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Do age-related word retrieval difficulties appear (or disappear) in connected speech?

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Abstract

We conducted a comprehensive literature review of studies of word retrieval in connected speech in healthy aging, and reviewed relevant aphasia research that could shed light on the aging literature. Four main hypotheses guided the review: (1) Significant retrieval difficulties would lead to reduced output in connected speech. (2) Significant retrieval difficulties would lead to a more limited lexical variety in connected speech. (3) Significant retrieval difficulties would lead to an increase in word substitution errors and in pronoun use, as well as to greater dysfluency and hesitation in connected speech. (4) Retrieval difficulties on tests of single-word production would be associated with measures of word retrieval in connected speech. Studies on aging did not confirm these four hypotheses, unlike studies on aphasia that generally did. The review suggests that future research should investigate how context facilitates word production in old age.

Keywords

Narrative; discourse; spontaneous speech; word finding; lexical retrieval; aging; aphasia

Introduction

Cognitively healthy older adults often complain of difficulties in word finding (Burke & Shafto, 2004; Condret-Santi, Barbeau, Matharan, Le Goff, Dartigues, & Amieva, 2013; Goral, 2004; Wingfield & Stine-Morrow, 2000). Studies of word retrieval in healthy aging have traditionally employed tasks that require single-word production, such as naming to definition, picture naming, or verbal fluency, generally showing a decline in performance with increased age (e.g., Connor, Spiro, Olber, & Albert, 2004; Gordon & Kindred, 2011; Goral, Spiro, Albert, Olber, & Connor, 2007; Ivnik, Malec, Smith, Tangalos, & Peterson, 1996; James & Burke, 2000; Kavé & Knafo-Noam, 2015; Kavé, Knafo, & Gilboa, 2010; Troyer, Moscovitch, Winocur, 1997; Zec, Burkett, Markwell, & Larsen, 2007). Aging presumably affects word retrieval not only in isolation but also in context (e.g., Mortensen,

Meyer, & Humphreys, 2006). However, most research on connected speech production in healthy aging has addressed aspects of communication such as discourse structure (e.g., Cannizzaro & Coelho, 2013), off-topic speech (e.g., Arbuckle & Gold, 1993; Arbuckle, Nohara-LeClaire, & Pushkar, 2000; Pushkar, Basevitz, Arbuckle, Nohara-LeClaire, Lapidus, & Peled, 2000; Pushkar-Gold & Arbuckle, 1995), or information content (e.g., Wright, Capilouto, Srinivasan, & Fergadiotis, 2011), and did not focus specifically on word retrieval.

Research on word production in aphasia, an acquired language impairment characterized by significant word retrieval difficulties, has emphasized the importance of assessment and treatment of deficits beyond the single word level, and studies have increasingly shifted to focus on discourse level performance (Boyle, 2014). This change in focus reflects the understanding that testing and treating word retrieval in connected speech are more ecologically valid than is looking at word retrieval in isolation. Although it is often difficult to determine the cognitive processes that underlie retrieval deficits in context, researchers agree that semantic, phonological, syntactic, and prosodic factors facilitate word retrieval in connected speech (Pashek & Tompkins, 2002). In healthy older adults, retrieval difficulties might be more subtle than they are in aphasia, and higher order cognitive skills (Cannizzaro & Coelho, 2013), as well as working memory, speed, or timing (Griffin & Spieler, 2006) might have a greater impact on retrieval in discourse. Hence, retrieval in context might differ from retrieval in isolation.

According to the Transmission Deficit Hypothesis (TDH, Burke, MacKay, Worthley, & Wade, 1991; Burke & Shafto, 2004; MacKay & Burke, 1990), aging weakens the connections between a word's semantic representation and its phonological representation. A weak connection transmits too little excitation and thus a given representation cannot reach the threshold necessary for activation, resulting in a production failure. If the locus of the deficit is in the connection between levels of representations, older adults should find it difficult to retrieve words across a variety of tasks, whether testing retrieval in isolation or in context. Yet, transmission deficits may have more detrimental effects on single word production than on connected speech, since retrieval of single words requires an exact match between the semantic level and the phonological code, whereas retrieval in context is more flexible. Indeed, tasks of naming to definitions or picture naming examine the retrieval of specific target lexical entries, judged as either correct or incorrect against responses that the examiner pre-defines. Verbal fluency tasks allow more variability in terms of word choice than do picture naming tasks, but they constrain retrieval according to a given rule, place a strict time limitation, and rely heavily on executive functions. Lexical retrieval in connected speech differs from lexical retrieval in isolation because it occurs within contextual support, and because speakers may use various words to replace any specific item that might be temporarily inaccessible. Older adults use such compensatory strategies in language comprehension (Wingfield & Grossman, 2006) and might be using them also while producing words in connected speech. Thus, it is unclear whether retrieval difficulties in isolation attest to the pattern of retrieval in context.

