Poster Abstracts

(Even #s: Presented on Monday; Odd #s: Presented on Tuesday)

#1 Acoustic correlates of clear speech vowel intelligibility for elderly hearing-impaired listeners

Earlier work on vowels in clear and conversational speech produced by a single talker suggested that the acoustic cues that underlie the superior intelligibility of clear speech for older adults with hearing loss may differ from the cues that young normal-hearing listeners find beneficial. In the present study, clear and conversational vowel stimuli produced by all 41 talkers from the Ferguson Clear Speech Database were presented in a background of 12-talker babble to 40 older adults with mild-to-moderately severe sloping sensorineural hearing loss. Acoustic analyses (vowel duration, steady-state formant frequencies, and measures of dynamic formant movement) were also performed for all stimuli. Vowel intelligibility scores for each talker in each speaking style as well as the magnitude of the clear speech vowel intelligibility effect for each talker will be compared to those obtained from young listeners with normal hearing in a previous study. Regression and other statistical analyses of intelligibility and acoustic data will also be performed to determine the acoustic correlates associated with improved clear speech vowel intelligibility for each listener group. [Work supported by NIHDCD-008886].

Sarah Hargus Ferguson, University of Kansas

#2 Age effects and individual differences in spatial selective auditory attention

Understanding speech in the presence of competing speech maskers is a challenging task requiring selective attention. Anecdotal reports and previous studies suggest that aging interferes with this ability, especially in everyday settings containing reverberant energy. Past work also hints at large individual differences in performance of such tasks, which may be related to both aging and cognitive ability. By measuring the performance of normal-hearing listeners ranging from young to middle-aged, this study explores age- related changes in selective auditory attention, testing the hypothesis that deficits begin to take place in middle-aged adults even before significant peripheral hearing loss is present. Subjects were asked to report a stream of digits spoken from a simulated source directly ahead while ignoring competing digit streams spoken by the same male talker from simulated locations 15 ˚ to the left and right of straight ahead. The three source locations were created using an acoustic rectangular-room model and head- related transfer functions. Three levels of reverberation were achieved by varying the wall absorption coefficients of the room model. To perform the task, listeners had to focus attention on the target location, ignore the distracting digit streams, and hold the perceived digits in memory until after the stimulus had played, a design that taxed spatial discrimination, attention, and memory. Relationships between age, working memory capacity, hearing status, and performance are analyzed, with a special emphasis on the types of errors made in selection and object formation and how such errors relate or fail to relate to working memory capacity.

Dorea Ruggles, Boston University
With Lauren Ronsse; Barbara Shinn-Cunningham

#3 Elucidating the effect of continuous babble on memory performance in young and old adults

We investigated why a continuous babble background exerts an adverse effect on memory for spoken words. We presented babble only between word pairs, concurrent with the word pairs or flanking the word pairs (babble starting 500 ms before and ending 500 ms after). In young adults, background babble adversely affected memory because it forced listeners to focus part of their limited attention on the auditory stream to segregate the words from the noise background, which subsequently compromised the amount of attentional resources left for word encoding. The effect was particularly pronounced in conditions in which the babble was present somewhat continuously (continuous or flanking babble), presumably because there it bound limited attentional resources over an extended period of time. We also tested older listeners. To control for hearing, the babble level was adjusted so that both age groups could hear the words equally well. Older listeners showed the same adverse effect of streaming for prolonged babble as young listeners, but with a pool of attentional resources already diminished by age. Consequently, their memory performance was compromised in all tested conditions. Additionally, they showed a distinct pattern of memory loss for word-only babble that was not present in young adults. This effect was possibly due to older listeners needing more time to set up stream segregation processes. In summary, our results suggest that older adults are more affected than young adults in complex listening situations because they need more time to segregate auditory streams and have fewer attentional resources available.

Antje Heinrich, University of Cambridge
With Bruce Schneider

#4 Neurophysiological measurement of auditory segregation across the lifespan.

When an interaural phase difference (IPD) or frequency inharmonicity is introduced in one component of a harmonic complex tone, we perceive this component as distinct from the remainder of the complex tone. This ability to segregate concurrent sounds is of paramount importance when listening to speech in adverse listening conditions. Adults report greater difficulties in these listening situations as they age. We recorded auditory cortical evoked potentials (EPs) in young (n=10, age range 20-35 years), middle-aged (n=11; age range 47-58 years) and older (n=10; age range 61-68 years) individuals with normal hearing. Subjects watched a muted movie of their choice. The stimulus was a 5-tone harmonic complex tone (3 seconds) with a 250 Hz fundamental frequency, amplitude enveloped at a 40 Hz rate. An IPD (180 degrees) and/or frequency mistuning (2,4, or 8%) was introduced in the second harmonic at 1500 ms after stimulus onset, evoking a change EP characterized by the P1-N1-P2 complex. Mixed ANOVAs were conducted on the factor scores of a temporo-spatial PCA. Neurobiological aging was observed for middle and older aged listeners in the P2 component, when the auditory object was parsed using IPDs, but not when mistuning was present as a cue for auditory segregation. These findings support previous reports of aging in binaural hearing in midlife and at older age and document the impact of aging on auditory segregation. [Work supported by the Deafness Research Foundation].

Ilse Wambacq, Montclair State University
With Janet Koehnke; Joan Besing; Ann Marie De Pierro; Laurie Romei; David Cooper

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#5 Effects of age on spatial localization in listeners with normal hearing.

Virtual reality techniques have been used to develop clinical audiological tests to measure complex auditory processing abilities in realistic listening situations and environments. These tests evaluate the ability of listeners to localize sound sources in quiet and in noise. The Spatial Localization in Quiet test (SLIQ) and the Spatial Localization in Noise Test (SPLINT, SNR=0 dB) measure the accuracy with which listeners can locate sound sources (90° to -90° azimuth) in a virtual reverberant environment. We have obtained data using these tests in clinical settings for young (n=13, mean age 25 years), middle-aged (n=13, mean age 53 years) and older listeners (n=13, mean age 64 years) with normal hearing. Paired samples t-tests comparing the mean RMS error on the SLIQ and the SPLINT in each age group indicates that performance is similar in quiet and in noise for young adults. On the other hand, middle-aged and older adults have significantly greater difficulty localizing in noise than in quiet indicating that the effect of noise on localization increases with age. [Work supported by the Deafness Research Foundation].

Janet Koehnke, Montclair State University
With Joan Besing; Ilse Wambacq; David Cooper; Ann Marie De Pierro; Laurie Romei

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#6 What actions do older people take after failing a telephone-based hearing screen?

The actions taken by individuals who received a failing result on Telscreen, a telephone-based screening tool for hearing loss, were investigated using a telephone-administered questionnaire. 305 participants (184 females, 121 males), aged between 24 and 93 years (M = 66.14 years, SD = 12.06), were involved in the study. Of the 305 participants who failed Telscreen, approximately only 22% subsequently sought help from a range of sources (e.g., audiologist, hearing service or hearing aid provider, family doctor). A logistic regression model for a binary outcome was fitted to the data to identify which factors influenced a person's decision to seek professional help for their hearing impairment. Five significant predictors were identified. Participants who perceived a hearing loss prior to calling Telscreen (adjusted OR = 2.826, 95% CI = 1.000-7.988), acknowledged their Telscreen result (adjusted OR = 2.406, 95% CI = 1.129-5.127), and/or indicated they were ready for hearing aids (adjusted OR = 4.200, 95% CI = 1.919-9.191) were significantly more likely to seek professional help for their hearing impairment. Female participants were less likely than males to seek help (adjusted OR = 0.408, 95% CI = 0.192-0.869) and participants aged between 60 and 80 years were significantly less likely than those less than 60 to seek help for their hearing impairment (adjusted OR = 0.290, 95% CI = 0.117-0.715). Results will be discussed in the context of the Health Belief Model.

