Since Cohen introduced the term "gerolinguistics" in 1979, there has been accelerating interest in understanding the nature of language in old age. Searching PsychINFO using the key words "language and aging" generated 9 citations for the decade from 1970 to 1979, 80 for 1980 to 1989, 270 for 1990 to 1999, and 171 for the 5-year period from 2000 to 2004. This surge in interest in language and aging is not surprising. Language is a complex domain that involves the integration of multiple sources of information, including sound, vision, meaning, and intention. Both comprehension and production of language require integration of current inputs and prior knowledge in evolving mental representations. As such, language deals with very high-level constraint integration and thus can serve as a testing ground for theories of language, as well as theories of cognitive aging (see reviews by Burke, MacKay, & James, 2000; Kemper & Mitzner, 2001; Light, 1988, 1990, 2000; MacKay & Abrams, 1996; Schneider & Pichora-Fuller, 2000; Wingfield & Stine-Morrow, 2000). Moreover, older adults rate many aspects of their own receptive and expressive language abilities less highly than young adults, and both young and older adults believe that aging is associated with poorer performance in both areas (Ryan et al., 1992). Declines in language processing can impede effective communication, with negative effects on older adults' social interactions and psychological well-being (Hummert et al., 2004; Kemper & Lacal, 2004; Tesch-Romer, 1997).

This chapter is divided into three major sections that deal with age-related constancy and change in word, sentence, and discourse level processes. Within each section we consider issues related to language perception or comprehension and to language production. This is a structure that is convenient for organizing the material to be covered, but because language is highly interactive, it is not always possible to adhere strictly to this classificatory scheme. Our deviations from it are apparent when they occur. Because our focus is on work that has contributed to framing or resolving theoretical debates about the nature of cognitive aging, we begin with a brief outline of the major cognitive aging
perspectives that have been used to interpret findings on language in normal aging. Our review deals almost exclusively with findings at a behavioral level. Although there is increasing interest in the cognitive neuroscience of aging, work on the brain bases of high-level language processing across the life span has lagged behind that in such domains as memory and attention, as suggested by the absence of a chapter on language in a recent volume (Cabeza, Nyberg, & Park, 2004).

Generally speaking, hypotheses about the nature of age-related change and stability in cognition have been couched within broad organizing frameworks rather than systematically developed and computationally implemented theories (for discussions of this issue, see Burke, 1997, Light, 1991; MacKay & James, 2001a). Five such approaches have been prominent over the last two decades. Three attribute age-related deficits in cognition to cognitive slowing (e.g., Salthouse, 1996), problems in working memory that affect storage and manipulation of information (e.g., Carpenter, Miyake, & Just, 1994), or to weakening of inhibitory processes so that older adults are less able to suppress information irrelevant to ongoing goals than are younger adults (Hasher & Zacks, 1988; Zacks & Hasher, 1997). A fourth approach, the transmission deficit account, hypothesizes that many age-related changes in cognition stem from weakened connections among memory representations that reduce the transmission of excitation (e.g., Burke et al., 2000). As elaborated later, this account postulates not only cognitive processes, but also a cognitive architecture that increases its explanatory power. A fifth view targets the possibility that sensory deficits are causally related to reductions in diverse aspects of cognition (e.g., Baltes & Lindenberger, 1997; Lindenberger & Baltes, 1994). In the context of language processing, this question has been raised most explicitly with respect to speech perception and comprehension (e.g., CHABA, 1988; Frisina & Frisina, 1997; Light, 1988; Schneider & Pichora-Fuller, 2000; Wingfield & Tun, 2001).

Current models usually assume interactions across sensory, phonological or orthographic, lexical, syntactic, and semantic levels of processing, with an interplay between top–down (conceptually driven) and bottom–up (data driven) processing (e.g., Burke et al., 2000; Dell, Burger, & Svec, 1997). The possibility that aging is accompanied by an increase in the effect of top–down processes permeates recent literature on language in old age. An additional theme that has emerged is the possibility that redefined goals, increases in expertise, or changes in processing strategies to compensate for reductions in processing efficacy affect language function as well as cognitive functioning, more generally, in older adults (Adams et al., 1997; Carstensen, Isaacowitz, & Charles, 1999; Hasher & Zacks, 1988; Radvansky et al., 2001; Wingfield & Stine-Morrow, 2000).

I. Lexical Processing

A. Word Recognition

Although changes in vision have consequences for visual language processing (MacKay, Taylor, & Marian, 2005; Scialfa, 2002; Speranza, Daneman, & Schneider, 2000), the role of sensory deficits in auditory language processing has been investigated more extensively (Schneider & Pichora-Fuller, 2000). Presbycusis, or pure-tone hearing loss, especially at higher frequencies represented in speech, constitutes a major sensory decrement in old age and can contribute to poorer identification of single words even in quiet listening situations (e.g., Humes, 1996). Aging is also associated with other
changes in the auditory system, including temporal processing of speech (e.g., Pichora-Fuller, 2003). For instance, older adults have difficulty in differentiating voiced from voiceless consonants (e.g., /b/ and /p/), a discrimination that requires detection of the presence or absence of a voice onset time gap of 20–40 ms in duration (Tremblay, Piskosz, & Souza, 2002). The impact of changes in the auditory system may be exacerbated by the fact that sounds in conversational speech are often lost or modified when combined with each other (e.g., Great Britain may be rendered as Grape Britain). There is also considerable variation in acoustic realizations of speech sounds by different speakers. Listeners maintain perceptual constancy in the face of this variability by a process known as perceptual normalization (Pisoni, 1993). Older adults have poorer perceptual normalization abilities than young adults, i.e., their word identification performance suffers more when words are presented by many talkers rather than by a single speaker (Yonan & Sommers, 2000).

Even older adults with good audiometric profiles show greater impairment than young adults when speech perception is measured under adverse listening conditions, such as when speech is presented in noise (e.g., Frisina & Frisina, 1997; Pichora-Fuller, Schneider, & Daneman, 1995; Tun, 1998; Tun & Wingfield, 1999). Adjusting signal/noise ratios so that identification of easy words (those phonetically similar to few other low-frequency words) is equated across age does not eliminate age differences in identifying hard words that are phonetically similar to many other high-frequency words (Sommers, 1996). Young adults’ recall of spoken sentences is not impacted by a single competing speaker talking at a low level of conversational noise, but older adults recall is impaired at low as well as high levels of conversational noise (Tun & Wingfield, 1999). Difficulties in attention needed to segregate the speech of multiple speakers are implicated here.

