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Why Do Older Adults Have Difficulty Following Conversations?

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Age-related declines in understanding conversation may be largely a consequence of perceptual rather than cognitive declines. B. A. Schneider, M. Daneman, D. R. Murphy, and S. Kwong-See (2000) showed that age-related declines in comprehending single-talker discourse could be eliminated when adjustments were made to compensate for the poorer hearing of older adults. The authors used B. A. Schneider et al.'s methodology to investigate age-related differences in comprehending 2-person conversations. Compensating for hearing difficulties did not eliminate age-related differences when the 2 talkers were spatially separated by 9° or 45° azimuth, but it did when the talkers' contributions came from one central location. These findings suggest that dialogue poses more of a problem for older than for younger adults, not because of the additional cognitive requirements of having to follow 2 talkers rather than 1, but because older adults are not as good as younger adults at making use of the auditory cues that are available for helping listeners perceptually segregate the contributions of 2 spatially separated talkers.

Keywords: speech understanding in aging, hearing, comprehending conversations, listening to dialogue

Older adults have more difficulty understanding speech in everyday conversational settings than do their younger counterparts. Indeed, many report that they have difficulty following one-on-one conversations and that the problem is exacerbated when they have to follow two or more talkers, and when the environment is noisy (Hamilton-Wentworth District Health Council, 1988; see also CHABA Committee on Hearing, Bioacoustics, and Biomechanics, 1988). Because they miss part of what is said and lack confidence in the accuracy of their understanding of the parts they do hear, older communicators are prone to anxiety or frustration and may avoid or be excluded from social interactions. Consequently, it is not surprising that older adults consider speech understanding declines as one of the most serious consequences of the aging process (Hamilton-Wentworth District Health Council, 1988).

Tracking down the source of the speech understanding difficulties of older listeners is a complicated enterprise. Although it appears that linguistic knowledge is well preserved in normal aging (Kempler & Zelinski, 1994; Light, 1990), the application of this knowledge during spoken language comprehension could be adversely affected by a number of factors known to decline with aging. The speech understanding difficulties of older listeners could be a consequence of age-related declines in the auditory processes that support word recognition (Humes, 1996; McCoy et al., 2005), age-related declines in cognitive functions such as working memory, attentional control, and processing speed (DeDe, Caplan, Kemtes, & Waters, 2004; Fisher & Glaser, 1996; Hasher & Zacks, 1988; Kwong-See & Ryan, 1996; Salthouse, 1991, 1994; Titone, Prentice, & Wingfield, 2000; Tun, O' Kane, & Wingfield, 2002; Wingfield, 1996; Wingfield, Stine, Lahar, & Aberdeen, 1988), or age-related declines in both auditory and cognitive functions (Tun & Wingfield, 1999; Wingfield & Tun, 2001).[1] Indeed, a complicating factor in determining how perceptual and cognitive declines may contribute to age-related declines in speech understanding is that the two are highly correlated (Baltes & Lindenberger, 1997; Lindenberger & Baltes, 1994; Salthouse, Hancock, Meinz, & Hambrick, 1996; Uhlmann, Larson, Rees, Koepsell, & Duckert, 1989), and researchers have recognized the need to investigate the complex interactions between the aging perceptual and cognitive systems (Baltes & Lindenberger, 1997; CHABA, 1988; Stern & Carstensen, 2000) and how these interactions contribute to the speech understanding difficulties of older listeners (e.g., Humes, 1996; Murphy, McDowd, & Wilcox, 1999; Schneider, Daneman, Murphy, & Kwong-See, 2000; Tun & Wingfield, 1999; Wingfield & Tun, 2001).

Some researchers have used a correlational approach to investigate the relative contributions of auditory and cognitive factors to speech understanding difficulties in older adults (e.g., Humes, 1996; Humes et al., 1994; van Rooij & Plomp, 1990, 1992). To assess auditory and cognitive competence in younger and older listeners, these researchers administered tests of basic auditory abilities (e.g., pure tone sensitivity, frequency and duration discrimination) and basic cognitive functions (e.g., visual and audi-

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[1] From an information-processing standpoint, the boundary between perception and cognition is fuzzy. Consequently, we follow the usual practice of using the term *perceptual* for processes that occur relatively early and depend heavily on signal properties and the term *cognitive* for processes that occur relatively late and depend more on semantic and linguistic knowledge (see also Schneider & Pichora-Fuller, 2000).

tory digit span; Wechsler Adult Intelligence Scale—Revised; Wechsler, 1981). Scores on these auditory and cognitive tests were then correlated with performance on a number of tests of speech recognition in which listeners were required to detect, discriminate, or identify nonsense syllables, phonemes, spondees, isolated words, words presented in sentences, or whole sentences in quiet and noise. The best single predictor of word and sentence recognition across the studies was the listener's pure tone threshold function. Most of the cognitive measures (with the possible exception of the speed-of-processing measures) correlated poorly with speech recognition. Results such as these led Humes (1996) to conclude that "individual variations in the amount of sensorineural hearing loss among the elderly are most responsible for individual variations in speech understanding performance" (p. 161). As provocative as these findings are, there is always the concern about making causal inferences from correlational designs. Moreover, it is possible that these particular correlational studies underestimated the contribution of cognitive factors because (a) their particular choice of cognitive measures may not have been the most appropriate and (b) it is unlikely that their simple speech detection and discrimination tests fully engaged the linguistic and cognitive processes that operate in everyday listening situations.

To redress some of the limitations of the correlational studies, our research uses more natural listening tasks and an experimental approach that controls for age-related hearing differences. In a recent study, we showed that age-related declines in understanding single-talker discourse could be eliminated by adjusting the listening situation to compensate for the poorer hearing of the older adults (Schneider et al., 2000). In the present series of studies, we extend the Schneider et al. methodology to investigating the nature of age-related declines in understanding two-person conversations.

Schneider et al. (2000) approximated naturalistic listening conditions in the laboratory by having their participants listen to complex single-talker discourse in quiet or in a background of conversational noise (12-talker babble), conditions that would be similar to attending a 10- to 15-min lecture with an audience that is either very attentive or a lot less so. The methodology involved presenting the discourse and noise under identical physical conditions to the younger and older listeners, which is the typical approach in cognitive aging research, or adjusting the listening conditions to compensate for the poorer hearing abilities of the older listeners. When the younger and older adults listened to the discourse under identical stimulus conditions (passages were presented at the same sound pressure level [SPL] to all participants, and the noise, when present, was identical for all participants), the older adults provided fewer correct responses to questions about the discourse than did the younger adults. This finding replicates several other studies in which a negative age difference was found in spoken discourse comprehension when listening conditions were identical for younger and older listeners (e.g., Titone et al., 2000; see also Wingfield & Stine, 1992).[2] The finding would not surprise cognitive aging researchers who have proposed that cognitive factors, such as generalized slowing, declines in working memory capacity, and deficits in inhibitory processes, should adversely affect the comprehension and recall of spoken or written discourse (Cohen, 1987; Hasher & Zacks, 1988; Salthouse, 1991, 1994; Tun et al., 2002; Wingfield, 1996; Wingfield & Stine-Morrow, 2000; Wingfield & Tun, 2001). In other words, the negative age difference could easily have been attributed to cognitive factors known to decline with aging. However, the notion that age differences were primarily because of cognitive factors was challenged by the results of a second experiment that adjusted the listening situation to make it equally difficult for both younger and older adults to identify individual words. When the younger and older adults were equated for perceptual stress (passages were presented at 50 decibels [dB] above an individual's babble threshold, and the signal-to-noise ratio [SNR] was adjusted to equate individuals on their ability to hear single words in noise), age-related differences in comprehension and recall of the monologues were largely eliminated. The latter finding suggested that the speech understanding difficulties of older adults may be largely a consequence of age-related perceptual declines rather than of age-related cognitive-linguistic declines. Presumably, perceptual declines in older adults result in inadequate, or error-prone representations of external events. These inadequacies and errors at the perceptual level then cascade upward and lead to errors in comprehension (see also McCoy et al., 2005).

