ASHA American Speech-Language-Hearing Association

JSLHR

Research Article

The Influence of Semantic Context on the Intelligibility Benefit From Speech Glimpses in Younger and Older Adults

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ARTICLE INFO

Article History:
Received August 27, 2024
Revision received November 7, 2024
Accepted January 12, 2025

Editor-in-Chief: Rachael Frush Holt
Editor: Vishakha Waman Rawool

https://doi.org/10.1044/2025_JSLHR-24-00588

ABSTRACT

Purpose: Speech is often masked by background sound that fluctuates over time. Fluctuations in masker intensity can reveal glimpses of speech that support speech intelligibility, but older adults have frequently been shown to benefit less from speech glimpses than younger adults when listening to sentences. Recent work, however, suggests that older adults may leverage speech glimpses as much, or more, when listening to naturalistic stories, potentially because of the availability of semantic context in stories. The current study directly investigated whether semantic context helps older adults benefit from speech glimpses released by a fluctuating (modulated) masker more than younger adults.
Method: In two experiments, we reduced and extended semantic information of sentence stimuli in modulated and unmodulated speech maskers for younger and older adults. Speech intelligibility was assessed.
Results: We found that semantic context improves speech intelligibility in both younger and older adults. Both age groups also exhibit better speech intelligibility for a modulated than an unmodulated (stationary) masker, but the benefit from the speech glimpses was reduced in older compared to younger adults. Semantic context amplified the benefit gained from the speech glimpses, but there was no indication that the amplification by the semantic context led to a greater benefit in older adults. If anything, younger adults benefitted more.
Conclusions: The current results suggest that the deficit in the masking-release benefit in older adults generalizes to situations in which extended speech context is available. That previous research found a greater benefit in older than younger adults during story listening may suggest that other factors, such as thematic knowledge, motivation, or cognition, may amplify the benefit from speech glimpses under naturalistic listening conditions.

Many adults over the age of 60 years live with some form of hearing loss and most frequently experience difficulty understanding speech in the presence of background masking sounds (Heidari et al., 2018; Helfer & Freyman, 2008; Humes, 2013; Pichora-Fuller et al., 1995; Weissgerber et al., 2022). Even older adults with audiometrically normal hearing thresholds often have lower speech intelligibility when background noise is presented, compared to younger adults (Füllgrabe et al., 2015; Herrmann, 2023; Lee, 2015; Taitelbaum-Swead & Fostick, 2016; Tremblay et al., 2015; Weissgerber et al., 2022; Zeng et al., 2020). Reduced speech understanding can be socially excluding and isolating (Dawes et al., 2015; Shukla et al., 2020), with long-term negative consequences for quality of life and health (Arlinger, 2003). Understanding the nature of speech-in-noise perception in older adults is thus important to support social participation throughout older adulthood.

Investigations of speech-in-noise perception usually involve individuals listening to target speech amidst a background noise masker, such as multitalker babble

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(Bent et al., 2009; Cooke, 2006; Füllgrabe et al., 2015; Herrmann, 2023; Irsik et al., 2022; Pichora-Fuller et al., 1995; Snell et al., 2002; Vickery et al., 2022). Listeners are asked to report back the target speech verbatim by either repeating it out loud or typing their responses into text field on a computer (Dubno et al., 2002; Gustafsson & Arlinger, 1994; Herrmann, 2023; Irsik et al., 2022; Pichora-Fuller et al., 1995; Sheldon et al., 2008). The speech reception threshold (SRT), defined as the signal-to-noise ratio (SNR) between the speech and the masker at which participants correctly report 50% of the presented words, can then be calculated as a measure of speech intelligibility (Herrmann, 2023; Ramkissoon et al., 2002; Smits et al., 2004, 2013; Yoon et al., 2023).

Critically, background masking sounds in everyday environments, such as busy restaurants, are often not stationary, but fluctuate in intensity over time (henceforth referred to as modulated masker). A modulated masker releases parts or glimpses of the speech signal for brief periods at which the masker intensity is reduced. Listeners can benefit from the speech glimpses (also sometimes referred to as temporal dips; Guan et al., 2015; Li et al., 2016) when masker intensity is low to understand what is said. Both younger and older adults benefit from a modulated masker, such that speech intelligibility is greater compared to a stationary (or unmodulated) masker (George et al., 2006; Gustafsson & Arlinger, 1994; Herrmann, 2023; Irsik et al., 2022; Tanner et al., 2019). However, several works have shown that older adults benefit less from speech glimpses released by a modulated masker than younger adults (Dubno et al., 2002, 2003; Füllgrabe et al., 2015; George et al., 2007; Gifford et al., 2007; Gustafsson & Arlinger, 1994; Helfer & Freyman, 2008; Herrmann, 2023; Irsik et al., 2022; Mamo & Helfer, 2021; Summers & Molis, 2004). The reduced benefit from modulated maskers in older adults is typically attributed to deficits in temporal processing that hinder older adults from gathering information relevant for speech understanding from the briefly exposed speech glimpses (Fogerty et al., 2021; Füllgrabe et al., 2015; Grose et al., 2009; Hopkins & Moore, 2011; Pichora-Fuller & Singh, 2006; Schneider et al., 1994; Stuart & Phillips, 1996).

The masking-release benefit from a modulated masker is typically studied using short, disconnected sentences (Fogerty et al., 2021; George et al., 2006; Gifford et al., 2007; Gustafsson & Arlinger, 1994; Herrmann, 2023; Irsik et al., 2022) or unrelated syllables/consonants (Cooke, 2006; Dubno et al., 2002; Füllgrabe et al., 2015). These stimuli are not as engaging or contextually rich as speech in real-life conversations. Speech in everyday life often follows a topical thread, is rich in context, and the listener is intrinsically motivated to listen (Bohanek et al., 2009; Hamilton & Huth, 2018; Herrmann & Johnsrude, 2020; Irsik et al., 2022; McLean et al., 2007; Mullen & Yi, 1995). Using spoken stories, a recent study suggests that the age-related decline in the benefit from speech glimpses may not generalize to more naturalistic speech (Irsik et al., 2022). Specifically, older adults benefited more than younger adults from speech glimpses for highly engaging spoken stories. For moderately engaging stories, older adults benefited as much as younger adults, whereas older adults benefited less for a sentence list derived by randomly presenting the sentences from the same moderately engaging story (Irsik et al., 2022). The authors suggested that motivational factors or the greater semantic context available (compared to disconnected sentences) could have helped older adults to benefit more or equally from speech glimpses than younger adults (Irsik et al., 2022). The current study investigates whether indeed semantic context affects the release-from-masking benefit in younger and older adults.

Previous work suggests that when the function of auditory sensory systems decreases as individuals grow older, they may begin to rely on alternative mechanisms to listen better, such as contextual information of speech (Bieber et al., 2022; Moberly et al., 2023; Pichora-Fuller, 2008; Pichora-Fuller et al., 1995; Sheldon et al., 2008; Sun et al., 2022). Semantic knowledge typically remains intact or is even greater in older adulthood, potentially providing an important resource for understanding speech in noise (Aydelott et al., 2010; Burke & Peters, 1986; Buss et al., 2019; Moberly et al., 2023; Sheldon et al., 2008). Consistent with this, several studies have found that older adults rely on contextual information of speech more than younger adults do when listening to speech in noise (G. Cohen & Faulkner, 1983; Pichora-Fuller et al., 1995; Pichora-Fuller & Singh, 2006; Sheldon et al., 2008; Sun et al., 2022), suggesting that they turn to these contextual clues to listen when auditory speech-in-noise processing is reduced (Pichora-Fuller, 2008; Pichora-Fuller & Singh, 2006; Sheldon et al., 2008; Sun et al., 2022).