Both young and older adults identify words in noise better when these are presented in highly predictive sentence contexts (The witness took a solemn oath) rather than nonpredictive ones (e.g., John hadn’t discussed the oath), with older adults often benefiting more (Frisina & Frisina, 1997; Pichora-Fuller et al., 1995; Yonan & Sommers, 2000). In a systematic investigation of this phenomenon, Pichora-Fuller et al. (1995) varied the signal-to-noise ratio of sentences heard in multitalker babble over a wide range to examine the effect of semantic context. Older adults had a greater maximum benefit from sentence predictability than young adults, arguing for a greater top–down benefit for this group.

Older adults are also affected more adversely when speech is time compressed by periodic deletions of small segments, although again such effects are moderated by the presence of semantic or syntactic constraints (e.g., Gordon-Salant & Fitzgibbons, 2001; Tun, 1998; Wingfield et al., 1985). The interaction of processes at various levels is also clear in studies of time-compressed speech in young and older adults. For instance, prefamiliarization of voices improves speech perception in noise for older adults more than for young adults when there are multiple speakers, especially in identifying high probability words in sentence endings (Yonan & Sommers, 2000). When discrimination of consonants is made difficult by artificially varying speech stimuli along continua so that it is hard to decide whether one is hearing digress or tigress, the perceived boundary between categories is sensitive to the placement of syllabic stress; this effect is stronger in old than in young adults, to the extent that metrical structure may override voice onset time.
as a cue for phonemic boundaries (Baum, 2003). Older adults also need more information, i.e., greater word onset duration (or gate), than young adults to recognize spoken words, but word recognition is facilitated to the same extent across age by adding prosodic information indicating number of syllables and syllabic stress (Wingfield, Lindfield, & Goodglass, 2000). Rapid auditory presentation of sentences with list intonation rather than normal prosody produces repetition deafness, namely failure to report repeated words (contrast I live at one two two four Canyon Street with I live at one five two four Canyon Street). Older adults are more prone to repetition deafness when sentences are presented as aprotodic lists (MacKay, Miller, 1996); however, normal prosody eliminates repetition deafness for both young and older adults. These are all cases in which higher level cues (e.g., prosody) are constraining lower level speech perception.

There are, nonetheless, limits on the usefulness of linguistic context. Wingfield, Alexander, and Cavigelli (1994) edited words from connected speech and played them in isolation, with context added before the critical word, after the critical word, or both before and after the target. Both young and older adults benefited from context that preceded the target, but context that followed the target was less effective for older adults, suggesting that they were less able to maintain information from unclear stimuli in working memory.

B. Lexical Retrieval

One often-cited example of a positive age-related change in cognitive abilities is the fact that vocabulary continues to grow with age, such that older adults have larger vocabularies than younger ones for a large meta-analysis, (see Verhaeghen, 2003). Despite this positive change, there is a large body of research demonstrating problems older adults have with retrieving lexical information from memory (for a review, see Griffin and Spieler, in press). For example, Connor and colleagues (2004) presented longitudinal data from the Boston naming test and found that performance declined an average of 2% per decade. Research in this area has been particularly fruitful for theory, as some of the most explicit models of language and aging have been developed to explain changes in lexical retrieval.

Two major theories have been invoked to explain age-related changes in lexical processing, above and beyond accounts of general slowing. The inhibition deficit hypothesis proposes that aging weakens inhibitory processes so that older adults are less able to suppress irrelevant information than younger adults (Hasher & Zacks, 1988; Zacks & Hasher, 1997). An alternative theory, the transmission deficit account, hypothesizes that many age-related changes in linguistic processes stem from weakened connections among memory representations that reduce the transmission of excitation, resulting in weakened patterns of activation (Burke et al., 1991; James & Burke, 2000; MacKay, Abrams, & Pedroza, 1999; MacKay & James, 2004).

One of the most studied aspects of lexical retrieval problems in aging is the tip-of-the-tongue (TOT) state, in which a person temporarily cannot recall a well-known word. The frequency of TOT states seems to increase with age, a finding that has been demonstrated both with experimental techniques (e.g., James & Burke, 2000; Maylor, 1990; White & Abrams, 2002) and in natural production (e.g., Burke et al., 1991; Heine, Ober, & Shenaut, 1999).

It is important to note that this age-related change may not affect all words equally. A number of studies have focused on how aging affects the retrieval of proper names (e.g., Burke et al., 2004;
James, 2004), finding that older adults have more retrieval problems than young adults. For example, James (2004) found that older adults had more retrieval failures for proper names than younger adults, but this was not true for remembering someone’s occupation (for similar findings, see Barresi, Obler, & Goodglass, 1998 and Evrard, 2002). Instead of suggesting a specific impairment for proper names, these data have been interpreted as resulting from the nature of the semantic representation for words. In the transmission deficit model, proper names have a sparser semantic representation, i.e., fewer interconnections with other concepts in memory, whereas common names are more interconnected. Thus, weakened connections in semantic memory differentially impact the representations for proper names. The James (2004) study is striking in this regard in that she used proper names that could also be occupation titles [e.g., Mr. Farmer versus farmer] and found that TOT rates were higher for a given word when it was presented as a proper name than as an occupation. Maylor (1997) argued that the perception of greater age-related problems in this area may arise because common objects can have more than one acceptable name and retrieval failures for people’s names may have social consequences.

One intuitive explanation for TOTs is that the underlying cause of the TOT state is that a persistent alternative word is competing for activation, thereby blocking activation of the intended word, which would be expected by an inhibition deficit. Interestingly, several lines of research argue against this intuition (e.g., Abrams & Rodriguez, in press; Abrams, White, & Eitel, 2003; Cross & Burke, 2004; James & Burke, 2000; White & Abrams, 2002, 2004). First, if a failure to inhibit alternatives were the cause of TOTs, one would expect to see older adults with more persistent alternatives than young adults, but the opposite is true (e.g., Burke et al., 1991). Second, older adults have less partial information available about TOTs than young adults (e.g., Burke et al., 1991). Third, providing phonological primes improves retrieval and helps with the resolution of TOTs rather than blocking resolution. For example, James and Burke (2000) found that when TOTs were elicited for a word such as abdicate, having been primed by words that shared phonological structure, such as abstract, indigent, and locate, helped with retrieval rather than blocking it. This finding argues against a blocking or inhibition-deficit account of TOTs and supports the transmission deficit model, under the assumption that the phonological primes helped strengthen age-weakened activation in the phonological system.

