

An Age-Related Deficit in Resolving Interference: Evidence From Speech Perception

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The presence of noise and interfering information can pose major difficulties during speech perception, particularly for older adults. Analogously, interference from similar representations during retrieval is a major cause of age-related memory failures. To demonstrate a suppression mechanism that underlies such speech and memory difficulties, we tested the hypothesis that interference between targets and competitors is resolved by suppressing competitors, thereby rendering them less intelligible in noise. In a series of experiments using a paradigm adapted from Healey, Hasher, and Campbell (2013) we presented a list of words that included target/competitor pairs of orthographically similar words (e.g., ALLERGY and ANALOGY).

both members of the target/competitor pair, but could only be completed by the target. We then assessed the consequence of having successfully resolved this interference by asking participants to identify words in noise, some of which included the rejected competitor words from the previous phase. Consistent with a suppression account of interference resolution, younger adults reliably demonstrated reduced identification accuracy for competitors, indicating that they had effectively rejected, and therefore suppressed, competitors. In contrast, older adults showed a relative increase in accuracy for competitors relative to young adults. Such results suggest that older adults' reduced ability to suppress these representations resulted in sustained access to lexical traces, subsequently increasing perceptual identification of such items. We discuss these findings within the framework of inhibitory control theory in cognitive aging and its implications for age-related changes in speech perception.

Keywords: suppression, aging, interference, speech perception

A frequent complaint among older adults is that they often struggle to understand what is being said to them by a conversation partner if there are one or multiple voices talking in the background. More generally, background noise, whether in the form of environmental ambient noise, background speech, or directly competing speakers, is a major source of disruption to speech perception, and this is particularly true for older adults (Duquesnoy, 1983; Gordon-Salant, Frisina, Popper, & Fay, 2010; Pichora-Fuller, Schneider, & Daneman, 1995; Schneider, Daneman, & Pichora-Fuller, 2002; Tun & Wingfield, 1999). Thus, understanding how older adults deal with interference in complex listening situations is a matter of considerable practical importance.

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Although extracting a meaningful signal from background noise has largely been considered a sensory process, a case can be made that there is an additional significant cognitive component as well. In addition to age-related hearing loss, there is also evidence to suggest that reduced efficiency in attentional control may cause older listeners to be more susceptible to interference from noise and background distraction. For example, tests of recall for target speech when presented with a background competing speaker show that relative to young listeners older adults are disproportionately impaired by meaningful distractors compared with non-meaningful distractors (Tun, O'Kane, & Wingfield, 2002). For instance, Tun and Wingfield (1999) tested word identification and recall in young and older adults, comparing the effects across various types of background noise. When the background noise was white noise, older and younger adults exhibited similar declines in recalling words as the signal-to-noise level was reduced (i.e., as the level of the noise was increased). However, when the interfering background was a single talker, a very different pattern emerged in which young adults showed nearly identical performance for the more and less favorable signal-to-noises (SNRs), whereas older listeners were significantly poorer in the less favorable SNR. Tun and Wingfield suggested that older adults show additional declines when a single-talker is used as a masker because they have a reduced ability, relative to young adults, to

suppress the linguistic content of the background masker. That is, general increases in noise levels did not consistently magnify age differences. Instead, particular age-related increases in susceptibility to interference in speech suggest that impaired attentional control may contribute to listening difficulties experienced by older adults, and this issue has been the subject of much investigation in recent years (e.g., Akeroyd, 2008; Helfer & Freyman, 2008; Paulmann, Pell, & Kotz, 2008; Thompson & Malloy, 2004; Tun, McCoy, & Wingfield, 2009; Wild et al., 2012).

Such changes in attentional control have been theorized to be a function of age-related reductions in inhibitory function (Hasher & Zacks, 1988), in which older adults are more likely than younger adults to be susceptible to intrusions from nonrelevant task representations, thereby disrupting the processing of goal-relevant information (e.g., Hasher & Zacks, 1988; Hasher, Zacks, & May, 1999; Zacks & Hasher, 1994). Indeed, a significant body of work in the cognitive aging literature has highlighted failures in inhibitory control, chiefly in the domain of memory (Balota, Dolan, & Duchek, 2000; Best, Hamlett, & Davis, 1992; Craik, 1994; Grady & Craik, 2000; Light, 1991), such that related but irrelevant memory traces directly interfere with retrieval of target traces. Thus, interference results when the retrieval of a particular target memory simultaneously activates several, often similar, representations. For example, demonstrations of the fan effect (Anderson, 1974) show that a greater number of facts, that is, a larger fan, associated with a target probe results in greater interference during a retrieval attempt, and that older adults are disproportionately impaired by larger fans (Gerard, Zacks, Hasher, & Radvansky, 1991). Indeed, postretrieval deficits have been exhibited in a number of paradigms, such as category-stem completion (Baxton & Neely, 1983) and the retrieval-induced forgetting paradigm (M. C. Anderson, Bjork, & Bjork, 1994; M. C. Anderson & Spellman, 1995), in which multiple representations of similar traces or responses directly interfere with and hinder correct retrieval. Accordingly, it becomes necessary to resolve this interference between competing representations to differentiate the target from its competitors for correct retrieval. Thus, successful resolution is effectively characterized by correct target retrieval amid competitors (Healey, Campbell, Hasher, & Osher, 2010; Healey, Hasher, & Campbell, 2013). For instance, Mecklinger, Weber, Gunter, and Engle (2003) showed that creating conditions of proactive interference slowed response times and decreased accuracy to probes that had been previously irrelevant on the preceding trial but relevant to the current trial, thus reflecting the persistent activation of previous events and consequently, the extended time needed to resolve interference between competing representations.

The question, remains as to what mechanisms mediate interference resolution. Advocates of the suppression mechanism (M. C. Anderson & Spellman, 1995; Bjork, 1989; Hasher, Lustig, & Zacks, 2007; Hasher et al., 1999; Zanto & Gazzaley, 2009) have posited that actively rejecting and subsequently inhibiting a competitor reduces its subsequent accessibility (Anderson & Spellman, 1995; Aslan & Bäuml, 2011; Healey et al., 2010; Norman, Newman, & Detre, 2007; Storm, 2011), thereby facilitating target retrieval. This account is consistent with a wealth of research implicating age-related impairments in inhibitory ability and its negative effects on resolving interference (e.g., Campbell, Hasher, & Thomas, 2010; Hulicka, 1967; Ikier & Hasher, 2006; Kane &

Engle, 2002; Logan & Balota, 2003; Radvansky, Zacks, & Hasher, 2005; Winocur & Moscovitch, 1983). In contrast, a facilitation account proposes that interference resolution entails directly enhancing the accessibility of target information (e.g., R. Anderson et al., 2004; J. R. Anderson & Reder, 1999). While these accounts are not necessarily mutually exclusive and continue to be debated (e.g., MacLeod, Dodd, Sheard, Wilson, & Bibi, 2003), recent work (Healey et al., 2010, 2013) provides some of the strongest evidence to date that it is suppression that is responsible for resolving interference between competing memory traces.