The current review presents findings of studies that investigated word retrieval in connected speech in healthy older adults, and then provides relevant findings from the aphasia literature. The aphasia literature has served to formulate our hypotheses and we use it to

examine whether significant word retrieval difficulties occur across tasks. We begin with a short note on methodological considerations. Next, we review studies of connected speech in aging that measured variables of retrieval success (e.g., word quantity, lexical diversity), variables of retrieval failure (e.g., word substitution, dysfluency), and the connection between retrieval of words in isolation and in context. We examine four hypotheses, as depicted in Figure 1. We assume that significant retrieval difficulties would lead to (1) reduced productivity in connected speech; (2) a more limited lexical variety in connected speech; (3) an increase in retrieval errors; and (4) an association between retrieval difficulties on tests of single-word production and measures of word retrieval in context. Following an examination of these hypotheses in the aging literature, we assess comparable data from the aphasia literature.

Methodological considerations

Two major methodological obstacles might have limited research on word retrieval in connected speech in old age, one relates to the elicitation mode and the other to the variables under study. Spontaneous speech has been obtained by a variety of methods. Researchers asked participants to refer to a personal event such as a vacation that they had taken (e.g., Gould & Dixon, 1993), talk about their work and family (e.g., Glosser & Deser, 1992), or describe their personal history (e.g., Kemper & Sumner, 2001). Some studies have also analyzed conversations between participants and communication partners (Arbuckle et al., 2000; Gould & Dixon, 1993), or phone dialogues on more general topics (Horton, Spieler, & Shriberg, 2010). In such studies, it is often difficult to determine which words the person had intended to retrieve. Other researchers have used more constrained elicitation methods that make it possible to identify words that participants are likely to retrieve. Semi-spontaneous speech has been elicited by instructing participants to describe a well-known story, a picture scene, a series of still pictures, or a short video clip (e.g., Fergadiotis, Wright, & Capilouto, 2011; Heller & Dobbs, 1993; Kavé et al., 2009). Each mode of elicitation may lead to different production patterns and constraints (Olness, Ulatowska, & Wertz, 2002), thus limiting possible generalizations about word retrieval in context.

Furthermore, there is no agreement as to the measures that indicate success or failure of word retrieval in context. Unlike the clearly defined correct or incorrect responses on tests of single-word production, in connected speech many words might be appropriate, and determining whether an individual retrieved the right word or failed to do so is not a straightforward decision. Turning to research in aphasia, we see that authors have examined retrieval efficiency, defining this construct quantitatively as the total word output (e.g., Andreetta, Cantagallo, & Marini, 2012; Crutch & Warrington, 2003; Eiesland & Lind, 2012), or quantitatively and qualitatively as the number of *meaningful* words a person retrieves (e.g., Boyle, 2014; Gordon, 2008; Hadar, Jones, & Mate-Kole, 1987; Nicholas & Brookshire, 1993). The use of word count measures rests on the assumption that lexical difficulties would lead to reduction in productivity, which is true for some, albeit not all, types of aphasia. Studies of both aging and aphasia have also evaluated the diversity of the words that participants produce (e.g., Fergadiotis et al., 2011; Fergadiotis & Wright, 2011; Horton et al., 2010; Kemper & Sumner, 2001). The use of measures of lexical diversity relies on the assumption that individuals who have trouble in word retrieval are likely to use

only words that are more accessible to them and to repeat the same words within their narrative. In addition, research has shown that retrieval failure may result in an increase in word substitution errors, or in an increase in hesitations and false starts that reduce fluency (e.g., Pashek & Tompkins, 2002). This multitude of different measures further precludes quantitative generalizations.

Our aim in this review was to systematically identify, assess, and synthesize all relevant studies of word retrieval in connected speech within the aging literature. We thus searched Medline, PsychNET, and SocINDEX with full text, with no restrictions as to publication dates. We used the following search terms: connected speech; spontaneous speech; speech production; narrative; and discourse, together with lexical or word retrieval. We used each of the possible combinations of terms together with aging, old age, or aphasia. We then identified additional studies through the reference lists of the papers that came up in our search, as well as through relevant review papers (e.g., Boyle, 2004; Burke & Shafto, 2008; Mortensen et al., 2006; Prins & Bastiaanse, 2004). Initial screening excluded studies of connected speech that dealt with diverse aspects of communication other than lexical retrieval, studies in which healthy older individuals served as a control group (e.g., in studies of dementia) with no reference to age-related changes, and studies that looked at written rather than spoken language. Table 1 lists the 21 studies on connected speech in healthy aging that met these selection criteria, according to our four hypotheses. Studies varied greatly in age and number of participants, in elicitation modes, as well as in the variables that were used to document word retrieval. Hence, we could not conduct a meta-analysis that would quantify effect sizes across studies, and instead chose to present the main findings in a narrative format.

Word retrieval in connected speech in healthy aging

First, we looked at productivity or word quantity, a measure that could indicate ease of word retrieval (see summary of studies on this measure at the top of Table 1). Only two studies of connected speech found an age-related reduction in output quantity (Heller & Dobbs, 1993; Kemper & Sumner, 2001). Several studies reported no age differences in word number (e.g., Capilouto, Wright, & Maddy, 2016; Castro & James, 2014; Cooper, 1990; Kavé, Samuel-Enoch, and Adiv, 2009; Shewan & Henderson, 1988). Contrary to our assumption that word finding difficulties would lead to reduction in productivity, many studies found an increase in word number with age (e.g., Arbuckle et al., 2000; Arbuckle & Gold, 1993; Bortfeld, Leon, Bloom, Schober, & Brennan, 2001; Dennis & Hess, 2016; Horton et al., 2010; James, Burke, Austin, & Hulme, 1998; Juncos-Rabadan et al., 2005; Saling, Laroo, & Saling, 2012; Trunk & Abrams, 2009). Elicitation mode may affect word output in older age, as older adults believe that it is best to provide a rich background on some but not all communication tasks (James et al. 1998; Trunk & Abrams, 2009). Yet, if productivity reflects successful word retrieval, there is no reliable evidence that difficulties in access are prevalent in connected speech produced by older adults.

