WHY DO YOUNGER ADULTS COMPREHEND MORE WHEN LISTENING TO CONVERSATIONS IN NOISY ENVIRONMENTS AND WHEN OTHER PEOPLE ARE TALKING?

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Abstract

Age-related deterioration in one's ability to comprehend speech plays a primary role in the difficulties many older adults experience when communicating, especially in a multi-talker auditory scene, which increases the complexity of both the perceptual and cognitive processes required for comprehension. These age-related difficulties could reflect age-related declines in the auditory, cognitive, and/or linguistic processes that support speech comprehension. In a recent line of studies, we asked younger and older participants to listen to conversations played against a babble background noise and to answer questions regarding their content. Individual hearing differences were compensated for by creating the same degree of difficulty in identifying individual words in babble. In addition, the precedence effect was used to create a perceived separation in order to eliminate interaural signal-to-noise (SNR) differences. The results show that once the SNRs are adjusted, no significant differences in speech comprehension were found between younger and older participants.

The ability to communicate in a noisy multi-talker environment is an essential requirement in everyday life. Unfortunately, age-related deterioration in one's ability to comprehend speech plays a primary role in the difficulties many older adults experience when communicating. Not being able to efficiently communicate in the presence of other talkers might lead to social isolation and loss of psychological/emotional and other support sources. These difficulties significantly increase in challenging listening environments containing more than one talker and background noise. Such multi-talker auditory scenes increase the complexity of both the perceptual and cognitive processes required for comprehension. For example, when listening to a dialogue, the listener needs to be able to perceptually segregate the two talkers from one another and from background chatter in order to comprehend what each person said, so that this information can be stored in memory and integrated with past knowledge.

Schneider et al. (2000) showed that age-related declines in the ability to process and remember a monologue could be eliminated when individual adjustments are made to compensate for the poorer hearing of older adult listeners. Murphy et al. (2006) adapted Schneider et al.'s methodology to study the ability of younger and older adults to follow two-talker conversations instead of single-talker monologues. They selected a series of engaging one-act plays, each involving dialogue between two characters of the same gender. Participants listened to the dialogues either in quiet or in a background of multi-talker babble noise. After listening to a 10-15 min dialogue, participants answered a set of 10 multiple-choice questions that tested their comprehension and/or memory of details about the conversation. In Experiments 1–3, the talkers were separated by 9^{o} or 45^{o} azimuth in order to

imitate a typical conversation where the two talkers participating in it are in different locations from one another. However, in a control experiment, no such spatial separation was present.

Their results indicated that the listening-to-conversation task produced a negative age difference when younger and older listeners were tested under identical stimulus conditions (Experiment 1) and that this negative age difference could be reduced but not eliminated when the listening situation is adjusted to make it equally difficult for younger and older adults to hear individual words when the two talkers are spatially separated (Experiments 2 and 3). The results of their last experiment (Experiment 4) showed that the negative age effect could be eliminated when listening situations were individually adjusted when there was no spatial separation present.

These results provided some evidence that older adults are indeed less skilled than younger adults at extracting and remembering information from a two-person conversation if adjustments have not been made for their poorer hearing abilities. In addition, the consistent age difference which was found as long as spatial separation between the two talkers was present, even after compensations had been made for the older listeners' deficits in hearing individual words, suggests that older adults might benefit from spatial separation to a lesser extent than younger adults.

When talkers are spatially separated, older listeners may not be able to take advantage of the auditory cues (such as SNR differences and interaural timing differences) that exist in such situations to help them perceptually segregate the two talkers to the same extent as younger listeners can. Alternatively, they might not be as adept as younger adults at switching attention from one spatial location to another. In order to further explore the sources of the age difference in the ability to comprehend a dialogue when two talkers are spatially separated, we used the precedence effect to change the apparent location of each talker while reducing the auditory cues available to the listener. A number of studies have shown that if the same sound is played over two loudspeakers located to the left and right of the listener, with the sound on the left loudspeaker lagging behind that on the right, the listener perceives the sound as emanating from the right and vice versa. Because the sound is played over both loudspeakers, a perceived spatial separation is achieved without altering the SNRs at each ear.

Twenty-four normal hearing younger adults and 24 normal hearing older adults were asked to listen to the dialogues used in the previous studies with and without spatial separation which was achieved in two ways: 1) by a physical separation of 90^0 between the loudspeakers presenting each talker (real spatial separation); 2) by using the precedence effect to achieve a perceived spatial separation without altering the SNRs at each ear. Also include were two conditions in which 1) the two talkers were played over the same central loudspeaker; and 2) both talkers were played over the same loudspeaker with no delay between the left and right voices, for a total of 4 conditions. In the latter conditions the two talkers were perceived to be co-located in the center.

In all four conditions the dialogues were played in a background of conversational noise (12-talker babble) at an SNR which was adjusted to compensate for individual differences in hearing sensitivity and to create the same degree of difficulty in identifying individual words. Speech-perception-in-noise (SPIN) thresholds were first measured under each of the 2 separation conditions (no separation vs. separation) X 2 listening conditions (real vs. perceived) for each individual. Then the SNRs used when the dialogues were presented were adjusted for hearing differences using these SPIN thresholds. The signal level was set at 45dB + the babble threshold, and the SNR level was set at -21dB + the SPIN threshold. At the end of each conversation, participants were asked to answer 10 multiple-choice questions regarding the content of the conversation.

Figure 1 shows that once the SNRs are adjusted using the SPIN thresholds, no significant differences in speech understanding were found between younger and older participants when listening to the dialogues. Hence when younger and older adults find it equally difficult to hear individual words, their comprehension of dialogues is equivalent.