A signature of inhibition according to a suppression account, in contrast to facilitation, would be observed by measuring the consequences of interference resolution for the rejected competitor word, rather than the target word. Using an adapted procedure from Healey et al. (2010); Ikier, Yang, and Hasher (2008) presented participants with three experimental phases. In the first phase, participants were visually presented with both members of orthographically similar word pairs (e.g., ALLERGY/ANALOGY) embedded within a longer word list during an incidental encoding task. In a second phase, participants were presented with word fragments for completion in an implicit memory task. Critically, some of these fragments, for example, A_L_ _GY, could only be correctly completed by one of the words in the critical pair, i.e. the target ALLERGY, and not its competitor ANALOGY. Thus, the fragment was intended to elicit both the target and competitor representations, and successful resolution of this interference would require active suppression and, consequently, reduced accessibility of the competitor, to correctly solve the fragment. This hypothesis was tested in a final third phase, in which participants were required to name words presented on the screen as quickly as possible. Among these words were the rejected competitor items from the second phase, thus allowing the experimenters to assess the levels of accessibility of competitors relative to new control words via naming latencies (where slower naming latencies = reduced accessibility). Consistent with a suppression account, younger adults were indeed slower to name the competitors in comparison to control conditions in which no interference was present, indicating successful interference resolution via competitor rejection. Older adults, in contrast, actually demonstrated faster naming times for the competitors compared with control conditions (Healey et al., 2013). The results indicated that not only does active suppression reduce accessibility of competitors, but that older adults fail to suppress and, in fact, retain accessibility to incompletely suppressed items. These findings are consistent with an inhibitory account of both interference resolution as well as age-related impairments in memory retrieval (e.g., Hasher & Zacks, 1988; Ikier & Hasher, 2006; Ikier et al., 2008; Radvansky et al., 2005), in addition to providing direct evidence for the role of suppression.

The consequences of lexical similarity and the need for subsequent inhibitory control is also common to many aspects of spoken-word recognition (Wey & Sommers, 2015; Sommers & Danielson, 1999; Taler, Aaron, Steinmetz, & Pisoni, 2010). This work has demonstrated that older adults' reduced inhibitory function impairs correct identification of speech in the face of interfering elements. One influential model of spoken word identification is the Neighborhood Activation Model (NAM; Luce & Pisoni, 1998), which describes the process of lexical discrimination and access of phonological representations in the mental lexicon (Luce & Pisoni, 1998). It proposes that words in the lexicon are organized into similarity neighborhoods based on phonological overlap

between target and neighboring words. According to the model, the process of accessing a single target proceeds within an activation-competition framework, in which recognition of a target occurs by relative heightened activation of the target, and relative inhibition of phonetically similar competitor words within the neighborhood. Specifically, target words with relatively few neighbors (i.e., low density, LD), are more intelligible than words with a greater number of neighbors (i.e., high density, HD) (Goldinger, Luce, & Pisoni, 1989; Luce & Pisoni, 1998; Sommers, 1996). This is in part because of the fact that with a greater number of competitor words comes an accompanying increase in the need to suppress such competitors; thus, requiring a greater degree of suppression of said competitors (Sommers and Danielson (1999) found direct evidence for this hypothesis; under conditions that produced approximately equivalent identification performance for LD targets across age groups, older adults exhibited significantly poorer recognition than young adults for HD words. Moreover, performance for HD, but not LD, words was further found to be negatively correlated with tasks of cognitive inhibition, suggesting that correct lexical selection and recognition in speech is related to successful inhibition of task-irrelevant information (Dey & Sommers, 2015). Such findings are strikingly analogous with the interference paradigms from memory research (e.g., M. C. Anderson et al., 1994; Blaxton & Neely, 1983; Ikier & Hasher, 2006; Ikier et al., 2008; Radvansky, Zacks, & Hasher, 2005), reflecting competition between lexical representations during retrieval. Thus, the NAM provides the ideal framework to investigate the generality of competition and suppression across domains and, thus, motivates the current experiments.

As reviewed above, the role of inhibition in speech has for the most part, been demonstrated only indirectly by demonstrating the accessibility of targets via speech recognition. The distinguishing feature of a suppression account, however, is that it acts not on targets but on competitors. Therefore, we would expect a comparable finding in resolving interference during speech perception as was observed in the memory experiments by Healey and colleagues (2010, 2013): reduced accessibility, hence intelligibility, of competing traces following interference resolution. Here we adopted a variant of the Healey et al. (2010, 2013) procedure to assess the consequences of interference between targets and competitors for both young and old adults in the speech domain. If active suppression of competitors is critical to interference resolution, this should also be apparent when presented in the speech domain, characterized by reduced perception of competitor items compared with new items. Moreover, if suppression is the mechanism by which interference resolution takes place, then older adults' deficits in this regard should manifest as relatively enhanced perception of competitors because of incomplete rejection of competitors during interference resolution, as compared with control conditions. That is, incomplete competitor suppression would result in retained accessibility to a degree that facilitates future perceptual identification of such items.

In Experiment 1, we set out to determine whether interference resolution mechanisms in the visual memory domain also extend to the speech domain by testing a group of older adults in the paradigm developed by Healey et al. (2010, 2013). In Experiments 2 and 3, we directly investigated age differences and modified experimental conditions to further examine the mechanisms of interference resolution.

Experiment 1

Method

The participants in Experiment 1 consisted of 44 older adults recruited from the Washington University in St. Louis Older Adult Subject Pool. All participants were native speakers of English, scored within clinically normal ranges on the Mini-Mental Status Examination (MMSE; Folstein, Folstein, & McHugh, 1975) and the vocabulary subtest of the WAIS-R (Wechsler, 1981). Pure-tone thresholds were assessed using standard audiometric procedures for frequencies of 500, 1,000, and 2,000 Hz. All participants had thresholds within the clinically normal range of ≤ 20 dB HL.

Demographic data for all three experiments is presented in Table 1. The methodological protocol used in these studies was approved by Washington University's Institutional Review Board and participants were treated in accordance with the ethical standards of the American Psychological Association (1992).

Procedure

Similar to Healey et al. (2010), the paradigm consisted of three phases. A schematic of the procedural design is shown in Figure 1. This was a between-subjects design, in which separate groups of participants in the Interference ($n = 12$), No-Resolution ($n = 12$), and No-Conflict ($n = 11$) conditions completed all three phases of the experiment, whereas a fourth group of participants in the Baseline ($n = 9$) only completed Phase 3.

The stimuli were recorded by a male native English speaker with a Midwestern dialect using a sampling rate of 44.1 kHz and a 16-bit A/D converter. They were presented in a background noise of 6-talker babble at a SNR of 0 dB, such that the signal and noise were equally intense at a level of 70 dB SPL.

Phase 1: Vowel-counting (encoding). The purpose of Phase 1 was to create the potential for interference by embedding pairs of orthographically similar words in a longer word list as part of a vowel-counting task.

Stimuli were identical to those used by Healey et al. (2010), adapted from a set of materials from Smith and Tindell (1997) initially developed to demonstrate blocking effects and repetition priming (see Appendix). These stimuli consisted of a list of words containing orthographically similar target-competitor pairs, which were roughly equated for length, letter onset, and shared letters (see Smith & Tindell, 1997, for more a more detailed description of the stimuli). Participants were presented with a list of 56 words, and were instructed to report aloud the number of vowels in each word. The words were presented orthographically on a computer screen as well as simultaneously through headphones. This was done to ensure that participants had the opportunity to encode the stimulus in both visual and auditory modalities to prevent any

¹ Although the NAM proposes activation of all lexical representations during spoken word recognition, for computational purposes neighbors are defined as all words that can be created from a target by adding, deleting, or substituting a single phoneme.

² In Healey et al. (2010), two different word lists were used and counterbalanced across participants. Only one of those lists was used in the current study as the primary target-competitor list, but as certain words were randomly selected from the nonpresented list, both types are listed in the Appendix.