Another factor that has been shown to affect TOTs and word retrieval more generally is the number of phonologically similar words and their related frequencies. The term neighborhood refers to the set of words that differ from the target by changing exactly one phoneme. Under this definition, the word cat’s neighbors would include bat, sat, cut, and car, among a large number of other words. The term neighborhood density refers to the total number of neighbors a word has, whereas the term neighborhood frequency refers to how frequently those neighbors are used. Both neighborhood density and frequency have been shown to affect word recognition (e.g., Vitevitch & Luce, 1998). Older adults report more TOTs for words with low neighborhood frequency (Vitevitch & Sommers, 2003). This finding is consistent with the transmission deficit model because words with high neighborhood frequencies would receive supporting activation from their neighbors, resulting in fewer TOTs. However, because words with low neighborhood frequency would receive little support from neighbors, the...
observed age-related increase in TOTs is expected. Age-related neighborhood effects show up in other tasks as well. For example, Sommers (1996) found that older adults have greater difficulty identifying relatively low frequency words from dense neighborhoods than young adults. Sommers (1996) interpreted this finding in terms of an inhibition deficit in that low frequency words in high density neighborhoods would be difficult to isolate from higher frequency, phonologically similar competitors. As such, an age-related inhibition deficit would explain the effect in that older adults would be less able to inhibit the competitors, resulting in greater processing difficulty. Sommers and Danielson (1999) further examined the nature of neighborhood effects by examining the effect of context on word identification. They found that the age-related neighborhood effect, that older adults had great difficulty with the “hard” neighborhood words (low frequency, dense neighborhood), was attenuated by context: with highly constraining sentence contexts, no age differences were found. This finding again highlights the beneficial effect that top–down semantic information has in offsetting lower level age-related cognitive problems.

Spieler and Balota (2000) also examined how neighborhood variables affect word recognition in aging. To assess how simple word naming changes with age, they examined three factors known to influence word naming: word frequency, word length, and neighborhood density. They performed a large-scale regression analysis on the naming times of both young and older adults for over 2800 words. They found that all three factors accounted for significant variance in both age groups, but that frequency had a larger influence for the older adults and that length and neighborhood density had less of an influence, contrary to earlier studies that found similar frequency effects across age groups [e.g., Allen et al., 1993; Stine, 1990]. Spieler and Balota (2000) suggested that this effect was observed because older adults typically have more reading experience than younger adults, so their lexical representations have become more unitized, resulting in larger lexical effects (frequency) and smaller sublexical effects (length and neighborhood density). Their data are complicated by a neuroimaging study by Whiting et al. (2003) who found that in a lexical decision task, the regression coefficients for word frequency were similar for young and older adults, whereas word length had a great influence for older than young adults, the opposite of Spieler and Balota’s finding. Thus, how the influence of these lexical variables changes with age is still not clear and some of these differences may stem from the task being used [e.g., naming, lexical decision] as well as whether the target words are presented in context [e.g., Stine, 1990] or in isolation [e.g., Spieler & Balota, 2000]. Another issue that has not been addressed in detail is the role of visual acuity in age differences in visual word recognition. Although most studies control for basic acuity, some research suggested that even small differences in acuity can have a surprising effect in cognitive aging research [MacKay et al., 2005].

Another finding relevant to the inhibition deficit account comes from work by Hartman and Hasher (1991). When asked to read sentences that have high probability endings that were not actually presented, older adults were more likely to subsequently produce these in a sentence completion task. Hartman (1995), however, reported that older adults were not more likely than young adults to use expected but disconfirmed study words as completions if the to-be-selected words were clearly indicated at study. Also, when the unexpected ending that is to be remembered is
followed by a sentence that embeds the to-be-selected target in an elaborated context, age differences in completion rates for no-longer-relevant words are abolished (Hasher, Quig, & May, 1997). Both findings are consonant with the view that older adults have difficulty tracking contextual information about which words are to be remembered and which are to be forgotten, but that this problem can be mitigated under some circumstances (see also May et al., 1999).

Given these well-documented problems older adults have with lexical retrieval, an open question is how these problems affect higher level processing more generally. For instance, Federmeier et al. (2003) found delays on general sensory components of word processing in older adults, as seen in evoked potential responses, but not on associative priming. Also, if older adults are slower and less accurate in lexical processing, then we might expect to see language production in older adults slow down even more as utterances get longer, as a backlog of words to be produced would build. However, this does not seem to be the case. Although older adults might speak a bit more slowly or be slightly less fluent than younger adults [e.g., Bortfeld et al., 2001], we do not observe a lexical traffic jam in their production. A suggestion about how older adults achieve fluency despite retrieval problems is offered by Spieler and Griffin (in press) who presented evidence from a constrained sentence production task that older adults tend to speak more slowly and to plan ahead further so that production is fluent and error free—when they are not under time pressure. However, under time pressure to respond, older adults cannot plan as far ahead and consequently are less fluent, as they are not able to retrieve words to be produced as quickly.

C. Asymmetries in Processing

One problem in applying general theories of cognitive aging, e.g., general slowing, working memory, or inhibition deficits, to linguistic phenomena is that they are indeed general and consequently lack machinery to account for asymmetries in the effects of age on processing. One such asymmetry is between comprehension and production, at least for single words, with observable production deficits for older adults who do not seem to have comparable comprehension deficits. For example, MacKay et al. (1999) examined age-related differences in comprehending (perceiving) and producing spelling. In their comprehension task, participants were presented with a word and pressed a button to indicate whether or not it was spelled correctly. No differences between older and younger adults in detection accuracy were observed. However, older adults were less accurate on the production task, in which participants had to write out the words they had seen, because they misspelled words they had correctly rejected in the comprehension task [also see MacKay and Abrams (1998) MacKay and James (2004) and Stuart-Hamilton and Rabbitt (1997) for similar studies of age-related changes in spelling, as well as Abrams and Stanley (2004), for evidence that even spelling comprehension is impaired in very old adults]. This production-comprehension asymmetry has been demonstrated across a variety of tasks (Burke & MacKay, 1997).