On the other hand, EEG studies investigating semantic predictability suggest that compared to younger adults, older adults are not as efficient in using contextual information to make predictions about upcoming words in sentences (Federmeier et al., 2002, 2003, 2010; Wlotko et al., 2010). This age difference in the use of predictive context also generalizes to story materials (Broderick et al., 2021). A reduced contextual predictability could result in older adults demonstrating lower intelligibility benefit from context despite their larger semantic knowledge (Federmeier et al., 2002, 2010). It is important to note that these studies investigated visual speech processing (Federmeier & Kutas, 2005) or speech-listening in quiet (Broderick et al., 2021; Federmeier et al., 2002, 2003) and have not considered the added load and strategies employed when listening in noise. Other studies have found reduced or similar context effects between younger and older adults during speech in noise listening, citing individual and cognitive differences between the groups to explain their results (Moberly et al., 2023). Relevant to our study, this discrepancy regarding benefit from context makes it unclear whether older adults are able to successfully utilize semantic context to facilitate their benefit from speech glimpses in noise compared to younger adults. That is, whether it is the availability of semantic context that can also help older adults to benefit more from speech glimpses is unknown.

The current study comprises two experiments to address this question. In Experiment 1, we investigate whether the masking-release benefit declines more in older than younger adults when semantic information in sentences is reduced. In Experiment 2, we examine whether the masking-release benefit amplifies more in older compared to younger adults when additional, semantically supporting speech is provided. We first describe the general methods that are similar across both experiments, before detailing the specific methods and results for each experiment successively.

General Methods

Participants

Younger (21–33 years) and older adults (58–76 years) were recruited from the Amazon's online research platform Mechanical Turk (MTURK) via the Cloud Research Interface (formerly TurkPrime; Litman et al., 2017). Prior to the beginning of the experiment, participants were provided with information about the experiment and they checked a box to indicate their consent for participating in the study. All participants were required to be native English speakers born in the United States of America, have no self-reported history of neurological disorders, no self-reported hearing loss, and not wear or have been prescribed hearing aids. Participants also indicated whether they were distracted during the experiment. All this information was collected by self-report, and the breakdown of the number of participants included and excluded due to the eligibility criteria is outlined in the participants section of each experiment. Participants were compensated with \$8.25 (Experiment 1) and \$14 (Experiment 2) at the same hourly rate. The study was conducted in accordance with the Declaration of Helsinki and the Canadian Tri-Council Policy Statement on Ethical Conduct for Research Involving Humans (2014) and was approved by the Research Ethics Board of the Rotman Research Institute at Baycrest Academy for Research and Education (ID#21–04).

Experimental Setup

Experiments were conducted online in an internet browser. The experiment code was written in JavaScript using jsPsych libraries (Version 7.2.1; de Leeuw, 2015) and hosted on a Pavlovia server online (https://gitlab.pavlovia.org). Eligible participants were provided a link on MTURK that redirected them to the Pavlovia platform for the experiment. No specifications as to the type/brand of equipment participants should use (e.g., computer, screen, operating system) were provided, but participants were asked to use headphones. All participants indicated having used headphones or in-ear phones.

A sound-level calibration task was administered at the beginning of the experiment. In this task, a pink noise was played for 30 s during which the participant was asked to adjust the audio volume of their computer such that the pink noise would be played at a comfortable level. This was done to ensure that participants will be able to hear the stimuli in the experiment at a comfortable level, without it being too soft or intense. Although, this method does not control for changes in volume made during the experiment, the Irsik et al. (2022) study, on which our study was built, used a similar approach and found different masking-release benefits between younger and older adults, and modulations by context (story vs. sentence list).

Hearing Assessment

A digits-in-noise (DIN) task was administered to measure the hearing ability of participants (Calandruccio & Smiljanic, 2012; De Sousa et al., 2020; Ramkissoon et al., 2002; Smits et al., 2004, 2013). Procedures were similar to our previous work (Herrmann, 2023). Participants heard three digits (e.g., 9–4–7) in varying levels of a 12-talker background babble noise (similar to the ones used during the experiment; Bilger et al., 1984). The SNR was manipulated by varying the level of the spoken digits relative to the level of the babble noise. The duration of the babble was 3 s, and the first digit started at 0.5 s after babble onset (onset-to-onset interval: 0.85 s). After a DIN stimulus was played, participants had to type the three digits in the order in which they were presented into a textbox. Digit triplets were presented at 29 SNRs (range: −18 dB to +15.6 dB; step size: 1.2 dB). One hundred digit triplets were pregenerated for each of the 29 SNRs by randomly selecting three different digits ranging from 1 to 9. For each participant, 29 digit triplets (one per SNR) were randomly selected. Each participant completed two practice trials with high SNRs followed by the 29 test trials.

For data analysis, a trial was only considered correct if all three digits were typed in the order they were presented. Hearing thresholds of each participant were calculated as an objective measure of hearing ability. This was achieved by fitting a logistic function to the performance data against the SNR levels. The SRT was calculated for each participant by determining the SNR value required for 50% correctly reported digit triplets (Herrmann, 2023; Ramkissoon et al., 2002). DIN tasks are widely and consistently used as measures of hearing thresholds to assess hearing abilities (De Sousa et al., 2020; Herrmann, 2023; Ramkissoon et al., 2002; Smits et al., 2004, 2013), and these SRTs correlate well with the pure-tone average (PTA) threshold derived from pure-tone audiometry (Chee et al., 2024; Ramkissoon et al., 2002; Smits et al., 2004). An independent-samples t test was used to compare DIN thresholds between age groups. In addition, previous work has provided the regression coefficients that describe the linear relation between audiometric PTA thresholds and DIN thresholds ($\beta1 = 4.94$, $\beta0 = 33.84$; for slope and intercept, respectively; Smits et al., 2004). We used Smits et al.'s regression coefficients to provide mean PTAs for both age groups (Herrmann, 2023). The PTAs were used to describe the hearing thresholds by age group. However, these were not used to classify participants into different hearing classes (normal, mild, severe, etc.) due to the indirect estimation through the DIN thresholds and the variation in hearing abilities with age (Humes, 2013; Liu & Yan, 2007; Olusanya et al., 2019).

Sentence Materials

The basic English lexicon (BEL) sentences were used as the main auditory stimuli in both Experiment 1 and Experiment 2 (Calandruccio & Smiljanic, 2012; O'Neill et al., 2020). The BEL sentences are a set of relatively simple, short sentences with documented syntactic structures that have been used in several speech perception experiments (Calandruccio & Smiljanic, 2012; O'Neill et al., 2020). The BEL sentences comprise high-meaning sentences (e.g., "my DOCTOR WORKS in that BUSY HOSPITAL") and low-meaning sentences (e.g., "my HAT DRINKS in the CROWDED SCHOOL"). High-meaning sentences had intact syntactic structure and were semantically congruent, whereas low-meaning sentences had intact syntactic structure and were semantically incongruent. Each sentence of both sentence types comprised four keywords (nouns, adjective, verb, or adverb; indicated in block letters in the examples above) that were used to score word report accuracy (O'Neill et al., 2020). In Experiment 1, high-meaning and low-meaning sentences were contrasted. In Experiment 2, only high-meaning sentences were used and paired with additional context speech, described in detail below.

Auditory sentence materials were created using Google's artificial intelligence (AI)-based text-to-speech synthesizer (van den Oord et al., 2016). Modern AI-based speech is highly naturalistic, shows similar speech-in-noise perception effects compared to human-spoken speech, and can be generated quickly (Herrmann, 2023). The male US-English Studio voice (*en-US-Studio-Q*) with default speaking rate (1.0) and pitch (1.0) was used. Sentences were sampled at 44,100 Hz.

Sentences were masked by a 12-talker babble (i.e., 12 people talking in the background while the target speech was played; Bilger et al., 1984). Background babble was added to the sentences at different SNRs. Speech in quiet was used as well. For Experiment 1, the levels were as follows: speech in quiet and speech at −11, −8.33, −5.67, −3, −0.33, +2.33, and +5 dB SNR. For Experiment 2, slightly different levels were chosen to fully capture the effects of speech context (described below): speech in quiet and speech at −13, −10, −7, −4, −1, +2, and +5 dB SNR.