Carly Meyer, HEARing CRC and University of Queensland
With Louise Hickson; David Hartley; Asad Khan

#7 Perceptual learning of a foreign accent in young and elderly listeners

In this study we investigated perceptual learning of a foreign accent in young and elderly listeners by testing speech-perception thresholds over consecutive blocks of speech materials. Participants (20 young and 30 elderly) were first presented with four blocks of Standard Dutch sentences to establish their baseline speech-perception thresholds (SRTs). They were then presented with four sentence blocks spoken by the same speaker, but now in an artificial foreign accent of Dutch in which pronunciation of all vowel phonemes was systematically altered. We studied whether young and elderly listeners show similar-sized effects of accent on their SRTs and similar amounts of adaptation. SRTs in both age groups were higher in the accented than in the non-accented condition. In the accented condition, SRTs decreased more over blocks than in the non-accented condition, indicating that listeners adapted to the accent. Importantly, a triple interaction between speech type, block and age group indicated that the pattern of adaptation to the accent differed for the age groups: whereas the elderly hardly show further adaptation beyond the second block, the young adults do show further improvement with longer exposure. Among the elderly participants, hearing acuity predicted one's SRT and predicted the accent effect on one's SRT. Furthermore, a measure of executive function predicted the impact of the accent on one's SRT. In sum, these results indicate that accentedness is more detrimental to speech understanding in elderly than in young adults. This seems to be due both to poorer hearing and decreased mental flexibility in the elderly.

Esther Janse, Utrecht University & MPI Nijmegen
With Patti Adank

#8 Recognizing the Structure of Spoken Narratives: Effects of Age and Hearing Acuity.

A group of younger and older adults with good hearing and a group of younger and older adults with mild-to-moderate hearing loss were tested for recall of spoken narratives. The narratives were heard without interruption or with a self-paced presentation. The poor hearing older adult group recalled significantly fewer main ideas than the better hearing older adult group while listening to the passages without interruption. The poor hearing older adult group was aided in determining the narrative structure of the speech by intermittent pauses. Results were taken as support for the notion that the extra effort that a hearing-impaired listener must expend to achieve perceptual success comes at the cost of processing resources that might otherwise be available for encoding the speech content in memory.

Tepring Piquado, Brandeis University
With Arthur Wingfield

#9 Effect of age on directional microphone hearing aid benefit and preference

Despite the recognition that the directional microphone hearing aid (DMHA) is an important intervention aimed at helping older hearing-impaired adults understand speech in noisy environments, there is little evidence that older listeners can actually benefit from directional processing. The objective of this study was to determine if older and younger adults can obtain and perceive comparable benefits afforded by DMHAs. Twenty-four hearing-impaired adults aged 36 through 79 years were fit with

switchable-microphone hearing aids and tested in the laboratory and the field. In the laboratory, the listeners' directional benefit and preferences for microphone modes (directional vs. omnidirectional) were assessed using various speech recognition in noise tests. In the four-week field trial, a paired-comparison technique and paper-and-pencil journals were used to determine the benefit provided by directional processing. The effects of age on directional benefit/preference were analyzed using generalized linear models with controlling for the effect of hearing loss. The results revealed that age did not have a significant effect on directional benefit and preference as measured in the laboratory. However, the field data showed that older age was significantly associated with a lower preference for the directional mode. These results indicate that although listeners of different ages may obtain and perceive comparable benefits from DMHAs in laboratory testing, older users tend to perceive less benefit than do younger users in the real world. Possible explanations, including age-related social changes and age-related cognitive changes, will be discussed.

Yu-Hsiang Wu, The University of Iowa
With Ruth Bentler

#10 Is the influence of auditory training on temporal resolution different in old versus young adults?

A number of studies have shown that the performance of young adults on auditory perceptual tasks improves with practice. There is, however, only limited information regarding the effects of practice in older adults. Learning in the elderly is of particular interest because auditory skills are known to deteriorate as part of normal aging. The purpose of the current study was to compare the influence of auditory training on temporal resolution in old versus young adults. The comparison includes time course of learning, amount of learning gains, generalization to untrained conditions and long-term retention. Twelve younger and older normal-hearing listeners were trained for 10 days to detect a temporal gap between two 1kHz narrow-band markers. At 24 hours and 1-month post training, retention of gap detection thresholds (GDT) was measured in the trained condition and generalization was tested using different frequency markers: 2kHz-2kHz (with-in channel condition) and 2kHZ-1kHZ markers (between channel condition). Additional 36 normal hearing (old and young) served as controls for the different conditions. The results showed that despite significant differences between the two groups in the first few days, the elderly achieved similar GDTs as the young. Moreover, significant learning gains (above 50%) were attained in both groups. Generalization was observed to the untrained conditions, more so for the 2kHz-2kHz markers than for the 2kHZ-1kHZ markers. Retention of learning was evident at 24 hours and 1-month post training in both groups. These results provide evidence that the elderly can perform as well as the young following training.

Meital Avivi, University of Toronto
With Daphne Ari-Even Roth; Liat Kishon-Rabin

#11 Relationship between Stochastic FM Discrimination and Speech Perception in the Elderly

Recent work indicates that the temporal fine structure (TFS) of speech can of itself convey linguistic information, with a role of TFS processing implicated in the perception of speech in noise. The present work evaluated whether the difficulties in speech perception experienced by elderly listeners relates to a deficit in the ability to discriminate among patterns of TFS modulation. Data were collected from 14

young normal-hearing listeners and 14 elderly participants with either normal hearing or a mild-to-moderate hearing loss. Using stochastic frequency modulators derived from lowpass noise with a 5-Hz bandwidth, psychoacoustic tasks measured modulation-discrimination thresholds in terms of maximum instantaneous-frequency excursion (dF), stimulus duration, and S/N when stimuli were presented against a background of four-talker babble. As a measure of informational masking, dF thresholds were obtained both in quiet and in the presence of a low-level babble masker. In all conditions, the carrier frequency was 1 kHz. Speech perception ability was evaluated in terms of discrimination of NU6 words in quiet and QuickSIN sentences in four-talker babble. Significant differences between young and elderly listeners were obtained in all measures. Correlation analysis indicated that listener age among other variables was most strongly related to the S/N measure of TFS processing, while listener PTA showed the highest correlation with QuickSIN SNR loss. Furthermore, a significant correlation between the TFS S/N thresholds and QuickSIN performance suggests that a TFS processing deficit may hinder speech-in-noise intelligibility. Overall, results indicate that consideration of non-linguistic TFS measures may offer insight into effects of aging on auditory processing. [Work supported by NOHR and NIDCD.]

Stanley Sheft, Rush University Medical Center
With Rachel McMullen; Caitlin Farrell; Valeriy Shafiro; Christian Lorenzi

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#12 Brainstem Correlates of Speech-in-Noise Perception in Older Adults

Older adults frequently complain of trouble hearing in background noise and these difficulties cannot be solely attributed to reduced audibility. Recent brainstem studies have found that speech-in-noise perception is related to the strength of low-frequency encoding in young adults and children. We hypothesized that poor speech-in-noise perception would be reflected in diminished representation of the fundamental frequency in brainstem responses to speech as well as greater degradation of responses in background noise compared to responses in quiet. Our subjects included 22 older adults (age 60 to 74) whose hearing levels ranged from normal hearing to mild to moderate sensorineural hearing loss. They were evaluated using speech-in-noise perceptual measures (HINT and QuickSIN) and brainstem recordings to a speech syllable presented in quiet and in noise (competing multi-talker speech babble). Consistent with previous studies, the pure-tone audiogram failed to accurately predict speech in noise perception. We compared brainstem responses in groups of good and poor speech-in-noise perceivers and found that the spectral magnitude of the fundamental frequency was significantly higher in the good group than in the poor group. Quiet-to-noise inter-response correlations revealed that poorer speech-in-noise performance was related to lower inter-response correlations, indicating a greater degree of response degradation in noise. Overall results indicate that brainstem processing, including the strength of neural encoding of the fundamental frequency, plays an important role in speech-in-noise perception in older adults. Knowledge of the importance of encoding of the fundamental frequency may help guide future auditory training programs designed to improved listening-in-noise performance.

Samira Anderson, Northwestern University
With Erika Skoe; Alexandra Parbery-Clark; Nina Kraus

#13 Age-related auditory temporal resolution deficits: Neural manifestations

Older adults have difficulty resolving rapid changes in an ongoing stimulus, one of many auditory skills thought to be important for understanding speech in everyday listening environments. Our objective was to describe the cortical auditory evoked potentials (CAEPs) to a well-studied temporal cue, a silent gap, in younger versus older adults using stimulus conditions identical to those used in psychophysical studies of gap detection. For 12 young adults and 24 older adults, within-channel (i.e., spectrally identical signals marking the gap) and across-channel (i.e., spectrally different signals marking the gap) gap detection thresholds were determined psychophysically. CAEPs were recorded from 32 channels using within-channel and across-channel markers (i.e., signals before/after the gap) identical to those used for the psychophysical task and four perceptually-weighted gap durations. P1-N1-P2 peak latencies and amplitudes were analyzed at Fz and a temporal-spatial principal component analysis was conducted to evaluate responses across all electrodes. Young adults showed amplitude and latency differences related to the perceptual salience of the stimuli and activity related to gap detection threshold in the temporal-parietal region. Relative to young adults, older adults showed broader peaks, longer P2 latency, larger P1 amplitude, and laterality effects. The responses of the older adults represented a greater number and duration of responses following the onset of a 2nd marker in a gap detection paradigm. Older adults appear to recruit neural generators in the temporal regions (related to stimulation ear) of the brain to process temporal cues to a greater extent than young adults. The cortical response to a silent gap is unique to specific age groups, marker characteristics, and gap durations, providing non-invasive, non-behavioral indicators of the neural coding of this important temporal cue in the thalamic-cortical region of the central auditory system.