Another possibility that we explored was that difficulties in word retrieval would result in impoverished lexical diversity. Capilouto et al. (2016) found that older adults produced a more restricted selection of words than did younger and middle-aged adults when required

to describe a single picture, with no age differences in lexical diversity for descriptions of sequential pictures. However, other studies reported that the speech of older adults consisted of increased rather than decreased lexical diversity in comparison to the speech of younger adults. Studies of type-token ratio suggest that older adults retrieve a greater variety of words relative to younger adults, especially when elicitation involves no pictures (e.g., Fergadiotis et al., 2011; Kemper & Sumner, 2001). Horton et al. (2010) found a positive association between type-token ratio and age as well as a negative association between type-token ratio and word frequency, so that speakers who produced more unique types per token also produced more low frequency words. Focusing on nouns alone, Kavé et al. (2009) found no age-related differences in type-token ratio but documented a decrease in noun frequency with age. Similarly, according to Dennis and Hess (2016), older adults used more non-normative words (words generated by fewer than 5% of all participants) than did younger adults. These findings suggest that older adults do not resort to production of a more restricted set of words in connected speech (see Table 1 for a summary of the relevant studies).

In addition to word quantity and lexical diversity that may attest to retrieval success, evidence for retrieval failure can also indicate that individuals are searching for words in connected speech. We list various types of failures in Table 1, along with the studies that documented evidence of the presence or absence of these failures in healthy older adults. Two studies reported greater word choice errors in old age (Heller & Dobbs, 1993; Shewan & Henderson, 1988). Yet, while as a group individuals over age 60 made significantly more word choice errors than did 40–49-year-olds, two-thirds of participants produced no such errors at all (Shewan & Henderson, 1988). Moreover, Schmitter-Edgecombe, Vesneski, and Jones (2000) found no age-related increase in word substitutions (i.e., selecting a word that clearly did not fit the context). Several studies that specifically looked for circumlocutions or digressions from the main topic found no age-related differences (e.g., Cooper, 1990; Mackenzie, 2000; Schmitter-Edgecombe et al., 2000). Schmitter-Edgecombe et al. (2000) documented an age-related increase in word reformulations, defined as changes or modifications made to one or more previous words. However, Cooper (1990) reported that the number of self-corrections was unrelated to age, and Dennis and Hess (2016) found no age difference in selection of multiple terms to describe one object (e.g., “here comes a train... or a railcar or cable car of sorts”). Thus, the assumption that older adults fail to retrieve specific words in context and substitute them with less appropriate words receives no consistent empirical support.

The use of pronouns can provide indirect evidence of retrieval failure, since pronouns could replace words that are more specific. Ulatowska et al. (1986) found an age-related increase in the proportion of pronouns relative to nouns in most but not all narrative types. Heller and Dobbs (1993) documented an age-related increase in pronoun-to-noun ratio but no increase in the use of ambiguous pronouns. Juncos-Rabadan et al. (2005) measured clear reference, ambiguous reference, and referential elements with no reference at all, analyzing only pronouns that referred to elements within the story. They argued that reference clarity declined with age. Mackenzie (2000) reported that pronouns whose referents could not be reasonably presumed, as well as contradictions in referencing (e.g., “My son came to visit me. She wasn’t looking very well”) were more common among older adults than among

younger adults. In contrast, Le Dorze and Bédard (1998) found no age effect in the use of pronouns that referred to a content unit produced elsewhere in the sample. Castro and James (2014) noted that reference errors (i.e., misuse of pronouns) were extremely rare and did not differ across age groups. Furthermore, several studies reported no age-related increase in the use of indefinite terms, such as ‘thing’ (Cooper, 1990; Le Dorze & Bédard, 1998; Schmitter-Edgecombe et al., 2000). Thus, while overuse of pronouns or other indefinite terms could indicate word retrieval difficulties, such difficulties do not emerge consistently in all studies of the speech of older adults.

Investigation of dysfluency in speech can also shed light on word retrieval in context. Bortfeld et al. (2001) measured the rates of repeated elements, restarts, and fillers. When calculating the mean of all three measures together, older adults were significantly less fluent than were middle-aged adults and younger speakers, although they had only one more dysfluency per 100 words than did younger speakers. Across age groups, dysfluency rates increased when speakers were faced with heavier planning demands, such as when they were asked to refer to unfamiliar versus familiar domains (i.e., tangrams versus pictures of children), as well as in longer versus shorter turns. The authors identified between-constituent and within-constituent fillers, arguing that the former type of fillers might indicate difficulties in syntactic planning, whereas the latter type of fillers might indicate word-finding difficulties. Older adults demonstrated an increase in within-constituent fillers that may reflect word search (Bortfeld et al., 2001). Similarly, Castro and James (2014) found more indications of dysfluencies in the speech of older adults who described pictures with negative content (but not in descriptions of pictures with neutral content), and Horton et al. (2010) reported an increase in the use of fillers with age. Dennis and Hess (2016) reported that older adults produced more non-word fillers but made no more pauses than did younger adults, while Cooper (1990) and Schmitter-Edgecombe et al. (2000) found no significant age-related differences in either fillers or pauses. It is possible that studies that failed to find clear age differences in dysfluency elicited speech through an easier task (i.e., neutral picture description), yet these findings suggest that the lack of fluency is not necessarily a hallmark of the speech produced by older adults.