A modulated and an unmodulated masker were created to investigate the masking-release benefit for speech intelligibility (Gustafsson & Arlinger, 1994; Irsik et al., 2022; Tanner et al., 2019). For the modulated masker, an amplitude modulation was implemented by multiplying a 4-Hz sinusoidal wave (100% depth) to the 12-talker babble. This frequency was chosen as it is within the range of amplitude modulation frequencies that are particularly important for speech processing (Edwards & Chang, 2013; Rosen, 1992) and because previous work, including the Irsik et al. (2022) study on which the current study is built, also used a 4-Hz modulated masker (Herrmann, 2023; Irsik et al., 2022). Moreover, this modulation frequency allows for consistency across electroencephalography studies in neural synchronization during speech processing (Goossens et al., 2016; Irsik et al., 2021). The SNR was determined after the modulation was applied to the masker. For the unmodulated masker, no amplitude modulation was implemented. Note that no babble was added to the target speech in quiet, nor to any of the context speech for Experiment 2 (see below). Details about the experimental procedures and the number of sentences for each condition are provided in the respective methods sections of each experiment.

Data Analysis

Word report scores were calculated using AutoScore (Borrie et al., 2019; Herrmann, 2025), which is a package in R code (Rstudio v.2022.12.0) that determines the number of words that match between two sentences (i.e., the target sentence and the participant's response). AutoScore accounts for specific errors that a human rater typically corrects before scoring, such as variations in tense (e.g., "start" in the target and "started" in the response; Borrie et al., 2019; Herrmann, 2023). Word-report scores using

AutoScore have been shown to be highly similar to word-report scores from humans, while the former drastically reduces scoring time (Borrie et al., 2019; Herrmann, 2025). Prior to generating word-report scores from Autoscore, data were cleaned and organized. Specifically, determiners (e.g., the, a, that, there) were excluded from participants' responses to focus analyses on the keywords in the sentences (nouns, adjectives, etc.; O'Neill et al., 2020). It is common practice to analyze word-report data for just the keywords in sentences and to exclude determiners when assessing speech intelligibility in younger and older adults (see Gifford et al., 2007; Gustafsson & Arlinger, 1994; Helfer & Freyman, 2008; Mamo & Helfer, 2021; Sun et al., 2022). Word-report scores were used to calculate the proportion of correctly reported words, separately for each participant, speech-clarity condition, masker type, and context manipulation.

The dependent measure was the SRT. SRTs have been widely used as a measure of intelligibility and hearing abilities in the literature (Chee et al., 2024; George et al., 2006; Herrmann, 2023; Irsik et al., 2022; Ramkissoon et al., 2002; Smits et al., 2004, 2013; Sun et al., 2022; Yoon et al., 2023). A logistic function was fit to the proportion of correct words against the seven SNR conditions, separately for each participant and condition (speech in quiet was not included in this analysis because it has no numerical SNR). The logistic function used here comprised three parameters:

$$y = \frac{K}{\left(1 + e^{-r(x - x_0)}\right)}, \tag{1}$$

where r is the slope, x_0 is the inflection point or the SRT associated with 50% speech intelligibility, and K is the capacity or limiting value (allowing for the maximum proportion of correctly reported words to be lower than 1 (e.g., "low-meaning" sentences may lead to a lower than 1 proportion of correct words even for speech at very high SNRs). The variable x refers to the SNR levels. The SRT was used as the dependent variable in both experiments of the current study.

Experiment 1

Experiment 1 investigated whether reducing the semantic meaning in a sentence would reduce the intelligibility benefit from the masking release (unmodulated minus modulated maskers) for older adults more so than for younger adults. To this end, we contrasted word-report performance (SRTs) of younger and older participants listening to "high-meaning" and "low-meaning" sentences in background babble.

Methods and Materials

Participants

Sixty-nine participants completed the study, with 36 younger adults (22–33 years, $n_{\text{female}} = 13$, $n_{\text{male}} = 23$, $M_{\text{age}} = 25.56$ years, $SD_{\text{age}} = 2.35$ years) and 33 older adults (58–76 years, $n_{\text{female}} = 10$, $n_{\text{male}} = 23$, $M_{\text{age}} = 64.70$ years, $SD_{\text{age}} = 5.10$ years). Data from 16 additional participants were recorded but excluded from the study for a failure to meet one and/or more of the following criteria: Two participants reported being distracted during the experiment, 10 participants had scored lower than 0.85 in the proportion of correctly reported words in the speech-in-quiet conditions (speech in quiet is highly intelligible, suggesting that these participants did not comply with the task), two participants reported using hearing aids, one participant had a history of neurological disorders, and one participant had a very high DIN hearing threshold (> 10 dB SNR), suggesting either severe hearing loss or task noncompliance. Hence, out of an initial sample of 85, data from 69 participants were used for analysis.

Speech Intelligibility Task

In Experiment 1, 128 low-meaning and 128 high-meaning BEL sentences were used (O'Neill et al., 2020). For all sentences, we analyzed the degree of sentence meaning using large language models. Specifically, we calculated two metrics: a meaningfulness rating score and a word-similarity score. For the rating score, OpenAI's chat completions were used with the gpt-3.5-turbo model (OpenAI Platform, 2023). The model was prompted with "Rate the meaningfulness of the following sentence on a scale from 0 (not meaningful) to 100 (very meaningful):" followed by a sentence. This resulted in one meaningfulness rating score for each sentence. Rating scores were significantly lower for low-meaning compared to high-meaning sentences, $t(254) = 21.785$, $p = 4 \times 10^{-60}$ (see Figure 1B, left). For the word-similarity score, OpenAI's text-embedding model was used (e.g., text-embedding-3-small; OpenAI Platform, 2023) to obtain an embedding vector with 1,536 dimensions that represents the semantic meaning of a word. An embedding vector was obtained for each keyword of a sentence. The Spearman correlations between the embedding vectors of all keywords of a sentence were calculated and subsequently averaged to obtain a word-similarity score for each sentence. The word-similarity score was greater for high- compared to low-meaning sentences, $t(254) = 7.335$, $p = 3 \times 10^{-12}$ (see Figure 1B, right). These analyses highlight the semantic differences between the low- and high-meaning sentences.

Each participant listened to 64 low-meaning and 64 high-meaning sentences (see Supplemental Material S1 for Experiment 1 stimulus list; https://osf.io/bjzr8/). Half of

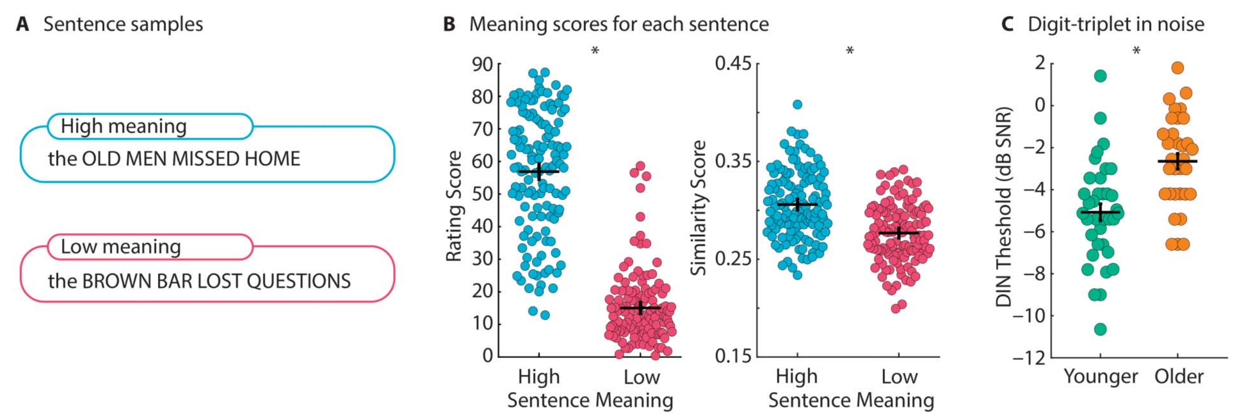


Figure 1. Stimuli, stimulus quantification, and digits-in-noise (DIN) thresholds. (A) Samples for the high- and low-meaning sentences. The words capitalized are the keywords from O'Neill et al.'s list (2020). (B) Scores that characterize the meaning of each sentence. Left: meaning scores as rated by gpt-3.5-turbo (on a scale from 0 to 100). Right: average correlation of text-embedding vectors between key words of a sentence. (C) DIN speech reception thresholds for younger and older adults. In Panels B and C, individual dots reflect the scores for each sentence (B) or participant (C). The black horizontal line reflects the mean across sentences/participants. Error bars reflect the standard error of the mean. $^{*}p \leq .05$.