Of course, natural listening situations do not simply involve listening to a single talker in a noisy background. Consider the consequences of introducing just one additional talker into the situation. When there are two talkers rather than one, the listener faces the additional cognitive tasks of having to follow not just what is being said but who is saying what and when (Clark, 1996). The ability to selectively attend to and integrate the contributions of the two talkers could be facilitated by a number of factors. At the cognitive level, the ease of integrating information will depend on similarities and differences in the semantic content of the two messages. At the perceptual level, the ability to attend selectively to the two talkers will depend on features of the auditory scene. For example, selective attention will be facilitated by greater differences in spatial separation between the two talkers. Because the two talkers participating in a conversation are typically in different locations from one another, perhaps close to each other, perhaps farther apart, the auditory scene provides listeners with cues to help them to segregate perceptually the two talkers. Spatially separating a signal source from a masker increases the SNR at the ear nearest to the signal and introduces interaural timing differences between signal and masker that improve signal recognition (Arbogast, Mason, & Kidd, 2002; Cherry, 1953; Dubno, Ahlstrom, & Horwitz, 2002; Duquesnoy, 1983; Gelfand, Ross, & Miller, 1988; Hirsh, 1950; Noble & Perrett, 2002; Zurek, 1993). For instance, if the masking noise is straight ahead, and the two talkers are on opposites sides of the listener, then the SNR at the left ear for the talker on the left side is much better than if that talker were located directly in front of the listener. In addition, there are interaural timing cues to help the listener segregate the two talkers that would not be present if both talkers were located directly in front of the listener. If younger adults are more sensitive to these two types of cues than are older adults, then we would expect younger adults to benefit from the spatial separation typically present in dialogue more so than older adults.

[2] Note that studies have typically used much shorter pieces of discourse than those used by Schneider et al. (2000); for example, the mean length of discourse was 150 words in Titone et al. (2000), whereas it was 1,510 words in Schneider et al.

In addition to being less able to capitalize on the additional perceptual cues that arise from talker separation, older listeners could also be disproportionately affected by the additional cognitive requirements of following two-person conversations. Hence, both perceptual and cognitive factors could be responsible for the problems experienced by older adults when listening to conversations in everyday listening situations. We designed the present studies to investigate the factors that contribute to age-related declines in following naturalistic two-person conversations.

Following Schneider et al.'s (2000) methodology with monologue, our goal was to establish that our naturalistic listening-to-conversation task produced a negative age difference when younger and older listeners were tested under identical stimulus conditions (see Experiment 1) and then to see whether the negative age difference could be eliminated when we adjusted the listening situation to make it equally difficult for younger and older adults to hear individual words (see Experiments 2 and 3). For our naturalistic conversations, we selected a series of engaging one-act plays, each involving dialogue between two characters of the same gender. Digital recordings were made of each play, with two professional actors reading the parts. Participants listened to the dialogues either in quiet or in a background of multitalker babble noise. After listening to a dialogue, participants answered a set of questions that tested their comprehension of and/or memory for details about the conversation.[3]

Experiment 1

In Experiment 1, the dialogues were presented at the same SPL to all participants, and the noise, when present, was the same for all participants. On the basis of the Schneider et al. (2000) findings, with single-talker discourse presented to younger and older adults under identical physical conditions, we predicted that older listeners would be less accurate than younger listeners in answering questions about the two-person conversations.

A subsidiary goal of Experiment 1 was to determine whether the ability to follow dialogue is influenced by the spatial distance between the two contributors to the conversation. In Schneider et al. (2000), the monologue and babble were both presented monaurally (over the right headphone). For our dialogue study, the presentation was binaural via three loudspeakers arranged in different physical locations in the sound-attenuating chamber but all situated 1.5 m from the listener. The babble noise, when present, came from the centrally located loudspeaker, and the dialogue came from the two other loudspeakers, one to the left of the central loudspeaker and one to the right of the central loudspeaker. In one condition, the spatial separation of the left and right loudspeakers (and, hence, the two talkers in the conversation) was 9° azimuth (9° to the left and right of the imaginary plane passing through the center of the central loudspeaker); in a second condition, the spatial separation of the left and right loudspeakers was 45° azimuth. The prediction was that listeners would have less difficulty keeping track of which contribution was from which talker when the spatial separation between the two was greater.

Experiments 2 and 3

A finding that older adults performed more poorly on our listening-to-dialogue task in Experiment 1 could be open to at least two classes of interpretation. The poorer performance could be a consequence of age-related declines in cognitive functioning (e.g., Cohen, 1987; Titone et al., 2000; Tun et al., 2002; Wingfield, 1996). Or, the poorer performance could be a consequence of age-related declines in auditory processes (Humes, 1996; Schneider et al., 2000). Even though we screened our older participants to ensure that they had relatively good pure-tone hearing (using the criteria set out by Pichora-Fuller, Schneider, & Daneman, 1995), several investigators have noted that pure-tone audiometric status is not necessarily correlated with other measures of auditory competence in older adults (see Schneider, 1997, for a review).

To investigate whether age-related auditory declines may still be responsible for the observed age-related declines in the ability to process and remember dialogue, we conducted two more experiments in which we presented the dialogues after adjusting the listening situation to make it equally difficult for both younger and older adults to identify individual words. Schneider et al. (2000) showed that age-related declines in the ability to process and remember monologue could be eliminated when adjustments were made to compensate for the poorer hearing of older adults. In Experiments 2 and 3, we investigated whether age-related declines in the ability to process and remember dialogue could also be eliminated when the same adjustments were made for differences in the hearing status of the younger and older listeners. If age-related differences in performance on our dialogue comprehension task disappeared after adjusting for individual differences in hearing status, then we could conclude that hearing-level differences rather than higher level cognitive and linguistic differences are the primary factor controlling the ability to process and remember dialogue. However, if we still observed age-related differences on our task after adjusting for hearing status, then we could conclude that hearing-level differences were not primarily responsible for differences in performance on the dialogue comprehension task.

As in Schneider et al. (2000), we adjusted both the level of the speech signal and the level of the background noise to compensate for individual differences in hearing sensitivity. Rather than presenting the dialogue at a fixed SPL to all individuals (as was the case in Experiment 1), we attempted to equate the audibility of the signal for all participants in Experiments 2 and 3 by determining each individual's detection threshold for multitalker babble and then presenting the dialogue at a fixed number of decibels above that individual's threshold (at a fixed sensation level [SL]). In addition, rather than presenting the background babble noise at a fixed level to all participants (as was the case in Experiment 1), we adjusted the SNR in Experiments 2 and 3 by determining the background noise that would result in each individual having the same degree of difficulty in identifying individual words when these words were unsupported by context (e.g., the word *skirt* in the sentence, *Nancy didn't discuss the skirt*; see Bilger, Nuetzel, Rabinowitz, & Rzeczkowski, 1984).

