

Aging and Language Production

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ABSTRACT—*Experimental research and older adults' reports of their own experience suggest that the ability to produce the spoken forms of familiar words declines with aging. Older adults experience more word-finding failures, such as tip-of-the-tongue states, than young adults do, and this and other speech production failures appear to stem from difficulties in retrieving the sounds of words. Recent evidence has identified a parallel age-related decline in retrieving the spelling of familiar words. Models of cognitive aging must explain why these aspects of language production decline with aging whereas semantic processes are well maintained. We describe a model wherein aging weakens connections among linguistic representations, thereby reducing the transmission of excitation from one representation to another. The structure of the representational systems for word phonology and orthography makes them vulnerable to transmission deficits, impairing retrieval.*

KEYWORDS—aging; word production; tip of the tongue; phonological retrieval; spelling

Older adults report that one of their most annoying cognitive problems is the inability to produce a well-known word. Although people of all ages suffer such word-finding failures, this type of error becomes more frequent with age, and older adults report that it is the cognitive problem most affected by aging. Understanding the nature and cause of word-finding failures is an important goal for aging research because these failures may diminish older adults' success in communicating, and weaken the evaluation of their language competence by themselves and others. Such negative self-appraisal promotes withdrawal from social interaction. Moreover, the age-related decline in word retrieval is theoretically significant because many language abilities are relatively well maintained in old age and models of aging must explain this pattern. For example, retrieval of the meaning of words and other semantic processes involved in understanding language show little change with aging. In this article, we focus on word production, that is, producing the sound or spelling for a word. (For age-related declines in other components of language production, see Kemper, Thompson, & Marquis, 2001.) We review evidence for the decline in word retrieval in old age and describe a cognitive aging model that explains why this language function declines.

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MEASURING SPOKEN WORD PRODUCTION

One of the simplest methods for measuring the effect of aging on word retrieval is comparing young and older adults' ability to name pictures of objects. A number of studies have shown that older adults make more errors in naming pictures than young adults do (Feyereisen, 1997). During discourse, a more natural form of speech than picture naming, older adults produce more ambiguous references and more filled pauses (e.g., saying "um" or "er") and reformulate their words more than young adults do (Kemper, 1992; Schmitter-Edgecombe, Vesneski, & Jones, 2000). These dysfluencies suggest that older adults have difficulty retrieving the appropriate words when speaking.

Another type of dysfluency is a slip of the tongue in which the speaker produces one or more incorrect sounds in a word, for example, saying *coffee cot* when *coffee pot* was intended. Slips of the tongue have been an important source of data for developing models of speech production because they exhibit regular patterns that reveal production processes. Because slips of the tongue occur infrequently, techniques for inducing slips have been used to elevate their frequency in the laboratory. In a study by MacKay and James (in press), participants viewed written words containing either /p/ or /b/, and the task was to change the /p/ to /b/, or vice versa, and produce the reformulated word as quickly as possible. For example, the correct response for the stimulus "ribbed" was "ripped." An analysis of errors showed that older adults were more likely than young adults to omit sounds (e.g., saying "rip," given "ribbed"), whereas young adults were more likely than older adults to substitute a different sound (e.g., saying "tipped"). Older adults' omissions suggest they had difficulty retrieving the phonology (i.e., the sounds) of words; in contrast, young adults had multiple sounds available.

One of the most dramatic word production failures is the tip-of-the-tongue (TOT) experience—being unable to produce a word one is absolutely certain that one knows. Two studies investigating naturally occurring TOTs during everyday life demonstrated that older adults experience more TOTs than young adults (Burke, MacKay, Worthley, & Wade, 1991; Heine, Ober, & Shenaut, 1999). Participants kept diaries in which they recorded information about each TOT that they experienced during a 4-week interval. In both studies, the older participants reported more TOTs than young adults did. In one of the studies (Burke et al.), the majority of TOTs for both young and older participants involved proper nouns; the proper nouns for people were the names of people who had not been contacted recently. TOT words that were not proper nouns had a low frequency of occurrence in the language. Thus, although participants rated all TOT words as very familiar, they were words, including proper nouns, that were used neither frequently nor recently, making them vulnerable to retrieval failures.