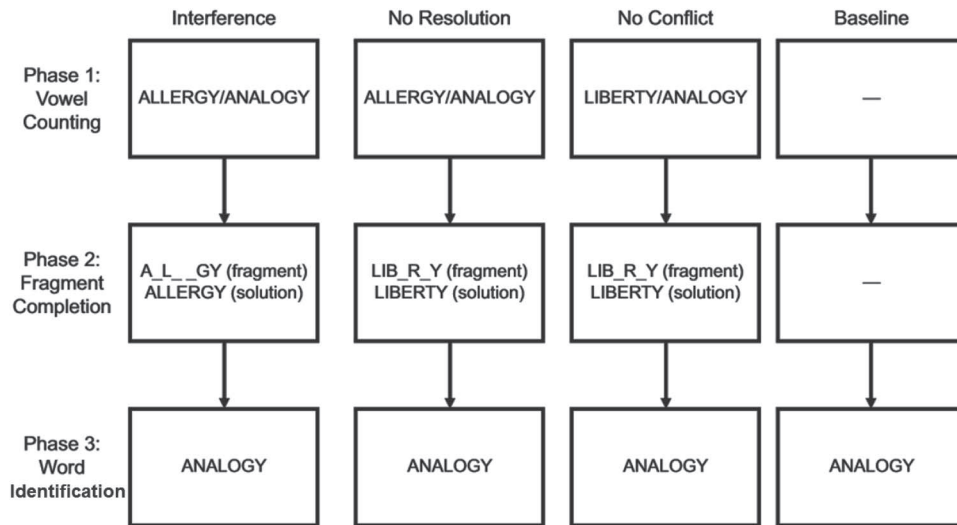


Figure 1. Comparison of the sequence of events in the four conditions (Interference, No-Resolution, No-Conflict, and Baseline). The top row shows examples of the target-competitor pairs presented in Phase 1. The middle row shows examples of the critical word fragments to be solved in Phase 2, along with their corresponding solutions. The bottom row shows examples of the competitor words to be identified in Phase 3. With the exception of the baseline condition, all participants saw the competitor word (e.g., ANALOGY) in Phase 1. Nb. While this schematic only depicts the competitor-target pairs across conditions, the lists of words in each phase and condition also included filler/new items. From "Direct Evidence for the Role of Inhibition in Resolving Interference in Memory," by M. K. Healey, K. L. Campbell, L. Hasher, and L. Osher, 2010, *Psychological Science*, 21, p. 1465. Copyright 2010 by SAGE Publications. Adapted with permission.

Data Analyses and Results

Accuracy in the Phase 1 vowel-counting task was highly accurate (above 95%) and did not differ across the three experimental conditions excluding Baseline ($F(2, 32) = .01, p = .98, \eta_p^2 = .001$). In keeping with the Healey et al. (2010, 2013) studies, we also asked participants in all but the Baseline condition if they noticed any connection between any of the phases after the experiment ("Did you notice any connection between the tasks?"). Eight participants reported some awareness of connections between the words presented in the different phases of study. We subsequently analyzed the data both including and excluding these participants, and, consistent with the findings from Healey et al. (2013), found no significant difference in performance either in Phase 2 or 3. Therefore, we report the results including all participants, regardless of awareness, stressing that including aware individuals did not change the outcome of any significance test reported below.

Manipulation check. To establish that the older participants indeed experienced interference, we examined whether completion rates of the critical fragments in Phase 2 differed across the three experimental conditions (Table 2, first two rows). If interference occurred, then participants in the Interference condition should be less successful at correctly completing these fragments, compared with those in the No-Conflict condition in which conflict was not present during Phase 1. Test analyses revealed that participants' completion rates for critical fragments were indeed significantly lower in the Interference condition than in the No-Conflict condition, $t(21) = 4.68, p < .001, \text{Cohen's } d = 1.62$, suggesting increased interference from the conflicting item in the word pair. Completion rates in the Interference condition were also signifi-

cantly lower than the No-Resolution condition ($t(22) = 3.81, p = .015, \text{Cohen's } d = 0.78$; but the No-Resolution and No-Conflict conditions did not significantly differ, $t(21) = 1.85, p = .16, \text{Cohen's } d = 0.21$).

To ensure that the difference in completion rates across conditions was not merely because of inherent group differences, we reanalyzed completion rates to include filler fragments as a factor in a two-way analysis of variance (ANOVA). We obtained a significant Fragment Type (critical vs. filler) \times Condition interaction, $F(2, 32) = 7.43, p = .002, \eta_p^2 = .32$. Pairwise t test comparisons using with Bonferroni corrections revealed that while there were expectedly no differences in correctly completed filler fragments between conditions (p values = 1.00), the difference in critical versus filler fragments was disproportionately largest in the Interference condition ($p < .001$); although this difference was also significant for the other two conditions (p values $< .014$). Because of microphone problems, we were not able to directly record participants' responses.

Table 3 depicts identification accuracy for competitor and new words in Phase 3 across the four conditions. Note that for participants in the Interference condition, we included in our analyses only those competitors for which the participant had correctly solved the corresponding word fragment during Phase 2, as failure to solve the word fragment could indicate that suppression was not successful. The results of a two-way ANOVA revealed a significant interaction of Word Type (competitor vs. new) \times Condition, $F(3, 40) = 7.28, p < .001, \eta_p^2 = .35$, such that accuracy across conditions varied as a function of word type. While correct identification of new words did not significantly differ across the four

Table 2
Mean Percentage (%) of Correct Fragment Completion for Younger and Older Adults in Phase 2 of Experiments 1 and 2

Variable	Condition			
	Interference-Competitor	Interference-Target	No-Resolution	No-Conflict
Experiment 1 (older adults)				
Critical fragments (SEM)	43.6 (1.9)	—	52.1 (1.9)	57.8 (2.1)
Filler fragments (SEM)	66.2 (1.4)	—	65.6 (1.4)	65.3 (1.5)
Experiment 2				
Younger				
Critical fragments (SEM)	51.9 (3.1)	52.6 (4.3)	59.7 (3.2)	61.5 (3.3)
Filler fragments (SEM)	79.3 (2.8)	81.3 (4.0)	83.9 (3.0)	81.5 (3.0)
Older				
Critical fragments (SEM)	42.0 (3.5)	46.2 (3.5)	55.3 (3.5)	68.3 (3.4)
Filler fragments (SEM)	68.4 (3.2)	78.2 (3.2)	72.2 (3.2)	77.5 (3.1)

Note. Note that only older adults were tested in Experiment 1, and that the Interference-Target condition was only added for Experiment 2, hence no data shown for Experiment 1.

conditions, $F(3, 40) < 1.00$, $p = .99$, $\eta_p^2 = .001$; identification of competitor words did significantly differ $F(3, 40) = 3.68$, $p = .021$, $\eta_p^2 = .22$. Follow-up pairwise analyses with Bonferroni corrections showed that identification accuracy for competitor words in the Interference condition was significantly higher than in the No-Resolution condition ($p = .043$), and marginally significantly higher compared to No-Conflict and Baseline conditions ($p = .052$). There was no significant difference among the three control conditions, p values = 1.00.

In directly examining the difference between competitor and new words as a function of condition, the results showed that while new word accuracy exceeded that of competitor items in all three control conditions, F values > 4.05 , p values $< .048$, competitor accuracy was significantly superior to new word accuracy in the Interference condition only $F = 8.43$, $p = .006$. That is, competitor items appeared to be facilitated above a baseline level of identification.