the sentences were assigned to the modulated masker condition, whereas the other half were assigned to the unmodulated masker condition. Sentences were presented under eight different speech-clarity conditions: speech in quiet and speech at −11, −8.33, −5.67, −3, −0.33, +2.33, and +5 dB SNR. Hence, participants listened to four sentences per sentence type (low, high), masker type (unmodulated, modulated), and SNR (eight levels). Note that for counterbalancing purposes, the speech-in-quiet condition was also included in the factorial design that includes masker type, but no background babble was added. Hence, eight clear sentences were presented. They were used to screen out participants who did not comply with the task, but otherwise not further considered in the data analysis. The 128 sentences (8 SNR levels × 2 sentence types × 2 masker types × 4 sentences) were randomly distributed across four separate blocks of presentation.

To avoid confounding a specific sentence with a specific SNR, we generated 32 versions of the experimental stimuli, and participants were randomly assigned to one of these versions. In each version, the SNR levels and masker types were pseudorandomly assigned to a specific sentence.

On each trial, participants were presented with one sentence concurrently with a fixation cross at the center of the computer monitor. Upon the offset of the sentence, a text box appeared on the screen and participants were instructed to type the sentence they heard into the text box verbatim (for other work using typed responses, see Cooke & García Lecumberri, 2021; Herrmann et al., 2023; Irsik et al., 2022; Melguy & Johnson, 2021; Shen & Wu, 2022). They were encouraged to type any part of the sentence they could comprehend, even if it was only selected words from the target sentence. After a response was made, the experiment moved on to the next trial.

In addition to the 128 sentences used in the main experimental procedures, participants also listened to six training sentences (modulated and unmodulated at high SNRs) at the beginning of the speech intelligibility task to become familiarized with the task. Only meaningful sentences were presented in the training block, and no feedback was provided.

The SRT (the SNR at which participants report 50% of the words correctly) was calculated from logistic function fits for each condition, as described in the General Methods section, and used as the dependent variable in a repeated-measures analysis of variance (rmANOVA). Masker type (modulated, unmodulated) and sentence type (high meaning, low meaning) were within-participant factors, and age group (younger, older) was a between-participants factor. Generalized eta square (η^2_G) was used as a measure of effect size for the rmANOVA. The Holm correction (Holm, 1979) was applied for post hoc tests, and Cohen's *d* (J. Cohen, 1988) is provided as the corresponding effect size measure.

Results

Older adults had significantly higher thresholds in the DIN task compared to younger adults, $t(67) = 4.381$, $p = 4.3 \times 10^{-5}$, $d = 1.056$ (see Figure 1C). DIN thresholds correspond to an approximate mean four-frequency PTA of ~8.8 dB HL for younger adults and ~20.8 dB HL for older adults.

For the speech intelligibility task, SRTs were lower for high-meaning than low-meaning sentences (effect of sentence type: $F(1, 67) = 124.927$, $p = 5.8 \times 10^{-17}$, $\eta^2_G = 0.144$), modulated than unmodulated maskers (effect of masker type: $F(1, 67) = 132.343$, $p = 1.6 \times 10^{-17}$, $\eta^2_G = 0.185$), and younger than older adults (effect of age group: $F(1, 67) = 27.227$, $p = 1.9 \times 10^{-6}$, $\eta^2_G = 0.216$; see Figures 2A and 2B).

Critically, younger adults benefited more from the modulated relative to the unmodulated masker compared to older adults (Masker Type × Age Group interaction: $F(1, 67) = 20.822$, $p = 2.2 \times 10^{-5}$, $\eta^2_G = 0.034$; see Figure 2C, left), but both younger and older adults had lower thresholds, that is, better intelligibility, for the modulated compared to the unmodulated masker (younger: $t(67) = 11.616$, $p_{Holm} = 6.3 \times 10^{-17}$, $d = 1.313$; older: $t(67) = 4.805$, $p_{Holm} = 2.7 \times 10^{-5}$, $d = 0.567$).

The Sentence Type × Masker Type interaction was also significant, $F(1, 67) = 4.298$, $p = .042$, $\eta^2_G = 0.007$, showing that the benefit from masking release (unmodulated minus modulated masker) was greater for high-meaning compared to low-meaning sentences. The masking-release benefit was significant for both high-meaning sentences, $t(67) = 9.586$, $p_{Holm} = 3.4 \times 10^{-16}$, $d = 1.110$, and low-meaning sentences, $t(67) = 6.648$, $p_{Holm} = 2.1 \times 10^{-9}$, $d = 0.770$ (see Figure 2C, right).

The Sentence Type × Age Group interaction, $F(1, 67) = 0.102$, $p = .750$, $\eta^2_G = 1.4 \times 10^{-4}$, and the Sentence Type × Masker Type × Age Group interaction, $F(1, 67) = 0.802$, $p_{Holm} = 0.372$, $\eta^2_G = 0.001$, were not significant. The latter may indicate that the release-from-masking effect (unmodulated minus modulated masker) was not specifically reduced for older adults when listening to low- compared to high-meaning sentences. In fact, an explorative analysis indicates that reducing sentence meaning lead to a smaller masking-release benefit in younger adults, $t(35) = 2.098$, $p = .043$, $d = 0.350$ (see Figure 2B, left), but not in older adults, $t(32) = 0.387$, $p = .409$, $d = 0.146$. This suggests that even with a higher number of participants, and thus greater statistical power, it appears unlikely that we would observe a greater impact of the reduced sentence meaning on the masking release in older compared to younger adults.

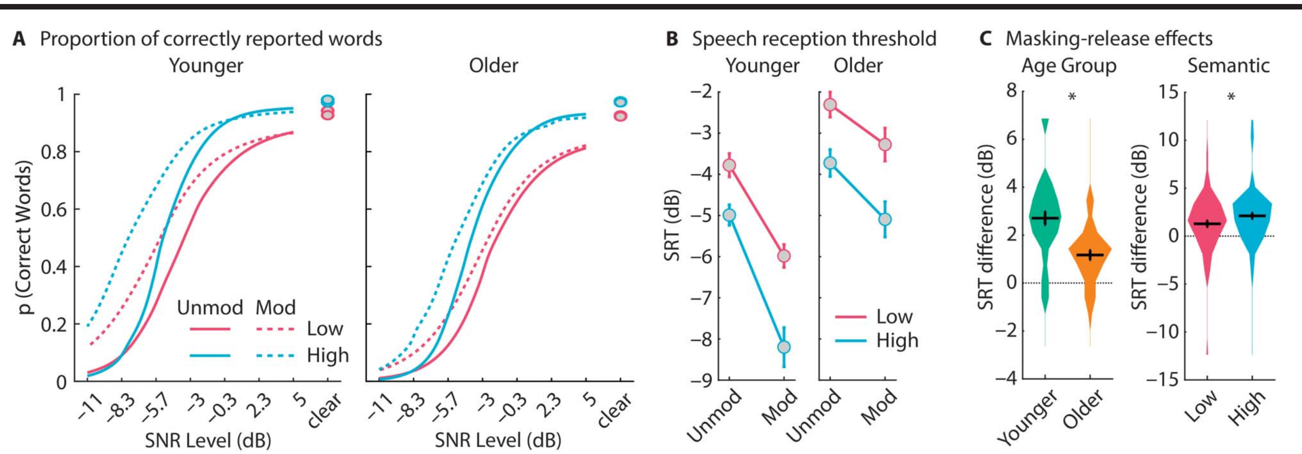
Summary

Experiment 1 aimed to elucidate whether reducing semantic context (quantified as sentence meaningfulness) would impair older adults' intelligibility benefit from speech glimpses released by amplitude-modulated background maskers more than younger adults. Although we find evidence that the benefit from speech glimpses was reduced for low-meaning compared to high-meaning sentences, we did not observe that this differed between age groups. The results suggest that semantic information at the level of short sentences cannot explain previously observed enhanced benefits from speech glimpses in older people during story listening (Irsik et al., 2022).