Jennifer Lister, University of South Florida
With Nathan Maxfield

#14 Does Executive Control Function Predict Speech Understanding and Processing?

Evidence suggests that cognition may play an important role in the ability of older adults to perceive speech. Executive Control Function (ECF) is an area of cognition guiding complex, goal-directed behaviors in the face of novel or ambiguous environmental cues. The purpose of this study was to determine whether ECF was a significant predictor of speech understanding in noise and of dichotic speech perception, while also considering the contributions of age and hearing loss. Participants were 116 individuals 45-85 years of age, with better pure tone averages between 0-65dB HL. Two multiple regressions were executed with independent variables: 1) Speech understanding in noise as measured by the Quick Speech In Noise test (QuickSIN) and 2) Dichotic speech understanding as measured by the Dichotic Digits Test (DDT). Dependent variables included the CLOX test (a screening measure of ECF), the EXIT25 (a comprehensive measure of ECF), degree of hearing loss, age, gender, measures of education and measures of health. Together, the dependent variables predicted 51% of the variance in binaural QuickSIN. As expected, degree of hearing loss was the most important predictor of QuickSIN, the EXIT25 was the next most important variable, explaining 25% of the variance when all other variables were controlled for. For the left ear DDT scores, 33% of the variance was explained by the dependent variables, and in this analysis, the EXIT25 was the most important predictor with a partial correlation of .266. This suggests that individuals with poor ECF are likely to display poor speech understanding and poor dichotic listening skills. In conclusion, it is reasonable to infer that ECF is an important factor to consider in clinical audiology and that it may impact on delivery of audiologic

services and hearing aid benefit. Acknowledgement: This research was supported by a grant from the Starkey Hearing Research Center.

Abby Bradshaw, University of Louisville
With Leeann Berger; Kerrie Roberts; Aynsley Weddle; Jill Preminger

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#15 Discriminability of speech tempo

Older people talk at a slower tempo than younger talkers. Previous corpus studies have indicated, however, that older talkers produce larger *changes* in tempo than younger talkers (Quené, 2008, JASA). These changes in tempo are relevant for communication, e.g. to indicate grammatical structure, emphasis, and attitude. It is also known that older people prefer a slower listening tempo than younger listeners. But do older listeners also prefer larger tempo changes than younger listeners? As a preliminary step to answer this question, we investigated the discriminability for speech tempo by older and younger listeners, for speech produced by older and younger talkers. Using a 2IFC task, the just-noticeable-difference (JND) of speech tempo was assessed for 5 test sentences spoken by 3 older and 3 younger talkers, with various manipulated tempo versions. Participants were 25 younger listeners (ages 20 to 28) and 21 older listeners (ages 65 to 84). The results show an interesting interaction: as expected, younger listeners yield better JNDs for younger talkers (5.5%) than for older talkers (6.3%). Older listeners, however, perform equally well for speech produced by younger talkers (JND 6.5%) and by older talkers (6.6%). Although only marginally significant (p=.092), these results indicate that older listeners may indeed have difficulties in hearing relevant changes in tempo when listening to younger talkers.

Hugo Quené, Utrecht University
With arah Klein; Aukje Lingsma

#16 Subjective Comprehensibility and Accentedness Ratings of Foreign-Accented Speech by Older and Younger Adults

Title: Subjective ratings of foreign-accented speech by older and younger adults Abstract: In this study, subjective ratings of foreign-accented speech were compared for young normal-hearing (YNH) and elderly hearing-impaired (EHI) listeners. Sentences and phrases produced by two native and two non-native speakers of English were presented in quiet. Listeners rated each utterance using a seven-point scale assessing either comprehensibility (how easy the utterance was to understand) or accentedness (the strength of any foreign accent). Comprehensibility scores were lower and accentedness scores were higher for the non-native speakers than for the native speakers. Despite previous studies showing poor understanding of foreign-accented speech by EHI listeners, comprehensibility ratings were identical for the two listener groups. We were also surprised to find that the EHI listeners assigned lower accentedness ratings to the non-native speakers than did the YNH listeners. This suggests that the EHI listeners either were more tolerant of foreign accent, or perhaps that the acoustic markers of foreign accent were less audible for this listener group.

Anne Baldwin, University of Kansas
With Sarah Hargus Ferguson; Kristine Williams

#17 Binaural and Monaural Temporal Integration with Older Ears

Binaural processing is both essential for understanding speech in multi-talker situations (e.g., Kidd et al., 2005) and can be substantially impacted by the effects of age (e.g., Singh et al., 2008). Consequently, effective rehabilitation of speech-in-competition performance hinges on understanding and addressing binaural dysfunction. To that end, the impacts of age and hearing loss on binaural function were assessed in a group of forty-two listeners ranging in age from 20 to 75, with roughly equal numbers older and younger than 50 years. Similarly, half of each age group had normal hearing thresholds, while half had mild to moderate impairment. Stimuli were 4 ms tone pulses centered at 2 kHz. In a monaural task, listeners detected the presence of one, two, four, eight, or sixteen pulses. In a binaural task, listeners discriminated pulses with a left-leading interaural time difference (ITD) from those with a right-leading ITD, across the same range of numbers of pulses. Adaptive thresholds were obtained and temporal integration functions were calculated. For the monaural task, differences in the temporal integration functions across listeners (i.e., the amount by which thresholds were reduced by doubling the number of clicks) were fairly small, and those differences obtained were largely predicted by the detection threshold at 2 kHz, with little impact of age. For the binaural task, however, performance was worse and the improvement with additional clicks was less for the groups with either older ears or thresholds outside the normal range. The combination of age and hearing loss led to especially poor performance in all conditions. These results indicate that binaural hearing, which is so important for success in complex situations, may be one of the earliest casualties of an aging auditory system. (Work supported by VA RR&D CDA2 C4963W).

Frederick Gallun, National Center for Rehabilitative Auditory Research
With Anna Diedesch; Robertson Beasley; Patrick Tsukuda

#18 Processing of temporal fine structure as a function of age

This study examined age effects in temporal processing using the discrimination of Inter-aural Time Differences (ITDs) as a measure of fine structure coding. Three age groups participated: Younger (18-28 yrs, N=15), Middle-aged (40-55 yrs, N=10), and Older (63-75 yrs, N=12). All had relatively normal hearing (thresholds ≤ 20 dB HL, 250 – 4000 Hz). Exp. 1 measured 0- versus π-radian ITD discrimination as a function of frequency for 5-Hz amplitude modulated tones presented at 65 dB SPL. The maximum frequency at which the discrimination could be made was lower for Middle-aged listeners than Younger listeners but higher than Older listeners. Exp. 2 measured ITD discrimination for fixed tone frequencies from 250 – 1500 Hz using sequences of two 200-ms tone pulses (75-ms rise, 25-ms fall). Older listeners had higher ITD thresholds than Younger listeners. Middle-aged listeners were intermediate and tended to hit test limits (π radians) at lower frequencies than Younger listeners. These results suggest that deficits in temporal fine structure processing are evident in the pre-senescent (middle-aged) auditory system. [Work supported by NIDCD 5-R01-DC01507].

