects who viewed a mug book were more likely to pick the foil who appeared in both the mug book and lineup, there was no age difference in this tendency.

The Verbal Overshadowing Effect. Memon and Bartlett (2002) also attempted to assess age-related susceptibility to the “verbal overshadowing” effect (Schooler and Engstler-Schooler, 1990). Verbal overshadowing refers to a situation in which verbal descriptions of a target interfere with later target recognition. However, the authors reported only a small effect of verbal descriptions prior to attempted identification of a culprit, and no evidence of greater susceptibility in older jurors was found.

Interviewing Procedure: Effects of Context Reinstatement. Because false identifications are considered to result in part from inaccurate source monitoring, a number of investigators have examined the effects of context reinstatement on identification accuracy (see the review in Searcy et al., 2001). The results of these investigations have been mixed. Nevertheless, Searcy and colleagues (2001) tested the effects of context reinstatement on identification accuracy of young and old adults, 1 month after a personal interaction with the target. No beneficial effects were obtained in either population.

Similarly, Memon and colleagues (2002) found no benefit from verbal reinstatement of the context of a previously viewed crime on identification accuracy. Although other procedures for context reinstatement may prove more effective, there is currently no overall support for the effectiveness of context reinstatement.

The “cognitive interview” (Fisher and Geiselman, 1992) includes such techniques as context reinstatement, minimizing background noise, asking open-ended questions, and encouraging use of nonverbal responding. This interview method has been shown to enhance the amount of correct information recalled. Although they did not examine accuracy of eyewitness identification, Mello and Fisher (1996) found that, whereas the cognitive interview enhanced accuracy for young and old adult witnesses to a
videotaped crime, enhanced recall was greater for older adults. However, McMahon (2000) found no overall or age-specific effects of the cognitive interview (vs. a structured interview) but did find a significant age effect on amount of true (but not false) information recalled.

Overall, research investigating remedies for age-related declines in eyewitness accuracy has been disappointing, yielding conflicting findings that make firm conclusions premature. Given the importance of accuracy in eyewitness testimony, this search for improvements should not be abandoned.

Eyewitness Metamemory: Are Aging Eyewitnesses Aware of Their Inaccuracy? Eyewitness researchers have shown that the relationship between confidence in accuracy and actual accuracy is often weak (Bornstein and Zickafoose, 1999; Brewer et al., 2002; Olsson, 2000). Some researchers have examined the relative strength and direction of this relationship in older and younger witnesses. Yarmey (1985) reported that, although elderly witnesses were less confident than younger witnesses, there were no age differences in the relationship between confidence and accuracy. In contrast, although replicating the main effect of age on accuracy, four studies found positive relationships between confidence and accuracy in young adults, and no significant relationships among older adults (Memon and Bartlett, 2002; Memon et al., 2002, 2003; Searcy et al., 2000). Searcy and colleagues (2001) further found that seniors’ self-rated memory self-efficacy was positively associated with false identifications in target-absent lineups. It appears, then, that seniors may less accurately monitor the quality of their identification performances.

A New Area for Expert Testimony? Stereotypes of older eyewitness are mixed. That is, although older witnesses are seen as less accurate (Groth, 1979; Kwong See et al., 2001), they are also seen as more honest (Brimacome et al., 1997; Kwong See et al., 2001). Thus, juror intuition is consistent with actual overall age differences — at least with respect to accuracy. Even so, aging witnesses are not always seen as less credible. Nunez and colleagues (1999) presented a case involving an aggravated assault, in which the victim identified the defendant. The victim was described as a generic adult victim or as one of five variations of older adults varying in apparent abilities. Ratings of believability were not significantly lower for older witnesses. Thus, in some cases, jurors may not be sensitive to age-related inaccuracies.

It is also important to remember that age does not exert uniform effects on all measures of accuracy (e.g., hits in target-present lineups are comparable, whereas false identifications are greater), and age-related decline is widely variable across individuals. Thus, jurors would benefit from some mechanism for distinguishing between impaired and relatively unimpaired older witnesses. Reflecting this need, Geiselman and his colleagues (2001) examined the effects of disclosing the results of a witness’s Benton Facial Recognition Test scores on juror verdicts. Witnesses described as scoring lower on the BFRT were seen as less credible. When the testimony included an explanation of the conditions under which BFRT scores are most predictive of accuracy, jurors correctly placed more weight on the BFRT scores when witnessing conditions for the reported crime were poor. These results indicate that testimony regarding individual witness abilities (including age-related abilities) can significantly affect witness credibility.