Experiment 2

Experiment 2 investigated whether providing additional semantic context for a sentence would increase the

Figure 2. Results for Experiment 1. (A) Logistic function fits to the proportion of correctly reported words (average across predicted data from fits to individual participants). A function shifted to the left indicates greater intelligibility (lower speech reception thresholds). (B) Mean speech reception threshold for each sentence type (high meaning, low meaning), masker type (modulated [mod], unmodulated [unmod]), and age group (younger, older). Error bars represent standard errors of mean. (C) Release from masking effect calculated as the difference in speech reception threshold between the unmodulated and the modulated masker for the two age groups (younger vs. older; left) and the sentence types (low vs. high meaning; right). A value of 0 indicates no masking release (i.e., no difference between the benefit). Masking release was greater for younger compared to older adults (Masker Type × Age Group interaction) and for "high meaning" compared to "low meaning" sentences (Sentence Type × Masker Type interaction). *$p \le .05$. SNR = signal-to-noise ratio.



intelligibility benefit from the masking release (unmodulated minus modulated maskers) for older adults more so than for younger adults. To this end, we generated context sentences for the target speech and contrasted word-report performance (SRTs) of younger and older participants listening to speech where the context sentences "matched" versus "mismatched" with target sentences in background babble.

Methods and Materials

Participants

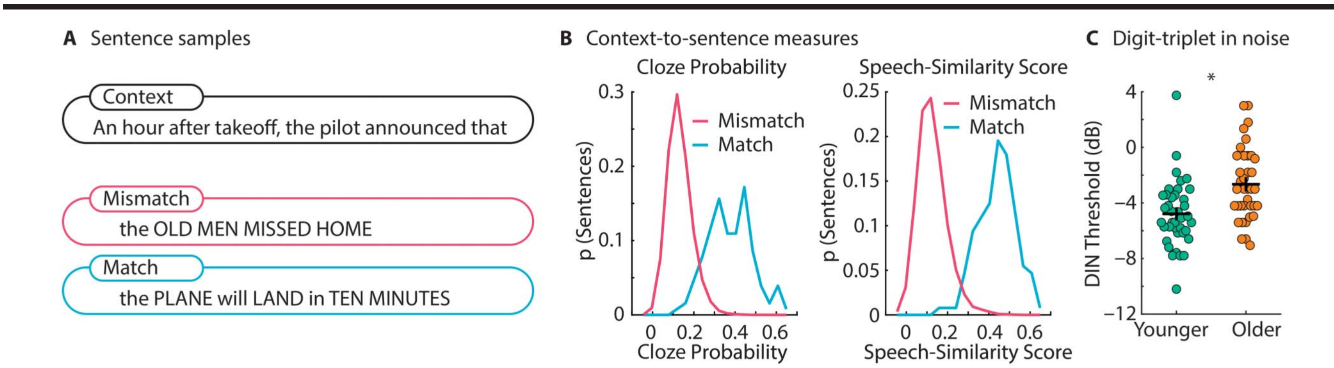
Seventy-six participants completed the study, with 39 younger adults (21–33 years, $n_{\text{female}} = 12$, $n_{\text{male}} = 27$, $M_{\text{age}} = 27.82$ years, $SD_{\text{age}} = 3.36$ years) and 37 older adults (59–76 years, $n_{\text{female}} = 13$, $n_{\text{male}} = 24$, $M_{\text{age}} = 65.54$ years, $SD_{\text{age}} = 4.69$ years). Data from 12 additional participants were recorded but excluded from analysis due to one or more of the following reasons: One participant reported being distracted, three participants reported having a neurological disorder, one participant was wearing or was prescribed a hearing aid, five participants had scored lower than 0.85 in the proportion of correctly reported words in the speech-in-quiet conditions, and one participant had a very high DIN threshold (> 10). This led to the exclusion of 12 participants from an initial sample of 88.

Sentence Materials

In Experiment 2, we selected 128 sentences of the high-meaning BEL sentences (O'Neill et al., 2020). For each of the 128 sentences, we generated context speech that consisted of a sentence part. Context speech was created using OpenAI's chat completions with the gpt-3.5-turbo model. We used the model prompt "Provide a short first half of a sentence that leads towards the following second half of a sentence:", followed by the high-meaning sentence to obtain several suggestions. Since some of the gpt outputs appeared too generic to provide specific context to some target speech, we further modified and edited the responses from gpt-3.5-turbo (e.g., by providing more details or providing specific contextualizing words), if deemed beneficial, before selecting the best 128 pairs of the generated context and their target, high-meaning sentences. Modifications of gpt outputs were done manually through discussions among the two authors. The generated context speech provided additional context for the target, high-meaning sentence that followed, without using any of the words from the target sentence (see Figure 3A). The context speech was designed such that it could be the first half of a longer sentence that ended with the target sentence (see Supplemental Material S2 for Experiment 2 stimulus list; https://osf.io/bjzr8/).

To investigate the degree to which context speech predicted target sentences, two metrics were calculated: cloze probability (inspired by cloze probability for sentence final words; Bieber et al., 2022; Block & Baldwin, 2010; Frade et al., 2024) and a speech-similarity score. For the cloze probability, each of the 128 context speech items was fed into OpenAI's gpt-3.5-turbo model (OpenAI Platform, 2023) to generate 100 target sentences (using the prompt: "Finish this sentence:", followed by the context speech item). For each of the 100 generated target sentences, the corresponding embedding vector was obtained

Figure 3. Stimuli, stimulus quantification, and digits-in-noise (DIN) thresholds. (A) Sample of context speech and samples for mismatching and matching sentence. The words capitalized in the "Mismatch" and "Match" sentences are the keywords from O'Neill et al.'s (2020) list. (B) Histograms of the scores that characterize the relationship between context and target sentences (mismatch, match). Left: Cloze probability was calculated by using OpenAI's GPT-3.5 to generate a target sentence given the context speech and then calculating the Spearman correlation between the embedding vector of the generated target sentence and the embedding vector of the actual target sentence. Right: The speech-similarity score was calculated as the Spearman correlation between the embedding vector of the context speech and the embedding vector of a target sentence. (C) DIN speech reception thresholds for younger and older adults. Individual dots reflect the threshold for each participant. The black horizontal line reflects the mean across participants. Error bars reflect the standard error of the mean. *$p \le .05$.



(model: text-embedding-3-small). The Spearman correlation between the embedding vectors of the 100 gpt-generated target sentences and the embedding vector of the actual target sentence was calculated. The median across the 100 correlation values was taken as the cloze probability value for the target sentence. Cloze probability was also calculated for mismatching context speech. To this end, Spearman correlations between the embedding vector of the actual target sentence and the embedding vectors of the 100 gpt-generated target sentences for all other 127 context speech items were calculated. Histograms of the cloze probability for matching and mismatching context speech are shown in Figure 3B (left). The cloze probability for 93% of target sentences with matching context was equal or greater than the 95th percentile of the cloze probability for target sentences with mismatching context. Cloze probability significantly differed between matching and mismatching contexts, $t(254) = 25.493$, $p = 5.7 \times 10^{-72}$.

