

Older adults in complex listening environments

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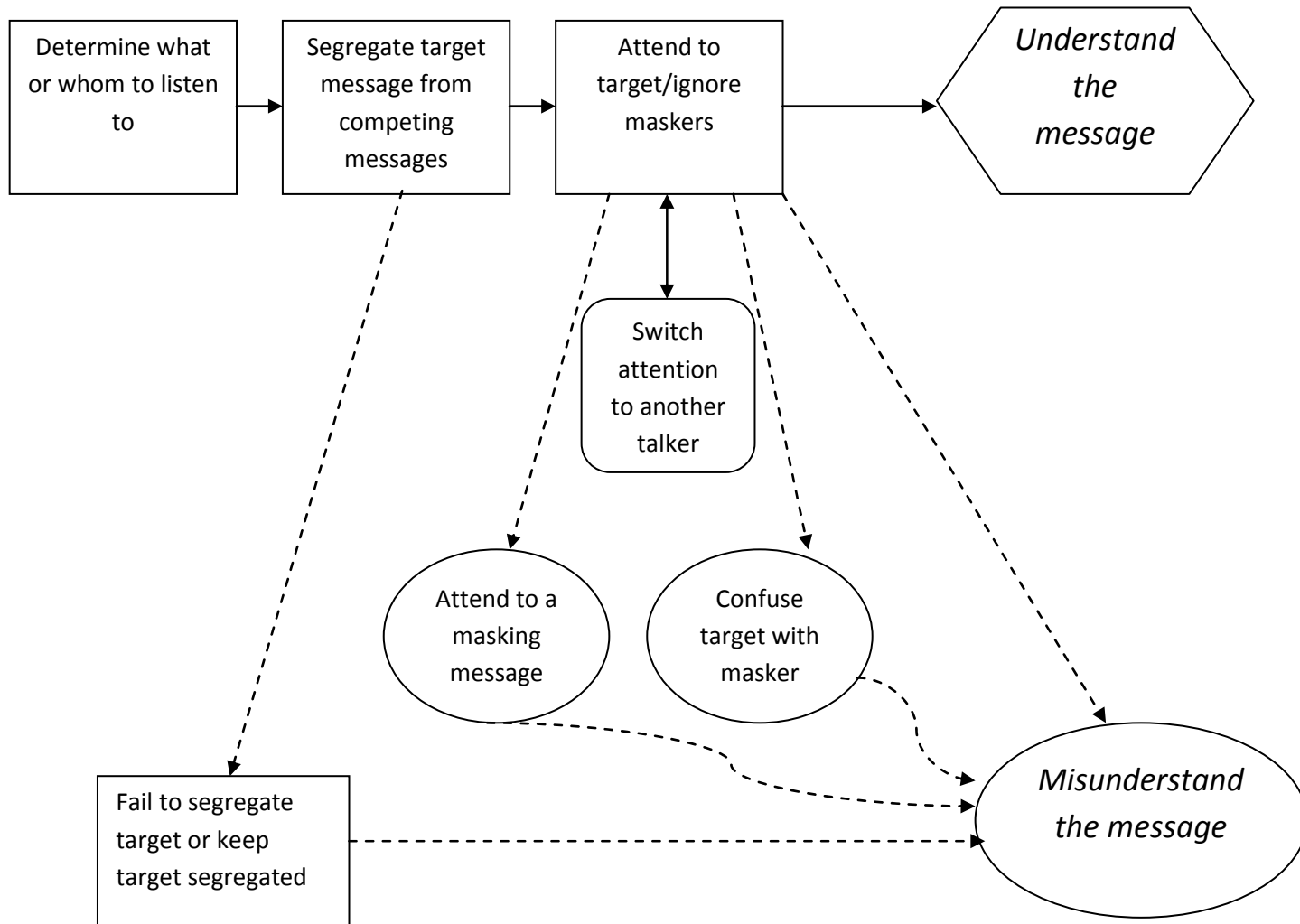
- *Three parts of this presentation:*
 - Why understanding one voice in complex listening environments can be difficult;
 - Why older adults might have particular difficulty when there is more than one talker;
 - How we can help our older patients cope in these situations.