Voice Perception and Earwitness Identification
Forensic research addressing “earwitness identification” is far less extensive than that on eyewitness identification but has received increasing attention in recent years (see the review by Yarmey, 1995). Like eyewitness identification, evidence suggests that earwitness identification accuracy will decline with age. In line with the general age-related decline in auditory acuity, pitch discrimination, and so on, older adults suffer declining ability to recognize specific speakers (Bull and Clifford, 1984; Maylor, 1997). In part, this difference is due to encoding difficulties. For example, older adults are less accurate at initial discrimination between male and female voices (Kausler and Puckett, 1981). Furthermore, older adults — particularly those with relatively poor frontal lobe functioning — show poor source memory for voices (Glisky et al., 1995). After hearing several sentences spoken in one of two voices, those with poor frontal function showed impaired memory for the voice, but not for the sentences.

Although there is a burgeoning literature on earwitness identification (Yarmey, 1995), we were unable to locate any studies of the relationship between speaker identification and age conducted within a witness identification paradigm. Therefore, much remains to be investigated regarding the elderly earwitness.
11.4 Age-Related Judgment and Decision-Making Processes in Jurors

Stereotypes of the cognitive status of older adults appear to be both realistic and overly optimistic. Several studies of beliefs regarding age and cognitive function among German adults (Heckhausen et al., 1989; Heckhausen and Krueger, 1993; Hummert et al., 1994) found that, although age is viewed as associated with memory problems (e.g., slow, forgetful, absentminded) and inflexibility (e.g., overcautious, obstinate, headstrong, stubborn, inflexible), it is also viewed as associated with knowledge (e.g., knowledgeable, smart, experienced, well read, educated, well informed, etc.) and wisdom (e.g., open minded, reasonable, levelheaded, wise, intelligent, etc.). Thus, stereotypes of aged thinkers do include forgetfulness, but also appear to include confidence in more rational and wise decision making. How, if at all, do such stereotypes reflect actual differences in juror decision-making processes?

Thus far, we have summarized a number of differences in cognitive/information-processing abilities between younger and older persons. In this section, we first consider some implications of age-related declines in perception and memory for jury information processing. Second, we briefly review what is known about age-related differences in judgment and decision processes that would affect how jurors use the information they acquire to come to verdict/sentencing/damage decisions. As we consider these issues, we offer recommendations for effective presentation of information to older jurors if they are seated on the trial jury.

Age-Related Differences in Information Processing

Perhaps most relevant for aging jurors are age-related declines in perceptual abilities (see Faubert, 2002; Scialfa, 2002) that will compromise ability to process speech, nonverbal cues to meaning and deceit, and visual and auditory exhibits successfully. The most central of these, of course, are speech and discourse processing/understanding, which unquestionably decline with age. However, much of this decline is due to simple perceptual difficulty, and can be reduced by slower and louder speech (see the review in Schneider et al., 2002). Thus, attorneys facing older jurors should take care not to speak too quickly, to face jurors and have witnesses face jurors when possible (to allow the jurors to clarify unclear speech through lip reading and nonverbal cues), and to maintain adequate volume at all times.

Unfortunately, even when aging jurors do understand the content and the point of the presented evidence, they will (on the average) retain less of that information, particularly across the long retention intervals required in lengthy trials. For example, Fitzgerald (2000) examined memory for evidence among younger vs. older jurors. In a measure of free recall, jurors were asked to write an account of a 2-hour toxic tort trial they had just witnessed, written "so that someone who had not watched the trial would know what had taken place."

Overall, the accounts of older jurors were judged as significantly less "cohesive" than those of younger jurors. Older jurors' accounts also included fewer statements of probable facts, but more evaluative statements regarding parties to the case or lines of argument (although these differences were attenuated when legal instructions were provided before, rather than after, the evidence). Older jurors did not, however, include more erroneous statements or reports of evidence that was not actually presented. Recognition measures of memory for evidentiary statements and testimony were similarly influenced by age, in that older jurors recognized fewer actual statements, but did not show greater false recognition for nonpresented statements.

Clearly, older jurors will be at greater risk of failure to understand and remember evidence. Thus, these jurors may benefit more than younger ones from standard presentation tactics designed to enhance memory, such as redundancy, vividness in language and visual exhibits, exhibits designed to reinforce points, enumeration of points of evidence and drawing connections between them and trial issues, and so on. Fitzgerald (2000) also varied whether jurors were permitted to take notes, showing that older and younger jurors benefited. Thus, note-taking may be another valuable support for older jurors.
Implications of Age-Related Failures in Source Monitoring

We have already documented the age-related relative inability to monitor the contextual source of information or events accurately. In jurors, failures of source monitoring would be expected to result in failure to track the source of testimony and evidence accurately, as well as to track the association between information and other cues relevant to the accuracy of that information. Indeed, older persons are less able to remember accurately which person gave them specific items of information (Ferguson et al., 1992; Hashtroudi et al., 1989; Schacter et al., 1991) and less able to remember the source of conversational contributions accurately (Brown et al., 1995; see Davis et al. [Chapter 12 in this volume], Davis and Friedman, in press for reviews).