Le Dorze and Bédard (1998) counted comments that clearly indicated that participants were searching for words or evidence that participants were uncertain as to their choice of words (e.g., “Let’s see, now, how do you say that?”). They showed that the occurrence of these comments increased with age. Similarly, Heller and Dobbs (1993) measured hedges that indicated one’s uncertainty (e.g., “I guess it is a sunken ship”) and found that they were more common among older individuals. In contrast, Dennis and Hess (2016) found no age differences in the use of such modifying language (e.g., “There’s what looks like a...”). Note that the uncertainty in these self-hedges could reflect a general lack of confidence rather than search for words. Yet, Heller and Dobbs (1993) also tallied comments on visual misidentification (e.g., “don’t know what it is”), and reported no association with age. As these studies suggest, older adults experience some failures of word retrieval in context, but these difficulties are rather minor and do not emerge for all elicitation modes or for all variables. Even when age differences do emerge, they are not consistent nor do they necessarily occur across the same measures in different studies.

In addition to reduced productivity and diversity, as well as increased indications of retrieval failure, we expected to find an association between scores on tasks of single-word production and measures of retrieval in connected speech. We identified six studies that looked at the association between single-word retrieval and retrieval in connected speech within the same older adults (see bottom of Table 1). Saling et al. (2012) reported that scores on a letter fluency task correlated with fluency in discourse as measured by the number of words uttered per second, but scores on a picture-naming test did not correlate with this variable or with other measures in context. Heller and Dobbs (1993) found correlations between letter and category fluency scores and indices of word retrieval on a video description task. However, the correlations were not very strong and were evident only for some fluency conditions as well as for some but not all of the connected speech variables. Le Dorze and Bédard (1998) reported that scores on a picture-naming task were associated with the number of different content units and the number of words produced per minute, but not with repetitions or comments about word retrieval difficulties. Schmitter-Edgecombe et al. (2000) administered a picture-naming task, a letter fluency task, a category fluency task, and a picture description task. They found no association between single-word test scores and variables of retrieval failure in connected speech, such as word substitution, reformulation, repetition, empty words or fillers. Kemper and Sumner (2001) used tasks of letter and category fluency, and documented no correlation between scores on these tasks and lexical diversity on the connected speech task. Finally, Kavé et al. (2009) administered both a picture naming task and a semantic fluency task, and found no correlation between performance on these tasks and any of the connected speech variables that they examined (e.g., percent of nouns relative to all words, noun type-token ratio, noun frequency). Each of these six studies used different single-word retrieval tasks and defined different variables as evidence of retrieval success or failure in connected speech. Nevertheless, taken together, these studies reveal no strong support to the idea that older adults' failure to retrieve words on structured tests of single-word production predicts similar failure in connected speech.

Word retrieval in connected speech in aphasia

In light of the findings from the aging literature, we wanted to reexamine our hypotheses concerning word retrieval in context by looking more thoroughly at research in aphasia. Virtually all people with aphasia demonstrate word retrieval difficulties, which are quite noticeable on tests of single-word production (Boyle, 2014; Davis, 2007; Martin, 2013). Research on aphasia diagnosis and rehabilitation has often targeted anomia, and studies of connected speech have repeatedly demonstrated that lexical retrieval difficulties in aphasia are not limited to production in isolation (e.g., Armstrong, 2000; Boyle, 2004, 2014). Many studies in aphasia have investigated grammatical factors that might affect word retrieval in aphasia. These studies focused primarily on word class, comparing retrieval of content words to retrieval of function words and retrieval of nouns to retrieval of verbs (e.g., Bastiaanse, Hurkmans, & Link, 2006; Crutch & Warrington, 2003; Rochon, Saffran, Berndt, and Schwartz, 2000; Vigliocco, Vinson, Druks, Barber, & Cappa, 2011). We note that difficulties with either specific word class or with sentence structure can obviously limit word production, yet a review of such difficulties is beyond the scope of the current paper.