[3] There is a psycholinguistic literature on dialogue (e.g., Clark, 1996; Schober & Clark, 1989; see also Pickering & Garrod, 2004, for a review); however, here, *dialogue* is used in the interactive sense; that is, the listener is an active participant in the dialogue and so has the dual role of speaking and comprehending. In the context of this research tradition, the listeners in our dialogue comprehension experiments are "overhearers" rather than "addressees" (see Schober & Clark, 1989).

The perceptual adjustment was performed in two ways. In Experiment 2, an individual's babble threshold and threshold for low-context words were established by presenting all stimuli (babble and sentences with low-context final words) from the central loudspeaker in the testing chamber. In Experiment 3, the perceptual adjustments were made to fit the listening-to-dialogue portion of the experiment more closely. Because the listening-to-dialogue portion involved presenting the dialogue from loudspeakers at 9° and 45° azimuth, we established each individual's babble threshold for stimuli presented from a 9° loudspeaker and from a 45° loudspeaker, and we established each individual's threshold for low-context words presented from a 9° loudspeaker and from a 45° loudspeaker.

Method

Participants

The participants were 36 normal hearing younger adults and 36 normal hearing older adults, 12 per age group in each experiment. Table 1 presents the gender breakdown, mean age, and educational level for each age group and each experiment. The younger participants were volunteers recruited from the students and staff at the University of Toronto at Mississauga. The older participants were volunteers from the local community. A questionnaire was used to screen participants for general health, hearing, vision, and cognitive status. Only participants who reported that they were in good health and had no history of serious pathology (e.g., stroke, head injury, neurological disease, seizures, and the like) were included. Typically, our older participants had equivalent or greater levels of education than our younger participants, and they outperformed them on the Mill Hill test of vocabulary knowledge (Raven, 1965; see Table 1 for mean vocabulary scores). All participants were paid $10/hr for their participation.

None of the participants had any history of hearing disorders, and none used hearing aids. Pure-tone air-conduction thresholds were measured at nine frequencies (0.25–8 kHz) for both ears using an Interacoustics Model AC5 (Interacoustic, Assens, Denmark). All participants were required to have pure-tone air-conduction thresholds ≤ 25 dB HL, between 0.25 and 3 kHz (ANSI S3.6–1989) in both ears. Exceptions to this rule were allowed if a participant had a hearing level > 25 but ≤ 35 dB HL at only one frequency. There were 6 older participants in Experiment 1, 2 older participants in Experiment 2, and 4 older participants in Experiment 3 who fell into this category. Although older adults with hearing in this range are usually referred to as having normal hearing, their hearing is by no means equivalent to that of younger adults. Older adults' average thresholds are 8–10 dB poorer than those of younger adults for frequencies ≤ 2 kHz. For frequencies > 2 kHz, threshold differences can increase and differ by as much as 40 dB at the highest frequency tested. This audiometric pattern is typical for older adults whose hearing is considered to be clinically normal. In general, their thresholds are significantly increased at higher frequencies, and they are suffering from a number of anomalies with respect to temporal processing (Fitzgibbons & Gordon-Salant, 1996; Schneider & Pichora-Fuller, 2001; Wingfield, 1996; Wingfield, Poon, Lombardi, & Lowe, 1985).

In all three experiments, participants completed an audiometric hearing test and the Mill Hill Vocabulary Test during the first session.

Dialogue Comprehension Task

In all three experiments, participants listened to the same six dialogues played over two loudspeakers in a sound-attenuating chamber, and, immediately following each dialogue, they answered a series of 10 multiple-choice questions about the contents of that dialogue. Two dialogues were presented in quiet, two in moderate babble noise, and two in high babble noise. For each of the three noise conditions, the spatial separation between the speech signals from the two talkers was close (9° azimuth) for one of

Table 1
Demographic Information (Mean Age and Educational Level in Years, Gender Distribution, Mean Vocabulary Scores) and Mean Babble and R-SPIN Thresholds for the Participants in Experiments 1–4

	Exp. 1				Exp. 2				Exp. 3				Exp. 4			
	Young		Old		Young		Old		Young		Old		Young		Old	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Age	20.17	1.47	68.83	5.04	21.67	1.37	73.50	6.08	20.58	1.73	69.83	4.55	20.25	1.36	69.08	5.60
Educational level	15.33	1.78	13.08	3.06	16.17	1.59	15.75	2.26	15.63	1.40	14.92	2.87	15.67	1.56	14.42	2.27
Gender	9 F 3 M		6 F 6 M		8 F 4 M		6 F 6 M		9 F 3 M		10 F 2 M		9 F 3 M		7 F 5 M	
Vocabulary (max = 20)	13.33	1.61	15.00*	2.34	13.83	1.11	16.75*	1.96	14.25	1.66	15.17	2.08	13.83	2.12	15.50*	2.07
Babble threshold at 0° in dB SPL					15.87	3.52	21.39*	4.58					16.59	1.92	21.08*	6.18
Babble threshold at 9° in dB SPL									15.17	1.58	20.77*	4.89				
Babble threshold at 45° in dB SPL									14.88	1.40	20.89*	4.60				
R-SPIN threshold at 0° SNR in dB					−0.19	1.61	1.11	2.31					0.06	2.24	3.70*	3.02
R-SPIN threshold at 9° SNR in dB									0.23	1.83	2.46*	1.77				
R-SPIN threshold at 45° SNR in dB									−3.97	2.10	−1.14*	1.81				

Note. Exp. = Experiment; max = maximum; dB = decibel; SPL = sound pressure level; R-SPIN = Revised Speech Perception in Noise; SNR = signal-to-noise ratio.
* $p < .05$ (significantly different from younger adults in the same experiment).

the dialogues, and further apart (45° azimuth) for the other dialogue. In Experiment 1, the dialogue presentation level and background noise levels were the same for all participants; in Experiments 2 and 3, the dialogue presentation level and background noise levels were adjusted according to each individual's hearing profile. As in Schneider et al. (2000), we used the babble and low-context words from the Revised Speech Perception in Noise (R-SPIN) test (Bilger et al., 1984) to determine babble thresholds and SNR for low-context words in noise. The dialogue comprehension task was completed over three sessions, with two dialogues being presented per session. Sessions were typically 1 hr in duration and spaced from 1 day to 1 week apart.

Materials. The dialogues were edited versions of six published one-act plays: (a) *Absolution* by W. Reynolds (1993); (b) *Breakfast* by N. A. Bert (1993); (c) *The Lemonade Stand* by B. P. Harnetiaux (1993); (d) *Out of Body* by B. Cooper (1994); (e) *Peace in Our Time* by L. Cadman (1994); and (f) *Slaughter in the Lake* by J. Rivera (1993). The plays were selected and edited to meet the following criteria: (a) each play had only two characters; (b) in three of the plays, the two characters were both male, and in the other three, the two characters were both female; and (c) complete comprehension of the dialogue between the two characters could be achieved from their spoken words (and intonation) alone; that is, comprehension did not depend on any visual or other nonverbal cues or actions. See the Appendix for an excerpt from *Absolution*, a play in which Bobby, an intense young man with an air of desperation, engages in conversation with a priest who is seated on the other side of the partition in a Catholic church confessional box.

For each dialogue, a set of 10 multiple-choice questions was constructed. Each question had four alternatives and tested for a specific item of information that had been mentioned explicitly only once during the course of the dialogue. Together, the set of 10 questions probed for information distributed across the entire dialogue. The extent to which the two talkers' contributions were probed was roughly proportional to their relative contributions to the dialogue. See the Appendix for sample questions.