Discussion

Exposure to interference from competing words during the fragment completion phase resulted in increased intelligibility for these items during identification, relative to conditions that did not present interference or conflict. That is, despite correctly solving the fragment, the interference between the target and competitor was not entirely resolved, and residual activation from the com-

petitor appeared to facilitate perceptual identification. These results are similar to those reported by [Lealey et al. \(2010, 2013\)](#) in which older adults showed shorter naming latencies for competitors, suggesting priming for such words via incomplete suppression during interference resolution. The results of Experiment 1 here demonstrate that interfering memory traces affect retrieval, such that older adults' failure to suppress competitors enhanced their intelligibility because of sustained activation levels. Such findings further support an inhibitory deficit account of cognitive aging ([Hasher & Zacks, 1988](#)), in which suppression failures have consequences for later retrieval. However, these findings in isolation are not sufficient to fully support a strict inhibition account, and we made a series of changes to address this question more thoroughly in Experiment 2.

Experiment 2

Method

We made two specific adjustments to the procedure of Experiment 2 to put the inhibitory account to a stronger test. The first change involved the inclusion of younger adult participants in addition to older adults, to directly examine age-related changes in the inhibitory mechanism. To address the issue of whether younger adults would show a different pattern of compared with older adults, we recruited and tested 73 younger adult participants in addition to 65 older adults (refer to [Table 1](#) for demographic information). Because of normal age-related hearing loss, we also sought to equate audibility between the groups by adjusting the SNR for stimuli presented in Phase 3 to 0 dB for younger adults, and 3 dB for older adults (such that the signal was 3 decibels greater in amplitude than the noise for older adults). This procedure has been used previously in our laboratory as well as in other studies (e.g., [Dey & Sommers, 2015](#); [Pichora-Fuller, 2008](#); [Pichora-Fuller et al., 1995](#); [Pichora-Fuller, Schneider, & Daneman, 2008](#); [Schneider, Daneman, & Murphy, 2005](#)) to produce roughly equivalent performance across the two age groups in a standard identification task.

The second adjustment was intended to determine what happens to the target words during the process of interference resolution.

Table 3
Experiment 1: Identification Accuracy (%) for Competitor and New Words in Phase 3

Word type	Condition			
	Interference	No-Resolution	No-Conflict	Baseline
Competitor words (SEM)	51.6 (5.4)	30.0 (5.4)	31.5 (5.4)	30.3 (5.4)
New words (SEM)	40.5 (7.2)	39.4 (7.2)	42.4 (7.5)	39.2 (8.3)

Note. Note that the competitor words are conditionalized, based on only correct critical fragment completions from Phase 2.

Assessing target accessibility is particularly important because of alternate accounts that propose a facilitatory mechanism in interference resolution (e.g., J. R. Anderson & Reder, 1999; Norman et al., 2007) as briefly discussed in the introduction, and a direct comparison of target versus competitor accessibility is a key factor in resolving the suppression versus facilitation accounts. If suppression is truly the primary mechanism responsible for interference resolution, then levels of target facilitation should not greatly differ across conditions. To address this, we eliminated the original Baseline condition that comprised only Phase 3, and replaced it with a second Interference condition that assessed not the accessibility of the competitor, but rather the accessibility of the target, forthwith referred to as the Interference-Target condition. That is, the two Interference conditions were identical with the exception that participants were presented with target words for perceptual identification in Phase 3 of the new Interference-Target condition, whereas the original interference condition presenting competitor words (Interference-Competitor) remained intact. These differences are more clearly depicted in Figure 2.

Thus, the four conditions in Experiment 2 were: Interference-Competitor (young: $n = 19$; old: $n = 17$); Interference-Target (young: $n = 19$; old: $n = 16$); No-Resolution (young: $n = 18$; old: $n = 16$); and No-Conflict (young: $n = 17$; old: $n = 16$). All stimuli and experimental procedures remained identical to Experiment 1. An awareness assessment revealed that nine younger adults and seven older adults indicated some awareness of the connection between the phases. As in Experiment 1, removing these individuals from analyses did not significantly alter the pattern of results, and so the following results are reported for all participants.

Results

Because of computer error, Phase 1 data were missing from two older adult participants and seven younger participants, resulting in 66 young and 63 older adults for this set of analyses only. Perfor-

mance on the vowel-counting task in Phase 1 exceeded 95% for all groups and conditions, and did not differ as a function of age group or condition, $F(1, 121) = .37, p = .77, \eta_p^2 = .009$.

Table 2 shows critical and filler fragment completion rates in Phase 2 for young and older adults across the four conditions. In addition to an overall main effect of Fragment Type, in which participants solved significantly fewer critical fragments compared with filler fragments, $F(1, 130) = 440.14, p < .001, \eta_p^2 = .79$, there was also a significant three-way interaction of Age \times Fragment Type \times Condition, $F(3, 130) = 3.12, p = .029, \eta_p^2 = .07$, such that the interaction of Age \times Fragment Type differed as a function of Condition. Pairwise post hoc analyses with Bonferroni corrections showed that while participants generally solved fewer critical fragments than filler fragments, older adults solved significantly fewer than did younger adults; this age difference was particularly exaggerated in the two Interference conditions (values $> 6.52, p$ values $< .01$ in comparing age differences for critical fragments; F values $< 1.98, p$ values $> .16$ in comparing age differences for filler fragments) compared with the other conditions (F values $< 2.01, p$ values $> .15$ for all Age \times Fragment Type comparisons).

As a more direct measure of interference, we measured how often participants made intrusion errors by responding with the competitors to solve the critical fragments, that is, incorrectly responding ANALOGY to A_L__GY (see Figure 3). There was an expected main effect of Condition, in which both age groups made significantly more intrusion errors in the two Interference conditions than in the No-Resolution and No-Conflict conditions, $F(3, 130) = 310.65, p < .001, \eta_p^2 = .87$. There was also a reliable main effect of Age in which older adults made more intrusion errors than younger adults ($F(1, 130) = 108.52, p < .001, \eta_p^2 = .45$). There was also a significant interaction of Age \times Condition, $F(3, 130) = 16.50, p < .001, \eta_p^2 = .27$. Follow-up pairwise comparisons using Bonferroni corrections revealed that while age

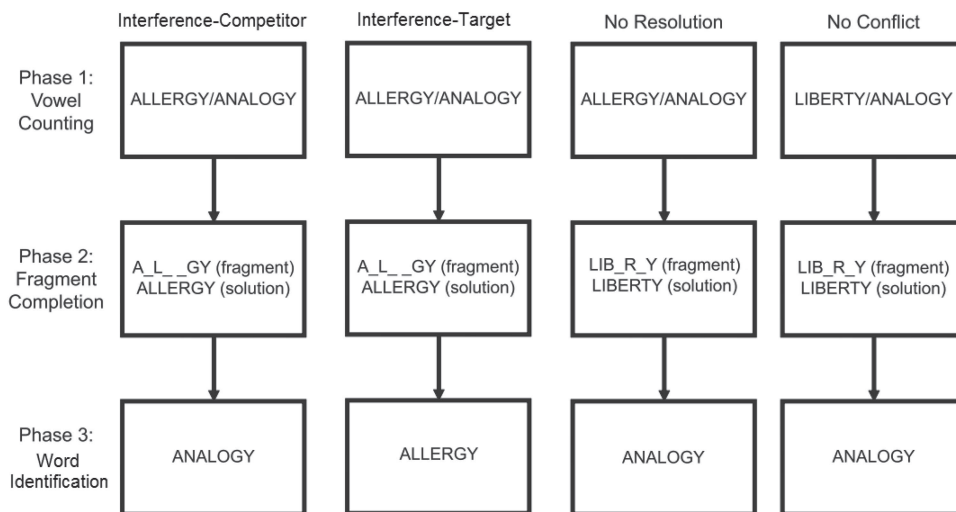


Figure 2. Comparison of the sequence of events in the four conditions (Interference-Competitor, Interference-Target, No-Resolution, and No-Conflict) in Experiment 2. Note that for the Interference-Target condition, the target word (e.g., ALLERGY) is presented as the key item for identification in Phase 3, as opposed to the competitor word (e.g., ANALOGY) as in the other conditions.