<http://files.wordpress.com/2008/03/dinnerparty4601.jpg>

Why is understanding one voice in the presence of other voices so difficult?

- Speech can cause two types of masking:
 - *Energetic*: swamping of target sound by masking sound
 - peripherally mediated
 - *Informational*: extra masking produced by speech beyond that caused by a noise with the same acoustics
 - confusion/uncertainty regarding target vs. masker



Why is understanding one voice in the presence of other voices so difficult?



- *S-N Ratio:*
 - As S-N ratio decreases, energetic masking increases.
 - Relationship between S-N ratio and informational masking is not always linear.
- *Number of masking voices:*
 - As additional masking voices are added, fluctuations in the masking complex are reduced, which may increase overall energetic masking.
 - Maximum informational masking is produced by 2-3 competing voices.

Why is understanding one voice in the presence of other voices so difficult?

- *Similarity between target and competing voices*

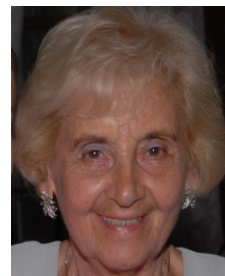
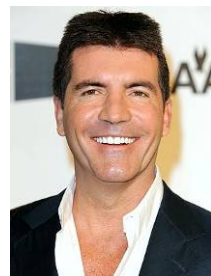
- Similarity increases both energetic and informational masking

- Energetic:

- overlap in spectral energy

- Informational:

- potential confusion between target and competing talkers

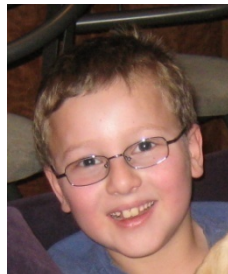
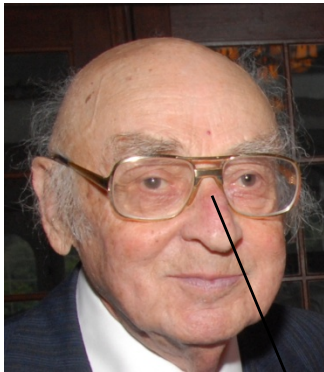


Why is understanding one voice in the presence of other voices so difficult?



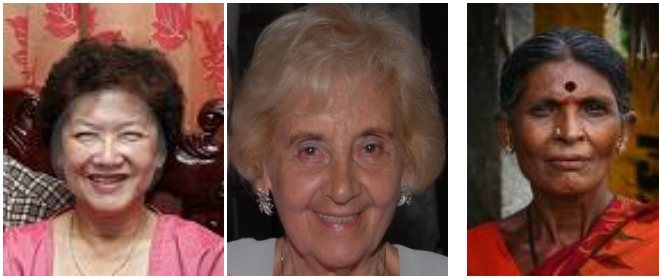
- *Spatial separation between target and competing voices*
 - Spatial separation reduces energetic and informational masking by...
 - creating S-N ratio advantages via head shadow and binaural interaction (MLD);
 - enhancing the ability to segregate the voices.

Why is understanding one voice in the presence of other voices so difficult?



- *Availability of visual speech cues in target*
 - Being able to see the target talker's face is even more beneficial in competing speech than in competing noise (Helfer & Freyman, 2005).
 - Visual cues help by...
 - filling in masked phonetic information
 - segregating the target talker from the competing talker(s).

Why is understanding one voice in the presence of other voices so difficult?



- *Understandability of the masker*
 - Competing messages that are not understandable (e.g., spoken in an unfamiliar language, presented time-reversed) produce less informational masking...
 - if masker and target are from same-sex talkers.
 - Elders demonstrate a greater understandable- vs. non-

Why is understanding one voice in the presence of other voices so difficult?

- *Familiarity with target talker and/or target message*
 - Familiar voices are easier to understand than unfamiliar voices in the presence of noise (e.g., Nygaard & Pisoni, 1998) for both older and younger listeners (Yonan & Sommers, 2000)
 - Giving the listener information about the target message helps reduce informational masking (Freyman et al., 2004)



Why might older adults have difficulty in competing speech situations?