Digital recordings were made of two male actors reading the three dialogues with male parts and two female actors reading the three dialogues with female parts. The actors attempted to read the dialogue in as natural a way as possible, keeping pauses between turns to a minimum and overlapping or interrupting each other where appropriate. Mean playing time for the six dialogues was 10.89 min ($SD = 4.80$). During each recording process, the two actors were situated in two adjacent double-walled sound-attenuating chambers whose background noise was < 20 dBA. Each actor was seated at a table with a script in front of him or her. The actor spoke into a microphone located approximately 15 cm away from his or her mouth. The actors could communicate with each other through the microphones and hear each other over headphones. However, they could not see each other. The voices of the two actors were sent to separate channels of a Tucker–Davis analog-to-digital converter, where they were digitized at a rate of 20 kHz and stored in time-linked digital files. Later, both channels of the recorded dialogue were edited to clean up any noise or problems in the actors' rendering of their parts. The edited files were stored in stereo format, with one actor appearing on the left channel and the other actor on the right channel.

During an experimental session, this stereo file was converted back to analog form and played over two laterally displaced loudspeakers. Programmable attenuators were used to set the SPLs of the actors' voices over the left and right channels. The 12-talker babble stimulus was generated on a second computer, converted from digital to analog using a separate Tucker–Davis digital-to-analog converter and then presented to the participant through a third channel to a loudspeaker that was positioned directly in front of the listener.

Dialogue presentation level. In Experiment 1, the dialogues were played at 61dB SPL to all participants. In Experiments 2 and 3, the dialogue level was adjusted according to each individual's detection threshold for multitalker babble (the SPL corresponding to a 79% probability of just being able to hear 12 voices talking simultaneously). In Experiment 2, the dialogues were presented at 45 dB above each participant's babble threshold; in Experiment 3, they were presented at 40 dB above each participant's babble threshold.[4]

To determine each Experiment 2 and 3 participant's threshold for babble stimuli, we used an adaptive two-interval forced-choice procedure. In this procedure, a babble segment was presented in one of two randomly chosen intervals. The two intervals, which began 1.5 s after the listener pressed a button, were each 1.5 s long and were separated by a 1.5-s silent period. Lights on a button box indicated the occurrence of each interval, and the listener's task was to identify the interval containing the babble segment by pressing one of two buttons. Immediate feedback was provided. We used an adaptive staircase procedure (Levitt, 1971) to determine babble threshold (the SPL corresponding to the 79% point on the psychometric function). In Experiment 2, the babble threshold was determined for each individual when the babble was presented over the central loudspeaker. In Experiment 3, two babble thresholds were determined for each individual: one for the condition in which the babble was presented over a loudspeaker at 9° azimuth, the other for the condition in which the babble was presented over a loudspeaker at 45° azimuth. In this way, separate babble thresholds were determined for the two different loudspeaker locations.[5] Table 1 shows the average babble thresholds of the younger and older participants.

Babble noise levels. In Experiment 1, the moderate babble noise level was set at −15 dB SNR, and the high babble noise level was set at −21 dB SNR. In Experiments 2 and 3, the two levels of babble noise were individually adjusted to take into account individual differences in the ability to identify words in noise when there is little or no contextual support for word recognition. The adjustment procedure involved determining an individual's threshold for detecting low-context words in the R-SPIN test and then setting the moderate babble noise level at an SNR of −15 dB plus the SNR corresponding to that individual's low-context R-SPIN threshold and the high babble noise level at an SNR of −21 dB

[4] The dialogues were presented at 45 and 40 dB above participants' babble thresholds in Experiments 2 and 3, respectively, to ensure that the background babble level experienced by older adults did not become excessive. Let B_t be the individual's babble threshold, SL stand for the sensation level to be used for presentation of the dialogues, SNR be the signal-to-noise ratio to be used, and SP be the individual's R-SPIN threshold. The level of the background babble experienced by each individual then becomes $B_t + SL - SNR - SP$. The average babble threshold for older adults was approximately 21 dB SPL in Experiments 2 and 3, with a standard deviation of approximately 5 dB. Hence, we might expect to encounter an older adult whose babble threshold was as high as 31 dB SPL. If we had set the SL for dialogue at 50 dB, then the level of babble noise for an older adult with a babble threshold of 31 dB SPL, and an SNR of −21 dB, would have been $31 + 50 + 21 = 102$ dB SPL before adjusting for his or her individual R-SPIN threshold. Now because older adults were expected to have positive R-SPIN thresholds of approximately 2 dB SPL, this would mean that had we followed the same protocol as in Schneider et al. (2000), we could have encountered a situation in which an older adult was tested in a level of babble of 100 dB SPL.

To keep the maximum level that an older adult might encounter to less than 95 dB, we reduced the SL in Experiment 2 to 45 dB. Finally, because some older adults in Experiment 3 might have had R-SPIN thresholds that were negative under the 45° condition, the sensation level for presenting the dialogue was reduced by another 5 dB in Experiment 3 to ensure that we did not present any stimuli at levels in excess of 95 dB SPL.

[5] To establish babble threshold for the 9° position, for half of the trials, the babble was presented through the right loudspeaker, and for the other half, it was presented through the left loudspeaker. We used the average babble threshold for left and right loudspeaker positions. A similar averaging procedure was used to establish babble threshold for the 45° position.

plus the SNR corresponding to that individual's low-context R-SPIN threshold. The method for determining an individual's low-context R-SPIN threshold is described below.

The R-SPIN test is subdivided into eight forms (sets of 50 sentences, 25 of which are low-context sentences, e.g., "Nancy didn't discuss the skirt"). The listener, when presented with a sentence in babble from one of the forms, was asked to repeat the last word and to indicate whether it was predictable from the context. Following the usual procedure, the sentences were always presented at a level that was 50 dB higher than the individual's babble threshold. Each listener was then presented with a series of forms (2–4) in which the decibel level of the babble was adjusted, relative to that of the sentences, to find a pair of SNRs that bracketed the 50% point on the psychometric function relating percentage of correct word recognition of low-context items to SNR. The 50% point (the low-context R-SPIN threshold) was then determined through linear interpolation. In Experiment 2, the babble and R-SPIN sentences were presented over the central loudspeaker. Note that this manipulation does not guarantee that listeners will be equally able to identify words when the talker's position is not the same as that of the noise. To ensure that listening conditions were adjusted so that listeners were equally able to identify words when the talker was off midline but the babble was not, in Experiment 3, the babble was presented over the central loudspeaker, but the R-SPIN sentences were not. In one condition, the sentences were presented over a loudspeaker positioned 9° to the side; in another condition, they were presented over a loudspeaker positioned 45° to the side. Hence, in Experiment 3, individual adjustments were made separately for words presented from the two different azimuthal positions. Table 1 shows the mean R-SPIN thresholds of the younger and older participants in Experiments 2 and 3.

In Experiment 2, a babble threshold test and the R-SPIN Test (Bilger et al., 1984) were administered at the first session along with the Mill Hill Vocabulary test and an audiometric hearing test. Because Experiment 3 required R-SPIN and babble thresholds to be determined for both left and right loudspeaker positions, these thresholds were determined in a second session.

Procedure. Participants were tested individually in a double-walled sound-attenuating chamber. They sat in a chair that faced three loudspeakers, each positioned at a distance of 1.5 m from them and at a height of about 1 m above the floor. For half of the passages, the left and right loudspeakers were placed at 9° azimuth, and for the other half, they were placed at 45° azimuth. The angle of each loudspeaker was adjusted so that the front of it faced the participant.