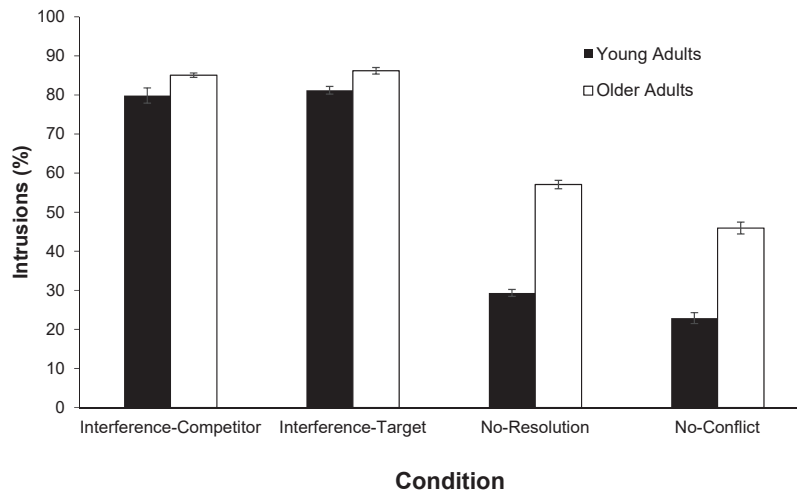


Figure 3. Percentage of errors of the intrusion type made by young and older adults across the four experimental conditions in Phase 2 of Experiment 2 to critical fragments, that is, completing the target fragment with the competitor. Error bars represent SEM.

differences in the Interference-Competitor and Interference-Target conditions were only marginally significant (F values < 3.32 , p values $< .07$, η_p^2 values $< .04$), older adults made significantly more intrusion errors in the No-Resolution and No-Conflict conditions, F values > 59.58 , p values $< .001$, η_p^2 values $> .31$. Recall that critical fragments in these two conditions still had corresponding conflicting solutions, even though they were not explicitly presented, for example, the critical fragment L I B _ R _ Y that could reasonably be confused for LIBRARY instead of the correct LIBERTY. That is, even in the absence of explicitly presented competitors, older adults still demonstrated higher intrusion rates

than younger adults (Hamm & Hasher, 1992; Logan & Balota, 2003).

Figure 4 depicts identification accuracy in Phase 3 for the competitor/target words across the four conditions. For the two Interference conditions, accuracy reflects only those words for which the corresponding fragment had been correctly solved in Phase 2. To ensure that we had successfully equated for audibility, we also tested participants on an additional baseline condition of identification in noise (at the same SNR as the main study) using words not presented in any part of the experiment. There was no significant difference between younger ($M = 70.23$, $SE = 1.72$)

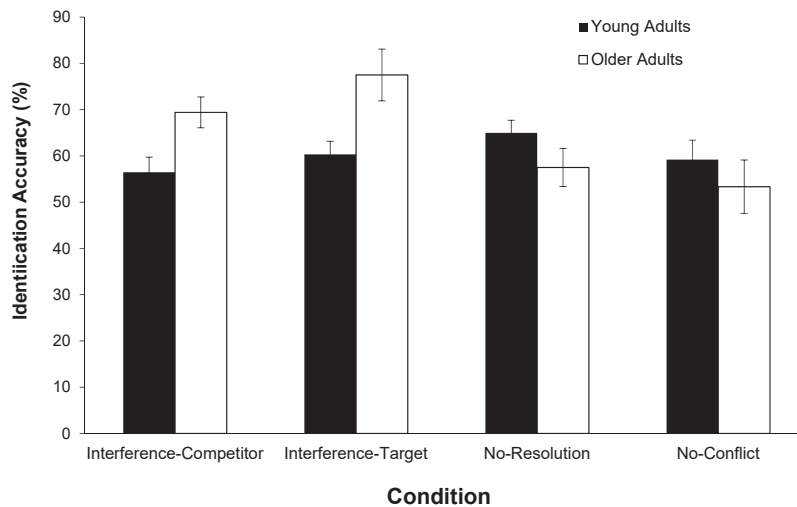


Figure 4. Identification accuracy of competitor/target items by young and older adults across experimental conditions in Phase 3 of Experiment 2. Note that identification accuracy in Interference-Competitor, No-Resolution, and No-Conflict conditions refer to correct identification of competitor words, while the Interference-Target refers to correct identification of target words. Nb. Accuracy in the Interference conditions are conditionalized, based on only correct fragment completions from Phase 2. Error bars represent SEM.

and older ($M = 66.25$, $SE = 2.35$) adults, $t(136) = 1.38$, $p = .17$, suggesting that the 3 dB difference in SNR (0 for young, 3 for older) served to equate overall intelligibility.

Initial analyses of identification accuracy revealed a significant Age \times Condition interaction, $F(3, 130) = 7.34$, $p < .001$, $\eta_p^2 = .15$, in which there were no age differences in competitor identification for the No-Conflict condition, but reliable age differences in the other conditions. Pairwise post hoc comparisons corrected for multiple comparisons revealed that while younger adults identified competitors significantly better than did older adults in the No-Resolution condition, $F(1, 130) = 3.93$, $p = .05$, the opposite was true in both Interference conditions, $F(1, 130) = 12.07$, $p < .01$, such that older adults identified competitor/target words in the Interference-Competitor and Interference-Target conditions, respectively, significantly better than did younger adults. Note that older adults identified competitors in the Interference-Competitor condition at a similar rate to targets in the Interference-Target condition, $p = .11$.

Although the older adult advantage for competitor identification in the Interference-Competitor condition replicates Experiment 1, younger adults did not show the expected benefit from repeated target presentation as well as the older adults in the Interference-Target condition. Given this unexpected lack of target facilitation for younger adults, we examined accuracy for new words across the four conditions for each age group to examine whether inherent group differences may have contributed to the pattern of results (see Table 4). Analyses revealed that while identification of new words did not significantly differ for younger adults across conditions, $F(3, 130) = .48$, $p = .69$, $\eta_p^2 = .01$, older adults in the Interference-Target group identified significantly more new words compared with older adult participants in the other three conditions, $F(3, 130) = 5.44$, $p = .001$, $\eta_p^2 = .11$, suggesting that the unexpected age-related difference in the Interference-Target condition may not have been entirely driven by underperforming younger adults, but rather by unusually high-performing older adults in this particular condition.

We further examined the pattern of Phase 3 intrusion errors made by young and older adults across conditions (see Table 5), in which an erroneous response for the Interference-Competitor condition would be the target, while an erroneous response for the Interference-Target condition would be the competitor. We observed a significant Age \times Condition interaction, such that while older adults made more intrusion errors overall and that most of these errors occurred in the two Interference conditions, young and older adults only significantly differed in their intrusion rates in the No-Resolution and No-Conflict conditions, $F(3, 130) = 16.49$, $p < .001$, $\eta_p^2 = .28$. These results are similar to those obtained in

Experiment 1, wherein older adults experienced interference even from nonpresented competitors.