We review the aphasia literature according to our four hypotheses. First, reduced overall productivity relative to speech of neurologically healthy participants is a hallmark of language production in non-fluent aphasia (e.g., Kertesz, 1982; Helm-Estabrooks, Albert, & Nicholas, 2014; Marini, Caltagirone, Pasqualetti, & Carlomagno, 2007). In fluent aphasia, inflated output is often observed, but many words do not contribute to the message or are difficult to interpret (Davis, Harrington, & Baynes, 2006; Marini, Andreetta, del Tin, & Carlomagno, 2011). Since language production of people with both non-fluent and fluent aphasia is characterized by multiple attempts, repetitions, and use of formulaic expressions, retrieval difficulties in connected speech are inferred not only from the total number of words in connected speech, but also from measures of appropriate production. For example, Nicholas and Brookshire (1993) defined correct information units (CIU) as all words except false starts, repetitions, or formulaic expressions. They demonstrated that connected language produced by people with aphasia of varying types and severity levels had fewer CIUs than did speech samples produced by neurologically healthy individuals. Similarly, Rochon et al. (2000) found a reduction in the proportion of narrative words (i.e., propositional speech, excluding false starts, repeated attempts, stereotyped utterances, and perseverations) in 29 people with non-fluent aphasia relative to neurologically healthy participants. Other analyses have shown lower proportions of CIU production relative to neurologically healthy controls, whether participants had non-fluent or fluent aphasia (e.g., Boyle, 2014; Gordon, 2008; Hadar et al., 1987). In addition, an increase in percent CIU out of total words has been reported following aphasia treatment (e.g., Avent, & Austermann, 2003; Ballard & Thompson, 1999; Boyle, 2004; Cameron, Wambaugh, Wright, & Nessler, 2006; Falconer & Antonucci, 2012; Wallace & Kimelman, 2013), suggesting that treatment can result in improved retrieval in connected speech. Such results point to significant impairment in overall productivity of correct words in connected speech of people with aphasia, which is documented across aphasia types, across elicitation modes, and across count measures.

Importantly, counting all words, or even all appropriate words, can provide a very general idea as to the extent to which a person retrieves the correct lexical entry. In order to assess deficits in lexical selection in context more specifically, some studies of aphasia pre-defined target words that fit the relevant context and then examined the retrieval of these target words. In such studies, the investigators either pre-determine the target words or define them according to the performance of healthy speakers. For example, Pashek and Tompkins (2002) compared video narration by 20 people with mild anomic aphasia and by 10 healthy speakers, and reported that people with aphasia produced significantly fewer pre-defined target verbs and nouns than did the healthy group. An increase in selection of pre-defined target words has also been used to document treatment-related change (e.g., Greenwood, Grassly, Hickin, & Best, 2010; Herbert, Best, Hickin, Howard, & Osborne, 2003; Rider, Wright, Marshall, & Page, 2008). In one such study, Rider et al. (2008) examined three people with non-fluent aphasia before and after a semantic feature analysis treatment. They asked participants to watch video clips and to report what happened in the clip. All three participants produced more of the pre-defined target words following treatment than prior to treatment. Although this measure of word retrieval provides greater specificity than do more

general word counts, it is effective only when tasks rely on known information, and is much less useful in personal narratives.

According to our second hypothesis, significant retrieval difficulties should limit lexical diversity in speech. Regardless of the total output or the total number of specific words they produce, most individuals with aphasia use a restricted set of words (e.g., Armstrong, 2001; Behrns, Wengelin, Broberg, & Hartelius, 2009; Crutch & Warrington, 2003; Fergadiotis & Wright, 2011; MacWhinney, Fromm, Holland, Forbes, & Wright, 2010). For example, Fergadiotis and Wright (2011) elicited connected speech from 25 people with mild to moderate anomic or conduction aphasia and from 27 neurologically healthy people, and found that people with aphasia produced a lower ratio of word types to word tokens (adjusted for narrative length, i.e., using the D measure). This finding was true across elicitation modes. A reduction in lexical diversity has been reported also when specific parts of speech (e.g., verbs, compounds) were examined (Crepaldi, Ingignoli, Verga, Contardi, Semenza, & Luzzatti, 2011; Eiesland & Lind, 2012). Furthermore, lexical diversity has been associated with aphasia severity, with greater diversity seen in milder aphasia (Gordon, 2008). Lexical diversity, as measured by either type-token ratio or the D measure, has also been used to document change in treatment studies in aphasia (e.g., Avent, & Austermann, 2003; Bastiaanse et al., 2006; Boo & Rose, 2011; del Toro, Altmann, Raymer, Leon, Blonder, & Gonzalez Rothi, 2008; Kempler & Goral, 2011; Medina et al., 2012; Raymer et al., 2007; Rider et al., 2008), though it is not always found, even when treatment is otherwise considered efficacious. As these studies suggest, when retrieval difficulties are substantial, people produce a restricted set of words, resulting in reduced lexical diversity.

Our third hypothesis concerns evidence of retrieval failure in connected speech. In general, people with aphasia tend to produce more paraphasias than do neurologically intact speakers (Andreeta et al., 2012; Jaecks Hielscher-Fastabend, & Stenneken, 2012; Meuse & Marquardt, 1985; Pashek & Tompkins, 2002; Shewan, 1988a). For example, Shewan (1988a) reported significant differences between a group of 47 people with varying types of aphasia and two groups of healthy participants (10 older adults and 20 younger adults) in the proportion of phonological and semantic paraphasias as well as neologisms out of all words. Andreeta et al. (2012) compared narrative production of 10 people with anomia and 10 neurologically healthy speakers. They found that the two groups did not differ in the number of phonological errors but that people with aphasia produced more semantic paraphasias than did healthy controls. Jaecks et al. (2012) reported that people with mild residual aphasia produced more semantic paraphasias, as well as other word finding difficulties (e.g., pauses, interjections) than did participants with no aphasia. Indeed, the reduction in occurrence of such errors may provide evidence for treatment success (Antonucci, 2009; Boyle, 2004; Peach & Reuter, 2010; Shewan, 1988b). In order to identify a paraphasia, as opposed to neologism for example, the investigator should figure out the intended word. This is not always possible. Pashek and Tompkins (2002) suggested that retrieval errors include not only paraphasias but also circumlocutions. However, while circumlocutions may indicate word-retrieval failure, they may also reflect a successful strategy to circumvent the lack of access to a specific word. These studies of word errors in connected speech of people with aphasia provide direct indication of word retrieval difficulty in context.