Participants were informed that the dialogue would be played through the loudspeakers to the left and right of the central loudspeaker and that they should listen carefully to it because they would be required to answer questions about its contents after listening to it. They were warned that noise may be presented through the central loudspeaker, and they were encouraged to ignore the noise and focus on the dialogue presented from the two other loudspeakers. After listening to a dialogue, participants were given a printed copy of 10 multiple-choice questions about the dialogue and asked to respond to them.

Counterbalancing of the six dialogues across the three noise conditions and the two spatial separation conditions was achieved by ensuring that an equal number of younger and older participants heard each of the six dialogues in one of the three noise conditions—quiet, moderate noise, high noise—and at one of the two spatial separations (9° and 45° azimuth). Order of presentation of the three noise-by-two spatial separation conditions was also counterbalanced across younger and older participants. The six dialogues were administered over three sessions, two dialogues per session.

Results and Discussion

Figures 1, 2, and 3 plot the average number of questions answered correctly (out of 10) as a function of the background babble level, the separation of the loudspeakers, and the age of the listener for Experiments 1, 2, and 3, respectively. The results showed the expected negative age difference in performance on the dialogue questions when younger and older participants listened to the dialogues under identical listening conditions (see Experiment 1 and Figure 1). Furthermore, neither the central method of adjustment (see Experiment 2 and Figure 2) nor the spatially separate method of adjustment (see Experiment 3 and Figure 3) succeeded in eliminating the negative age difference in performance. The persistence of a negative age difference in Experiments 2 and 3 differs from our previous finding for monologues (Schneider et al., 2000), which showed that age differences in performance could be eliminated when the listening conditions were adjusted to make it equally difficult for younger and older listeners to hear individual words. Below, we provide the results in more detail.

Experiment 1 (Baseline)

The main finding of interest was that older listeners correctly answered significantly fewer questions about the dialogue than did their younger counterparts (6.26 vs. 7.79), $F(1, 22) = 23.64$, $MSE = 0.59$, $p < .0001$. This negative age difference is consistent with the negative age difference found by Schneider et al. (2000) for monologues that had been presented at the identical signal level and background noise level to all participants. Figure 1 also shows that the number of questions answered correctly declined with noise for both younger and older participants, $F(2, 44) = 69.38$, $MSE = 2.15$, $p < .0001$. Although older adults appeared to have more difficulty at the

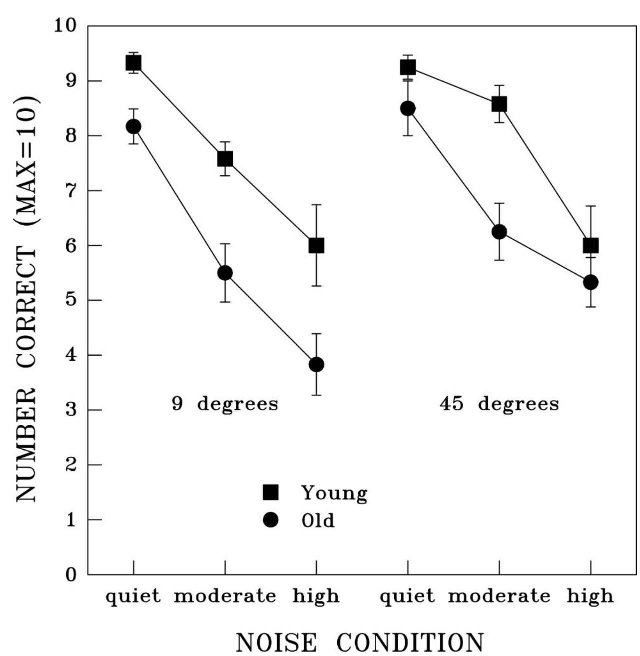

Figure 1. The average number of dialogue questions answered correctly (maximum [MAX] = 10) by younger and older adults as a function of background noise level and loudspeaker separation in Experiment 1. The signal level and the level of background noise were identical for all participants. Standard error bars are also shown.

highest levels of noise, the Age × Noise interaction was not significant ($p > .10$). And finally, there was some evidence to support the prediction that following dialogue would be easier if the contributors to the dialogue were farther apart, $F(1, 22) = 3.93$, $MSE = 3.12$, $p = .06$. None of the other main effects or interactions were significant (all Fs < 1).

Experiment 2 (Central Adjustment)

The findings were generally consistent with the findings in Experiment 1.[6] As in Experiment 1, all listeners answered fewer questions about the dialogue correctly when the two talkers were closer together (9° azimuth) than when they were farther apart (45° azimuth), $F(1, 22) = 8.61$, $MSE = 2.27$, $p < .01$. Also as in Experiment 1, performance declined with noise, $F(2, 44) = 84.29$, $MSE = 1.92$, $p < .0001$. However, now there was a significant Noise × Separation interaction, $F(2, 44) = 5.97$, $MSE = 1.92$, $p < .01$; as Figure 2 shows, only the highest level of noise interfered with performance in the easier 45° separation condition, whereas even moderate levels of noise interfered with performance in the harder 9° separation condition. Despite the efforts to equate the listening conditions for younger and older listeners in Experiment 2, there was still a significant effect of age, $F(1, 22) = 13.57$, $MSE = 0.41$, $p < .001$, with older listeners answering fewer questions correctly than did their younger counterparts (6.65 vs. 7.61). None of the other main effects or interactions approached significance (all ps $> .19$).

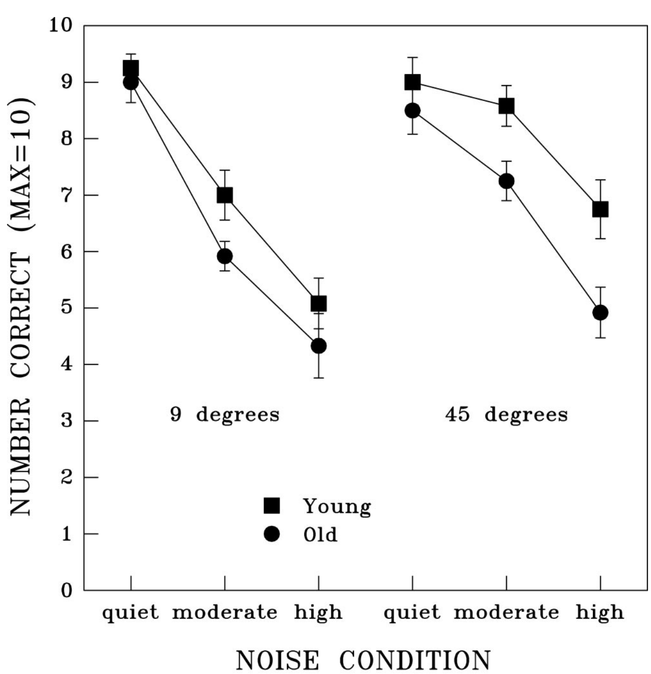

Figure 2. The average number of dialogue questions answered correctly (maximum [MAX] = 10) by younger and older adults as a function of background noise level and loudspeaker separation in Experiment 2. Both the signal level and the level of background babble (when present) were adjusted for individual differences in hearing (see text). Standard error bars are also shown.