John Grose, University of North Carolina at Chapel Hill
With Sara Mamo; Joseph Hall III

#19 Lexical decision in aging: Stimulus variables and response time components

It is known that different types of variables affect word retrieval, including lexical (e.g. frequency, length), subject (e.g. age, education) and task factors (e.g. mode of retrieval, composition of the stimulus set). Moreover, recent studies have demonstrated, through diffusion modeling, that reaction time can be decomposed into several processes, those related to the decision (stimulus information accumulation, response bias) and non-decision processes (encoding, response execution), which may be differentially affected. We tested older (>50 yrs.) and younger adults in an auditory lexical decision task to investigate how aging affects these different aspects of word retrieval. For both word and non-word responses, older subjects were both slower (Word: 71ms, p=0.016; Non-word: 159ms, p=0.003) and less accurate (Word: 0.8%, p=0.038; Non-word: 4.4%, p=0.003) than younger subjects. Both older and younger subjects were affected by the length and phonological neighborhood density of the word and non-word targets, and by the frequency of the word targets. Measures of phonotactic probability tended to influence the non-word responses of younger subjects, but the word responses of older subjects. This stronger effect of sub-lexical factors on word recognition is likely due to declines in peripheral processes (hearing acuity, speed of processing). In the diffusion model, older subjects had a significantly lower rate of information accumulation for both word (p=0.005) and non-word (p=0.0003) responses. For non-word responses, older subjects also took longer for non-decision processes (p=0.007). These results help clarify the cognitive and non-cognitive factors that contribute to word recognition, and how these change with age.

Jake Kurczek, University of Iowa
With Jean Gordon

#20 Objective and Subjective Speech Perception in Noise in Older Adults

Older adults with good hearing often complain of speech understanding difficulties. The purpose of this study was to characterize the objective and subjective abilities of older adults with normal or near normal hearing to understand speech in noise. Both younger (n=13) and older (n=19) listeners with (near) normal hearing participated. Speech understanding in noise was measured by the Quick Speech-in-Noise test (QuickSIN; Killion et al., 1994). Participants rated their level of difficulty on understanding speech in noisy environments using the Speech, Spatial, and Qualities questionnaire (SSQ; Gatehouse & Noble, 2004). On the QuickSIN, older adults performed significantly worse than younger adults. On the SSQ, older adults rated more difficulty hearing than younger adults on items associated with speech in speech situations. Age-related deficits were not observed for SSQ items addressing multiple speech-stream processing, or understanding speech in noise (i.e. non-speech noise). Within age groups, the QuickSIN and SSQ results were not significantly correlated. This lack of correlation suggests that subjective impressions of listening abilities reflect more than speech intelligibility. These results document specific complaints by older listeners with good hearing, and agree with other experiments showing age-related deficits on speech processing in complex listening environments. (Work supported by the NIH (R01-DC006014) and by the Bloedel Hearing Research Center.)

Christi Miller, University of Washington
With Pamela Souza; Kathryn Arehart; Melinda Anderson

#21 Older Adults' More Effective Use of Context: Evidence from Modification Ambiguities

The current study investigated how possible increased semantic effects in older adults (e.g., Laver & Burke, 1993) affect context use during sentence processing. We used modification ambiguities like "the handyman fixed the television with..." in which the temporarily ambiguous prepositional phrase could either modify the verb "fixed" or the noun "television". Studies with younger adults have demonstrated a strong initial preference for verb modification, but that manipulating the context can reduce but not overcome that preference. In the current study, we manipulated the contextual expectation as in (1-2): (1) Verb bias: The handyman wasn't sure which tool to use first, so he fixed the television with... (2) Noun bias: The handyman wasn't sure which television to work on first, so he fixed the television with... In (1), the context introduces multiple tools, so the prepositional phrase needs to modify the verb to specify which one was used. In (2), there are multiple televisions, so the prepositional phrase needs to modify the noun to specify which one. The prepositional phrases were manipulated to force the disambiguation ("with a soldering iron" vs. "with a broken screen"). These items were presented using self-paced reading. There was a significant 3-way interaction among Context, Disambiguation, and Age. In verb bias contexts, verb modification was strongly preferred for both age groups. But in the noun bias context, younger adults (age 18-23) showed no preference, whereas older adults (age 65-75) showed a significant noun modification preference. This suggests that the older adults relied more on context in that it fully flipped the preference, a finding never found for younger adults. The discussion will focus on the speed and timing of contextual use.

Robert Thornton, Pomona College

#22 Switching Time Affects Word-Recognition Performance on Tasks of Auditory Spatial Attention

The current study investigates the role of switching time on auditory attention in a multitalker, multispatial listening situation. Two conditions were used to explore auditory attention in 8 younger and 8 older adults who had normal audiometric thresholds below 4 kHz. In one condition a target sentence from the Coordinate Response Measure corpus was presented from one spatial location and competing sentences from two different locations, with cues specifying the target's identity and location. In the second condition, perceived spatial location of the target and competitors was achieved by manipulating time delays between presentations from two loudspeakers. Four different probability specifications indicated the likelihood of the target being presented at the left, centre, and right locations (0-100-0, 10-80-10, 20-60-20, 33-33-33). Four timing conditions (silent delays between cue and target of 0, 150, and 300 ms or a 300-ms filled delay) were presented which investigated the time course of attention switching. The main finding of interest is that for targets presented at unlikely locations with actual spatial separation, word-recognition performance was better when listeners had more (i.e., when listening to original sentences or sentences containing a 300 ms pause) time between the callsign cue and key words, than when listening to sentences containing shorter (i.e., 0 or 150 ms) pauses. Significant age-related differences were not observed. Implications for communication in naturalistic communication environments are discussed.

Gurjit Singh, University of Toronto
With Kathy Pichora-Fuller; Bruce Schneider

#23 Effects of Enhanced Bandwidth and Bimodal Presentation on Cognitive Function in Older Adults

Telephone communication is important for helping older adults maintain social engagement, but published data suggest that older adults' sensory and working memory limits may make telephone conversations. This study investigated the hypothesis that bimodal auditory-visual speech presentation would facilitate speech perception, and improve auditory working memory performance relative to that obtained with unimodal auditory speech presentation by reducing the cognitive effort needed for speech perception. Older adults with either age-normal hearing or mild to moderate sensorineural hearing loss participated in a running memory task. Each trial, the participant heard a list of bisyllable words. List length was unpredictable. The participant's task was to wait for the end of each list then repeat back the final three words. The stimuli were monaurally presented in telephone bandwidth (300-3000 Hz) or enhanced bandwidth (300-7000 Hz), with or without visual (lipreading) cues, under conditions of quiet and white noise (SNR 5 dB). Speech understanding was measured by checking for perceptual identification accuracy of the most recent (Lag 1) word in the three word set. Working memory was measured by checking for the recall accuracy of the lag 2 and lag 3 words. Bimodal presentation and enhanced bandwidth both improved speech understanding, producing additive effects. Data showed no interaction of display conditions by lag, however, indicating that easier speech comprehension did not allow greater working memory capacity. Bimodal presentation and enhanced bandwidth could be useful in improving speech understanding over the telephone by older adults, but do not appear to improve working memory performance. (Work supported by NIH PHS 1 P30AG023101 and The Beckman Institute Center for Healthy Cognitive Aging.)

Lynn Brault, University of Illinois at Urbana-Champaign
With Jaimie Gilbert; Charissa Lansing; Jason McCarley; Arthur Kramer

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#24 Cochlear Implantation in Older Adults: Standards of Care

Older adults who are evaluated for or receive cochlear implants often present professionals with complex and unique profiles. In addition to considerable hearing loss, older adults may experience other sensory and cognitive changes not typical of younger- or middle-aged adults. These non-auditory age-related changes may impact cochlear implant outcomes in older adults. We aim to establish if and how the current standards of care surrounding cochlear implantation in older adults differs from that of younger- and middle-aged adults. A comprehensive survey addressing cochlear implant services to older adults was designed that addressed demographics, areas of candidacy, device programming, outcomes assessment and rehabilitation. We have begun electronic delivery of the survey to audiologists across the United States who are involved with cochlear implant services. In this poster, we will present the content of the survey and report on preliminary findings. Ultimately, the information gathered will guide the formation of a needs-based assessment related to the provision of cochlear implants in an aging population. Work supported in part by the Center to Advance Research and Teaching in the Social Sciences at the University of Colorado.