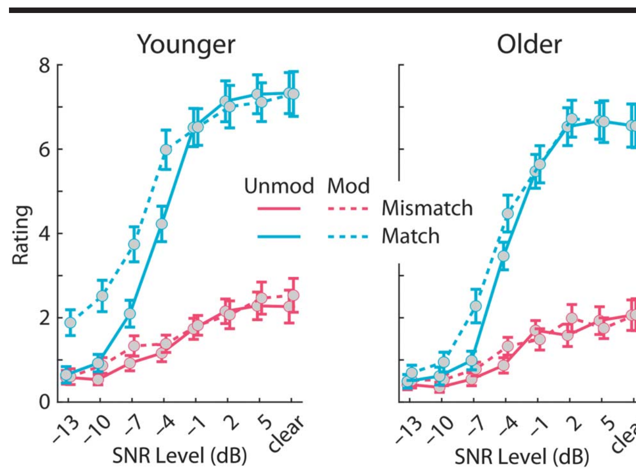
The speech-similarity score was calculated as follows: For each of the 128 sentences, we calculated the Spearman correlation between the embedding vector of context speech and the embedding vector of the target sentence. We further calculated the Spearman correlation between the embedding vector of the target sentence and the embedding vectors corresponding to the other 127 context speech items. Histograms of the speech-similarity score for matching and mismatching context speech are shown in Figure 3B (right). The speech-similarity score for 98% of target sentences with matching context was equal or greater than the 95th percentile of the speech-similarity score for target sentences with mismatching context. The speech-similarity score significantly differed between matching and mismatching contexts, $t(254) = 38.32$, $p = 1.4 \times 10^{-107}$.

Speech Intelligibility Task

Each participant listened to 64 high-meaning BEL sentences preceded by matching context speech and 64 high-meaning BEL sentences preceded by mismatching context speech. Context speech was always presented under clear conditions. Half of the target sentences were assigned to the modulated masker condition, whereas the other half were assigned to the unmodulated masker condition. Target sentences were presented under eight different speech-clarity conditions: speech in quiet and speech at −13, −10, −7, −4, −1, +2, and +5 dB SNR. Hence, participants listened to four sentences per context type (mismatch, match), masker type (unmodulated, modulated), and SNR (eight levels). For counterbalancing purposes, the speech-in-quiet condition was included in the SNR factor, but no background babble was added for the speech-in-quiet condition. Hence, eight clear sentences were presented. The 128 sentences (4 sentences × 8 SNR levels × 2 sentence types × 2 masker types) were randomly distributed across four separate blocks of presentation. As in Experiment 1, to avoid confounding a specific sentence with a specific SNR, we generated 32 versions of the experimental stimuli, and participants were randomly assigned to one of these versions. In each version, the SNR levels and masker types were pseudorandomly assigned to a specific target sentence.

On each trial, the context speech was presented under clear conditions and concurrently displayed in written form on the computer screen. Pilot testing suggested that writing out the context speech facilitates its processing. The context speech was followed by a 600-ms silence, during which a blank screen was presented, after which a high-meaning sentence was played while a green fixation cross was shown on the screen. After the offset of the target sentence, a text box appeared on the screen and participants were asked to type the words of the second sentence. Similar to Experiment 1, participants were encouraged to type any part of the sentence they could comprehend, even if they could only report selected words from the sentence. Following each response, participants rated how much the first sentence helped them understand the second sentence, using a rating scale that ranged from 0 (*did not help*) to 10 (*helped*). Rating scores for the matched context were greater than rating scores for the mismatched context, as expected, $t(75) = 16.455$, $p = 1.3 \times 10^{-26}$ (see Figure 4). As in Experiment 1, participants also listened to six training sentence pairs (modulated and unmodulated at high SNRs) in addition to the 128 sentence pairs used in the main experiment. This was administered at the beginning of the speech intelligibility task to allow participants to become familiarized with the task. Only matched context–target pairs of sentences were presented in the training block, and no feedback was provided.

Figure 4. Ratings of helpfulness of context speech. SNR = signal-to-noise ratio.



The SRT (the SNR at which participants report 50% of the words correctly) was calculated from logistic function fits for each condition, as described in the General Methods section, and used as the dependent variable in an rmANOVA. Masker type (modulated, unmodulated) and context type (mismatch, match) were within-participant factors, and age group (younger, older) was a between-participants factor. η^2_G was used as a measure of effect size for the rmANOVA. The Holm correction (Holm, 1979) was applied for post hoc tests, and Cohen's *d* (J. Cohen, 1988) is provided as the corresponding effect size measure.

Results

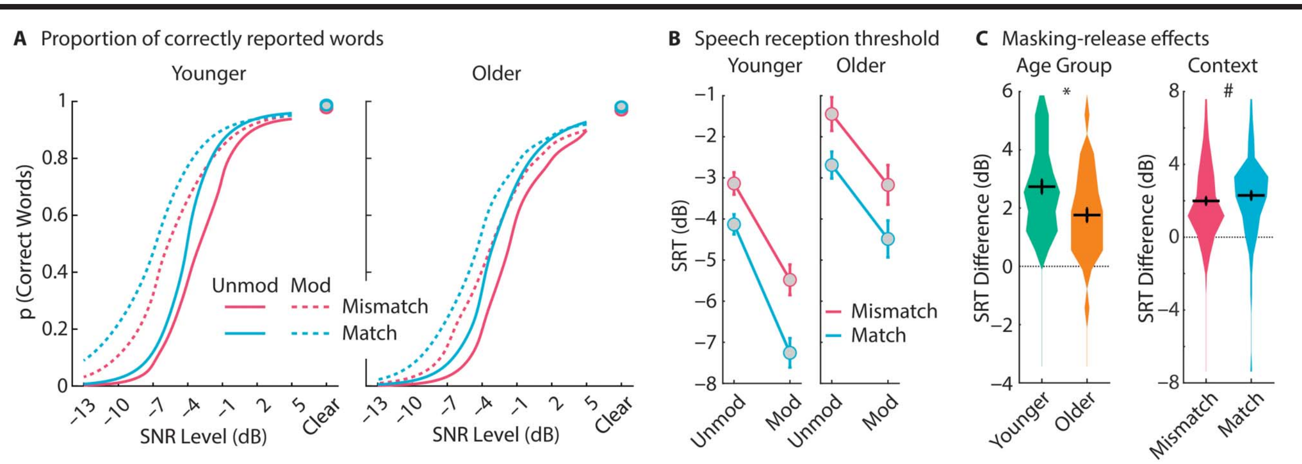
Older adults had significantly higher thresholds than younger adults in the DIN task compared to younger adults, $t(74) = 3.727$, $p = 3.8 \times 10^{-4}$, $d = 0.855$ (see Figure 3C, left). Younger adults had an approximate mean PTA of 10.2 dB HL, whereas that for older adults was 20.8 dB HL.

Thresholds were lower for sentences for which the context was matched compared to mismatched with the target sentences (effect of context type: $F(1, 74) = 99.260$, $p = 2.6 \times 10^{-15}$, $\eta^2_G = 0.081$). Thresholds were also lower for younger compared to older adults (effect of age group: $F(1, 74) = 19.822$, $p = 3 \times 10^{-5}$, $\eta^2_G = 0.174$) and for modulated compared to unmodulated maskers (effect of masker type: $F(1, 74) = 191.466$, $p = 3.2 \times 10^{-22}$, $\eta^2_G = 0.201$; see Figures 5A and 5B).

Critically, younger adults benefitted more from the modulated relative to the unmodulated masker compared to older adults (Masker Type × Age Group interaction: $F(1, 74) = 9.016$, $p = .004$, $\eta^2_G = 0.012$; see Figure 5C, left), but both younger and older adults had lower thresholds for the modulated compared to the unmodulated masker (younger: $t(74) = 12.067$, $p_{Holm} = 2.2 \times 10^{-18}$, $d = 1.206$; older: $t(74) = 7.562$, $p_{Holm} = 3.6 \times 10^{-10}$, $d = 0.776$).