W. James (1890) observed that a TOT produces a mental gap that “is intensely active,” having the “wraith of the name” in it (p. 251). Indeed, people in the throes of a TOT recall bits of information about the form of the word they are trying to recall. They often report the first sound or number of syllables of the word, and this was true more often for young than older adults in the diary studies. Participants also reported that an alternate (but incorrect) word came to mind persistently, and this word tended to share its initial sound with the TOT word. For example, during a TOT for *eccentric*, the persistent alternate was *exotic*. As was the case for partial information, these alternate words were reported more often by young than by older adults.

Age differences in the TOT experience are supported by laboratory studies. In this research, TOTs are induced by asking participants questions that are correctly answered by single low-frequency words (e.g., “What word means to formally renounce a throne?”). Older adults experience more TOTs than young adults when answering such questions, although the age difference is reliable for proper nouns, but not always for other words. Further research is needed to clarify how age-related increases in TOTs vary for different types of words. Compared with young adults, older adults report less partial phonological information and fewer persistent alternates for lab-induced TOTs (e.g., Burke et al., 1991; Maylor, 1990). In the next section, we

describe a model that accounts for these phenomena by postulating an age-related change in a fundamental word retrieval mechanism.

A MODEL OF AGING AND WORD RETRIEVAL FAILURES

Current models of language production postulate that verbal information is stored in a vast network of interconnected nodes organized into a *semantic system* representing word meanings and a *phonological* and *orthographic system* representing word sounds and spellings, as shown in Figure 1 (e.g., Dell, 1986; MacKay & Abrams, 1998). Word production starts with activation of semantic representations (propositional nodes) and transmission of excitation to lexical representations for words with these meanings. The lexical representation whose meaning corresponds most closely to the activated semantic information is then activated. Spoken production of this word requires activation of corresponding phonological representations.

TOTs occur when semantic and lexical representations corresponding to a word are activated, causing a strong feeling of knowing the word, but activation of phonological information about the word is incomplete. In the transmission-deficit model (Burke et al., 1991; MacKay & James, in press), activation of phonology fails because connections to phonological representations have become weak,