Jessica Rossi-Katz, Metropolitan State College of Denver
With Kathryn Arehart

#25 Adult age differences in the interaction between bottom-up and top-down influences on dichotic listening

The right-ear advantage (REA), indicating superiority of the left hemisphere in speech processing, can be observed during verbal dichotic listening (e.g. Hugdahl et al., 1999; Kimura, 1961). Recent studies with young adults focused on the interaction between bottom-up and top-down processes in affecting REA (Tallus et al., 2007; Westerhausen et al., 2009). Initial evidence suggests that normal aging affects top-down attentional control of the REA (Andersson et al., 2008; Hugdahl et al., 2001; Takio et al., 2009). Here, we investigate how normal aging alters the interaction between bottom-up and top-down processes in auditory perception. Twenty younger adults and 20 older adults were screened for their hearing acuity and inter-aural threshold differences. Bottom-up stimulus characteristics were manipulated by gradually varying the inter-aural intensity differences in discrete steps of 5 dB on a continuum of left-right differences ranging from -20 dB to 20 dB. The degree of top-down modulation was manipulated by forcing attention to the right ear (FR), the left ear (FL), or none of the two ears (NF). Initial analyses of preliminary results suggest: (i) bottom-up and top-down processes interact in younger adults; (ii) relative to younger adults, the REA is weakened in older adults; (iii) older adults' advantage for a given ear depends more on stimulus intensity, indicating a decreasing ability to exert top-down control with advancing adult age. Our results are in line with available evidence on senescent decline in attentional control and on alterations in hemispheric asymmetry during speech processing (Bellis et al., 2000). Neural correlates of these behavioral age differences will be investigated in follow-up EEG studies.

Susanne Passow, Max Planck Institute for Human Development
With René Westerhausen; Isabell Wartenburger; Hauke R. Heekeren; Ulman Lindenberger; Shu-Chen Li

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#26 Different neural networks underlie temporal synchrony and stimulus saliency effects with audiovisual speech

Behavioral audiovisual integration effects seen with temporal asynchrony and reductions in stimulus saliency can provide insights into the underlying mechanisms of speech perception as well as possible causes for impairments developed with age. Furthermore, differences seen in the neural networks underlying these effects may suggest that the underlying cause of impaired audiovisual speech perception may not come from a single source, but may differentially effect separate systems. In this two-part study, we identified multisensory networks of brain regions that are sensitive to modulations in either temporal synchrony or stimulus saliency using fMRI. The experiments included multisensory and unisensory presentations of single-word tokens. Experiment 1 included variations across signal-to-noise ratios, while Experiment 2 included parametric manipulations of temporal synchrony. Using such an additive-factors design allows an experimenter to test for interactions in integration across levels of a given added factor (stimulus saliency and temporal synchrony). A network of brain regions that showed such an interaction across both added factors, including, among others, superior temporal cortex. A number of non-overlapping regions were also identified. Regions sensitive only to stimulus saliency included insula, medial frontal, parahippocampal, and anterior cingulate cortex. Regions sensitive only to temporal synchrony manipulations included superior colliculus, fusiform gyrus and lateral occipital cortex. The amount of non-overlap between these two networks suggest that the behavioral effects seen through variations in saliency and synchrony may be modulated by significantly different neural

mechanisms. Likewise, behavioral impairments associated with either saliency or synchrony seen with aging may stem from qualitatively different neural sources.

Ryan Stevenson, Indiana University
With Nicholas A; Sunah Kim; David Pisoni; Thomas James

#27 SNR-Loss in Hearing-Impairment and Feature Enhancement

The primary purpose of this study is to investigate detailed consequences of hearing loss and to scrutinize if individual hearing impaired (HI) listeners exhibit individual patterns in their consonant confusion scores. 16 English nonsense consonant-vowel syllables, which produced by 18 various talkers in five speech-weighted noise (-12, -6, 0, 6, 12 dB SNR) and quiet conditions, were randomly presented to 22 HI subjects (32 HI ears) having mild to moderate sensorineural hearing loss, at two different amplified levels: with and without NAL-R (similar to fitting hearing aids). The HI ears showed flat (mild-to-moderate-to-severe), ski-slop at low or high frequencies, and cookie-bite configurations. To characterize the consonant loss, the performance of each HI ear was compared to average normal hearing (ANH) listeners in masking noise. Preliminary analysis shows that each HI ear has an individual profile, which is a characteristic of the impaired ear. On the basis of each HI ear's individual profile, the 16 consonants used in the study can be broadly classified into 3 categories - fixed loss, unintelligible and noise sensitive. These categories need specific processing that can personalize hearing aid fitting, and facilitate more detailed study for speech perception of individuals with hearing loss.

Woojae Han, Univ. of Ilinois at Urbana-Champaign
With Riya Singh; Jont Allen

#28 Effect of r-resonance information on intelligibility

We investigated the importance of phonetic information in preceding syllables for the intelligibility of minimal-pair words containing /r/ or /l/. Five utterances of each of 104 sentences containing one /l/ or /r/ target word were recorded. For each sentence, the target word was excised from one of the five utterances and inserted a) into a different utterance of the same sentence and b) into a sentence that was uttered with the minimal-pair word. This technique resulted in cross-spliced sentences in which sentence base and target word either matched (ll, rr) or mismatched (lr, rl). Only in the matching case did the preceding syllables contain the correct phonetic information for the target word. Target phonemes could be word onset (rakes) or word medial (Terry). In word-onset cases, the syllable immediately preceding the target phoneme always came from a different, though in half of the cases matched, utterance. In word-medial cases, the syllable before the critical phoneme always came from the same utterance and therefore preserved the acoustic coherence to the phoneme in all cases. Young and old adults heard the sentences, which were casually or carefully spoken, in cafeteria or 12-talker babble. Matched phonetic information in the syllable immediately before the target segment, and in earlier syllables, facilitated intelligibility of r- but not l-words. Older adults were able to use phonetic information in a similar way to young adults. Moreover, their use of resonance information was independent of the extent of their sensory-neural hearing loss.

Antje Heinrich, University of Cambridge
With Sarah Hawkins

#29 Modulation masking release for consonants and vowels: effect of hearing impairment

Speech recognition performance of normal hearing (NH) listeners is usually better in modulated noise than in steady state noise. This release from masking is thought to be due to glimpses of the target speech during the low intensity portions of the modulated noise masker. In this study we estimated the modulation masking release for individual speech features by measuring consonant and vowel confusions in the presence of modulated maskers. Miller and Licklider (1950) showed that the magnitude of modulation masking release depends on the rate of masker modulations. Our results show that vowel recognition is affected more by modulation rate than consonants. Listeners with elevated thresholds often fail to show modulation masking release (Festen and Plomp, 1990). It has been argued that hearing-impaired (HI) listeners cannot take full advantage of speech glimpses during the weak portions of masker modulations. In this study, we examine whether this disadvantage by HI listeners is limited to certain speech features. To address this question, data will be presented that compares the modulation masking release demonstrated by NH and HI listeners for consonant and vowel features as a function of masker modulation rate. This research was partially supported by Cooperative Research and Development Agreements between the Clinical Investigation Regulatory Office, U.S. Army Medical Department and School and the Oticon Foundation, Copenhagen, Denmark. The authors would like to thank the Department of Clinical Investigation at the Walter Reed Army Medical Center for their administrative support and Institutional Review of research involving human subjects under work unit #06-25025. The opinions and assertions presented are the private views of the authors and are not to be construed as official or as necessarily reflecting the views of the Department of the Army, or the Department of Defense.

SANDEEP PHATAK, Walter Reed Army Medical Center
With Ken Grant

#30 Spatial-Temporal Factors in Perception of Concurrent Speech in the Elderly

Using the coordinate Response Measure (CRM) corpus with multiple (2-4) talkers, the ability of elderly listeners with good hearing to both detect the presence of from one to three target callsigns (e.g., “Baron”, or “Baron and Hopper”) as well as to name the color-number spoken by a particular talker was tested under three different conditions: 1) presented dichotically; 2) presented dichotically, but time stretched so the stimuli were 25% slower than in the previous condition; and 3) spatially separated where the target callsigns could occur anywhere in the spatial display but the color-number pair to be named was either in the right or left ear. The deleterious effects of increasing both number of targets and talkers were consistent with those found in previous literature. However, somewhat surprisingly, the time-stretched stimuli showed a significant improvement over the normal-tempo for both p(c) for color-number pair (mean 0.49 vs. 0.41 across conditions) and d’ (mean 1.80 vs 1.25 across conditions), which differs from most literature on speech perception and CRM data for young listeners from Shafiro and Gygi (2009). The spatially separated stimuli showed an expected improvement compared to the dichotic condition for color-number identification (overall mean p(c) = 0.64), and a significant decrement in performance in d’ for target callsign detection (mean d’ = 1.18), with the largest difference occurring under the conditions of greatest attentional load (greater number of targets). The results show the complex interaction of peripheral and attentional factors in perception of concurrent speech in the

elderly. Research supported by the Merit Review Training Grant from the Department of Veterans Affairs Research Service, VA File # 06-12-00446, and the Rush University Medical Center.