- Filtering/attenuation from peripheral hearing loss leading to increased susceptibility to energetic masking

(e.g., Arbogast, Mason, & Kidd, 2005; Hallgren et al., 2005; Larsby et al., 2005; Marrone, Mason, & Kidd, 2008)

- Reduced ability to take advantages of masker fluctuations

(e.g., Takahashi & Bacon, 1992; Dubno, Horwitz, & Ahlstrom, 2002, 2003; Summers & Molis, 2004; George, Festen, & Houtgast, 2006)

Why might older adults have difficulty in competing speech situations?

- Problems segregating sound sources

(e.g., Summers & Leek, 1998; Alain et al., 2001; Grube et al., 2003; Vongpaisal & Pichora-Fuller, 2007)

- Reduced spatial release from masking (SRM)

(e.g., Duquesnoy, 1983; Festen & Plomp, 1996; Arbogast, Mason, & Kidd, 2005; Murphy, Daneman, & Schneider, 2006; Marrone, Mason & Kidd, 2008)

- Decline in the ability to learn and/or discriminate voice information

(e.g., Naveh-Benjamin & Craik, 1996; Yonan & Sommers, 2000; Pilotti & Beyer, 2002; Helfer & Freyman, 2008; Rossi-Katz & Arehart, 2009)

Why might older adults have difficulty in competing speech situations?

- **Cognitive changes:**

- *Diminished-resource hypothesis* (e.g. Craik & Byrd, 1982; Tun et al., 1991)
 - More resources needed to segregate the auditory scene (because of hearing loss) lead to fewer resources available for understanding the message
- *Reduction in control or efficiency of inhibitory mechanisms* (Hasher & Zacks, 1988; Hasher et al., 1991)
 - Decreased ability to attend to target message and/or ignore masking message(s)
- *Slowing in processing speed*
 - Difficulty processing speech in real-time
 - Increased time needed to switch attention
- *Reduction in working memory*
 - Problems processing simultaneous sources of speech

- Competing speech research in older adults

- Older adults (with varying degrees of hearing loss) typically demonstrate more difficulty than younger adults understanding speech in the presence of a speech masker

(e.g., Hygge et al., 1992; Wiley et al., 1998; Divenyi, Stark, & Haupt, 2005; Duquesnoy, 1983; Tun &

Wingfield, 1999; Humes, Coughlin, & Lee, 2006; Gates, Feeney, & Mills, 2008; Helfer & Freyman, 2008;

Marrone, Mason, & Kidd, 2008; Singh, Pichora-Fuller, & Schneider, 2008; Humes & Coughlin, 2009;

Rossi-Katz & Arehart, 2009)

- Older adults sometimes demonstrate problems when the masker is opposite-sex from the target; this is rarely an issue for younger listeners

(e.g., Divenyi, Stark, & Haupt, 2005; Humes, Lee, & Coughlin, 2006; Helfer & Freyman, 2008; Humes &

Competing speech research in older adults

- Aging results found in competing speech studies cannot be explained by amount of hearing loss alone (e.g. Tun et al., 2002; Humes, Lee, & Coughlin, 2006; Helfer & Freyman, 2008; Helfer & Vargo, 2009; Rossi-Katz & Arehart, 2009)
- Older adults appear to be affected to a greater extent by a meaningful (vs. non-meaningful) masker when target and masker are spoken by same-sex individuals and when both messages are syntactically and semantically realistic (e.g., Tun, O’Kane, & Wingfield, 2002; Larsby et al., 2005; Rossi-Katz & Arehart, 2009)
- Hearing loss in older adults limits the benefit from spatially separating a speech target from speech maskers (e.g., Duquesnoy, 1983; Festen & Plomp, 1996; Arbogast, Mason, & Kidd, 2005; Murphy, Daneman, & Schneider, 2006; Marrone, Mason & Kidd, 2008)
- *In general, most (but not all) older and/or hearing-impaired listeners obtain some benefit from spatial separation*