This failure to track the source of information accurately may contribute to failure to discount low-credibility evidence or testimony properly. For example, research on the “sleeper effect” (Priester et al., 1999; Underwood and Pezdek, 1998) has shown that although information associated with a source lacking in credibility may be initially discounted, as time passes the information becomes more credible. As the low-credibility source is forgotten or becomes dissociated from the information, the information ceases to be discounted, becomes more credible, and thus exerts greater influence on judgment. As noted earlier, using the misinformation paradigm, Underwood and Pezdek (1998) found that subjects became relatively more influenced by misinformation from a low-credibility source over time. To the extent that aging jurors will be more susceptible to confusion regarding the source of evidence, the testimony of witnesses who have been discredited may likewise become more influential with older jurors because they fail to connect the discrediting information with the discredited witness’s testimony.

Although the effects of the passage of time have not been directly tested, Chen and Blanchard-Fields (2000) studied age differences in reactions to true and false information, using the “false information paradigm” developed by Gilbert and his colleagues (1990, 1993). Participants read police reports containing true statements printed in black and false statements printed in red. They were told that the red statements had gotten into the report by accident and actually belonged to another crime report or an unrelated incident. Presumably, source-monitoring errors would be more prevalent among older adults — and among younger adults subject to distraction during their review of the report — and later cause them to include the discredited information in their judgments. As expected, undistracted older adults and distracted younger adults were more influenced by the false statements. Thus, even when judgment immediately followed the presentation of information, older adults were more likely to lose the link between a fact and the credibility of the fact than younger adults.

A related failure may occur with respect to attorney claims or arguments. People tend to rate repeated statements or claims as more valid and believable than those presented less often — an effect known in the marketing and advertising literature as the “truth effect.” Older persons are more susceptible to this effect (Law et al., 1998), suggesting that older jurors may be more persuaded by oft-repeated claims, whether backed by good evidence or not. This tendency is assumed to result from the increasing sense of familiarity resulting from repetition, combined with failure of source memory.

Although we know of no direct tests of our suggestion that source forgetting may selectively enhance the credibility of discredited witnesses or attorney arguments in aging jurors, one study directly tested source memory for plaintiff, defense, and neutral facts (i.e., correct linking of statements to witnesses and other participants in the trial). Older jurors made fewer correct links than younger jurors (Fitzgerald, 2006). (See also Davis et al. [Chapter 12 in this volume] and Davis and Friedman, in press for reviews of age differences in source monitoring in conversation.)

A final kind of source monitoring is potentially more important that those we have cited thus far; that is, maintaining the mental link between an item of evidence and the implications of that evidence for the central issues of the case. Such links are often a problem for jurors because attorneys do not always take care to tell jurors why a particular fact is important and to link it to the case issues — often because they believe it is so obvious as not to need connection.

In both senses, however, older jurors may be at a disadvantage. Cohen (1979) suggested that even when elderly people are able to understand what was said, they are less able to draw inferences from the literal content, so others often view them as failing to “get the point.” This point has been supported in
studies of comprehension of medical information. Older patients answer questions concerning the literal content of drug information somewhat more inaccurately than younger adults (e.g., "What are the side effects of this drug?"), but perform much more poorly when answering inferential questions requiring searching for information in several places and putting it together sensibly (e.g., "How long will this medication last?"—which requires use of information concerning number of times daily the medication is to be taken, along with the number of pills in the bottle).

The age difference became even stronger for more complex inferential questions, although both groups performed more poorly on more complex questions (Finucane et al., 2002; Park et al., 1994). This age-related deficit in inferential processes would suggest that attorneys must go to greater lengths to connect the information they provide to the inferences and conclusions they wish the jurors to draw. Furthermore, given that older jurors may also be more susceptible to forgetting such connections, attorneys should reinforce these connections more frequently for them.