Brian Gygi, Veterans Affairs Northern California Health Care System
With Valeriy Shafiro

#31 Effects of Signal Quality and Level, Background Noise, Age, and Hearing Loss on Word-Recognition Performances

This study describes the word-recognition performances in quiet and in noise for older listeners with near-normal hearing (ONH) and older listeners with hearing loss (OHL) in the following four conditions: (1) undistorted, (2) jitter, (3), smear, and (4) jitter-smear. A group of young listeners with normal hearing (YN) served as a control group. The ONH listeners (N = 72) outperformed the OHL (N = 72) in all conditions. In quiet, both groups performed best in the intact condition, followed by jitter and smear, with the poorest performance in the combined jitter-smear condition. Increasing the level of the speech in quiet improved performance for the hearing loss group, but decreased performance for the near-normal hearing group. In babble, both groups performed best in the intact condition, followed by similar performances for jitter and smear, with the poorest performance again in the combined jitter-smear condition. The performances of both listener groups in babble are related to age, but audiometric thresholds also contribute to performance for the older listeners with hearing loss. At more favorable S/B ratios, where listeners achieve their asymptotic performance, there is a resemblance between the performance of younger listeners in distortion conditions and the performance of older listeners in intact conditions. At less favorable S/B ratios, the performance of the YN listeners in distorted conditions is superior to the performance for ONH listeners, whose performance is in turn, superior to the OHL listeners. Thus, the degree of hearing loss is an important factor contributing to performance, particularly at less favorable S/Bs. This work was supported by a VA Rehabilitation Research and Development (RR&D) Career Development Award to the first author (C6394W; Drs. Pichora-Fuller and Wilson serve as research mentors) and by the VA RR&D Auditory and Vestibular Dysfunction Research Enhancement Award Program to the first and third authors (#C4339F).

Sherri Smith, VA Medical Center
With M. Kathleen Pichora-Fuller; Richard Wilson

#32 Workload Capacity as a Measure of Integration Efficiency in Audiovisual Speech Perception: A Time-Based Approach

In a landmark study carried out over 50 years ago, Sumby and Pollack (1954) investigated the visual contribution (i.e., lip-reading) to auditory speech intelligibility using different auditory signal-to-noise ratios and vocabulary sizes. The authors observed that the proportion of audiovisual gain, or the visual contribution, was independent of the clarity of the auditory signal, although low signal-to-noise ratios afforded more opportunity for the listener to utilize visual speech cues. While audiovisual enhancement in terms of accuracy is well documented, speech perception occurs in real time and time-based statistical measures are necessary for making broad claims regarding audiovisual enhancement or processing efficiency. A replication of Sumby and Pollack's experimental design was carried out in which reaction time and accuracy measures were obtained for auditory, visual, and audiovisual trials at three

different signal-to-noise ratios: Clear, -12 db, and -18 db. A time-based measure of efficiency known as workload capacity that utilizes integrated hazard functions (Neufeld, Townsend, & Jetté, 2007; Townsend & Nozawa, 1995; Townsend & Wenger, 2004) was computed to determine whether processing efficiency increased, decreased, or remained constant when visual information was added to the signal. The obtained capacity measure demonstrated that the addition of visual information was used efficiently only at low signal to noise ratios (-12 db and -18 db), particularly for early reaction times. Time distributional-based approaches for measuring integration efficiency provide converging evidence for accuracy based measures and provide a powerful tool for investigating audiovisual integration in clinical and aging populations.

Nicholas Altieri, Indiana University
With James Townsend

#33 Behavioral and Electrophysiologic Gap Detection in Listeners With and Without Hearing Loss

Hearing loss may interfere with the auditory system's ability to process temporal changes in the acoustic signal. Well-studied behavioral measures of temporal processing (e.g., gap detection) have shown conflicting results with regard to the effects of hearing loss on performance (Moore, 1996). One key unresolved question is whether or not high-frequency sensorineural hearing loss (HFSNHL) affects temporal processing in regions of normal low-frequency hearing. Recent evidence in guinea pigs suggests that HFSNHL contributes to reduced temporal processing even in regions of normal hearing (Yin et al., 2008). The purpose of this study was twofold: (1) to determine the extent to which HFSNHL impacts temporal processing in regions of normal low-frequency hearing and (2) to establish the relationship between behavioral and electrophysiologic measures of gap detection. Behaviorally and electrophysiologic gap detection thresholds (GDTs) were recorded in ten listeners with normal hearing and ten listeners with HFSNHL. The stimulus spectrum was restricted to <2000 Hz to assure testing of low-frequency regions where hearing was within normal limits for both groups. The stimulus was modeled after the first two formants of the bilabial /ba/ sound (i.e., F1 = 620 Hz and F2 = 1330 Hz with F0 = 120 Hz). GDTs were recorded in within-channel (WC) and between-channel (BC) conditions. For the WC condition, gaps were bounded by temporally and spectrally similar markers. For the BC condition, gaps were bounded by temporally and spectrally different markers. Electrophysiologic GDTs were measured by evoked responses (i.e., P1-N1-P2) recorded with gap durations based on individual behavioral GDT (i.e., sub-threshold, threshold, and supra-threshold gap values). Comparisons between groups and across gap detection conditions will be discussed (work supported by VA RR&D Career Development Award C4323V).

Elizabeth Leigh-Paffenroth, Mountain Home VAMC
With Saravanan Elangovan

#34 Age-related differences in the production and understanding of emotion in speech

The process of understanding spoken language involves the integration of two forms of information; transactional (content, what is said) and interactional (how it is said). While speech intelligibility tasks control for the former (e.g., by equating word frequency, neighbourhood density, etc.), they have neglected the latter. Visual experiments have shown that the emotional meaning of a stimulus can

significantly influence attention and recall; however, similar effects of emotion on auditorally presented information have not been investigated. The current experiments were designed to examine the influence of lexical and prosodic emotional speech cues on spoken language understanding. In the first experiment, 200 sentences from the Northwestern University Auditory Test No.6 were rated on emotional valence and arousal. The majority of the original 200 sentences were rated as neutral and only moderately arousing. In the second experiment, a younger actress and an older actress re-recorded these sentences with seven emotions and the acoustic dimensions of their productions were analyzed. The sentences recorded by the younger actress were spoken more slowly, loudly, and in a higher pitch than those recorded by the older actress. In the third experiment, younger and older adults identified the emotion of the new stimuli. Although participants were quite accurate at identifying emotion, older adults were less accurate overall. This is one of the first attempts to create a more ecologically-relevant measure of spoken language incorporating emotion, and to examine age-related changes in affective speech processing.

Kate Dupuis, University of Toronto
With Kathleen Pichora-Fuller

#35 Age-related differences in context use in intact and distorted speech: An electrophysiological investigation

Investigations using measures of event-related potentials have consistently identified a negative-going waveform approximately 400 milliseconds after stimulus onset (N400) which is more strongly elicited by unpredictable (The cat chased a pizza.) than predictable sentence-final words (The cat chased a mouse). Thus, the N400 provides an index of the use of context. While separate studies have shown that increased age and degradation of auditory stimuli attenuate the N400, these factors have not been studied simultaneously using sentence stimuli. In the current study, we investigated the effects of both age (younger: ages 18-30 years, older: ages 65-75 years) and stimulus degradation (intact, degraded) on participants' ability to successfully identify sentence-final words. Multi-band noise-vocoding was used to degrade the speech. Notably, the amount of distortion was varied in an attempt to equate intelligibility across the two age groups (6-band vocoding for younger, 8-band vocoding for older) and older listeners were actually less negatively affected by degradation than were younger listeners. All participants were more accurate in identifying the final words of high- compared to low-predictability sentences, and their accuracy was reduced by degradation. The N400 was observed for both age groups, but its amplitude was significantly attenuated by increased age, high context, and signal degradation. Importantly, the change in N400 amplitude across stimulus degradation conditions was similar for both age groups, suggesting that when the degree of degradation is adjusted to equate for intelligibility across the younger and older listeners, they demonstrate similar accuracy and N400 responses.

Kate Dupuis, University of Toronto
With Natalie Phillips; Katie Boodhoo; Kathleen Pichora-Fuller

#36 Comodulation Masking Release (CMR) to detect cochlear dead regions in hearing impaired ears

The main purpose of this study is use investigate whether comodulation masking release (CMR) experiments with hearing-impaired individuals can be used as a reliable method to detect dead regions in the cochlea, if any. The experiment involves detection of a pure tone in a narrow band of noise (the on-signal band) in presence of four other narrow bands of noise that fall outside the auditory bandwidth at the centre frequency of the on-signal band. These flanking bands are either all co-modulated so as to have the same amplitude envelope as the on-signal band or are randomly modulated, and are presented monaurally to a hearing-impaired ear. Each band is level adjusted so as to be audible to the hearing impaired ear. Data is being collected for both these cases from normal hearing listeners and HI listeners with no dead regions. Every HI individual also undergoes psychophysical tuning curve (PTC) and threshold equalizing noise (TEN) tests which are currently used clinical measures to detect dead cochlear region(s). Each HI individual also takes speech perception tests with nonsense CV syllables under various noise conditions. The consonant loss profiles from the perception experiments help make a reasonable estimate of the possibility of a dead region.