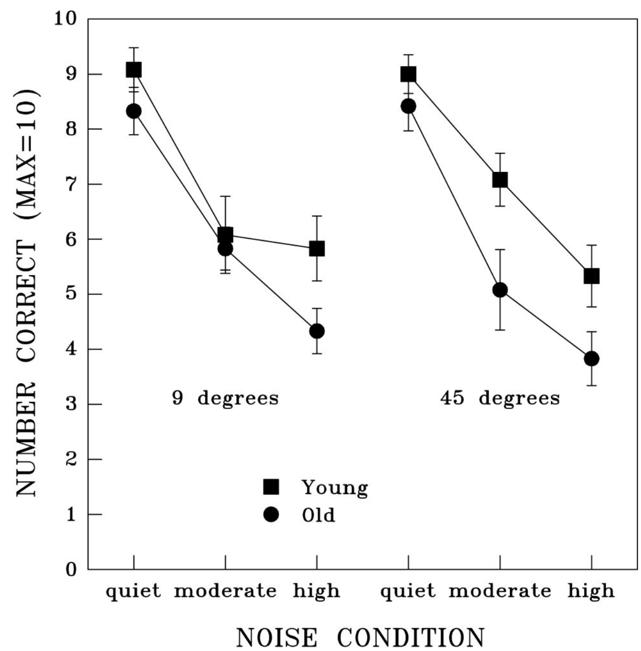

Figure 3. The average number of dialogue questions answered correctly (maximum [MAX] = 10) by younger and older adults as a function of noise level and loudspeaker separation in Experiment 3. Both the signal level and the level of background babble (when present) were adjusted for individual differences in hearing (see text). Standard error bars are also shown.

Experiment 3 (Spatially Separate Adjustment)

The findings of Experiment 3 were very similar to those in Experiment 2, except that the tighter adjustment procedure eliminated the advantage for the 45° spatial separation ($F < 1$). As in Experiments 1 and 2, the number of questions answered correctly declined with noise, $F(2, 44) = 96.67$, $MSE = 1.96$, $p < .0001$, with the effect being equivalent for all participants ($p > .34$ for the Age × Noise interaction). However, unlike Experiment 2, the effect of noise was now equivalent for both loudspeaker separations ($p > .60$ for the Separation × Noise interaction). And finally, despite tighter hearing adjustment procedures than in Experiment 2, there was still a significant effect of age, $F(1, 22) = 7.04$, $MSE = 1.03$, $p < .02$, with older listeners answering fewer questions correctly than did their younger counterparts (5.97 vs. 7.07).

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[6] In this experiment, one of the older participants did not complete one condition (the quiet, 9° separation condition) because of a clerical error. Thus, this condition for older adults contained only 11 entries. The data displayed in Figure 2 are based on all 12 older participants for all of the conditions except this one. In statistical analyses, the missing data point was treated in two ways. First, the missing value was replaced by the mean value for that condition. Second, the number of older participants was reduced to the 11 who completed all conditions without error. The pattern of results obtained from each of these two ways of handling the missing data did not differ in any significant way. The statistical analyses reported here are for the case in which the missing value was replaced with the mean value.

Possible Explanations for the Persistence of a Negative Age Difference in the Dialogue Comprehension Task

Compensating for the poorer hearing of older adults eliminated age-related declines in processing and recalling monologue (Schneider et al., 2000), but the same compensation techniques did not eliminate age-related declines for dialogue. What could account for this difference?

One possibility is that dialogue poses a problem for the older listener because of the additional cognitive demands introduced by requiring the listener to follow two talkers rather than one. In other words, older listeners may be deficient at attending to, coordinating, and integrating the verbal contributions of two talkers, those aspects of language comprehension not required for following simple monologue. If this were indeed the case, then compensating for older listeners' poorer hearing would not have been sufficient to eliminate these cognitively driven, age-related declines in processing and remembering dialogue.

However, there could still be a more perceptual explanation for the age-related differences in processing and remembering dialogue observed in Experiments 2 and 3. Remember that the two talkers were spatially separated from one another. Spatial separation provides listeners with potentially useful auditory cues (e.g., differences in SNR and interaural timing) to help them attend to and integrate information from the two talkers (Bregman, 1990). If younger listeners are more sensitive to these cues than are older listeners, then we might expect them to benefit from the spatial separation more than older adults do. If this were the case, then we might expect age-related differences in our dialogue task even after compensations were made for the older listeners' deficits in hearing individual words.

If the age-related differences observed in Experiments 2 and 3 are a consequence of younger listeners being better able to capitalize on the auditory cues that are available when two talkers are separated in space, then their advantage should be eliminated if we remove the spatial separation of the two talkers. This possibility was tested in Experiment 4.

Experiment 4

In Experiment 4, we introduced two new features to the methodology used in Experiments 2 and 3: (a) We directly compared listening to monologue versus listening to dialogue in a within-participant design; and (b) we removed the spatial separation of the two talkers in the dialogue by having the two talkers' contributions, and the background babble, come from one centrally placed loudspeaker, as in a radio play. This design allowed for a direct investigation of age-related similarities and differences in processing monologue versus dialogue. And the design allowed us to determine the factor(s) responsible for the persistence of a negative age difference for processing dialogue despite efforts to equate younger and older listeners for hearing differences.

Because the younger and older adults were tested under equally difficult listening situations, we predicted that there would be no age difference in performance on the monologue questions, as was the case in Schneider et al. (2000) when similar adjustments were made to the listening situation to compensate for the reduced hearing abilities of older adults. For the dialogue questions, there were two possible outcomes. If older listeners were at a disadvantage relative to younger listeners in Experiments 2 and 3 because they were less effective at making use of the auditory cues available for helping listeners perceptually segregate the contributions of spatially separated talkers, then the removal of the spatial separation of the two talkers in Experiment 4 should eliminate the advantage younger listeners had enjoyed with spatial separation and thus eliminate the negative age difference in processing and remembering dialogue. However, if older listeners were more adversely affected by the additional cognitive costs of having to comprehend and integrate the contributions of two talkers rather than one, then removal of the spatial separation of the two talkers should not eliminate the negative age difference in processing and remembering dialogue.

Method

Participants

The participants were 12 normal hearing younger and 12 normal hearing older adults who had not participated in the previous experiments. The younger participants were volunteers recruited from the students and staff at the University of Toronto at Mississauga. The older adults were volunteers from the local community. All participants were paid $10/hr for their participation. None of the participants had any history of hearing disorders, and none used hearing aids. All participants were required to satisfy the same pure-tone air-conduction threshold criteria specified in previous experiments. As in previous experiments, participants were allowed to have one exception. There was 1 younger participant and 3 older participants in this category. Experiment 4 was completed in five sessions, each approximately 1 hr in duration and spaced from 1 day to 1 week apart. Participants completed the Mill Hill Vocabulary Test, an audiometric hearing test, a babble threshold test, and the R-SPIN test in the first session. The monologue and dialogue comprehension task was completed during four subsequent sessions, with two selections (monologue or dialogue) being presented per session.

Monologue and Dialogue Comprehension Tasks

Participants listened to four monologues and four dialogues played over a central loudspeaker in a sound-attenuating chamber, and, immediately following each piece, they answered a set of multiple-choice questions about its contents. The monologues and dialogues were all played at 40 dB above the individual listener's babble threshold. Two monologues were presented in quiet, and the other two monologues were presented in noise (SNR = −15 dB + the SNR corresponding to that listener's threshold for low-context R-SPIN words). Two dialogues were presented in quiet, and the other two dialogues were presented in noise (SNR = −21 dB + the SNR corresponding to that listener's threshold for low-context R-SPIN words).[7]

[7] Pilot testing revealed that we needed a lower SNR for the dialogues than for the monologues to produce similar levels of accuracy on their respective multiple-choice questions. The actors who were engaged in conversational speech (the dialogues) introduced a larger range of emotions into their voice than did the actor reading the lectures (the monologues); this produced much more variation in the amplitude, frequency content, and prosody of their contributions and made the dialogue more intelligible in noise.