**Age-Related Differences in Judgment/Decision Processes**

Once the evidence is in, jurors must consider the nature and weight of the evidence for each side, compare that evidence to legal standards for verdict and damage decisions, and arrive at their final decision. Again, some evidence suggests that older adults face greater difficulties in reasoning, judgment, and decision making. For example, Salthouse (1993; Verhaeghen and Salthouse, 1997) found that younger adults outperformed older adults on a variety of tests of reasoning ability. In fact, age-related declines in matrix reasoning and analytical reasoning (which test such abilities as perception of relationships between information, integration of information to reach a conclusion, abstraction, verification, and so on) have shown some of the largest correlations with age of any behavioral variable (Salthouse, 2001). Such deficits present a clear challenge for jurors faced with the lengthy presentations, substantial processing demands, and complex decisions necessitated by their role.

**Gathering and Combining Information**

In part, older adults seem to shortchange the information-gathering stage of decision making, relying on less complete evidence gathering and comparisons between fewer alternatives prior to making a decision. Some have suggested (Cole and Balasubramanian, 1993) that restrictions on working memory capacity may lead aging decision-makers to reach a point of information overload with less information than their younger counterparts. Beyond this point, additional search can yield dysfunctional consequences and incorrect decisions (Malhotra, 1982).

Zwahr and colleagues (1999) studied the implications of limitations in working memory for information use in medical decisions. Younger and older women studied detailed information regarding the pros and cons of hormone replacement therapy (HRT) for menopause and recommended a decision for a hypothetical woman in a vignette. Although age was unrelated to the recommended decision to take HRT, the manner in which the participants arrived at their decisions did vary with age. Older women sought out less information, made fewer comparative judgments, and considered fewer alternatives to HRT prior to arriving at their decisions (see also Meyer et al., 1995, for age and decisions regarding breast cancer). Path analyses indicated that cognitive abilities (including text memory, vocabulary, working memory, and perceptual speed) directly affected decision-making processes, whereas age exerted only indirect effects due to its strong negative association with cognitive abilities.

Studies of decision making in arenas such as product choice (Beatty and Smith, 1987; Cole and Balasubramanian, 1993; Furse et al., 1984; Johnson, 1990, 1993; Schaninger and Sciglimpaglia, 1981) have shown a similar age-related restriction in information search and review of alternatives prior to a decision, and/or poorer final choices. Although not directly analogous to information processing in court, studies of computer search and retrieval tasks, such as searches for information on the Internet, library, or customer service databases, have shown that older adults have less efficient search strategies and greater difficulty remembering previously followed links or information on previously viewed pages (see the review in Czaja et al., 2001).
In a particularly elaborate design, Streufert and colleagues (1990) studied decision making among four-person young, middle-aged, and older teams. Participants studied background materials about a fictitious nation and simulated the performance of a "national security council" required to manage the nation over a simulated compressed time scale of events across several months. The simulation posed management, governance, diplomatic, and emergency problems. As with the individual decision-making research reviewed previously, older teams considered less information, came to fewer decisions, and were less responsive to incoming information.

Furthermore, whereas younger and middle-aged teams had more focused discussions and reached decisions more quickly, older teams talked more but were more diffuse and less task oriented and "engaged in many seemingly endless discussions or arguments, often about minor details" (Streufert et al., 1990, p. 556). However, they did respond to unexpected positive and negative (emergency) information as well as the younger teams. Older teams also expressed satisfaction with their performance, apparently unaware of their failure to handle a wide range of events unsuccessfully.

The literature on aging and decision making appears to converge in indicating that older jurors are likely to give less complete consideration to the evidence before arriving at an individual verdict. To the extent that the jury contains mostly older people, the Streufert et al. (1990) study suggests that the entire group may collectively review the evidence less completely. At this point, however, it is premature to conclude that older jurors will ultimately vote differently than younger jurors because they will, perforce, be exposed to the full jury's deliberations.

Schematic Processing

Evidence also suggests that older jurors may use the information they acquire differently because they are more susceptible to biases due to personal attitudes and values and, more generally, to schematic processing (see the review in Hess, 1999). Hess (1999) suggested that aging will affect judgment through three components. The first, a processing component, refers to the cognitive resources brought to bear, including such components as speed, working memory, and inhibition that are known to decline with age. This decline should result in fewer resource-consuming modes of processing, including greater use of more automatic and effortless "top-down," or schematic, processing, and less use of more effortful "bottom-up," or systematic, piecemeal processing.

Hess (1999) explicated the implications of greater use of schematic processing for construction of mental models. Generally, mental models refer to representations of specific situations constructed by individuals to reflect their current level of understanding (Johnson-Laird, 1983; 1989). They include an integrated view of the available information regarding the situation at hand, in the context of the person's general world knowledge and world view, which results in a coherent conceptual representation independent of the surface structure of incoming information. In the trial context, construction of mental models may include those of specific individuals, products, situations, etc., or of the juror's overall trial story.