A second age-related asymmetry has been observed for processing of semantic and phonological information. Although older adults demonstrate deficits in a number of areas, several studies have shown only very minor, if any, differences in semantic processing [e.g., Federmeier et al., 2003; Madden, Pierce, & Allen, 1993; Mayr & Kliegl, 2000; Radvansky et al., 2001], with some
finding even larger semantic effects for older adults (e.g., Laver & Burke, 1993; Madden, 1988). Several studies have examined the differential impact aging has on phonological and semantic processing in the same individuals. For example, Taylor and Burke (2002) had participants name pictures while ignoring auditory word distractors. They found no age-related differences in interference from the phonologically related distractors, whereas older adults showed more interference from the semantically related distractors. Semantic interference in the picture-naming task arises from priming of semantic connections linking conceptually related nodes and is expected under the transmission deficit hypothesis to be greater in older adults for the same reasons that semantic priming effects are larger—greater richness of semantic connections in old age leading to greater convergence of priming at a lexical node. Another finding that supports the view that older adults tend to rely more on semantics and less on phonology than young adults is reported in Cortese et al. (2003). They examined age-related spelling differences for homophonic words (e.g., plane vs plain) and found that young adults tended to rely on phonological information, choosing the most regular spelling, whereas older adults tended to rely more on semantics, choosing the orthography consistent with the dominant meaning. The overall pattern of results indicates that the pattern of semantic and phonological effects is different across age (Burke & MacKay, 1997) and is theoretically significant because although predicted by the transmission deficit hypothesis, it runs contrary to the inhibition deficit hypothesis. Inhibitory processes are not specific to semantic or phonological information, so no asymmetry is predicted.

Several accounts have been offered of the preservation and, in some cases, apparent increases in semantic processing in older adults (Light, 1992). For example, Madden (1988) examined semantic priming from a sentence context to a target word and found that older adults showed a greater effect of context when the target word was degraded. He suggested that this effect resulted because of age-related slowing in the bottom–up processing of the target word, resulting in a compensatory increase in top–down semantic processing, presumably because it has more time to have an effect and support recognition. A second account for the relative sparing of semantic processing with a concomitant decrease in phonological processing comes from the transmission deficit account. In this model, normal aging weakens memory connections. However, semantic representations have more redundant connections, whereas phonological representations are more sparse. Thus, given the same amount of connection weakening, semantic memory will be relatively preserved because of the redundancy of connectivity. This relative sparing of semantics, along with problems with phonology and sensory deficits, explains why we see greater top–down context effects in older adults.

II. Sentence Processing

In order to understand a sentence, comprehenders must encode orthography or phonology to identify and access the meanings of words (word level processes). They must instantiate concepts, assign thematic roles (e.g., identify predicates and their arguments), and form propositions (commonly called idea units). New concepts must be processed when they appear and maintained in memory for later integration with other concepts within and across sentences. Processing times increase at major syntactic boundaries within sentences and at sentence
ends, reflecting so-called “wrap-up” or integrative processing of concepts as well as ambiguity resolution. As discussed in more detail later, readers also go beyond what is stated directly to create a mental representation of the situation model of what is described by the text (Gernsbacher, 1990; Kintsch, 1998; Zwaan & Radvansky, 1998). Despite the importance of discourse level processes in sentence comprehension, a great deal of research has been carried out using single sentences in unconnected discourse. The motivation for doing so is to study sentence-level processes independent of discourse. As we will see in our review, however, it can be difficult to disentangle these levels of processing.

A. Sentence Comprehension

It has been widely argued that individual differences in language processing, including age differences, are associated with individual differences in working memory capacity as measured on standard working memory tasks (e.g., Just & Carpenter, 1992). Given well-established declines in working memory with age, it is easy to see why research on language and aging has intensively examined how age-related deficits in memory, especially working memory, affect language, rather than searching for possible age-related deficits in linguistic processes per se (e.g., Burke & Light, 1981; Light, 1988, 1990, 2000). As a result, much of this work is “off-line” in that the experimental material is presented some time before the experimental task. Because of this interval between presentation and task, performance on the task depends not only on how the stimuli were processed originally, but how they have been encoded and stored in memory. Waters and Caplan (e.g., Caplan & Waters, 1999; Waters & Caplan, 1996, 2001, 2005) have failed to find a relationship between on-line syntactic processing and traditional measures of working memory. They have argued that rather than a single resource theory of the relationship between working memory and language, a separate sentence interpretation resource theory is needed. On this view, interpretive processes that assign meaning to sentences are largely unconscious and obligatory and should be resistant to aging, whereas post interpretive processes that involve retaining and referring to sentence meaning and form may be related to traditional working memory measures and should be sensitive to age.

Interpretive processing is studied in on-line comprehension tasks that tap processes that unfold as words are recognized and integrated into the developing syntactic and semantic representation. In auditory or visual moving window paradigms, participants pace themselves through the material, which is presented word by word or in small segments, and the amount of time spent on each word or segment is recorded. In eye-tracking studies, both first pass and regressive eye movements to earlier text provide clues to processing. An assumption is that complex syntactic constructions (e.g., temporary syntactic ambiguities in garden path sentences such as The experienced soldiers warned about the dangers conducted the midnight raid) cause interpretive difficulties that result in processing slow-downs at predictable points. Single resource capacity theories predict that older adults should be disproportionately slowed at such points, whereas the Waters and Caplan theory predicts no differential slowing.

Contrary to single resource theory, reading and listening times for isolated sentences in young and older adults have been found to be affected in very similar ways by syntactic manipulations, although older adults are sometimes (but, contra general-slowing views, not always) slower and sometimes perform
more poorly on off-line measures collected in the same studies (e.g., Kemper, Crow, & Kemtes, 2004; Stine-Morrow, Loveless, & Soederberg, 1996; Waters & Caplan, 2001). Using structural equation modeling, DeDe et al. (2004) found that verbal working memory measures mediated age-related differences in off-line sentence and text comprehension tasks, but did not predict performance on on-line listening measures. However, outcomes less supportive of separate sentence interpretation resource notions have also been observed (DeDe et al., 2004; Kemper, Crow, & Kemtes, 2004; Kemtes & Kemper, 1997; Stine-Morrow, Ryan, & Leonard, 2000; Waters & Caplan, 2005). For instance, older adults may make more regressive eye movements in reading sentences containing ambiguities, contrary to separate resource views, even when first pass fixations do not show age effects (Kemper, Crow, & Kemtes, 2004; Liu, Kemper, & Herman, 2004). In general, Waters and Caplan have maintained their separate working memory account by suggesting that the evidence that does not support their theory reflects postinterpretative rather than early (i.e., interpretive) syntactic processes (e.g., DeDe et al., 2004), but the way that different types of working memory cooperate in their account has not been elaborated systematically to date (see commentary following Caplan and Waters, 1999).