Riya Singh, University of Illinois at Urbana-Champaign
With Woojae Han; Jont Allen

#37 Aging alters the perception and physiological representation of frequency: Evidence from human FFR recordings

Older adults, even with clinically normal hearing sensitivity, have difficulty understanding speech in the presence of background noise. This difficulty may be partly due to age-related declines in the neural representation of frequency. The purposes of this study were to examine the effect of age on behavioral and physiological measures of frequency representation. Thirty one adults (ages 21 – 77) with clinically normal hearing sensitivity (equal to or better than 25 dB HL at octave frequencies 0.25 – 8.0 kHz) participated in this experiment. Frequency discrimination was tested at 500 and 1000 Hz using a two-interval, two-alternative forced choice procedure. Frequency-following responses (FFRs) were elicited by tonebursts at six frequencies: 463, 498, 500, 925, 998, and 1000 Hz. Tonebursts of 500-ms duration (15-ms rise/fall) were used for both the behavioral and physiologic conditions. FFRs were analyzed using phase coherence and amplitude. Results showed a decline in behavioral and physiological responses with increased age. Linear regression analyses showed a statistically significant decrease in frequency discrimination at both 500 and 1000 Hz with increasing age. Linear regression analyses of phase coherence and amplitude also showed statistically significant decreases with increasing age. These results are consistent with age-related declines in the neural representation of frequency. (Work supported, in part, by NIH grants R01-DC007705 (KT), T32-DC00033 (CC).)

Chris Clinard, University of Washington
With Kelly Tremblay; Ananthanarayan Krishnan

#38 Age-related differences in the contribution of auditory and cognitive factors to word recognition and discourse comprehension

Two analyses examined the contributions of auditory and cognitive factors to the performance in younger and older adults on different listening tasks. First, we examined the extent to which auditory measures (pure tone thresholds, energetic masking thresholds) and/or cognitive measures (vocabulary, reading comprehension) could predict the ability of participants to recognize the last word of a nonsense sentence in an informational masking paradigm (word recognition accuracy). Despite age-related differences on all measures, multiple-regression analysis did not reveal a significant contribution of any of these variables to word recognition performance. To examine whether such factors would play a role in more cognitively complex listening situations, we examined the contributions of audiometric thresholds and babble thresholds (auditory measures), and working memory and reading comprehension ability (cognitive measures) to an individual's ability to comprehend and remember monologues or dialogues when they were masked by babble (discourse comprehension). In this more realistic situation, only the cognitive measures were correlated with performance. Once again, despite age-related differences on all measures, the pattern of results in the multiple-regression analysis was equivalent for both younger and older adults. These results suggest that individual differences in auditory and cognitive abilities do not have the same consequences for word recognition and discourse comprehension, underscoring the importance of the type of materials and task used to evaluate the factors contributing to listening performance. Interestingly, the extent to which these individual differences can account for word recognition and discourse comprehension in difficult listening situations is equivalent for younger and older adults.

Payam Ezzatian, University of Toronto
With Kathy Pichora-Fuller; Bruce Schneider

#39 Effects of age on melody and timbre perception in simulations of electro-acoustic and cochlear-implant hearing

Traditional cochlear implants (CI) do not convey musical information very well. New developments in CI technology include electro-acoustic systems (EAS) which combine low-frequency residual hearing with CI stimulation in the mid- and high- frequencies. Recent clinical reports suggest that music perception improves with EAS devices. However, preliminary evidence also suggests that older adults may have reduced benefit with EAS systems. Our current study utilizes the Clinical Assessment of Music Perception test (Nimmons et al, 2008, Otology & Neurotology 29:149-155) to quantify the ability of older and younger adults to identify common melodies and the timbre of common instruments for music processed in three listening conditions: unprocessed music (UNP), acoustic simulation of CI music (CIsim), and a hybrid electro-acoustic simulation (EASsim) that combines low-frequency unprocessed music with an acoustic simulation of higher-frequency CI music. While acoustic simulations do not fully represent the nature of EAS and CI hearing in real devices, the use of simulations allows us to separate age-related effects from other factors that may be present in older patients with actual EAS systems (e.g., varying durations of deafness, varying degrees of residual low-frequency hearing). Results to date include the following: First, older adults' timbre and melody identification is significantly worse than younger listeners in the CIsim condition. Second, both older and younger listeners show melody identification that is comparable in the UNP and EASsim conditions. Third, timbre identification is substantially reduced in the EASsim condition compared to the UNP condition, with the reduced

performance especially pronounced in the older listeners. These results support the idea that in timbre perception, older adults have more difficulty extracting and integrating cues contained in the low-frequency unprocessed and higher-frequency CI portions of the EAS stimulus.

Kathryn Arehart, University of Colorado
With Naomi Croghan; Melinda Anderson; Ramesh Kumar Muralimanohar

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#40 Listening in the Gaps: The Effects of Age and Hearing Loss on Three Measures of Temporal Resolution

Temporal resolution is thought to be important for understanding speech-in-noise. We used three tasks (gap detection, temporal masking, and word recognition in interrupted noise) to assess the temporal resolution of young listeners with normal hearing (YNH) and older listeners with hearing impairment (OHI). Gap detection thresholds (GDT) were established for each listener using broad-band noise (BBN) markers. Forward-backward masked and simultaneously masked thresholds for a click inserted in BBN were measured. For the forward-backward masking condition, the click was inserted in the center of a silent gap in the BBN. For the simultaneous masking condition, the click was centered in the BBN without a gap. For the word recognition task, the signal-to-noise ratio (SNR) required for 50% correct recognition of monosyllabic words presented in interrupted speech spectrum noise was measured. Four conditions of interrupted noise were used: no interruptions, 5 interruptions/second, 10 interruptions/second and 20 interruptions/second. Significant differences between groups were found for all listening conditions ($p < .05$). No significant difference was found for either group between forward-backward and simultaneous masked thresholds. Young listeners showed significant benefit from interrupted noise, with scores for 0 ips significantly worse than for the other three conditions ($p < .05$). Older listeners did not show significant benefit from interrupted noise. Significant correlations between GDT and 50% SNR for all word recognition conditions were found for the OHI. The results of this study suggest that older listeners may have more difficulty "listening in the gaps" as compared to younger listeners; this may contribute to the difficulties this population experiences in understanding speech-in-noise.

Susan Fulton, University of South Florida
With Jennifer Lister; Richard Wilson; Rachel McArdle; Theresa Chisolm

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#41 Temporal masking of brief vowels with noise and vowel-pattern maskers: Performance across the adult lifespan.

Young (N=53; 18-31 years), middle-age (N=18; 40-55 years), and older (N=125; 60-88 years) adults identified vowels in forward and backward temporal masking conditions. Experiments used forced-choice adaptive-tacking methods to determine the smallest stimulus asynchrony between brief 40-ms vowels that enabled identification of the vowel. Vowels modified from four words (pit, pet, pot, put) served as stimuli. All listeners identified the vowels in isolation with better than 90% accuracy. Maskers consisted of either noise or a pattern of overlapping vowels and were presented at two intensity levels. Results indicated that older listeners performed significantly poorer on all temporal masking tasks than young listeners, with middle-age listeners in between. Performance for forward masking conditions was better than backward masking and noise maskers were easier than pattern maskers. An effect of masker

intensity level was also observed with less intense maskers yielding better performance. Correlations of performance with age across the full age span were moderate. (Work supported, in part, by NIA R01 AG022334.)