It is well known within the social cognition literature that more automatic and schematic processing occurs under conditions of limited attentional resources or heavy processing load (Bargh, 1994). Thus, in line with reduced processing capacity views of aging, studies of the relationship of age to construction of mental models have shown that age-related resource limitations posed by working memory and reduced efficiency due to failing inhibitory capacity combine to impair construction, updating, and access to mental models (see the review in Hess, 1999).

Essentially, schematic, top-down-driven processing results in more rapid categorization, less systematic review of new information, and therefore less updating and revision of impressions as new input comes in. Along with increased schematicity, age-related enhanced susceptibility to the effects of priming on judgment (Hess et al., 1998) is consistent with the notion that the initial impression a person forms becomes, in effect, the schema that controls further processing. Information relevant to that schema (or initial trial story) will be noticed and remembered better and will later become more influential in the final impression.

To the extent that older adults are more susceptible to schematic processing, for example, they should also show greater selective memory for schema-relevant information. Consistent with this expectation,
Hess and his colleagues (see the review in Hess, 1999) showed that older adults attempting to remember a narrative showed poorer memory for items that were atypical for, or irrelevant to, the type of situation depicted than younger adults. Essentially, script-inconsistent or -irrelevant information that could not be linked to the operative script was simply not processed sufficiently to promote memory.

Generally, research on reproduction of recently learned stories has shown that older adults remember less information and are more likely to impose schematic narrative themes, morals, or lessons on their recall of story elements, thus remembering more highly integrative and succinct representations of the story's essential meanings than younger adults (Adams et al., 1990, 1997; Pratt et al., 1989; Mergler et al., 1984/1985 — see the review in Isacowitz et al., 2000).

Hess and his colleagues also showed that older adults are less likely to process apparently schema-inconsistent information carefully in order to try to understand the inconsistency. In research with younger adults, schema-inconsistent information is typically remembered better than consistent information (Hastie, 1984). Presumably, the effort to understand how the inconsistent information can be explained in light of the overall mental model causes it to be processed more deeply, leading to superior memory for it. However, Hess (1999) showed that this effect occurred for younger but not older adults. In line with Craik's (2000) argument that self-initiated, effortful processing becomes less likely with age, the author interpreted these results to mean that older adults simply did not choose to engage in the effort to try to integrate the apparently contradictory information and therefore did not remember it better (or sometimes at all). In turn, failure to process apparently contradictory information carefully renders it less influential — hence, the lesser tendency of older adults to update and revise mental models as indicated by incoming information.

In addition to its effects on memory for information that is presented, as noted earlier, schematic processing can lead to pseudomemories for information that is not presented, but consistent with (or implied by) the information that was presented. For example, in the false recognition paradigm developed by Roediger and McDermott (1995), participants study a list of words (such as symphony, song, lyrics, piano, jazz, etc.) semantically connected to a particular theme (e.g., music). Although the theme word (music, in this example) is implied by the other words, it is never presented. Nevertheless, many participants falsely recognize “music” as a word they previously learned. Older adults are reliably more susceptible to this effect (see the review in Koutstaal and Schacter, 2001). Thus, older adults may be susceptible to developing pseudomemories for nonpresented evidence or testimony implied by or consistent with the trial stories they have developed based on the actual presentation.

Schematic processing can also influence the nature of source monitoring errors. For example, Mather and colleagues (1999) found that those who had previously watched a videotaped discussion tended to misattribute a liberal statement to a Democrat (rather than to the Republican who actually made it) or a statement regarding working out to an athlete (rather than to the writer who actually made it) and that older adults were more susceptible to such schema-driven misattributions. In other words, source memory was reconstructed so that the statements matched the person from the social category schematically associated with the behavior or attitude reflected in the statement. Similar results have been obtained by others (Bayen et al., 2000; Sherman and Bessenoff, 1999).

Generally, schematic influences on memory tend to be greater when veridical memory is poorer, when processing demands are high in comparison to processing resources, or when processing capacity is restricted in some way (Bayen et al., 2000; Sherman and Bessenoff, 1999; Spaniol and Bayen, 2002) — all conditions more likely to occur for older adults. Such schematic influences can include, among other processing biases:

- Selective attention
- Biased interpretation of evidence
- Selective memory for evidence
- Schema-consistent source misattributions and other schema-driven memory distortions
- False memories for nonpresented evidence
Thus, memory is trimmed of schema-irrelevant material and shaped by schema-driven distortions and additions to form a generally schema-consistent account of what has occurred.