Stine-Morrow and colleagues have carried out an extensive program of research comparing young and older readers using the visual moving window technique and carrying out regression analyses to determine the contributions of word level, text base level, and situation model variables to reading times, typically at the word level. These studies have found (not surprisingly) that older adults are slower overall than young adults, but that reading times of both groups are responsive to manipulation of variables at the word, textbase, and situation model levels. One area in which differences in resource allocation may differ across age is in sentence wrap-up effects, with young adults showing larger end of sentence wrap-up effects (Stine, 1990; Stine, Cheung, & Henderson, 1995), whereas older adults have shown larger effects of attention to conceptualization within a sentence (Miller & Stine-Morrow, 1998). This suggests that older adults may be breaking up the discourse into small processing units, a strategy to possibly offset age-related working memory problems. Nonetheless, this pattern of differences in wrap-up processes is not observed universally. For instance, in different studies, there have been no age differences in wrap-up times at clausal boundaries coupled with greater sentence boundary wrap-up effects for older adults (Smiler, Gagne, & Stine-Morrow, 2003) and larger wrap-up effects for older adults at both intrasentence and between sentence boundaries (Miller, Stine-Morrow, Kirkorian, & Conroy, 2004; Stine-Morrow et al., 2001). Interestingly, and consistent with the separate sentence interpretation resource hypothesis, resource allocation parameters for wrap-up apparently do not correlate with working memory as assessed by span measures (Smiler et al., 2003; Stine-Morrow, Milinder et al., 2001).

B. Sentence Production
Kemper et al. (2001a) analyzed both cross-sectional and longitudinal language samples and found that syntactic complexity (e.g., the number of propositions or clauses in a sentence, types of syntactic structure used) declines gradually across the life span. These data have been collected from diaries (Kemper, 1990), written language samples in response to elicitation questions (e.g., Kemper et al.,
1989; Kemper, Thompson, & Marquis, 2001), stories told in writing (Kemper et al., 1990), and autobiographies of nuns (Kemper et al., 2001; Snowdon et al., 1996). Consistent with hypotheses that working memory is critical in sentence production, age-related changes in complexity correlate with a number of measures of working memory (Kemper et al., 1989; Kemper, Thompson, & Marquis, 2001b).

Although naturalistic language samples provide important data, the studies are not experimental and variables expected to influence syntactic complexity cannot be manipulated directly. A number of factors beyond working memory limitations could lead to the production of simpler syntactic constructions by older adults, including possible differences in frequency of exposure to complex sentences that can lead to priming of simpler sentences (Altmann et al., 2004) and age differences in pragmatic choices about how to package information for listeners (Kemper, Herman, & Liu, 2004).

Constrained sentence production tasks that avoid these interpretive pitfalls have been used only recently to compare young and older adults. Davidson, Zacks, and Ferreira (2003) gave participants a subject pronoun and a verb followed by additional words and asked them to produce a well-formed sentence using these words. They found that when producing sentences that had two acceptable grammatical orderings (e.g., *he gave the book to the library* versus *he gave the library the book*), both age groups were faster than for sentences that had only one acceptable grammatical ordering (e.g., *he donated the book to the library* as in most dialects of English *he donated the library the book* is unacceptable). Crucially, older adults were just as fast and accurate as younger adults and both groups showed a similar effect of grammatical choice. This study has interesting theoretical implications. Under at least some conceptions of the task, both working memory and inhibition deficits would have predicted age differences in that it should be harder to keep both alternatives in mind or inhibit the irrelevant grammatical option. Additionally, the findings by Davidson et al. (2003) are interesting because they provide some evidence that the production deficit found at the lexical level does not replicate for sentence production.

Another area where we see syntactic preservation in old age is for subject–verb agreement. Thornton, Skovbroten, and Burke (2004) found that overall older adults produced more agreement errors than young adults, but that age did not interact with syntactic variables known to affect agreement (i.e., number). Although age-related memory problems might affect overall error rate, syntactic processing appears to be constant across age here.

Still, on-line sentence production studies that have used more demanding tasks have observed age differences consistent with greater working memory limitations in older adults. Kemper, Herman, and Liu (2004) gave both young and older participants sentence fragments to memorize that varied in syntactic complexity. Participants then had to produce a complete sentence using the fragment. The length, complexity, and propositional content of the young participants’ responses were all affected by the complexity manipulation, whereas this was not the case for the older participants’ responses. One explanation of this finding is that the difficulty for older adults lies in the comprehension of the material to be retained for elaboration. Also, young adults produce more syntactically complex sentences than older adults when the verb provided takes a complement (Kemper, Herman, & Lian, 2003). Thus, this line of research provides evidence consistent with more
naturalistic studies that working memory limitations constrain language production in older adults.

The kind of working memory assumed in accounts of age differences in interpretive processes in sentence production has received little attention. In a novel approach to constrained sentence production, Spieler and Griffin (in press) asked young and older participants to describe pictures containing two objects above a third one and analyzed duration of gazes to pictures, picture name production latencies, and speech disfluencies. They found very similar rates of speech although older adults were slower to initiate speech, similar gaze patterns, and similar delays associated with the difficulty of retrieving words. Moreover, there was evidence that both groups uttered object names shortly after retrieving them, with little buffering of object names while names of other objects to be produced later were accessed. However, when later objects were less codable (had two or more acceptable and presumably competing names) and when phonological encoding was slowed by low frequency names, older adults were considerably more disfluent. Spieler and Griffin (2005) noted that such results are beyond the explanatory power of general slowing theories, which have no detailed way to explain both those aspects of older adults’ speech that slowed and the fact of disfluencies in the face of lexical competition. They suggested that the transmission deficit hypothesis can account for their results because the activation of competing lexical names for an object could lead to convergence of semantic priming on more than one lexical node.

We should note that interpretation of constrained sentence processing tasks is not altogether straightforward. These tasks all require comprehension of the material to be produced. Also, one important aspect of production is repair of errors, a topic that is little studied by cognitive aging researchers (for an exception, see MacKay & James, 2004) but has been the object of study in the production literature more generally (Hartsuiker & Kolk, 2001; Levelt, 1989). Many accounts of monitoring for errors posit that speech is fed back through the comprehension system. Predictions about monitoring differences across age might vary depending on whether comprehension processes during production are thought to tap a separate sentence interpretation resource or some more general resource.