Discussion

Experiment 2 largely replicated the findings of Experiment 1 and Healey et al. (2013), demonstrating that older adults showed increased accuracy for identifying competitors after (incomplete) interference resolution. In contrast, younger adults showed poorer accuracy in comparison to older adults for such items, paradoxically reflecting better suppression abilities during interference. Older adults also appeared to identify competitors and targets at a similar rate, which may follow from previous work that has shown that facilitation effects, such as semantic priming and repetition priming, which are preserved or sometimes enhanced with age (e.g., Abrams & Farrell, 2011; Balota & Duchek, 1991; Laver, 2009; Laver & Burke, 1993). It is surprising, however, that younger adults did not show facilitation effects of the target, which, as noted, may have been in part because of group differences across conditions. These differences potentially obscure the actual role of facilitation, and we sought to further clarify the degree to which it is sensitive to age in tandem with suppression in Experiment 3.

Experiment 3

In Experiment 3, we set out to compare target and competitor accessibility to directly test the complementary roles of facilitation and suppression. If we assume that target facilitation and competitor suppression are equally important, then the degree of target identification should be proportional to the degree of competitor identification with no differences across age. That is, the degree of target facilitation should be equivalent to the degree of competitor suppression—indicating that the two processes are similarly complementary—with minimal age differences. However, if it is primarily suppression, rather than facilitation, that is the primary mechanism in interference resolution, then older adults should demonstrate significantly less competitor suppression compared with younger adults, with relatively minimal age differences in target facilitation.

Method

We tested a new group of 54 younger and 56 older adult participants (see Table 1 for demographic details) across three conditions: (a) Interference-Competitor (young: $n = 19$; old: $n = 18$), identifying the competitor during Phase 3; (b) Interference-Target (young: $n = 21$; old: $n = 20$), identifying the target during Phase 3; and (c) a new baseline condition requiring identification of the target, referred to as Baseline-Target (young: $n = 16$; old: $n = 16$). The purpose of the Baseline-Target condition was to assess baseline performance in identifying the target, against which to compare and observe the relative target facilitation/competitor suppression effects in the other two experimental conditions. Participants in the Interference conditions completed all three phases of the procedure, while participants in the Baseline-Target condition completed only Phase 3, identifying the same list of words as presented in the Interference-Target condition (see Figure 5). Note that the Interference-Competitor and Interference-

Table 4
Experiment 2: Identification Accuracy (%) for New Words in Phase 3

Age group	Condition			
	Interference-Competitor	Interference-Target	No-Resolution	No-Conflict
Younger adults	73.7 (4.08)	73.9 (3.9)	73.7 (4.0)	72.9 (4.1)
Older adults	67.5 (4.1)	85.8 (4.2)	74.2 (4.2)	68.8 (4.2)

Note. SEM in parentheses.

Table 5
Experiment 2: Mean Intrusion Errors (%) in Phase 3

Age group	Condition			
	Interference-Competitor	Interference-Target	No-Resolution	No-Conflict
Younger				
Mean intrusions (SEM)	79.8 (1.2)	81.2 (2.0)	29.3 (2.0)	22.8 (2.1)
Older				
Mean intrusions (SEM)	85.1 (2.1)	86.2 (2.1)	57.1 (2.1)	45.9 (2.1)

Target conditions are identical until Phase 3. We did not assess awareness in Experiment 3, because of its limited effects on the pattern of results from Experiments 1 and 2.

Results

As in Experiments 1 and 2, vowel-counting performance was highly accurate (above 95%) across age and condition, with no significant interactions, F values < 1.15 , p values $> .28$, η_p^2 values $< .01$.

Results from Phase 2 fragment completion for the Interference-Competitor and Interference-Target conditions are shown in Table 6, demonstrating an overall main effect of Age, $F(1, 74) = 47.61$, $p < .001$, $\eta_p^2 = .39$, in which younger adults correctly completed more critical and filler fragments than did older adults. There was also a significant main effect of Fragment Type, $F(1, 74) = 193.23$, $p < .001$, $\eta_p^2 = .72$, in which critical fragments were solved significantly less often than filler fragments. There were no reliable two-way or three-way interactions with Fragment Type or Condition.

In examining intrusion errors from the competitor word, we observed that older adults ($M = 90.11$, $SE = 1.08$) made significantly more errors of the intrusion type than did younger adults ($M = 82.32$, $SE = 1.05$), $F(1, 74) = 14.80$, $p < .001$, $\eta_p^2 = .30$. As expected, there was no significant effect of Condition (given that the two Interference conditions were identical until this point), nor an interaction.

Figure 6 depicts identification accuracy in Phase 3 across the three conditions for the competitor or target words. As in Experiments 1 and 2, we included in our analyses only those items for which the corresponding fragment had been correctly solved in Phase 2. A significant Age \times Condition interaction was obtained, $F(2, 104) = 8.48$, $p = < .001$, $\eta_p^2 = .14$, revealing that while older adults showed poorer accuracy for targets than younger adults in the Interference-Target condition, $F(1, 104) = 6.16$, $p = .01$, $\eta_p^2 = .06$, the opposite pattern was true for competitors in the Interference-Competitor condition, $F(1, 104) = 10.79$, $p = .001$, $\eta_p^2 = .09$, replicating the findings of Experiments 1 and 2. There were no age-related differences in the Baseline-Target

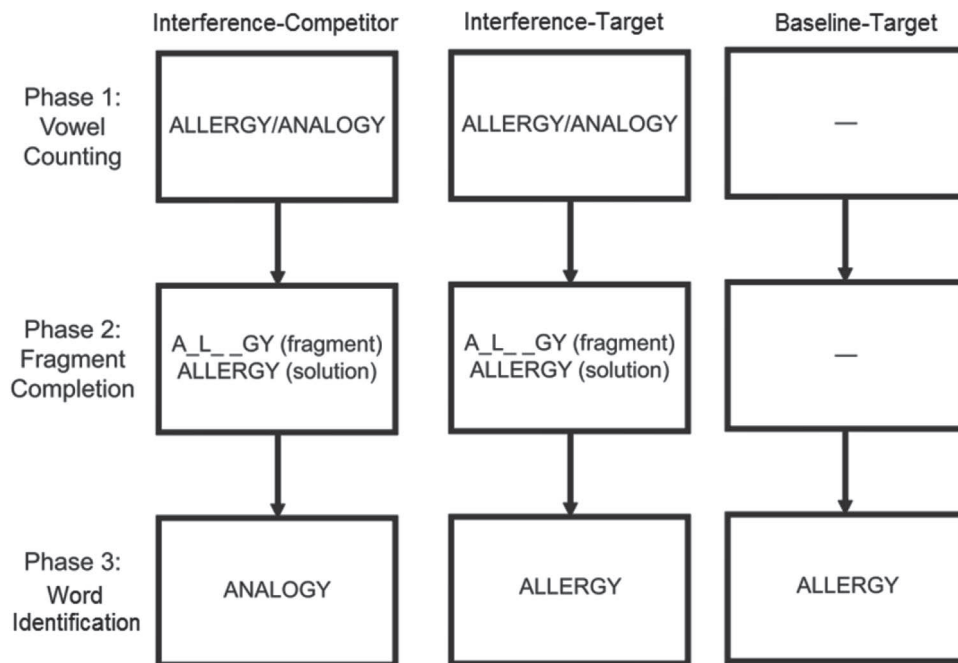


Figure 5. Comparison of the sequence of events in the three conditions (Interference-Competitor, Interference-Target, and Baseline-Target) in Experiment 3.