Monologue materials. These were four of the monologues used in Schneider et al. (2000). Digital recordings were made of a male actor reading four passages chosen from *Efficient Reading* (Brown, 1984). The passages were excerpts from previously published works and were recorded at a sampling rate of 20 kHz. The four topics were (a) Feeding the mind; (b) Of happiness and despair we have no measure; (c) Ten tips to help you write better; and (d) Mark Twain's speech making strategy. Mean playing time for the monologues was 12.75 min (SD = 2.63). For each monologue, there was a set of five multiple-choice questions. Each question had four alternatives and tested for a specific item of information that had been mentioned explicitly only once during the course of the monologue (see detail questions in Schneider et al., 2000).

Dialogue materials. These were four of the six dialogues used in Experiments 1–3, two with female talkers and two with male talkers. Mean playing time was 12.53 min (SD = 5.23). For each dialogue, there were 10 multiple-choice questions.

Procedure. Participants were tested individually in a double-walled sound-attenuating chamber. They sat in a chair that faced one loudspeaker positioned 1.5 m directly in front of them. The monologues, dialogues, and background babble noise were all presented through this central loudspeaker. The signal level and background noise level were adjusted for each participant on the basis of his or her babble threshold and R-SPIN threshold for stimuli presented through the central loudspeaker (see Table 1 for the babble and R-SPIN thresholds of the younger and older participants).

Counterbalancing of the four monologues and four dialogues across the two noise conditions was achieved by ensuring that an equal number of younger and older participants heard each of the four monologues and each of the four dialogues in one of the two noise conditions: quiet or noise. The order of presentation of the two discourse types by two noise conditions was also counterbalanced across younger and older participants. The four monologues and four dialogues were administered over four sessions, two pieces per session.

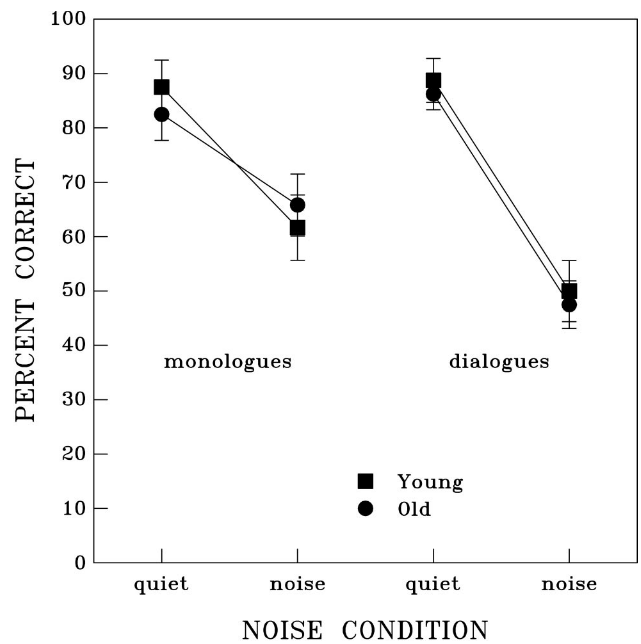

Figure 4. Mean performance (percent correct) for the monologue and dialogue questions as a function of the noise level and the age group of the listener in Experiment 4. Both the signal level and the level of background babble (when present) were adjusted for individual differences in hearing (see text). Standard error bars are also shown.

Results and Discussion

Figure 4 plots performance (percentage correct) on the monologue and dialogue questions as a function of the noise condition and the age of the listener. As Figure 4 clearly shows, the performance of younger and older listeners was virtually identical in all conditions of this experiment. An ANOVA (2 discourse types × 2 ages × 2 noise levels) confirmed this description of the results insofar as there was no age effect, $F(1, 22) = 0.03$, $MSE = 186.02$, $p > .85$, and no significant two-way or three-way interactions involving age (all interaction Fs < 1). In other words, older adults were as good as their younger counterparts at processing and remembering monologue when the listening conditions were adjusted to compensate for their poorer hearing (see also Schneider et al., 2000). In addition, they were as good as their younger counterparts at processing and remembering dialogue when the listening conditions were adjusted to compensate for their poorer hearing and there was no spatial separation between the two talkers. This latter finding presents an argument against the cognitive complexity explanation for the persistence of a negative age difference in performance on the dialogue questions in Experiments 2 and 3, despite efforts to compensate for the poorer hearing of the older listeners. If older listeners had been disproportionately penalized by the additional cognitive requirements of having to comprehend and integrate the contributions of two talkers rather than one, then the removal of the spatial separation of the two talkers in Experiment 4 should not have eliminated the negative age difference in processing and remembering dialogue. However, removal of the spatial separation of the two talkers did eliminate the negative age difference in processing and remembering dialogue, and a quick across-experiment inspection shows that this was because of a decline in the performance of the younger adult when spatial separation was removed. This finding is more consistent with the view that the disadvantage experienced by the older adults in Experiments 2 and 3 could be attributed to the fact that they were less able than younger adults to make as effective use of the available auditory cues for perceptually segregating the contributions of two spatially separated talkers. Removing the spatial separation between talkers eliminated the advantage young listeners had enjoyed, thereby eliminating the negative age difference in processing and remembering dialogue.

Finally, there were several other significant findings in Experiment 4 that were unrelated to the age of the listener. As Figure 4 shows, the addition of background noise adversely affected performance on both monologue and dialogue questions, $F(1, 22) = 157.36$, $MSE = 133.48$, $p < .001$, although the effect of noise was more pronounced for dialogue than for monologue, interaction $F(1, 22) = 14.20$, $MSE = 142$, $p < .01$. However, caution is needed in interpreting this Noise × Discourse Type interaction because the SNR was lower for the dialogues (−21 dB) than it was for the monologues (−15 dB). Caution is also needed in interpreting the main effect of discourse type, $F(1, 22) = 6.13$, $MSE = 133.29$, $p < .02$, because there was no way of knowing whether the comprehension questions were of comparable difficulty across the two discourse types.

Summary and Conclusions

The present studies were designed to investigate the factors that contribute to age-related declines in processing and remembering naturalistic two-person conversations. Older adults commonly report that they experience difficulties understanding conversations in everyday listening situations. Our research provided some evidence to substantiate their claims by showing that older adults were indeed less skilled than younger adults at extracting and remembering information from a two-person conversation if accommodations had not been made for their poorer hearing abilities (see Experiment 1). Schneider et al. (2000) showed that a similar age-related disadvantage in processing and remembering single-talker discourse could be eliminated if the listening conditions (signal level; background noise level) were adjusted to compensate for the poorer hearing of the older adults. Their finding suggested that age-related declines in comprehending and remembering monologue are primarily a consequence of age-related perceptual declines rather than of age-related cognitive declines.

To test the hypothesis that age-related declines in comprehending and remembering dialogue are also primarily a consequence of age-related declines in the ability of the auditory system to deliver a clear speech signal, we adjusted the dialogue listening conditions to take into account the reduced hearing abilities of older adults (see Experiments 2 and 3). Specifically, we individually adjusted SNRs to make it equally difficult for all individuals (younger or older) to recognize individual words when these words were unsupported by context. However, despite our efforts to equate for differences in speech recognition, the negative age difference for dialogue comprehension persisted. A potential explanation for the persistence of the age difference is that cognitive factors assume a more important role for dialogue comprehension than for monologue comprehension. When there are two talkers rather than one, the listener faces the additional cognitive tasks of having to follow not just what is being said, but who is saying what and when. It is possible that older listeners are disproportionately penalized by the additional cognitive tasks of having to attend to, coordinate, and integrate the verbal contributions of two talkers, all aspects of language comprehension not required for comprehending simple monologue. If this were indeed the case, then compensating for the reduced hearing levels of older listeners would not have been sufficient to eliminate the age differences in processing and remembering dialogue. However, there could still be another kind of perceptual explanation for the persistence of an age difference in processing and remembering dialogue, despite our efforts to equate for individual differences in the ability to recognize individual words.