III. Discourse Processes

A. Hearing Loss and Listening Comprehension

Schneider, Daneman, and Pichora-Fuller (2002) have argued that many age-related changes in comprehension of spoken language are due to lower level auditory declines instead of actual high-level changes in linguistic processing. Schneider et al. (2000) investigated age differences in spoken discourse by having both young and older adults listen to passages read in either a quiet or a noisy background. Despite the fact that older adults had good hearing, they answered fewer questions about the passages correctly than young adults. Schneider et al. (2000) hypothesized that the difference might be due to subclinical auditory problems in older adults. To test this hypothesis, they equated the signal-to-noise ratio on a participant-by-participant basis. When the signal-to-noise ratio was equated, no age differences in comprehension were found. Interestingly, adding a secondary task to divide attention had negative effects on comprehension for both young and old, but older adults were not differentially impaired, suggesting that distraction may not have more deleterious consequences for older adults when perceptual stress is equated.
Thus, this study provides good evidence that even subclinical age-related auditory declines can have significant effects on higher level language comprehension. Results from Federmeier et al. (2003) are interesting in this context. As noted earlier, they reported slowing of evoked potential responses at the sensory level in older adults and age differences at the discourse level, but interestingly, no differences at the lexical-semantic level.

One explanation of such effects is that older adults who have poorer processing of acoustic details of speech reallocate cognitive resources to determine the meanings of words from context with the result that higher level processes needed for integration of information (including working memory) suffer (Pichora-Fuller et al., 1995; see also Rabbitt, 1968, 1991). Evidence supporting this proposition comes from a study by McCoy et al. (2005). Older adults with good hearing and older adults with mild–moderate hearing loss were tested in a running memory span task that required recall of the last three words in speech that varied in approximation to English. Even though the hearing loss group could remember the most recent word as well as the good hearing group and though both groups could recall the first two words of a string quite well when approximation to English was high, performance for both groups, especially for the hearing loss group, was poorer when sequential constraints were low. The assumption here is that recall of the final words is proof that all words were perceived correctly by both groups (because the list could be stopped at any point), but that speech perception required extra resources in the hearing loss group that could otherwise have been devoted to maintenance of information in working memory (see also Murphy et al., 2000). As these results suggest, and consistent with the findings of Federmeier et al. (2003), the effects of sensory deficits are complex and may appear at different levels in different paradigms.

B. Situation Models and Discourse Comprehension

Updating a situation model involves tracking new people and objects that are introduced by the text, causal sequences, temporal and spatial shifts, and changes in the goals and emotional responses of characters. Inferences must often be generated to maintain discourse coherence, although the extent and timing of such inferences have been debated (Kintsch, 1998; McKoon & Ratcliff, 1992). A hypothesis that has garnered considerable recent attention is the possibility that older adults differ from young adults in lower (especially textbase) but not higher (situation model) levels of discourse comprehension.

There is clear evidence from both on-line and off-line paradigms for similar sensitivity to variables that influence situation model or discourse representations across age and, sometimes, for greater dedication of resources (i.e., reading time) to these variables on the part of older adults (Radvansky et al., 2001). For instance, young and older adults are equally responsive to changes in the goal status of characters in a narrative (Radvansky & Curiel, 1998), to shifts in the location of characters and objects within a spatial layout (Radvansky et al., 2003a; Stine-Morrow et al., 2004; Stine-Morrow, Morrow, & Leno, 2002), to the importance of functional spatial locations such as the consequences of standing under a street lamp or a bridge to avoid rain (Radvansky, Copeland, & Zwaan, 2003), to relative shifts in time requiring updating (Radvansky et al., 2003a), to incongruities of emotional responses of characters to situations (Soederberg & Stine, 1995), to discrepancies in the
appearance of objects in pictures and information in a text (Dijkstra et al., 2004), to causal relationships between sentences (Hess, 1995; Radvansky et al., 1990; Valencia-Laver & Light, 2000), and to topic shifts (Miller et al., 2004). Allocation of resources to textbase and situation model features can also vary with whether the text is being read initially or is being reread, and allocation strategies appear to depend on age and, within individuals, on text genre (Stine-Morrow et al., 2004). A noteworthy finding is that for both expository and narrative prose, older adults allocated more attention to situation model features on first but not second reading. Generally speaking, across studies in Stine-Morrow’s work, young and older adults perform at similarly high levels on off-line tasks, with young and older adults’ different in resource allocation strategies both promoting good performance.

With minor exceptions, young and old readers are similarly influenced by story structure variables in terms of reading times (Stine-Morrow, Miller, & Leno, 2001). People generally read faster as they proceed through a text so that less time is spent on sentences later in a passage. Following Gernsbacher (1990), this variable is sometimes treated as evidence that more resource investment (time) is needed early in passage reading to establish the basic form of the situation model, but this interpretation is not universal (e.g., Radvansky et al., 2001). Nonetheless, we note that older adults generally show at least as great an effect of serial position as young adults (e.g., Stine-Morrow et al., 1996).

C. Discourse Production

Processes involved in drawing anaphoric (and other) inferences also appear to be well preserved in old age unless working memory is taxed or specific bits of recently presented information must be retrieved actively over delays (Light & Albertson, 1988; Light & Capps, 1986; Light et al., 1994; Morrow, Leirer, & Altieri, 1992; Zelinski, 1988) or unless the inference requires understanding unfamiliar words (McGinnis & Zelinski, 2000, 2003) or eponyms (Zelinski & Hyde, 1996). One result that bears note here is the finding by Hamm and Hasher (1992) that when reading garden path passages, in which a plausible interpretation of an event is later shown to be incorrect, older adults are more likely to maintain both correct and incorrect inferences than young adults, consistent with a problem in inhibition. This finding is at odds with the fact that young and older adults are equally able to background completed goals. Radvansky and Curiel (1998) suggested that older adults may have difficulty in relinquishing incorrect inferences when these are both wrong and strong, which was not the case in the goals study. This hypothesis has not, to our knowledge, been submitted to empirical test as yet. Also, there is reason to believe that young adults do not invariably give up incorrect interpretations of sentences readily, so that the Hamm and Hasher (1992) findings may be the exception rather than the rule (Christianson et al., 2001).