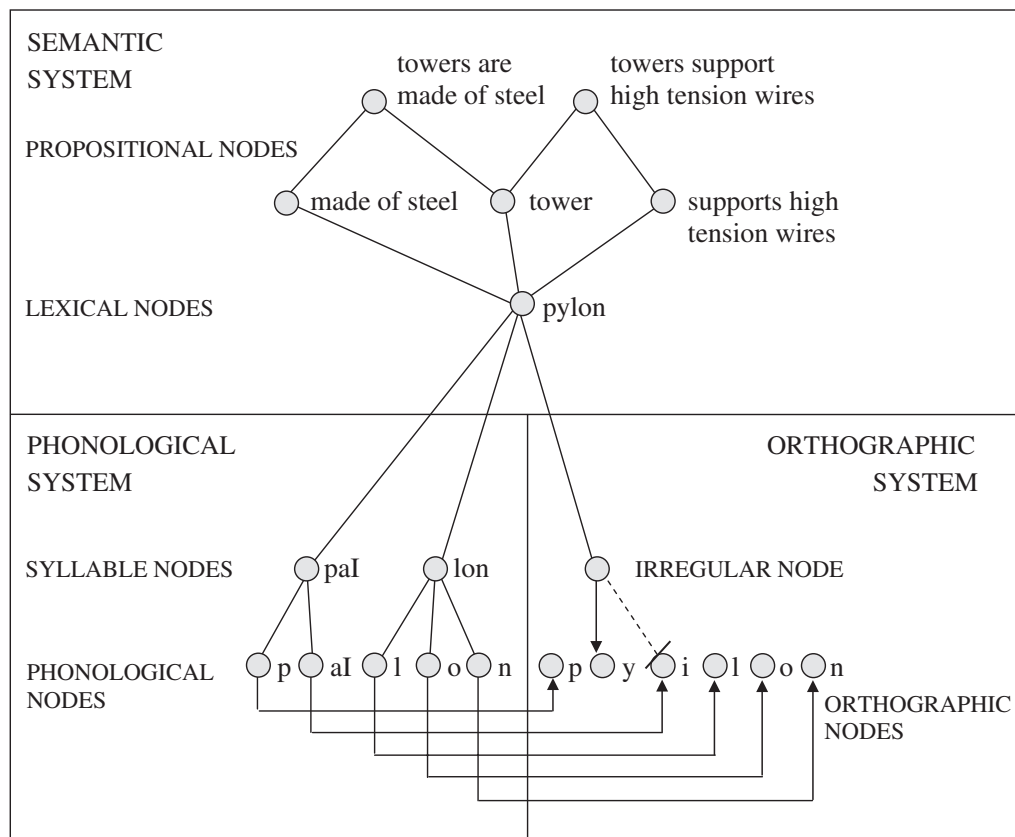


Fig. 1. Representation of semantic, phonological, and orthographic components of the word *pylon* (e.g., Burke, MacKay, Worthley, & Wade, 1991; MacKay & Abrams, 1998). Solid lines represent excitatory connections, and the broken line represents an inhibitory connection. All phonological nodes must be activated for spoken production of the word. Lateral connections between phonological and orthographic nodes produce correct spelling for regularly spelled words. However, because *pylon* is an irregularly spelled word, the lateral connections would lead to a misspelling; instead, the irregular node for *y*, connected to the lexical node, must be activated for the word to be spelled correctly. For the sake of simplicity, many nodes and connections have been omitted from this illustration.

reducing the transmission of excitation. For example, a TOT occurs for *pylon* (see Fig. 1) when weak connections transmit insufficient excitation to its phonological nodes. The model postulates three factors that weaken connections: aging of the speaker and lack of recent or frequent activation of representations. When a connection is sufficiently weak, it will transmit too little excitation to allow a representation to reach a threshold necessary for activation, resulting in production failure. This model explains why words that are produced infrequently are more likely than high-frequency words to be involved in TOTs. Moreover, age-related weakening of connections in older adults increases transmission deficits that cause both TOTs and omission errors in slips of the tongue.

Partial recall of the sounds of the target word during a TOT occurs when some but not all of the phonological nodes for producing that word are activated. Activated phonological nodes transmit excitation to other words that share these sounds, and if one of these words becomes activated, a persistent alternate will come to mind. For example, activation of the first syllable, /paɪ/, of *pylon* would send excitation to other lexical representations sharing this syllable, such as *pirate* and *pilot*, and one of these words may come to mind as a persistent alternate. Older adults report less partial phonological information and fewer persistent alternates than young adults because their weaker connections transmit less excitation to phonological nodes.

Why are age-related retrieval failures found for phonological but not semantic information? The architecture of the representational system renders the phonological system more vulnerable to transmission deficits than the semantic system because the functional effect of transmission deficits is more severe when one-to-one connections are involved than when connections are many to one. Because representations of semantic features of a word are highly interconnected (see Fig. 1), a transmission deficit in any one connection (e.g., *pylons are made of steel*) will be offset by other connections to the same feature (e.g., *towers are made of steel*). In retrieval of phonology, however, transmission of excitation diverges from lexical nodes along single connections to associated phonological nodes. A transmission deficit in a single connection will prevent retrieval of the phonology represented by that node.

TESTING THE ROLE OF PHONOLOGICAL RETRIEVAL IN TOTS

According to the transmission-deficit model, production of words sharing the sounds of a target word will reduce subsequent TOTs for the target word. This is because production of the phonologically related words strengthens weak phonological connections that cause TOTs. In one study (L.E. James & Burke, 2000), participants were asked a series of TOT-inducing questions, and whenever they responded “TOT” or “don’t know,” they were given 10 words to pronounce before the question was presented a second time. On some trials, half of these words shared some sounds with the answer to the question (e.g., “*indigent*” for the target “*abdicate*”). TOTs were more likely to be resolved following production of phonologically related rather than unrelated words. Further research has shown that production of the initial phonological component increases TOT resolution more than production of the middle or end sounds (White & Abrams, 2002).