The auditory scene differs between dialogue situations and monologue situations because the listener has to segregate the contributions of two talkers. Typically, the two talkers participating in a conversation are in different locations from one another (in Experiments 1–3, the talkers were separated by 9° or 45° azimuth). When talkers are spatially separated, listeners may 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. A number of studies have shown that the ability to track and comprehend a targeted talker in a multitalker situation improves when the target talker is perceived to be spatially separated from interfering talkers (e.g., Freyman, Balakrishnan, & Helfer, 2001; Freyman, Helfer, McCall, & Clifton, 1999; Li, Daneman, Qi, & Schneider, 2004). The notion here is that, in addition to peripheral masking of target speech by the speech of the irrelevant talkers (both target and irrelevant speech activate the same regions of the basilar membrane of the inner ear), there is also informational masking or cognitive-level interference from the irrelevant talkers (both the target and irrelevant talkers activate semantic and linguistic processes, leading to cognitive interference from the irrelevant talkers). These studies have demonstrated that perceived spatial separation of the target from irrelevant talkers reduces cognitive-level interference but not peripheral masking of speech by speech (see Li et al., 2004, for a more complete discussion of release from informational masking). Hence, it is not unreasonable to expect that perceived spatial separation of the two talkers in this experiment may also lead to a smaller amount of informational confusion between the two talkers even when the two are not speaking simultaneously. If older adults are less sensitive than are younger adults to the auditory cues from spatial separation, then we would expect them to benefit less from the spatial separation typically present in dialogue than would younger adults, and we would expect a negative age difference in our listening-to-dialogue task to persist even after compensations had been made for the older listeners' deficits in hearing individual words.

Our final experiment provided support for the perceptual segregation hypothesis over the cognitive complexity hypothesis by showing that the negative age difference in processing and remembering dialogue could be entirely eliminated when the spatial separation of the two talkers was removed (see Experiment 4). Thus, even though the comprehension of dialogue includes more cognitive components than the comprehension of monologue, age-related declines in our dialogue comprehension task still appear to be largely perceptual rather than cognitive in origin in the sense that age-related declines in the ability to segregate the auditory scene leads to less efficient cognitive processing of dialogue in older than in younger adults.

There is one feature of our results that requires us to be cautious in our conclusions that the age differences are because of differential sensitivity to spatial location cues. If younger adults are better able to benefit from cues to spatial separation than older adults, then we would have expected to find an Age × Spatial Location interaction in Experiments 1–3. Although Figures 2 and 3 suggest that the age difference is greater for the 45° than for the 9° spatial separation, this trend was not statistically significant.

Of course, we also need to be cautious about generalizing these results to all conversational settings. Even though our dialogues did capture many of the features of natural conversation, they probably did differ in ways that would have had perceptual and cognitive implications for the listener. On the perceptual side, our actors probably spoke more slowly, enunciated more clearly, and "talked over" each other less often than is typical in everyday conversations (Pollack & Pickett, 1964; Zimmerman & West, 1975); consequently, our studies may have even underestimated the disadvantages that perceptually handicapped older listeners encounter in following everyday conversations. On the cognitive and linguistic side, our literary dialogues were lexically and semantically richer and syntactically less fragmented than are natural dialogues (Pickering & Garrod, 2004; Stolcke et al., 2000): Because older listeners are good at making use of linguistic context

(Pichora-Fuller et al., 1995; Wingfield & Tun, 2001), we may have underestimated the degree to which age-related declines in cognitive factors contribute to the age-related declines in following conversations. And, of course, it is worth pointing out that the older adults in these experiments were all relatively high functioning, both cognitively and perceptually. Hence, we might expect to find greater age differences in the more general population.

Of course, so far, our research has been limited to the processes involved in comprehending and remembering two-person conversations. A next step would be to increase the cognitive complexity of the conversation by introducing a third talker. When there are only two talkers, it is perfectly predictable who is going to talk next. With three talkers, the conversational turn-taking (Sacks, Schegloff, & Jefferson, 1974) becomes much less predictable, and so the cognitive challenges of monitoring and integrating the contributions of each talker will increase significantly for the listener. Under these circumstances, we might expect age-related cognitive declines to assume a more prominent role.

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Appendix

Sample of Dialogue and Comprehension Questions

BOBBY: Bless me, Father, for I have sinned. My last confession was a week ago. Father . . . Father, are you there?

PRIEST: Hey? What? Uh, yes, my son, go ahead.

BOBBY: I mean, I've *really* sinned.

PRIEST: Go on. I'm listening.

BOBBY: It's too terrible. I'd better warn you.

PRIEST: Nothing is too terrible for the ears of our Lord. You go right on ahead.

BOBBY: I mean really terrible.

PRIEST: Don't be worried my son. I hear terrible things every day. Nature of the priesthood you know.

BOBBY: You'll be shocked.

PRIEST: My boy, I'll listen with the patience of Job. Only please get on with it.

BOBBY: I've . . . Oh, God . . . I can't even say it.

PRIEST: It's all right, my boy. Spit it out.

BOBBY: I've killed someone.

PRIEST: I see. (Sudden realization) Killed someone? . . . Killed someone?

BOBBY: Yes.

PRIEST: (Breathless excitement) Goodness gracious. That is something.

BOBBY: So you see, Father . . . I'm a murderer.

PRIEST: Well, what do you know about that. How did you do it? I mean, how did it happen?

BOBBY: It was one of those moments. I just lost control. I can't explain why.

PRIEST: Yes, yes, yes. Only what did you do?

BOBBY: I. . . . It was Ms. Sobel. My teacher. She's had it in for me all semester. Yesterday, she kept me after school. She said I plagiarized my term paper. I told her I didn't. I told her, but she just laughed. She said she was going to keep me from graduating, and tell my parents . . . I was scared to go home, so I just wandered around. I didn't know what I was doing. Anyway, I saw her. Out by the rear door, on my way home. And in my head, she was still laughing . . . and next thing I knew, I had her by the neck. She tried to yell, but she couldn't, her windpipe was shut off. Then she stopped struggling . . . she fell . . .

PRIEST: No blood then?

BOBBY: (Thrown) What?

PRIEST: Oh, uh, I mean. . . . Strangling. Only leaves marks, you know. The only bleeding comes from burst blood vessels in the eyes.

BOBBY: That's gross. . . . Where was I?

PRIEST: We'd just strangled her. So, would you say you're like the Unavoidable Felon?

BOBBY: The what?

PRIEST: Oh you know. "You felt your back against the wall. It was kill or be killed . . ."

Sample Questions

1. Who did Bobby profess to kill?

   A. His counselor.

   B. His principal.

   C. His coach.

   D. His teacher.

2. What method did Bobby report using to kill his victim?

   A. Strangulation.

   B. Shooting.

   C. Stabbing.

   D. Poisoning.

3. According to the priest, someone who kills because his/her back is against the wall is known as?

   A. The passionate murderer.

   B. The lover's killer.

   C. The unavoidable felon.

   D. A person in need of professional help.

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