As noted earlier, Kemper and colleagues observed a marked reduction in syntactic complexity in older adults in both longitudinal and cross-sectional studies. At the same time, there is evidence for increased skill in situation model level aspects of discourse. Older adults’ written diaries and oral stories are more structurally complex than those of young adults in that they include multiple episodes, embedded episodes, and codas that draw a moral lesson from events being narrated (Kemper, 1990; Kemper et al., 1989, 1990; Pratt et al., 1989; Pratt & Robins, 1991). In addition, discourse produced by older adults is
rated at least as highly (and sometimes more highly) as that of young adults for story quality, interest, clarity, and informativeness (James et al., 1999; Kemper, 1990; Kemper et al., 1989, 1990; Pratt et al., 1989; Pratt & Robins, 1991). When asked to interpret stories they have read, older adults are more likely to generate elaborated, integrative, symbolically rich responses than young adults, although older adults may recall less of the literal propositional content when asked to do so (Adams et al., 1997).

The conjunction of reduced syntactic complexity and increased narrative quality or focus on discourse level has been interpreted variously as an accommodation to decreases in processing resources or to growing expertise in the communicative nature of discourse (Adams et al., 1997; Kemper, 1990; Kemper et al., 1990), as well as to differences across age in the interpretation of what it means to tell a story or recall a narrative (Adams et al., 2002). This pattern of reduced grammatical complexity, increased structural complexity, and greater elaboration does not, however, mean that all aspects of discourse become more reader or listener friendly in old age. Decreased cohesiveness and greater likelihood of ambiguous reference have also been reported (e.g., Cohen, 1979; Glosser & Deser, 1992; Kemper, 1990; Kemper et al., 1990; Pratt et al., 1989).

D. Off-Target Verbosity

One area in which discourse production of older adults has been said to deteriorate is the ability to remain on topic during conversations. Although older adults do not give off-topic responses with greater frequency than young adults in speech production tasks that do not involve discourse (Burke, 1997), there have been reports of decreased global coherence associated with less good topical organization (Glosser & Deser, 1992) in older adults. When asked to answer questions about their lives or to narrate personal experiences, older adults do generate longer (more verbose) responses than young adults. In samples of adults over 60 years of age, extreme off-target verbosity may occur in as much as 20% of individuals (Arbuckle & Pushkar Gold, 1993; Gold et al., 1988; Pushkar Gold & Arbuckle, 1995) and has been associated with lower performance on some cognitive tasks that are purported markers of ability to inhibit irrelevant stimuli, less good management of instrumental activities of daily life, and psychosocial variables such as diminished satisfaction with social support. Off-target verbosity may limit the quality of social interactions by making interpersonal communication less satisfying for conversational partners (Pushkar Gold et al., 2000). Indeed, when compared to speakers who are verbose but not off-topic and to on-target speakers, off-target speakers are rated more negatively on dimensions such as intellectual competence, speed of learning, and forgetfulness (Ruscher & Hurley, 2000), and other studies suggest that off-target speakers may be less sensitive to the communicative needs of their partners (Arbuckle, Nohara-LeClair, & Pushkar, 2000).

The generality of off-target verbosity as a characteristic of the discourse of older adults has nevertheless been questioned. For instance, Vandeputte et al. (1999) found no age differences in topic continuations in the get-acquainted conversations of same and mixed-age dyads of younger and older adults. Off-target utterances, when they occur, may be specific to situations in which personal information or experience is transmitted. Comparing young and older adults (aged 60–80) on both descriptions of pictures and narrations of personal topics dealing with family, education, and vacations, James et al. (1999) found that the total number of words elicited for
personal topics, but not picture descriptions, was greater for older adults, and the effect for personal topics persisted when only on-topic speech was considered. In addition, instances of off-topic speech were more frequent for older than young adults only for personal topics. Young and older raters judged older speakers as more talkative than younger speakers and young speakers thought the older speakers were less focused on topics. However, older speakers were rated as higher on interest, informativeness, and story quality. James et al. (1999) argued that this pattern of results is inconsistent with inhibitory deficit accounts of off-target speech that have no principled way of accounting for differences across categories of topics and predicted that off-target verbosity should lead to low communicative efficiency, with poorer evaluations of story quality. Instead they suggested that older adults have differences in pragmatic aspects of discourse, placing greater value on meaningful interpretation of past events rather than concise factual descriptions (e.g., Boden & Bielby, 1983; Coupland & Coupland, 1995).

E. Language Addressed to Older Adults: Elderspeak

Negative assumptions about the communicative skills of older adults may lead to inappropriate overaccommodation by young adults who use a specialized speech register resembling baby talk in addressing older adults (Caporael, Lukaszewski, & Culbertson, 1983; Hummert et al., 2004; Ryan et al., 1986). This speech register, usually referred to as elderspeak, differs from speech addressed to young adults in information content and packaging. Kemper (1994) reported that speech addressed to older audiences (rather than younger ones) was characterized by fewer clauses per utterance, shorter utterances, fewer left-branching or self-embedded clauses, more lexical fillers (e.g., you know), more sentence fragments, fewer cohesive ties, fewer words of three or more syllables, more repetitions, slower speech rate, and longer pauses. In addition, the use of diminutives was more frequent in addressing dementing than nondementing older adults in this study, but this may be context specific, inasmuch as young speakers in mixed-age dyads rarely use diminutives in referential communication tasks (Kemper et al., 1995, 1998c). Evaluations of elderspeak may be moderated by context (e.g. institutional vs community settings), characteristics of the listener (e.g., degree of cognitive impairment), and relationship of speaker and listener (e.g., relative vs unfamiliar service provider), but such speech is generally judged to be both inappropriate and patronizing (Hummert & Mazloff, 2001; Kemper et al., 1998a; LaTourette & Meeks, 2000; O'Connor & St. Pierre, 2004; Ryan et al., 2000).

To some extent, use of elderspeak is driven by stereotypical expectations rather than by the actual characteristics of conversational partners. For instance, speech addressed to dementing and nondementing older adults varied very little (Kemper, 1994). Young speakers do not vary speech to older partners in a referential communication task very much regardless of whether the listeners are allowed to interrupt by asking questions or requesting clarification or to provide other feedback (Kemper et al., 1995, 1996). However, repeated practice on the same task (Kemper et al., 1998c), listener speech suggesting cognitive impairment (Kemper et al., 1998b), and simulation of speech to adults experiencing cognitive problems rather than living healthy, independent lives in the community (Kemper et al., 1998a) do lead to exaggerated forms of elderspeak in a referential communication task,
suggestive of responsiveness to the communicative needs of partners in this task. Older adults also receive more patronizing messages in a simulated persuasion task, especially if targets are described negatively (Hummert et al., 1998).