If word retrieval deficits increase with aging because older adults have greater deficits in phonological retrieval, one would expect prior

production of phonologically related words to have a greater beneficial effect for older than young adults. Under certain conditions, this age difference has been found. When participants attempted to name a picture of a famous person (e.g., Brad Pitt), prior production of the homophone for the surname (e.g., cherry pit) increased correct naming and reduced TOTs, but only for older, not young, adults (Burke, Lorcantore, Austin, & Chae, in press). Production of the homophone strengthened phonological connections that were especially weak in older adults, and this boosted their ability to produce a name corresponding to this phonology.

AGING AND ORTHOGRAPHIC RETRIEVAL

The transmission-deficit model predicts an age-related deficit in spelling that is parallel to the phonological deficit because retrieval of both orthography and phonology depends on single connections between nodes. A growing number of studies have demonstrated an age-related decline in the ability to spell words correctly. MacKay and Abrams (1998) used a dictation task to test the ability of young and older adults to spell words that had uncommon spellings for their speech sounds (e.g., *colonel*). Older adults made more errors than younger adults, and more errors were made for low- than high-frequency words. The age difference was larger for high- than low-frequency words, which was surprising because low-frequency words should be particularly vulnerable to retrieval failures in old age. The authors suggested that the young participants (undergraduates) may have been relatively unfamiliar with the low-frequency words, which would have led to high error rates. When familiarity was more controlled across participants by comparing the performance of 50- and 70-year-olds, the expected larger age difference for low- than high-frequency words was observed (Stuart-Hamilton & Rabbitt, 1997).

“Regular” words, such as *mint* or *worker*, are easy to spell because they follow the common spelling for their sounds; words with “irregular” segments, such as *yacht* or *beggar*, are difficult to spell because they follow uncommon spelling for their sounds. MacKay and Abrams (1998) found that most spelling errors involved irregularly spelled components of words, and the age decline in performance was greater for irregular than regular components. The misspellings of both young and older adults usually matched the correct pronunciation (e.g., *calender* instead of *calendar*, *spontaneous* instead of *spontaneous*).

Models of aging and spelling ability must explain how aging differentially affects the spelling of irregular versus regular words. To account for the difficulty of irregular spelling, many models postulate two independent routes for retrieving orthography: an *indirect route* that uses sound-to-spelling correspondence rules and a *direct route* that connects lexical representations directly to the orthography. The indirect route can be used to spell regular words, whereas the direct route is critical for spelling irregular words. In Figure 1, the lateral connections between the phonological and orthographic units allow for regular sound-to-spelling mappings. When a word with an irregular spelling (e.g., “y” in *pylon*) is produced, an irregular node is activated and inhibits the regular spelling (e.g., “i”), while sending excitation to the irregular spelling, “y.” The transmission-deficit model predicts greater age-linked deficits in retrieval of an irregular spelling because it depends on a one-to-one connection between nodes that are activated less frequently than the nodes for regular spelling (MacKay & Abrams, 1998).

CONCLUSIONS AND FUTURE DIRECTIONS

There is compelling evidence that normal aging selectively impairs certain language functions more than others: Although older adults maintain or improve their knowledge of words and word meanings, they suffer deficits in the ability to produce the spoken and written forms of words. The transmission-deficit model provides a framework for understanding this pattern of language change during adulthood, and points to important areas for future research. Inasmuch as these production deficits are caused by weak connections in the phonological and orthographic systems, recent and frequent word production should improve subsequent performance. Studies have supported this prediction. For example, prior production of the sounds of a target word facilitated its subsequent oral production and in some cases eliminated age differences in production. Further research is needed to identify the conditions of prior production that boost older adults' performance to the level of young adults'. Parallel effects need to be investigated for spelling: According to the transmission-deficit model, recent production of the orthography of irregularly spelled words should reduce age declines in spelling. This research will have important implications for models of language production, as well as for reducing decline in the everyday language production of older adults.

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