Finally, Hess and his colleagues (Hess, 1999) found that when coming to a judgment based on information in memory (such as would be the case for jurors arriving at a verdict at the end of trial), older jurors were less systematic in their use of that information.

It should be noted that a particularly unfortunate result of schematic processing and failing inhibitory control is increased prejudice among older adults. In an influential model of prejudice, Devine (1989) proposed that what differentiates prejudiced from non prejudiced people is their voluntary inhibition of negative and stereotype-related thoughts. She argued that because our culture is suffused with negative stereotypes concerning race, social class, sexual orientation, gender, age, and other social categories, we cannot fail to think of them when confronted with a member of such a category. The unprejudiced person is presumed to reject and inhibit such thoughts voluntarily, whereas the prejudiced person willingly accepts them.

Von Hippel and colleagues (2000) proposed that older people may become more prejudiced unwillingly, due to failing capacity to inhibit stereotype-based thinking and response. In support of their hypothesis, the authors found that older adults were more prejudiced, even though they reported stronger desire than younger adults to control these reactions. Furthermore, their judgments relied on stereotypes even when instructed not to, whereas those of younger adults did not. Finally, age differences in stereotyping and prejudice were mediated by age differences in inhibitory capacity. Thus, older jurors are likely to suffer stronger effects of stereotype-based processing and to reflect greater impact of prejudice in their verdicts.

Hess (1999) also pointed to a second "knowledge-based" age-related influence on processing. That is, he suggested that the nature of the person's experiential and knowledge base changes with age and that older persons tend to rely more on their own experience to arrive at judgments. For example, Erber and colleagues (2001) found that although younger adults were equally forgiving of a younger and older target who forgot she was wearing a hat and left the store without paying, older adults were more forgiving of the older target. Arguably, the older adults' experiences told them the older target had a better excuse for forgetting.

Older persons also employ different social rules than younger persons when attributing blame or causality to a person's behavior or to a social outcome (see the review in Blanchard-Fields, 1999). To the extent that social or other domain-specific knowledge increases or becomes more accurate, age may lead to greater accuracy in judgment.

Hess and Auman (2001), for example, reviewed evidence suggesting that older adults may become more sophisticated in judgments of people and their behavior. In two studies, the authors found that relative to younger adults, older adults tended to give greater relative weight to more diagnostic information regarding a person than to less diagnostic information. Thus, at least when the evidence is primarily social, older adults may suffer less disadvantage in processing trial input. In this vein, Yates and Patalano (1999) suggested that aging jurors may develop more and more strongly held story schemas for a wide variety of circumstances that they may bring to bear on judgments of a particular case.

If accurate, these strongly held schemas and stories among older jurors may facilitate accurate decision making. However, it should also be noted that relatively automatic application of this social knowledge base can become problematic if the juror fails to consider all information that might suggest an exception to general social-behavioral rules. Indeed, impaired executive function in younger adults has been shown to result in a pervasive memory bias favoring schema-consistent over schema-inconsistent material, whereas in unimpaired persons the bias is exactly the opposite (Macrae et al., 1999). The authors suggest that executive function is necessary to facilitate enhanced processing of (and thus better memory for) unexpected or schema-inconsistent material, and that failing executive function renders the mind less flexible and adaptable when confronted with unexpected information. This suggests that older jurors with impaired executive function may not fully recognize, consider, or remember evidence inconsistent with their existing expectations, stereotypes, and impressions.
Firmly established personal opinions and values can also bias the manner in which a person processes evidence. For example, Kaczynski and Robinson (2001) illustrated the importance of Hess's (1999) third age-related change in processing — that of motivation. The authors examined age differences in use of analytical vs. heuristic reasoning to support personal beliefs. Participants read vignettes with arguments supporting or attacking the value of their social groups (e.g., religion, social class). Both age groups tended to use heuristic reasoning to support belief-consistent arguments or evidence, whereas they tended to use scientific reasoning to support rejection of arguments contradicting their beliefs. Biased reasoning, however, was more common among middle-aged and older participants than among younger ones. Thus, particularly among older adults, motivation to discredit a particular point of view led to more systematic processing.

A final relevant line of research has concerned the “theory of mind” (TOM) performance of older adults (reasoning about mental states and how they predict and explain behavior). Participants read stories requiring an inference about the characters' thoughts and feelings and how they drive behavior. For example, in one story developed by Happé and colleagues (1998), a burglar has just robbed a shop. As he leaves the scene of the crime, a policeman sees him drop his glove. Not knowing of the burglary, the policeman wants to tell the burglar he has dropped his glove; however, when the policeman shouts out, the burglar gives himself up.