Daniel Fogerty, Indiana University
With Diane Kewley-Port; Larry Humes

#42 Cognitive rhythms in patients with fronto-temporal lobar degeneration

While Alzheimer's disease is the most common form of dementia, other less common forms such as fronto-temporal lobar degeneration (FTLD) may manifest through symptoms similar to Alzheimer's, including language-specific impairment. FTLD comprises four variants: behavioral (affecting social function and executive control), progressive non-fluent aphasia (affecting fluency and grammaticality of speech), progressive logopenic aphasia (fluent aphasia with anomia but intact word meaning and object recognition), and semantic dementia (aphasia characterized by loss of word meaning and object recognition) (Knopman et al., 2008). Currently, language-related tests of FTLD variants include measures of hesitancy; speaking rate; syntactic and morphological complexity; ratio of nouns, verbs, and pronouns; as well as semantic and pragmatic features (Gorno-Tempini et al., 2004; Peele et al., 2007; Ash et al., 2008; Bird et al., 2000; Grossman, 2002; Hodges et al., 1992; Neary et al., 1998). However, there is considerable overlap between linguistic manifestations of FTLD variants, making them difficult to diagnose. We investigate a speech characteristic not yet assessed in FTLD patients, that of "cognitive rhythms" (Henderson et al., 1966; Butterworth & Goldman-Eisler, 1979). Cognitive rhythms consist of alternating cycles of fluent and hesitant speech. As the figure in Levelt (1989:127) illustrates, steeper slopes indicate periods of hesitation and planning, and shallower slopes of fluent speech with fewer hesitations. We analyzed spontaneous speech from 19 older adults diagnosed with FTLD and found that greater length of cognitive cycles was negatively associated with performance on tests of memory, executive function, and attention. This preliminary study brings us closer to a more detailed understanding of how language is affected by FTLD, and of how cognitive rhythms can be used to characterize speech affected by neurodegenerative disorders.

Eden Kaiser, University of Minnesota
With Serguei V. S. Pakhomov; David Knopman

#43 The Role of Temporal Fine Structure in Sound Quality Judgments by Older Adults

Many Americans with hearing loss who are candidates for hearing aids do not actually own them and many of those who do own hearing aids are not satisfied with them. Sound quality is a primary factor contributing to this lack of satisfaction. This study focuses on sound quality perception in older adults. Both hearing loss and age can affect the ability of listeners to process important components of sound. Some of these components relate to the temporal structure of sound, and include slowly varying changes (temporal envelope) and much faster-changing components (temporal fine structure). The purpose of this project is to quantify how changes in a signal's envelope and fine structure contribute to the perception of sound quality. We hypothesize that temporal fine structure and envelope will play differential roles in sound quality perception and that these roles may change as a listener ages due to

age-related deficits in temporal processing. We will report quality ratings for older and younger listeners for speech that has been processed to vary in the amounts of temporal fine structure it contains: from none to complete. The results will be discussed in terms of how quality judgments are affected by age and by the amount of envelope and fine structure information in the signal. Results to date indicate that that listeners prefer speech with 16 bands opposed to 8 bands, and that inclusion of sounds below 300 Hz are beneficial to sound quality. Additionally, signals with a stationary Gaussian noise that has not been modulated to match the temporal envelope shows poorer sound quality than signals which contain a temporal-envelope-modulated noise of comparable levels, indicating that temporal envelope and temporal fine structure may play different roles in sound quality judgments. (Work supported by the Univ. of Col. Institute of Cognitive Science and by a grant to the Univ. of Col. from GN ReSound)

Melinda Anderson, University of Colorado
With Kathryn Arehart; James Kates

#44 Simulating an Age Related Sensory Change Can Mimic Age-Related Changes in a Selective Attention Test – Evidence from the Stroop Paradigm

Age-related changes in a person's ability to selectively attend to one signal among many could potentially account for some of the difficulties that older adults experience in listening to conversations in noisy environments. Age-related changes in selective attention are typically evaluated using the Stroop test: participants are asked to name the colors of printed words, irrespective of their content. The latency advantage for naming the print color of a color-neutral word (TABLE printed in blue) over an incongruent color-word (RED printed in blue) is termed Stroop interference (SI). An increase in SI with age is often interpreted as reflecting reductions in selective attention, or alternatively, cognitive slowing with age. In a cross-lab and a cross-sectional analysis, we linked Stroop declines to sensory losses instead of cognitive changes. Specifically, we found that the latency difference, or dimensional imbalance, between reading and naming the font color of color-neutral words increased with age. A cross-sectional analysis revealed that this dimensional imbalance can both mediate the effects of age on Stroop, and contribute to Stroop after controlling for age effects. In an empirical experiment, 88 younger adults performed a card Stroop test. Two color-sets were used: a standard set (with highly discriminable colors), and a low discriminability set simulating age-related color-vision deficiencies. Moving from high to low discriminability sets increased both dimensional imbalance and SI, but had no effect on reading latencies. We conclude that age-related changes in color perception contribute to and may mediate age-related changes in Stroop. These results complement those of Singh et al. (2008) who failed to find any age-related deficits in selective attention to one talker among many. More generally, sensory factors rather than cognitive factors may provide an alternative explanation for apparent age-related changes in selective attention behavior.

BoazBen-David, University of Toronto, Mississauga
With Bruce Schneider

#45 Examining the role of talker-specific details in older adults' perception of spoken words

Recent findings demonstrate that talker-specific details of spoken words affect younger adults' perception of spoken words relatively late during processing. Although listeners are faster to recognize

words heard recently (priming), words spoken by the same talker only have a perceptual advantage (talker-effects) when processing is relatively slow. The purpose of the present study was to examine the time course of talker effects in older adults. General slowing predicts that abstract information will still affect processing earlier than talker-specific details, as found with younger adults. Alternatively, older adults' slowed processing could lead to talker-effects relatively early during processing. Our results provide some support for the alternative prediction, and shed new light on how older adults represent and process spoken words.

Maura Wilson, Cleveland State University
With Teresa Markis; Ellen Bronder; Conor McLennan

#46 Effects of intra- and inter-talker differences in speech production on intelligibility when younger and older adults listen in noise

The Lombard Effect is the reflex that occurs when a talker modifies his or her vocal production when speaking in noise. These modifications, including increased intensity, fundamental frequency and word duration, as well as increased energy in high frequencies, may improve speech recognition in noise. Yet most speech-in-noise tests use materials recorded in quiet, which are then tested in noise. In this study, sentences from the SPIN-R test (Bilger et al., 1984) were recorded by a new talker, who was matched to the original talker on fundamental frequency and speaking rate. The new talker spoke in four different noise environments and under three different speaking instructions. The original and new recordings were used to test word identification accuracy in younger and older adult listeners with clinically normal hearing in the speech range, in listening environments with different signal-to-noise ratios. Word identification in noise was generally better for materials recorded in a noisy speaking environment or when the talker was instructed to speak loudly. These effects were greater in older adults than in younger adults, and in more challenging listening environments. The new talker was also found to be more intelligible than the original talker. The most likely acoustical explanation for the inter-talker difference is greater energy for the high-frequency region in the spectrum for the more intelligible talker.

Huiwen Goy, University of Toronto
With Kathy Pichora-Fuller; Pascal van Lieshout

#47 Development of a telephone-based hearing screening test for the United States

This project will develop a speech-recognition test in noise (SRTn) for use as a screening test for clinically significant hearing loss, suitable for delivery over the telephone. The test will be based on the National Hearing Test currently in use in The Netherlands. Recordings have been made of 150 random three-digit series ("triplets"), selected from the eight one-syllable digits, 1,2,3,4,5,6,8, and 9. Those stimulus files were then combined with speech-shaped noise for their total duration (including the silent periods before and after the speech sample). The noise spectrum was matched to the mean spectrum of the spoken triplets. Utilizing a method of constant stimuli, each of the 150 recorded sounds were presented once at each of 10 levels of SNR, from -18 to 0 dB, in two-dB steps to ten normal-hearing listeners. The noise level was at 70 dBA. Listeners used Sennheiser circumaural earphones and responded by entering the digits on a simulated telephone key pad, displayed on a computer monitor

(the layout of a telephone keypad is different from that of the digital keypad on a computer keyboard). A set of 80 triplets was selected on the basis of uniform slopes, giving preference to steeper functions. The SNR of the individual triplets were adjusted to produce a set of stimuli that are equally recognizable. A set of 64 of the triplets has now been selected for actual use in the telephone test, on the basis of a second behavioral test, this time using presentation over an actual telephone. Again, ten normal hearing listeners were employed. Probably because of the difference in transmission between the telephone system and the laboratory system used previously, 16 of the 80 triplets were found to be either significantly more difficult or significantly easier than the others, despite the adjustments intended to equate them in difficulty. The test has now been implemented on an IVR-platform and validation with normal-hearing and hearing-impaired listeners is presently underway. Results will be reported for data collected to date with this US version of the test, together with previous data obtained with the original Dutch version, by Smits et al.

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With James D. Miller; Gary Kidd