Competing speech research in older adults

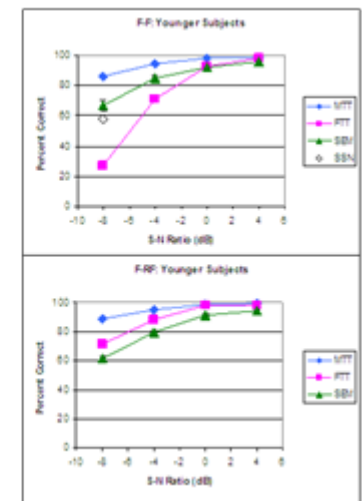
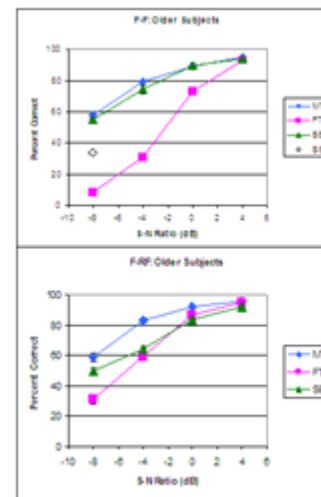
- There is no evidence of increased susceptibility with aging to the confusion or uncertainty part of informational masking (Li et al., 2004; Helfer & Freyman, 2008)
- Older adults are able to use information about target location to the same extent as younger listeners (Singh, Pichora-Fuller, & Schneider, 2008)
- Older adults are no more likely than younger adults to incorrectly report words in the masker rather than those in the target (Humes, Lee, & Coughlin, 2006; Agus et al., 2009), suggesting...
 - that older adults have less of a problem than younger adults inhibiting/ignoring information in the masker, and/or...
 - that older adults are less able to process information in the masker.

Research from our lab

- Helfer & Freyman (2008)
 - *Speech understanding in same-sex speech masker, different-sex speech masker, and modulated noise*
 - *spatially co-located and spatially-separated conditions*
 - *Voice discrimination task*
 - *Subjects:*
 - *younger, normal-hearing*
 - *older with no more than moderate high-frequency hearing loss*

Research from our lab

- High-frequency hearing loss limited performance in several listening conditions
- Spatial release from masking was about the same for older and younger listeners
- Largest relative difference between

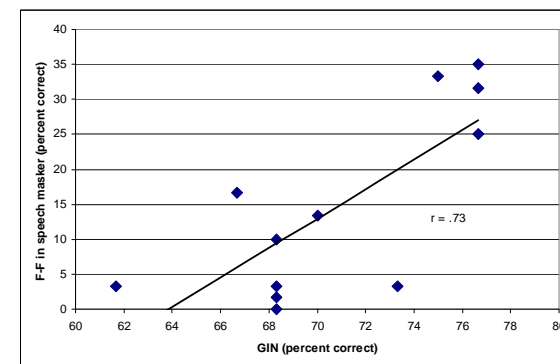
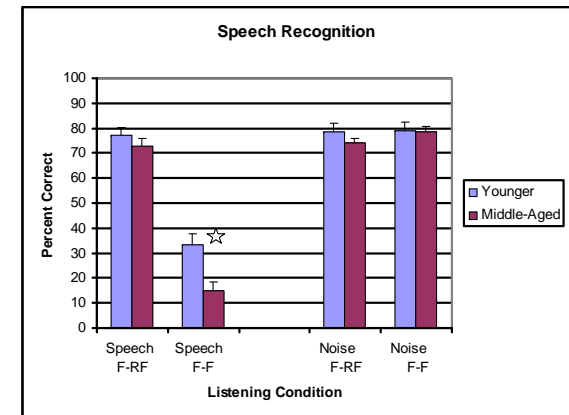


Research from our lab

- Helfer & Vargo (2009)
 - *Speech understanding and gap detection in middle-aged women*
 - *maskers: two-talker same-sex speech masker; steady-state noise*
 - *spatially co-located and spatially-separated conditions*
 - *gap detection task: GIN (Gaps-in-Noise) Test (Musiek et al., 2005)*
 - *Subjects:*
 - *young normally-hearing women*
 - *middle-aged (45-55 years) normally-hearing women*

Research from our lab

- Significant group difference for competing speech/spatially co-located condition
- Middle-aged listeners had significantly poorer temporal processing than younger listeners...
 - and this was correlated with speech recognition in the presence of a speech masker
- The slight high-frequency hearing loss in middle-aged listeners was correlated with speech perception in steady-state noise, but not with competing speech perception or



Summary of research

- Older adults demonstrate problems understanding speech in multi-talker environments
 - problems may begin in middle age
- Aging does not appear to cause increased susceptibility to the confusion/uncertainty part of informational masking
- Older adults appear to be affected to a greater extent than younger adults by the meaningfulness of a masker
- Most (but not all) older adults benefit from spatially separating the target speech from the interfering speech

Are hearing aids helpful in complex listening situations?