The participant is asked to explain why the burglar does this and thus must judge what the burglar thought about the policeman's shout. Two of three studies on this issue have found poorer performance among older adults (Sullivan and Ruffman, 2004, and Maylor et al., 2002, vs. Happé et al., 1998). Sullivan and Ruffman further found that performance in older (but not younger) adults was predicted by fluid as well as crystallized abilities, and that when these abilities were controlled for, age differences were eliminated. The latter authors also found poorer memory for the stories among older adults. Both findings would suggest poorer memory and judgment among older jurors.

Summary

The literature reviewed here suggests several preliminary conclusions regarding differences that might be expected between younger and older jurors. On the average, older jurors will experience greater difficulty with hearing, seeing, understanding, and integrating trial input to form their judgments. These jurors are likely to engage in more schematic processing of trial input, using existing knowledge structures to guide processing and using less detail in specific testimony and evidence to guide their judgments. Once an initial impression is formed, it may exert greater influence on subsequent information processing for older than for younger jurors, causing them to use less critical judgment for evaluation of later evidence or to be more biased in processing that evidence. Throughout, older jurors will exert less effort to process and integrate apparently contradictory information carefully.

In addition to general schematic processing, older jurors are specifically more prone to stereotype-based judgments. Thus, race and other heavily stereotyped social categories and issues can be expected to bias the judgments of older jurors to a greater degree than those of younger jurors. Furthermore, the specific stereotypes and social beliefs possessed by older adults are in many instances different from those of younger adults, so efforts to identify and take into account these strongly held values and beliefs will be important.

Older jurors will also tend to remember less trial input overall and will be more likely to make source-monitoring errors regarding the source or credibility of statements or evidence and the difference between evidence actually presented and schema-related and other inferences they have drawn from it. In particular, older adults may be less likely to correctly remember false or discredited information as false rather than true, and thereby more likely to be influenced by poor-quality evidence. Moreover, because of failing inhibitory capacities, older adults may be less able to follow judicial instructions to ignore inappropriate statements or evidence. Perhaps in light of these difficulties, older persons report less confidence in their ability to serve well as jurors than younger persons do (Boatright, 2001).

Despite at least some relative disadvantages in quality of processing of trial input, older jurors may be more committed to their judgments via choice-supportive biases in memory for choice-relevant evidence
(Mather and Johnson, 2000; Mather et al., 2000) and more resistant to influence from other jurors (Pasupathi, 1999). Thus, their decisions may be relatively unresponsive to correction in deliberation.

These conclusions must be considered in light of considerable individual variability in processing capacity among older jurors. Within older jurors, schematicity and reductions in range of information use are related to working memory capacity and other measures of cognitive functioning. Also, even in the context of these limitations on processing capacity, older jurors may possess enhanced ability to recognize more diagnostic information — particularly regarding domains (such as human behavior) in which their life experiences have provided them with greater expertise than their younger counterparts. Finally, older adults can engage in deeper processing when highly motivated and in possession of sufficient cognitive resources. Thus, many older adults will behave very comparably to their younger counterparts.

The study of age-related differences in juror behavior is still in its infancy. The cognitive aging literature provides evidence of age-related differences in cognitive processing and is a rich source of hypotheses regarding differences to be expected in juror behavior. However, it remains to conduct further research specifically with relevant trial-related stimulus materials and judgment tasks. Meanwhile, the consumer literature is also a rich source of findings of potentially great relevance to juror behavior. The arena of advertising effectiveness bears at least superficial resemblance to persuasion in trial because, in both cases, the recipient of persuasive messages must evaluate the relative credibility of competing claims for validity.

11.5 Overall Conclusions

The literature reviewed herein reveals that age is crucial to functioning in the legal system. Age-related declines in cognitive functioning can cause, or contribute to causing, incidents that are later litigated in the legal system and can affect the performance of witnesses and jurors. However, although substantial empirical evidence has directly linked age-related decline in cognitive functions to accidents, such as those related to driving, very little research has directly examined the influence of age on witness testimony or juror decision making. The basic research on memory and decision making clearly documents age-related changes in these processes that would predict a number of specific interactions of age with particular witnessing variables and with variations in evidence, trial procedures, etc. that might affect jury decision making.

Eyewitness researchers have begun to examine the effects of age on eyewitness identification and on susceptibility to the misinformation effect. However, other aspects of witness memory remain largely unaddressed. Moreover, the general area of age and juror decision making remains completely unexplored, with perhaps the single exception of the Fitzgerald (2000) study cited earlier. Finally, few studies of reactions to aging perpetrators or other case parties exist. Given the rapid aging of America, there is a clear and present need to develop better understanding of the many and varied ways in which aging victims, witnesses, and jurors can be expected to function differently than their younger counterparts.