A more indirect measure of retrieval failure reported in aphasia is a count of pauses, especially lengthy ones (Falconer & Antonucci, 2012; Hadar et al., 1987; Pashek & Tompkins, 2002). Studying 20 people with non-fluent aphasia and 10 neurologically intact speakers, Pashek and Tompkins (2002) found that people with aphasia had more frequent and longer pauses than did the control group. We note that pauses could also reflect difficulty with sentence structure or hesitation at a conceptual level and thus might not be a unique measure of lexical retrieval.

As for our fourth hypothesis, similar to studies with older adults, relatively few studies have compared retrieval performance in isolation and in context within the same individuals with aphasia. Some of these studies found significant associations between scores on tasks of single-word retrieval and measures of retrieval in context (e.g., Fergadiotis & Wright, 2016; Herbert, Hickin, Howard, Osborne, & Best, 2008; Hickin, Best, Herbert, Howard, & Osborne, 2001; Pashek & Tompkins, 2002; Williams & Canter, 1982). For instance, Williams and Canter (1982) compared production of the same nouns in isolation and in context in 40 people with varying types of aphasia. They used line drawings of 40 nouns for their confrontation-naming task and elicited connected speech with a set of composite pictures that included the same objects. A significant positive correlation ($r = .8$) emerged between scores on the two tasks. Studying a conversational task in 10 people with aphasia, Herbert et al. (2008) reported a significant correlation between accuracy on a confrontation-naming test and the proportion of nouns and content words within substantive turns. Pashek and Tompkins (2002) pre-identified target nouns and verbs in video stories and examined whether participants with aphasia produced these target words. Scores on a standard naming task predicted retrieval of nouns in the narrative task, accounting for 60% of the variance in retrieval in context. Furthermore, Fergadiotis and Wright (2016) found that scores on picture naming tasks predicted the percent of paraphasias in discourse as well as the proportion of correct information units in 98 people with various types of aphasia. As these studies suggest, when individuals have significant word retrieval impairment, difficulties occur across tasks.

Nevertheless, the aphasia literature also presents evidence for dissociation between retrieval in isolation and retrieval in context. A number of studies have found that people with aphasia failed to retrieve words in isolation but were more successful in context (Mayer & Murray, 2003; Pashek & Tompkins, 2002; Zingeser & Berndt, 1990). For example, participants with mild aphasia who were impaired on picture naming fell within the normal range in terms of the number of verbs that they retrieved in connected speech (Crutch & Warrington, 2003; Berndt & Haendiges, 2000; Hadar et al., 1987). Moreover, Ingles, Mate-Kole, and Connolly (1996) studied a woman with acquired fluent aphasia who had severe naming difficulties when tested on a confrontation-naming task, as reflected in her inability to name any items and her frequent use of circumlocutions. However, an analysis of her connected speech showed that she did not differ from a matched control participant in the number of total words or in the proportion of specific parts of speech (e.g., nouns, verbs, adjectives, overall open and closed class words) relative to the total number of words. In contrast, in three other single-case studies of aphasia, better retrieval performance was noted in confrontation naming than in connected speech (Manning & Warrington, 1996 for anomia aphasia; Schwartz & Hodgson, 2002 and Wilshire & McCarthy, 2002 for non-fluent aphasia). This

double dissociation further highlights the fact that single-word retrieval tasks and word production in connected speech place different demands on the speaker.

Thus, findings concerning the relationship between performance on tasks of word-retrieval in isolation and in context are mixed. Some studies of people with aphasia demonstrated high correlations between retrieval abilities across tasks, whereas other studies reported differential results for single words and for connected speech. These findings underscore the need to define the ways in which context affects lexical retrieval.

Discussion

We reviewed studies of lexical retrieval in connected speech in healthy older adults and in people with aphasia. Four main hypotheses guided our review: (1) Significant retrieval difficulties would lead to reduced output in connected speech; (2) Significant retrieval difficulties would lead to decreased lexical diversity in connected speech; (3) Significant retrieval difficulties would lead to an increase in word substitution errors and in pronoun use, as well as to greater dysfluency and hesitation in context; and (4) Retrieval difficulties on tests of single-word production would be associated with measures of word retrieval in context. We summarize the support that these hypotheses received (see Table 1) and list the advantages and disadvantages of the measures on which they are based (see Table 2).