The Context Type × Masker Type interaction was marginally significant, $F(1, 74) = 3.292$, $p = .074$, $\eta^2_G = 0.002$, due to the slightly larger benefit from masking release for sentences preceded by matching compared to mismatching context speech (see Figure 5C, right). The other interactions were not significant (Context Type × Age Group: $F(1, 74) = 0.159$, $p = .692$, $\eta^2_G = 1.4 \times 10^{-4}$; Context Type × Masker Type × Age Group: $F(1, 74) = 2.247$, $p = .138$, $\eta^2_G = 0.002$). The absence of the three-way interaction suggests that speech context, although improving overall intelligibility, did not help older adults to benefit more from the masking release than younger adults. In fact, if anything, younger adults showed a greater masking release benefit for sentences preceded by matching compared to mismatching context speech, $t(38) = 2.166$, $p = .037$, $d = 0.347$ (see Figure 5B), whereas this was not the case for older adults, $t(36) = 0.248$, $p = .806$, $d = 0.041$. Although this latter analysis is explorative, because the three-way interaction was not significant, it does indicate that even more participants, and thus more statistical power, would be unlikely to lead to the hypothesized context benefit for the masking release for older adults.

Figure 5. Results for Experiment 2. (A) Logistic function fits to the proportion of correctly reported words (average across predicted data from fits to individual participants). A function shifted to the left indicates greater intelligibility (lower speech reception thresholds). (B) Mean speech reception threshold for each context type (mismatch, match), masker type (modulated [mod], unmodulated [unmod]), and age group (younger, older). Error bars represent standard errors of mean. (C) Release from masking effect calculated as the difference in speech reception threshold between the unmodulated and the modulated masker for the two age groups (younger vs. older; left) and the context types (mismatch vs. match; right). A value of 0 indicates no masking release (i.e., no difference between the benefit). Masking release was greater for younger compared to older adults (Masker Type × Age Group interaction) and marginally greater for context speech that matched than mismatched with the target sentence (Context Type × Masker Type interaction). *$p \leq .05$, #$p \leq .1$. SNR = signal-to-noise ratio; SRT = speech reception threshold.



Summary

Experiment 2 aimed to determine whether older adults benefit more from speech glimpses for understanding speech when extended semantic context is present. Results show that although semantic context provides intelligibility benefits from speech glimpses (marginally significant), this did not differ between age groups. Hence, the data provide no evidence that semantic context drives greater speech-glimpse benefits in older compared to younger adults observed previously for story listening (Irsik et al., 2022).

Discussion

In the current study, we investigated the degree to which semantic context helps older adults to increase their intelligibility benefit from speech glimpses released by a fluctuating (modulated) background babble. In Experiment 1, we compared the intelligibility of low- to high-meaning sentences presented in modulated or unmodulated background babble. We show that younger adults benefit more from modulated compared to unmodulated background babble than older adults. This masking-release benefit was greater for high- than low-meaning sentences, but there was little indication that older adults benefit more than younger adults from high-meaning sentences. In Experiment 2, context speech that either semantically matched or mismatched was presented prior to target sentences in modulated or unmodulated babble. As for Experiment 1, speech intelligibility of younger adults improved more by the modulated compared to the unmodulated babble than intelligibility of older adults. Matching semantic context improved speech intelligibility, but there was again little indication that older adults benefit more than younger adults from semantic context. The current results suggest that semantic context is insufficient to enhance benefits from speech glimpses in older adults over and beyond the benefits in younger adults.

Speech Intelligibility and Masking Release Are Reduced in Older Adults

Many previous studies have found that older adults have lower speech intelligibility in noise than younger adults (Buss et al., 2019; Füllgrabe et al., 2015; George et al., 2006; Herrmann, 2023; Pichora-Fuller et al., 1995; Schneider et al., 2002; Tun, 1998; Weissgerber et al., 2022), and our results from both experiments replicate these findings (see Figures 2 and 4). Age-related differences in intelligibility for sentences may arise from peripheral decline in older adults (Bao & Ohlemiller, 2010; Dubno et al., 2013; Howarth & Shone, 2006; Keithley, 2020; Lee, 2015), changes in auditory neural structures (Auerbach et al., 2014; Herrmann & Butler, 2021; Presacco et al., 2016; Salvi et al., 2017; Zhao et al., 2016), and cognitive changes associated with aging processes (Dey & Sommers, 2015; Fogerty et al., 2021; Fortunato et al., 2016; Mamo & Helfer, 2021; Murman, 2015; Pichora-Fuller & Singh, 2006; Salthouse, 2010; Slade et al., 2020).

The DIN data and converted PTA thresholds suggest that the older adults in the current study had some hearing loss that is consistent with age-related hearing decline of community-dwelling older adults (Cruickshanks et al., 2003; Reed et al., 2023; Wiley et al., 2008). This may have contributed to the age-related differences in benefit from masking release. However, the Irsik et al. (2022) study used similar recruitment procedures and participant demographics. Their study shows that older adults can benefit from masking release more than younger adults in spite of different hearing thresholds. This suggests that factors above and beyond hearing abilities are contributing to this effect. Older adults can also have reduced working memory, verbal reasoning, and cognitive inhibition relative to younger adults (Aydelott et al., 2010; Füllgrabe et al., 2015; Pichora-Fuller, 2008; Pichora-Fuller et al., 1995), and intelligibility for sentences may be more vulnerable to changes in cognition than intelligibility for phonemes or consonants (Heinrich et al., 2015).

In both experiments, we observed that listeners find speech more intelligible when it was masked by a modulated compared to an unmodulated masker, such that individuals benefit from the speech glimpses released at times when the masker intensity is briefly reduced. Moreover, older adults benefited less from the modulated masker than younger adults (see Figures 2 and 4). Both results have been shown in previous studies (Dubno et al., 2002; Fogerty et al., 2022; George et al., 2006; Gifford et al., 2007; Herrmann, 2023; Irsik et al., 2022; Mamo & Helfer, 2021; Smith & Fogerty, 2021; Tanner et al., 2019). The age-related reduction in the masking-release benefit is thought to be due to deficits in temporal speech processing (Füllgrabe et al., 2015; Grose et al., 2009; Hopkins & Moore, 2011; Pichora-Fuller & Singh, 2006; Schneider et al., 1994; Stuart & Phillips, 1996). Moreover, studies have shown increased neural tracking of amplitude-modulated noises, similar to the speech maskers used here, in older compared to younger adults (Goossens et al., 2016, 2019; Herrmann et al., 2023; Irsik et al., 2021; Purcell et al., 2004). Such neural hyperresponsiveness to sound is thought to impair the processing of speech in the presence of background masking noise (Herrmann & Butler, 2021; Parthasarathy et al., 2020), potentially providing an additional contribution to a reduced benefit from speech glimpses.

The 12-talker babble used in the current study masks the speech energetically more than informationally (Brungart, 2001; Li et al., 2016; Lidestam et al., 2014; Pollack, 2005), because both overlap spectrally and the 12 talker babble does not permit identifying syllables or words in the masker that could interfere with the content of the speech. Future studies could explore age-related differences in masking release when more informational masking is also present, for example, by comparing speech perception using a two- or three-talker babble to babble-modulated noise, which mimics the fluctuations in everyday noise to a larger extent compared to the amplitude modulated noise (Li et al., 2016).

Semantic Information Facilitates Speech Intelligibility in Both Younger and Older Adults

The current results show that semantic context—in the form of high- versus low-meaning sentences or additional semantically matching versus mismatching speech—improves speech intelligibility in both younger and older adults. This result was expected given the extensive body of previous work showing better speech intelligibility in rich semantic contexts (Buss et al., 2019; Dubno et al., 2000; Fitzgerald et al., 2024; Gordon-Salant et al., 2008; Moberly et al., 2023; Pichora-Fuller, 2008; Sheldon et al., 2008; Smayda et al., 2016; Sun et al., 2022; Vickery et al., 2022).