11.6 Checklist: Relationships among Underlying Causes, Effects on Cognitive Processing, and Consequences for Victims, Witnesses, and Jurors

<table>
<thead>
<tr>
<th>Causes of impaired processing</th>
<th>Effects on cognitive processing</th>
<th>Examples of practical difficulties</th>
</tr>
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<tbody>
<tr>
<td>Brain structure and pathology</td>
<td>Reduced efficiency of neuronal transmission; impaired perceptual abilities; impaired formation and retention of memories; impaired efficiency and complexity of cognitive processing; impaired self-control and executive capacity</td>
<td>Victims: Failure to smell leaking gas</td>
</tr>
<tr>
<td>Causes of impaired processing</td>
<td>Effects on cognitive processing</td>
<td>Examples of practical difficulties</td>
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<tr>
<td>Hearing</td>
<td>Elevated sound detection thresholds; failure to understand speech; difficulty in localization of sound</td>
<td>Victims: Failure to understand instructions leads to accident  Witnesses: Inaccurate report of witnessed conversations  Jurors: Failure to understand courtroom instructions, arguments, and testimony</td>
</tr>
<tr>
<td>Vision</td>
<td>Failure to see clearly, particularly in poor light; restriction in range of peripheral vision; difficulty in motion perception, tracking objects, visual marking, etc.; difficulty reading nonverbal cues during conversation</td>
<td>Victims: Failure to see cars approaching from side at intersection, failure to estimate speed of oncoming vehicles  Witnesses: Failure to report accurately on things seen accurately; failure to report correct object locations, failure to identify persons or objects correctly  Jurors: Difficulty seeing courtroom exhibits, reading nonverbal cues to interpret speech or reading cues to deception</td>
</tr>
<tr>
<td>Reduced speed of cognitive processes</td>
<td>Slowed performance overall; impaired performance of complex tasks</td>
<td>Victims: Slowed reaction times in emergency situations  Witnesses: Enhanced impairment of perception and memory in complex circumstances  Jurors: Reduction in elaborative processing of trial input</td>
</tr>
<tr>
<td>Reduced capacity of working memory</td>
<td>Reduced ability to hold multiple items of information in mind; reduced ability to carry out complex cognitive operations such as reasoning, math, etc.; reduced ability to multitask; failures of binding and source memory</td>
<td>Victims: Victimization by scam artists due to failing ability to reason and critically evaluate proposals  Witnesses: Less complete memory; failure of source monitoring such as susceptibility to misinformation effect  Jurors: Greater use of relatively effortless schematic processing; failure to track source and credibility of testimony</td>
</tr>
<tr>
<td>Failures of inhibition</td>
<td>Inability to control attention; greater distractibility; reduced ability to divide attention; greater susceptibility to priming</td>
<td>Victims: Accidents due to enhanced distractibility; failure to focus attention on most important tasks of driving  Witnesses: Less memory for peripheral detail due to inability to divide attention between core event and context  Jurors: Stronger effects of racial prejudice on judgment of minority defendant; inability to follow instructions to ignore inadmissible evidence</td>
</tr>
<tr>
<td>Stereotype vulnerability</td>
<td>Greater anxiety when stereotype salient; belief in applicability of negative stereotypes to self; self-fulfilling prophecy</td>
<td>Victims: Elderly victim believes claims that he promised to send check to scam artist because of belief in fallibility of own memory  Witnesses: Witness loses confidence in own testimony under cross examination because of belief in age-related memory impairment suggested by attorney  Jurors: Failure to offer memories of evidence due to low confidence</td>
</tr>
</tbody>
</table>
Acknowledgment

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Defining Terms

Episodic memory — Memory for recently experienced events.
Inhibitory processes — The ability to control attention so that attention is focused on important or task-relevant information while attention to irrelevant information is inhibited.
Presbycusis — Decline in processing of auditory information.
Processing speed — The speed at which basic cognitive operations occur.
Source memory (source monitoring) — Memory for the context in which a core event occurred (such as memory for where a person was encountered, where or from whom information was obtained, where a conversation took place, etc.).
Stereotype vulnerability — The tendency to act in stereotype consistent manner when relevant stereotypes are salient.
Visual acuity — Ability to see clearly.
Visuospatial processing — Processing of spatial location and relationships through vision; includes object identification and perception of location and motion.
Working memory — The ability to hold information in short-term memory while simultaneously using that information to form judgments or solve problems.

References


Age and Functioning in the Legal System: Victims, Witnesses, and Jurors


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Further Information