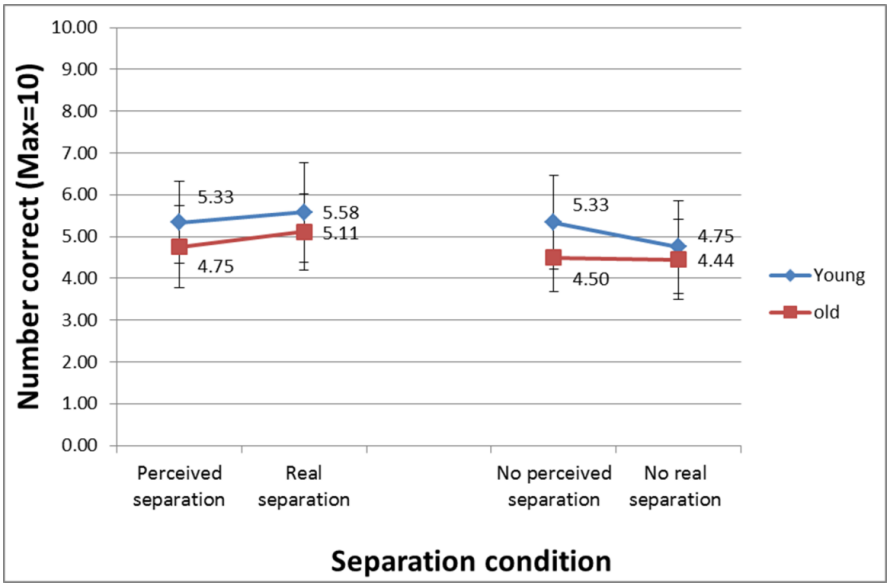

Fig. 1. Average number of multiple-choice questions which were correctly answered under each of the four spatial conditions with separate lines for each age group

However, as can be seen in Figure 2 older adults needed higher SNRs than younger adults to hear individual words when there is a separation (either real or perceived) between the talker and the background noise, but not when the talker and background noise appeared to originate from the same location in space, with this age difference being larger for real than for perceived spatial separation. Moreover, while younger adults benefited from both real and perceived spatial separation, older adults only benefited from real spatial separation.

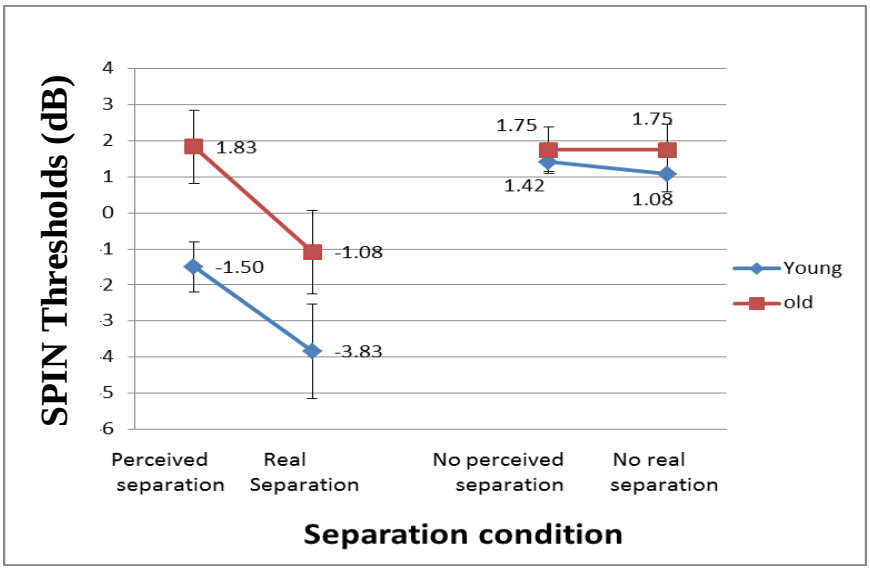

Fig. 2. Average SPIN thresholds (dB) calculated under each of the four spatial conditions with separate lines for each age group.

The SPIN results showed that older adults reaped a much smaller benefit from spatial separation than did younger adults with respect to the recognition of individual words. In addition, the comparison between real and perceived spatial separation indicated that older adults benefitted less than younger adults from the head-related SNR differences which accrue with real spatial separation. This, in turn, would make it more difficult for them to segregate the two talkers based on spatial separation, and to reap potential attention benefits which arise from efficient stream segregation. Hence, in real-life situations, spatial separation among talkers will prove to be much more beneficial to younger than to older listeners. The finding that age-related differences in the ability to process and remember a dialogue were absent once adjustments for recognizing a single word in babble were made, are consistent with the hypothesis that age-related differences in hearing are a major cause of the difficulties older adults experience when listening to a conversation in a noisy environment.

So far, these studies have been limited to the processes involved in comprehending and remembering two-person conversations. In a study in progress, we have increased the cognitive complexity of the conversation by introducing a third talker. When there are only two talkers involved in a conversation, it is predictable who is going to talk next. With three talkers, the conversational turn-taking becomes much less predictable, and so the cognitive challenges of monitoring and integrating the contributions of each talker while switching attention efficiently will increase significantly. Under these circumstances, we might expect age-related cognitive declines to assume a more prominent role.

Digital recordings were made of six plays, with three actors and three actresses reading the parts. Twelve younger and 12 older adults are currently being tested under conditions with and without real spatial separation between the three same gender talkers. Individual adjustments are being made using SPIN sentences for each location of the loudspeakers (left, right and center). Preliminary results from the data collected so far and the implication of those, combined with the results of previous studies conducted in this line of research, will be discussed.

Acknowledgments

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