Table 6
Experiment 3: Correct Fragment Completion (%) in Phase 2

Variable	Condition	
	Interference-Competitor	Interference-Target
Younger		
Critical fragments (SEM)	61.4 (1.6)	62.2 (2.9)
Filler fragments (SEM)	87.8 (1.9)	86.9 (2.3)
Older		
Critical fragments (SEM)	46.3 (3.6)	46.6 (4.1)
Filler fragments (SEM)	69.6 (3.3)	73.3 (2.5)

Note. In both conditions, correct completion for critical fragments involved correctly solving the fragment with the target of the target-competitor pair. Note that the Baseline-Target condition comprises only Phase 3, hence not being presented in this table.

condition, $F(1, 104) = .07$, $p = .79$, $\eta_p^2 = .001$, confirming that audibility had been successfully equated across age groups using the different SNRs.

Follow-up pairwise comparisons using multiple paired tests with Bonferroni corrections showed that younger adults' identification of targets in the Interference-Target condition was superior to identification in the other two conditions, $t(104) = 5.08$, $p < .001$, Cohen's $d = 2.11$, and that performance in the Interference-Competitor and Baseline-Target conditions did not differ significantly, $t(104) = .35$, $p = .34$, Cohen's $d = .07$. That is, younger adults showed a high degree of target facilitation, but identified rejected competitors at the same rate as a word to which they had not previously been exposed. In contrast, older adults' accuracy between the two Interference conditions was not significantly different, $t(104) = .93$, $p = .94$, Cohen's $d < .01$, and performance in both Interference conditions exceeded that of Baseline-Target (values > 3.78 , p values $< .02$, Cohen's d values $> .81$). That is to

say, older adults showed enhancement of both the target and competitor words above a baseline level. In contrast, a separate univariate ANOVA for new words showed that accuracy did not significantly differ as a function of Age or Condition, F values < 1.41 , p values $> .19$, η_p^2 values $< .02$.

In examining the pattern of intrusion errors in Phase 3, we observed a significant main effect of Age, $F(1, 104) = 53.65$, $p < .001$, $\eta_p^2 = .34$, in which older adults made more intrusion errors than did younger adults (see Table 7). There was also a significant main effect of Condition, $F(2, 104) = 635.86$, $p < .001$, $\eta_p^2 = .92$, which post hoc analyses confirmed was because of a higher percentage of intrusions in the two Interference conditions (with no significant difference between them, $p = 1.00$) compared with the Baseline-Target condition, $p < .001$. There was also a marginally significant interaction of Age \times Condition, $F(2, 104) = 2.50$, $p = .07$, $\eta_p^2 = .05$. Follow-up pairwise t test comparisons with Bonferroni corrections showed that although there were significant age differences at every Condition level, these differences were disproportionately large for the two Interference conditions (values > 5.30 , p values $< .001$, Cohen's d values > 3.01) compared with the Baseline-Target condition, $t(104) = 2.33$, $p = .021$, Cohen's $d = .69$.

General Discussion

A series of three studies reported here demonstrate that inhibition of competitors is a critical component of interference resolution during speech perception. While facilitation also appears to play a role in enhancing target accessibility, it is clear that with regard to the resolution of interference, it is the successful suppression of competitors that specifically leads to their reduced accessibility. As evident across these studies, older adults continue to have access to these competitors after initial exposure, and subsequently show enhanced identification of these competitors in

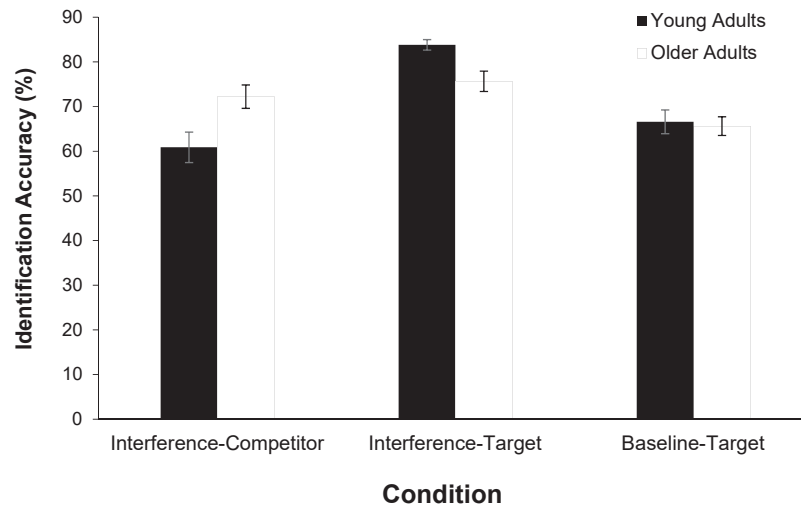


Figure 6. Identification accuracy of competitor/target items by young and older adults across conditions in Phase 3 of Experiment 3. Note that identification accuracy in the Interference Competitor condition involves correct identification of the competitor, while the Interference Target and Baseline-Target conditions involve correct identification of the target. Accuracy in the two Interference conditions are conditionalized, based on only correct fragment completions from Phase 2. Error bars represent SEM.

Table 7
Experiment 3: Mean Intrusion Errors (%) in Phase 3

Variable	Interference-Competitor	Condition Interference-Target	Baseline-Target
Younger			
Mean intrusions (SEM)	69.4 (1.9)	72.1 (1.8)	12.1 (2.1)
Older			
Mean intrusions (SEM)	85.2 (2.0)	84.5 (1.9)	18.9 (2.1)

noise compared with younger adults. Such findings demonstrate that not only do older adults show incomplete suppression of competitors, but that age-related inhibitory deficits may actually facilitate subsequent perception of these words.

To our knowledge, this is the first study to show direct evidence for age-related impairments in inhibitory abilities within the context of auditory speech perception. Previous studies to propose inhibition deficits in speech have done so largely using correlational methods and extrapolation (Sommers & Danielson, 1999; Stine & Wingfield, 1994; Tun, O’Kane, & Wingfield, 2002; Tun & Wingfield, 1999), demonstrating that, while it is apparent that older adults experiences difficulties from distraction during speech in noise, the mechanisms of this difficulty have not been well understood. The results from the current study establish the role of the inhibitory mechanism in suppressing irrelevant competitors, and how age-related reductions in inhibitory control result in continued access to residual representations. Evidence for this latter point comes from the high percentage of intrusions experienced by older adults during both fragment completion and perceptual identification, and which is further consistent with previous work that found age-related differences in competitor intrusions during auditory-visual perceptual identification (Dey & Sommers, 2015).

The results are also largely consistent with suppression-based theories from the memory literature (e.g., M. C. Anderson & Spellman, 1995; Bjork, 1989; Hasher et al., 2007; Zanto & Gazzaley, 2009), in which interference resolution entails active suppression of competitors. Our findings also provide a glimpse into the precise nature of what happens to the competitor trace following resolution, similar to examinations of trace suppression in studies of directed forgetting (DF). In DF paradigms, items are cued as either to-be-forgotten (TBF) or to-be-remembered (TBR). When both item types are requested at recall, efficient DF is obtained when significantly more TBR items are recalled than TBF items. The term “forgetting,” however, is a slight misnomer, given that TBF items must have been initially encoded and only upon instruction been deemed irrelevant. Accordingly, they may retain some degree of accessibility in memory. That is, a TBF item is not necessarily a forgotten item, that is, one that is expelled from memory altogether, but rather an item whose activation has been sufficiently suppressed. Several age-related investigations of directed forgetting have reported that older adults show a reduced DF effect, that is, the difference in recall for TBR and TBF items, that is largely driven by lower recall for TBR items and higher recall for TBF items compared with younger adults (Andrés, Van der Linden, & Parmentier, 2004; Earles & Kersten, 2002; Gamboz & Russo, 2002; Sego, Golding, & Gottlob, 2006; Zacks, Radvan-

sky, & Hasher, 1996), suggesting that TBF items are not entirely suppressed. Consistent with the inhibitory deficit hypothesis in older adults, Zacks et al. (1996) showed that older adults in comparison with younger adults produced more TBF word intrusions on an immediate recall test, took longer to reject TBF items relative to baseline, and both recognized and recalled more TBF items on delayed retention tests. That is, older adults’ reduced capacity for inhibition results in incomplete suppression of TBF items, facilitating future retrieval attempts and mirroring the pattern of results obtained in the current study in which persistent activation from competitors manifests as enhanced perception for such items.