With regard to the first hypothesis, our review suggests that word output does not decrease in old age, whereas aphasia leads to a significant reduction in the total number of words that individuals produce in context. Total word output is easy to measure and can attest to general speech fluency. It is undoubtedly a gross measure of lexical retrieval, which might be more suitable to the pronounced word finding impairment that characterizes aphasia and less appropriate for the more subtle changes in retrieval that are associated with healthy aging. Nevertheless, if older adults suffer from substantial lexical impairment, due to persistent transmission deficits, then difficulties should occur in context as well. Instead, older adults appear to produce more words rather than fewer words relative to younger adults. This increase may reflect inhibitory deficits or a pragmatic change of goals that shifts conversational focus toward more personal narratives (Burke & Shafto, 2008). According to Mortensen et al. (2006), older adults might produce more words to mask difficulties in conceptual planning. However, speech with much off-topic information appears to be no less effective than is speech with less excessive material (Arbuckle et al., 2000). In addition, listeners often rate talkativeness as more interesting (James et al., 1998; Trunk & Abrams, 2009). Thus, it is yet unclear whether off-topic speech results from inhibitory deficits or from changes in communication priorities, but retrieval difficulties do not preclude this excessive speech.

An investigation of our second hypothesis shows that older adults produce increased rather than decreased lexical diversity relative to younger adults, while aphasia leads to a consistent restriction of word choice. Healthy older adults have more words at their disposal (Bowles & Salthouse, 2008; Kavé & Yafé, 2014; Verhaeghen, 2003), and they seem to be able to rely on their large vocabulary when producing connected speech. Indeed, aging may weaken connections between a word's semantic representation and its phonological representation (Burke & Shafto, 2004), but it does not damage these representations, as may happen in

some aphasia types. Hence, while brain damage might impair representations in addition to access (James & MacKay, 2001), healthy aging appears to affect access alone. Note that according to Dennis and Hess (2016), production of atypical words is associated with greater interruption in speech, but at the same time, these unique words are accurate and reflect older adults' need for precision. It is thus unclear whether retrieval of unique words may indicate that the speaker encounters difficulty in producing typical words, or that the need for precision causes retrieval difficulty. Future research should shed more light on the processes that allow older adults to retrieve a greater variety of words in connected speech. We point out that even if less typical vocabulary causes temporary interruption in speech, older adults seem to overcome these interruptions, unlike people with aphasia.

The third assumption that guided our review was that retrieval difficulties would lead to an increase in word substitution errors and in pronoun use, as well as to greater dysfluency and hesitation in context. In contrast to measures of word number or lexical diversity, which offer only indirect indication of ease of retrieval, retrieval failures provide direct evidence of difficulty. Studies of healthy aging were much less consistent than were studies in aphasia, with the latter generally supporting our assumption, showing that the majority of people with aphasia demonstrate some failures of word retrieval in context. There have been some indications of word retrieval difficulties in connected speech produced by older adults, but a substantial increase in errors in word choice as well as considerable reliance on pronouns are quite uncommon. Some studies have shown greater dysfluency in the speech of older relative to younger adults, although significant age-related differences did not emerge for all elicitation modes. While it is admittedly harder to determine whether an error occurs in context than in isolation, since more words may be appropriate in context than on tasks of single-word retrieval, errors seem to be rather scarce in the speech of healthy older adults and much more prevalent in aphasia. These findings further suggest that older adults compensate for their retrieval difficulties when producing connected speech.

The fourth hypothesis concerned the relationship between word retrieval difficulty in isolation and in context. Our review reveals that relatively few studies have attempted to examine this relationship in both the aging and the aphasia literatures. Findings from aphasia highlight the association between the two abilities more so than do findings from studies of healthy aging. However, even if such an association exists, it is far from perfect, suggesting that different factors may affect retrieval in and out of context. Moreover, striking aphasia cases of a clear dissociation between the two abilities confirm that different variables affect word production in isolation and in context. Thus, although both traditional assessments and research on word-finding difficulties in picture naming and word generation tasks aim to predict the use of language in everyday communication, our review shows that we do not yet fully understand the connection between these two abilities. Given the tenuous relationship between decontextualized and contextualized naming, the assessment of word retrieval should focus more closely on the effect of context on word retrieval.

Connected speech undoubtedly involves many cognitive systems, and lexical retrieval in context is thus affected not only by the mechanisms that affect single-word retrieval (e.g., semantics, phonology) but also by communication goals, syntax, the location of a word within a sentence, speed, timing, working memory, or advanced planning (Griffin & Spieler,

2006). Studies of memory changes in old age suggest that age-related reduction in processing resources results in a failure to carry out self-initiated mental operations, but that when context induces or supports these operations, the effects of age are much less noticeable (Craik & Rose, 2011). Retrieval of single words imposes a search of a specific item, involving initiation of mental operations that may receive no support from the environment. Such retrieval is indeed more difficult for older adults. In contrast, when producing words in context, speakers may rely on sentence grammar or on the semantics of related words. As grammar and semantics remain mostly intact in old age (e.g., Burke & Shafto, 2008; Waters & Caplan, 2005), they can help word retrieval in context.

To conclude, the current review shows that there is little evidence for significant word retrieval deficits in connected speech production in healthy aging. Further research is required in order to examine the association between increased word number and retrieval, as well as the possibility that older speakers' need for precision leads to retrieval difficulties in context. It is especially important to investigate the ways in which context facilitates word production in old age, thus allowing older adults to speak more fluently than is expected by their single-word production difficulties. It is possible that aging impairs performance on tests of single-word production rather than the production process itself. Indeed, according to the Transmission Deficit Hypothesis (Burke et al., 1991; Burke & Shafto, 2004; MacKay & Burke, 1990), recent word use might ameliorate retrieval failures in old age. Context might involve such recent uses, thus priming the to-be-retrieved word. Nevertheless, we believe that instead of trying to identify those minor (or possibly inexistent) lexical deficits that may characterize connected speech of older adults, future research should further define the ways in which context helps older adults avoid the difficulties that they encounter on tasks of single-word production. This review might shift researchers' focus from looking for evidence of age-related impaired retrieval in connected speech to looking for evidence of compensation strategies.