Although often viewed as stigmatizing speech, some elements of elderspeak may benefit performance in older adults (Cohen & Faulkner, 1986; McGuire et al., 2000). Performance in a referential communication task is better when older adults receive instruction from young speakers (e.g., Kemper et al., 1995, 1996), but at a cost—older adults also report more expressive and receptive communication problems when interacting with young speakers. This conjunction of improved performance, together with negative self-evaluation, has led to a search for versions of elderspeak that impart performance benefits without being patronizing or insulting (Ryan et al., 1995; Williams, Kemper, & Hummert, 2003). Kemper and Harden (1999), in a careful dissection of the properties of elderspeak, found that increasing semantic elaborations and reducing use of subordinate and embedded clauses improved performance on a referential communication task, but that reduced sentence length, slower speech rate, and higher pitch did not; the latter trio of properties also increased complaints of communication problems.

According to the communicative predication of aging model (Ryan et al., 1986; see Coupland et al., 1988), recognition of old-age cues triggers stereotyped expectations about aging that give rise to overaccommodative speech to older adults. Recipients of elderspeak may experience diminished self-esteem, reduced communication efficacy, dissatisfaction with communication, and, ultimately, diminished social interaction and loss of control. A revised and elaborated version of this model, the age stereotypes in the interaction model, accounts for both positive and negative effects of stereotypes in communication and includes a feedback mechanism that permits revision of the assessment of the communicative competency of conversational partners (Hummert et al., 2004). In line with this model, older targets that evoke positive rather than negative stereotypes of aging are judged higher in communicative competence (Hummert, Garstka, & Shaner, 1995), instructions to competent older targets contain less patronizing speech (Thimm, Rademacher, Kruse, 1998), and humorous responses by older adults to patronizing speech appear to permit assertiveness without loss of appearance of competence and politeness (Hummert & Mazloff, 2001; Ryan et al., 2000).

Thus far, we have discussed only research on language in intergenerational dyads that has focused on overaccommodative speech by young adults. Interestingly, in referential communication tasks, older adults vary little in the ways in which they convey route information to young and older targets (Kemper et al., 1995, 1996). This does not appear to reflect an inability to change register as a result of working memory or other global age-related deficits—older adults do accommodate when speaking to cognitively impaired partners (Gould & Shaleen, 1999; Kemper et al., 1994) and in retelling stories to children (Adams et al., 2002). There are heated debates in the psycholinguistic literature about issues of common ground—the extent to which speakers take into account the specific conversational needs of their audience (Horton & Keysar, 1996; Lockridge & Brennan, 2002). An important but understudied question is whether there are age differences in the ability to take common ground into consideration. A related issue is the role of gesture, body language, and facial expression in communication.
by and to older adults. Although these topics have attracted interest in the wider research community (Goldin-Meadow, Alibali, & Church, 1993; McNeil, 1992), they represent terra almost incognita in the language and aging literature (for some exceptions, see Cohen & Borsoi, 1996; Feyereisen & Havard, 1999; Montepare et al., 1999).

IV. A Concluding Word

Many of the broad models of cognitive aging are simply too general to account for the diverse range of data. General slowing cannot readily account for processing asymmetries in lexical processing or for differences in outcomes within single tasks [e.g., different distributions of speech errors across age found by MacKay and James, (2004)]. In some instances, theoretical constructs are in flux or not sufficiently unpacked to be useful in explaining particular patterns of results. Inhibition deficit theory has been criticized for insufficient specificity of its theoretical constructs in particular paradigms [Burke (1997), but see Sommers (1996) for a more specific inhibition account of neighborhood effects]. Although single resource working memory hypotheses have been pitted against multiple resource hypotheses in the context of aging research, some psycholinguistic theorists have argued that there is no working memory resource separate from general processing [MacDonald & Christiansen, 2002]. As crucial constructs shift in interpretation, our understanding of the relationships among these constructs, language, and aging will perforce change too.

Unlike the transmission deficit model, the general slowing, working memory, and inhibition deficit hypotheses all lack specific cognitive architectures within which processes might act. This is not a necessary feature of such approaches. For example, one could imagine embedding an account of inhibition deficits within a specific architecture, such as that of the transmission deficit model, which might allow it to make principled predictions about paradigms to which it has been applied. Even models that do have specific cognitive architectures may lack mechanisms for carrying out particular kinds of language processes. As a case in point, the transmission deficit model does not have a fully developed syntactic processor. Extensions to syntactic processing are possible within the general framework of the transmission deficit model (MacKay & James, 2001b) and it would be interesting to see how it accounts for classic syntactic phenomena.

As emphasized throughout this chapter, understanding the effects of normal aging on language processing requires attention to a complex interaction of processes, from low-level sensory deficits that can affect high-level discourse processes and vice versa. Current models of cognitive aging have typically been applied to only a subset of the phenomena we have discussed at word, sentence, and discourse levels of language comprehension and production. For example, the transmission deficit hypothesis has been applied primarily to lexical processing, whereas working memory accounts of various types have been developed almost exclusively in the realms of sentence and discourse processing. Moreover, the influence of lower level sensory deficits, which can have substantial effects on working memory and higher level comprehension, has generally not played a large role in theory development. To give one example, one could imagine a more explicit model of sensory deficits that would explain some of the phenomena accounted for by inhibition deficits or transmission deficits, perhaps as a result of weakened activation in the system. One could also ask how a separate
sentence interpretation resource model might expect interpretive processes to operate on and repair low-quality sensory inputs and how top-down information might offset those degraded representations. Similarly, Waters and Caplan’s working memory accounts have been applied for the most part to the syntactic comprehension of single sentences, whereas existing data suggest that working memory can strongly influence the production of language and such models have been much less applied to language processing in connected discourse. Thus, one obvious direction for future research on language and aging is greater theoretical integration across levels of processing in comprehension and production. Incorporating pragmatic aspects of language use such as common ground and accommodation into these approaches serves as a further challenge for cognitive aging researchers.

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