The findings reported here implicate an attentional locus of inhibition that extends beyond the visual memory domain. Indeed, the present results offer evidence of the generality of such cognitive processes as interference resolution and inhibition (but see Guerreiro, Murphy, & Van Gerven, 2010⁴) that are responsible for our ability to distinguish the relevant from the irrelevant in our daily environments. Attentional dysregulation of this ability in older adults highlights a fundamental change during the aging process, but its explorations have been largely limited to paradigms in memory (e.g., Campbell et al., 2010; Ikier & Hasher, 2006; Radvansky, Zacks, & Hasher, 2005). In drawing upon studies from speech (e.g., Tun, O’Kane, & Wingfield, 2002; Tun & Wingfield, 1999) and models of spoken word recognition (Luce & Pisoni, 1998), our findings suggest that interference resolution and its underlying mechanisms are not limited to memory, but represent domain-general inhibitory function. This converging support will well serve future studies of similar phenomena that may be explored across these and other domains, thereby inviting further investigation into the common underlying mechanisms at work.

More generally, these findings contribute to a growing body of work showing that some changes in cognitive aging may confer certain “advantages.” Recent work has suggested that cognitive control in aging can be viewed as a “double-edged sword,” in which older adults’ increased susceptibility to interference and distraction can produce unexpected advantages for older adults with respect to taking advantage of previously irrelevant information (Amer, Campbell, & Hasher, 2016; May, 1999; Weeks & Hasher, 2014; Yang and Hasher, 2007), for example, one study (Rowe, Valderrama, Hasher, & Lenartowicz, 2006) showed that older adults performing a one-back task on pictures with superimposed distractor words showed a benefit from the distractors on a word-fragment completion task. More recent evidence has shown that older adults not only benefit from conceptual knowledge of distractors on subsequent conceptually based general knowledge tasks (Amer & Hasher, 2014), but rarely forget items that previously appeared as distractors, thereby effectively reducing age-

⁴ In their meta-analysis, Guerreiro et al. suggested that interference effects are modality specific, that is, when both targets and distractors and presented unimodally and are more likely in the visual domain. Although it is arguable that that modality is less of an issue in our current study given that the initial exposure to the test items was bimodal, we did not set out to specifically address the specific issue of modality. We instead suggest that our current findings provide evidence of a core cognitive ability, that is, attentional control and suppression, which mediates performance across domains as distinct as memory and speech perception.

related differences in forgetting (Biss, Ngo, Hasher, Campbell, & Rowe, 2013). Such findings suggest that older adults broadly maintain representations regardless of relevance, which can in turn facilitate retrieval. Incidentally, these findings mirror work in the developmental literature showing that younger children have more difficulty in ignoring irrelevant sources of information than do older children and hence show high levels of memory for irrelevant information, suggesting that performance benefits are actually indicative of less efficient cognitive control systems (e.g., Hagen & Hale, 1973; Thompson-Schill, Ramscar, & Chrysiou, 2009). This link to cognitive aging implies that reduced control results in a broader attentional field and processing of distractors that, in some cases, can produce incidental benefits.

However, we do not claim that all suppression failures are necessarily functionally beneficial per se, and, in the case of speech, most instances requiring selective attention do not possess concomitant advantages from failures to suppress; one can imagine that attending to multiple conflicting voices when trying to hear driving directions would hardly be advantageous. Rather, we argue that our findings are consistent with emerging research that suggest unique ways of examining age-related changes that do not strictly dwell on the shortcomings of reduced cognitive control (see Amer et al., 2016; for a review). Clearly, more work is needed in this regard to demonstrate whether such approaches confer additional “benefits” across multiple domains of perception and cognition.

Conclusions

The results of the above experiments demonstrate that while younger adults are successfully able to suppress competitors during interference resolution, older adults are less able to do so. As a result, older adults retain access to competitors, subsequently facilitating their ability to perceive these words when presented in noise. Indeed, older adults demonstrate superior identification accuracy in noise compared with younger adults under conditions of equivalent audibility. Such findings are consistent with age-related changes in suppression that can be observed across multiple domains of perception and cognition, and support a recent trend in the literature that highlights incidental benefits from changes in cognitive control across the life span.

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Appendix

List of Stimuli (Adapted From [Smith & Tindell, 1997](#))

Orthographic word pairs (presented list)	Orthographic word pairs (nonpresented list)	Filler + buffer words (Phase 1)	Filler + buffer words (Phase 2)	New + buffer words (Phase 3)
ALLERGY-ANALOGY	ABSENTEE-ABSOLUTE	ASBESTOS	ANTIQUE	ANYBODY
ANATOMY-ANAEMIA	ARCHIVE-ACHIEVE	ALMANAC	BLOCKADE	BACHELOR
BAROQUE-BRUSQUE	BAGGAGE-BRIGADE	ANTENNA	COCONUT	BOYHOOD
CATALOG-COTTAGE	BALCONY-BALONEY	ASSASSIN	COPYCAT	CANISTER
CHARITY-CHARTER	BARMAID-BERMUDA	BROCCOLI	CUTLERY	DIVISION
COLLATE-COLLECT	CONSERVE-CONSPIRE	CROQUET	DINOSAUR	DOLPHIN
CONTENT-CONTAIN	CULPRIT-CRUMPET	CUPCAKE	DISGUISE	FILTRATE
DECEASE-DIOCESE	DEFAULT-DEFUNCT	ELECTRON	ELEGANCE	FISHING
HARPOON-HAIRPIN	DIGNITY-DENSITY	ESPRESSO	HOSPITAL	JUSTICE
HEALTHY-HEATHEN	FAILURE-FIXTURE	GAZELLE	IDEOLOGY	MIGRAINE
PERFORM-PERFUME	HISTORY-HOLSTER	IMPULSE	LADYBUG	MOISTURE
REVOLVE-REPROVE	LIBERTY-LIBRARY	INERTIA	MAGAZINE	NIRVANA
THROUGH-THOUGHT	MONOPOLY-MULTIPLY	INKWELL	MYSTERY	OPPOSITE
TANGENT-TONIGHT	PRESERVE-PRESSURE	KEYHOLE	OPPOSITE	PROPHECY
VOLTAGE-VOYAGER	TRAGEDY-TRILOGY	LINEAGE	OUTSIDER	SPATULA
		MARTINI	PETUNIA	SYMPATHY
		MEMBRANE	QUARTET	TWILIGHT
		NEGLECT	RAINBOW	WARRANTY
		PADDOCK	SAPPHIRE	
		RESERVE	SHERIFF	
		SEGMENT	SILICON	
		SOLDIER		
		TEQUILA		
		THEOREM		
		URGENCY		
		WEDDING		

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