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Figure 1:
Schematic presentation of four hypotheses.

Table 1.

Summary of aging studies of word retrieval in connected speech, by hypothesis

Hypothesis	Variable	Studies that support hypothesis	Studies that do not support hypothesis
<u>Hypothesis 1:</u> Retrieval difficulty decreases productivity	Word number	Heller & Dobbs (1993)	Capilouto et al. (2016) ^a
		Kemper & Sumner (2001)	Castro & James (2014) ^a
			Cooper (1990) ^a
			Kavé et al. (2009) ^a
			Shewan & Henderson (1988) ^a
			Arbuckle et al. (2000) ^b
			Arbuckle & Gold (1993) ^b
			Bortfeld et al. (2001) ^b
			Dennis and Hess (2016) ^b
			Horton et al. (2010) ^b
			James et al. (1998) ^b
			Juncos-Rabadan et al. (2005) ^b
			Saling et al. (2012) ^b
Trunk & Abrams (2009) ^b			
<u>Hypothesis 2:</u> Retrieval difficulty decreases lexical diversity	Type-token ratio or D measure	Capilouto et al. (2016) ^c	Capilouto et al. (2016) ^c
			Fergadiotis et al. (2011)
	Word frequency or word normativeness		Kemper & Sumner (2001)
			Dennis & Hess (2016)
			Horton et al. (2010)
			Kavé et al. (2009)
<u>Hypothesis 3:</u> Retrieval difficulty increases errors in speech ^d	Substitutions or erroneous word selection	Heller & Dobbs (1993)	Schmitter-Edgecombe et al. (2000)
			Shewan & Henderson (1988)
	Circumlocutions, digressions or interjections		
			Mackenzie (2000)
			Schmitter-Edgecombe et al. (2000)
	Self-corrections, restarts, or word reformulations	Schmitter-Edgecombe et al. (2000)	Cooper (1990)
			Dennis and Hess (2016)
	Overuse of pronouns, or unclear reference	Heller & Dobbs (1993)	Castro & James (2014)
			Juncos-Rabadan et al. (2005)
		Mackenzie (2000)	Le Dorze & Bédard (1998)
		Ulatowska et al. (1986)	
	Overuse of indefinite terms		Cooper (1990)

Hypothesis	Variable	Studies that support hypothesis	Studies that do not support hypothesis
Hypothesis 4: Retrieval difficulty is seen across tasks	Pauses or fillers		Le Dorze & Bédard (1998)
			Schmitter-Edgecombe et al. (2000)
		Bortfeld et al. (2001)	Cooper (1990)
		Dennis & Hess (2016)	Dennis & Hess (2016)
		Horton et al. (2010)	Schmitter-Edgecombe et al. (2000)
	Comments on word retrieval	Heller & Dobbs (1993)	Dennis and Hess (2016)
		Le Dorze & Bédard (1998)	
		Heller & Dobbs (1993) ^e	Kavé et al. (2009)
	Verbal fluency or picture naming	Le Dorze & Bédard (1998) ^e	Kemper & Sumner (2001)
		Saling et al. (2012) ^e	Schmitter-Edgecombe et al. (2000)

Notes:

^aStudies in which there was no significant age-related difference in word output;

^bStudies in which older adults produced more words than did younger adults;

^cCapilouto et al. (2016) found age differences in type-token ratio (using the D measure) for single pictures but not for sequential pictures;

^dWe note that classification of errors in the original studies did not always fit our classification: Bortfeld et al. (2001) measured repetitions and restarts but they did not report age effects separately for each of these measures. Castro and James (2014) used a composite measure of dysfluency that included change of sentence topic, stuttering, and repetition, among other things. Cooper (1990) found a marginal effect of age on the use of indefinite wording and pause duration, which did not reach significance. Dennis and Hess (2016) reported that older adults used more non-word fillers but made no more pauses than did younger adults. Heller and Dobbs (1993) did not find an increase in use of pronouns with age but noted an increase in pronoun-to-noun ratio. Schmitter-Edgecombe et al. (2000) found a marginal effect of age on the percent of utterances that contained word substitutions, which did not reach significance.

^eHeller and Dobbs (1993), Le Dorze and Bédard (1998), and Saling et al. (2012) found associations between scores on single-word tasks and some connected speech variables, but also reported that other correlations between scores on single-word tasks and connected speech variables did not reach significance.

Table 2.

Advantages and disadvantages of measures of word retrieval in connected speech

Measures	Advantages	Disadvantages
Productivity	Easy to measure, reflects general fluency	Less appropriate for measuring subtle difficulties in retrieval
Lexical diversity	Reveals vocabulary knowledge and speakers' need for precision	Unclear whether unique words reflect retrieval failure or success
Retrieval failure	Provides direct evidence of retrieval difficulty	Difficult to identify word choice errors in context
Cross-task associations	Scores on traditional assessment may predict everyday language	Unclear whether underlying cognitive processes differ across tasks