Previous research suggests that cognitive abilities associated with crystallized intelligence, such as semantic knowledge, are well intact and may even be stronger in older adults (Aydelott et al., 2010; Burke & Peters, 1986; Moberly et al., 2023; Pichora-Fuller, 2008). Moreover, research suggests that in challenging listening conditions, older adults may deploy more cognitive resources toward semantic processing in order to compensate for the perceptual deficits faced during listening (Aydelott et al., 2010; Cabeza, 2002; Moberly et al., 2023; Pichora-Fuller, 2008). Consistent with these works, several studies have found that older adults benefit more from contextual information in speech than younger adults (G. Cohen & Faulkner, 1983; Pichora-Fuller et al., 1995; Pichora-Fuller & Singh, 2006; Sheldon et al., 2008; Sun et al., 2022). Pichora-Fuller et al. (1995) attributed this differential benefit from context to older adults possessing larger semantic knowledge and using this to facilitate speech-in-noise perception.

However, the results of the current study provide no evidence for an enhanced benefit from contextual information—both from within-sentence semantic context and by providing additional context—in older compared to younger adults. Even though removing semantic context resulted in worse speech intelligibility thresholds (Experiment 1) and providing additional context improved intelligibility thresholds (Experiment 2), these effects did not differ between age groups (lack of Context × Age Group interaction). The discrepancy between our findings and those from previous studies could result from several factors. Sentence stimuli in previous and the current work differed. Previous studies mainly used the Revised Speech Perception in Noise (Bilger et al., 1984) test stimuli (Dubno et al., 2000; Fogerty et al., 2022; Gordon-Salant et al., 2008; Pichora-Fuller, 2008; Pichora-Fuller et al., 1995; Sheldon et al., 2008; Vickery et al., 2022), whereas a newer set of speech materials was used in the current study (Calandruccio & Smiljanic, 2012; O'Neill et al., 2020). Often, the semantic context is also masked by background noise (Dubno et al., 2000; Fogerty et al., 2022; Pichora-Fuller, 2008; Vickery et al., 2022), such as in Experiment 1 (see Figure 2), which could interfere with leveraging context. In Experiment 2, however, we show that even when the contextually supporting speech is presented under clear, and thus highly intelligible, conditions, younger and older adults benefit similarly for speech intelligibility of sentences in noise (see Figure 5). Moreover, other work shows, similar to the current results, that additional semantic information in noise-vocoded speech improves speech intelligibility similarly in younger and older adults (Moberly et al., 2023). The results may suggest that the context-related benefit in speech intelligibility for older adults may not generalize to all stimulus materials.

Moberly et al. (2023) suggested that interindividual differences in cognition could contribute to the absence of age group differences in the intelligibility benefit from semantic context. Younger adults may benefit from relatively intact fluid cognitive abilities, such as inhibition of irrelevant information or working memory (Harada et al., 2013; Idowu & Szameitat, 2023; Jia et al., 2023; Murman, 2015; Pichora-Fuller, 2008; Spieler et al., 1996), whereas greater semantic knowledge in older adults (Lalla et al., 2022; Lindenberger, 2014; Nilsson, 2003; Pichora-Fuller, 2008) may benefit them more. Indeed, reduced working memory span in older adults was associated with impairments in making predictions about upcoming words in sentences, as found in a sentence-reading EEG study (Federmeier & Kutas, 2005). Age-related differences in predictive processing generalize to speech listening in quiet as well (Broderick et al., 2021; Federmeier et al., 2002, 2003), suggesting that reductions in working memory span in older adults (Aydelott et al., 2010; Pichora-Fuller et al., 1995) could impair them from using semantic context to make predictions (Federmeier et al., 2010), and this could further impact speech intelligibility especially in more challenging conditions such as noise. Ultimately, sentences enable using cognitive strategies more than for words and phoneme stimuli (Billings et al., 2023; Heinrich et al., 2015), and sentence intelligibility will depend on how each person leverages perceptual and cognitive strengths, relative to declines.

Collectively, these studies suggest that there is variance in stimulus materials, perceptual systems, and/or cognition that affects whether older adults benefit from context more or similarly relative to younger adults. Our results support the view that both age groups exhibit similar benefits of semantic context.

Semantic Information Amplifies Speech Intelligibility Benefit From Modulated Maskers

The main motivation of the current study was to investigate the extent to which semantic context facilitates the release-from-masking benefit—that is, the improvement in speech intelligibility from a modulated relative to an unmodulated masker. In previous work using naturalistic stories that are rich in context, highly enjoyable and absorbing, and motivating to listen to, older adults benefited at least as much or more from speech glimpses than younger adults (Irsik et al., 2022). Speech in everyday life is often story-like (Bohanek et al., 2009; Hamilton & Huth, 2018; Herrmann & Johnsrude, 2020; Irsik et al., 2022), and characterizing speech understanding in older adults under such naturalistic conditions, as compared to the more artificial approaches with disconnected sentences that are typically used (Buss et al., 2019; Fogerty et al., 2021, 2022; George et al., 2006; Gifford et al., 2007; Gustafsson & Arlinger, 1994; Herrmann, 2023; Irsik et al., 2022; Vickery et al., 2022), is critical to advancing hearing loss diagnosis and evaluating treatment effectiveness. An enhanced benefit from speech glimpses in older adults in this previous story-listening work may have resulted from the semantic context provided by the stories and by the motivation to listen resulting from the enjoyable and absorbing nature of stories (Irsik et al., 2022).

Both experiments show that semantic context can increase the benefit from the masker releasing speech glimpses (although this was only marginally significant in Experiment 2). However, there was no indication that older adults benefit more than younger adults from semantic context for the masking-release intelligibility advantage (absence of three-way interaction). In fact, explorative analyses suggested that only younger, but less so older adults, drive the enhanced release-from-masking benefit associated with semantic context. Our results may suggest that semantic context, at least in the absence of engagement, is not sufficient in affecting older adults' benefit from masking release. There is an increasing discussion about the role of motivational factors influencing listening under acoustic challenges (Herrmann & Johnsrude, 2020; Peelle, 2018; Pichora-Fuller et al., 2016), and that older adults may be particularly motivated to invest cognitively when stimuli are meaningful to them (Hess, 2014; Hess & Ennis, 2014). Overall, there may thus be something about the nature of listening to naturalistic stories, such as extended thematic knowledge, motivation, or leveraging cognition, that may help older adults to benefit from speech glimpses more than younger adults in naturalistic settings.

Conclusions

The current study investigated whether older adults benefit more than younger adults from speech glimpses released by a fluctuating (modulated) background masker in situations that provide semantic context. Across two experiments, our results show that both younger and older adults understood speech better in the presence of a modulated compared to an unmodulated babble masker, although this benefit was larger for younger compared to older adults. Moreover, semantic context increased the intelligibility benefit for both younger and older adults, but this benefit was not larger for older adults. Our results thus provide little indication that older adults utilize contextual information to increase their benefit from speech glimpses compared to younger adults. That previous research found a greater speech-glimpse benefit in older than younger adults during story listening (Irsik et al., 2022) suggests that other factors inherent to naturalistic listening conditions may play a larger role than semantic context, such as increased motivation and engagement associated with story listening. The current results suggest that the deficit in masking-release (speech-glimpse) benefit in older adults generalizes to situations in which extended speech context is available.

Author Contributions

Priya R. Pandey: Conceptualization, Methodology, Formal analysis, Investigation, Visualization, Writing – original draft, Writing – review & editing. **Björn Herrmann:** Conceptualization, Methodology, Software, Formal analysis, Investigation, Data curation, Visualization, Writing – original draft, Writing – review & editing, Supervision, Project administration, Funding acquisition.

Data Availability Statement

The data sets generated and/or analyzed during the current study, as well as the supplemental materials, are available in the Open Science Framework repository, https://osf.io/bjzr8/.

Acknowledgments

The research was supported by the Canada Research Chair program (CRC-2019-00156) and the Natural Sciences and Engineering Research Council of Canada (RGPIN-2021-02602).

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