- Why might hearing aids be helpful?
 - *Restoration of audibility might reduce resources needed to decode the target, leading to more resources available for higher-level processing.*
 - *Provision of high-frequency amplification may allow listeners to use interaural level difference (ILD) cues to help separate target from background.*
 - *Hearing aids with directional microphones may improve relative S-N ratio of target talker to background voices.*
 - *Enhanced localization ability would help the listener find the target talker visually, leading to better (i.e., more rapid) use of visual speech information.*

Are hearing aids helpful in complex listening situations?

- Why might hearing aids **not** be helpful?
 - *Disruption of interaural differences in time and/or level could lead to problems...*
 - *segregating sound sources*
 - *obtaining spatial release from masking*
 - *localizing sound sources.*
 - *Amplification may improve the audibility of competing voices in addition to the target voice.*
 - *Directional microphones may interfere with ability to switch attention to other messages.*
 - *Noise reduction algorithms may not identify competing speech as “noise”, especially in situations with only one or two competing talkers.*
 - *Background noise may reduce the amount of informational masking by masking the competing messages* (e.g., Kidd et al., 2001; Freyman et al., 2001; Agus et al., 2009).

Are hearing aids helpful in complex listening situations?

- Hallgren et al. (2005):
 - Greater benefit of hearing aids in a single-talker masking condition vs. in slightly modulated noise
 - *Differences between younger and older subjects not significant*
- Hornsby et al. (2006):
 - Hearing-impaired listeners (middle-aged and older) obtained less benefit from hearing aids when the masker was speech (two, four, or seven-voice masker) vs. modulated noise
 - *Difference between aided and unaided performance in presence of speech maskers was minimal and not statistically significant*

Are hearing aids helpful in complex listening situations?

- Marrone, Mason, & Kidd (2008):
 - Hearing aid use had little effect on perception of one talker in the presence of two other talkers
 - Bilateral hearing aids had little effect on spatial release from masking in either older or younger listeners with hearing loss
 - *Unilateral hearing aid fitting resulted in slightly less SRM*
 - *SRM was substantially less for the hearing-impaired listeners than for young, normal-hearing subjects*
- Even when speech stimuli are spectrally shaped to restore audibility, older hearing-impaired listeners demonstrate poorer speech-on-speech perception than young, normal-hearing listeners (Humes, Lee, & Coughlin, 2006; Humes & Coughlin 2009; Rossi-Katz & Arehart, 2009)

How can we help our older patients cope in complex listening situations?

- Use questionnaires (e.g., the SSQ [Gatehouse & Noble, 2004]) to determine problems each individual patient faces in complex listening situations.
- Fit binaurally whenever possible.
 - spatial release from masking is smaller in people with hearing loss, but still is present in most listeners;
 - monaural fitting may have a negative impact on spatial release from masking

How can we help our older patients cope in complex listening situations?

- Directional microphones should be helpful, particularly in low-reverberation rooms.
 - Directional microphones may help alleviate burden on working memory (Sarampalis et al., 2009) and may make competing voices less audible/intelligible...
 - *but there is some evidence that they interfere with the ability to localize sources in non-frontal locations (e.g., Bogaert et al., 2008).*
- Noise reduction algorithms may be helpful.
 - Any type of processing that accentuates the target speech and de-emphasizes the masking voices should be helpful since older adults need a more advantageous S-N ratio.
 - However, the effectiveness of noise reduction algorithms in competing speech situations is still undetermined (especially in situations with one or two competing talkers).

How can we help our older patients cope in complex listening situations?

- Emphasize communication strategies that help differentiate the target talker from the background:
 - *for the patient:*
 - stress the importance of rapidly finding and looking at the target talker
 - maximize visual speech cues
 - make effective use of directional microphones
 - *for the communication partner:*
 - clear speech
 - topic maintenance

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Thank you!

