Performance on auditory temporal-processing tasks for speech and non-speech stimuli by young and elderly listeners

Diane Kewley-Port, Larry E. Humes, Daniel Fogerty, & Dana Kinney
Department of Speech and Hearing Sciences, Indiana University

Introduction

Temporal processing generally slows with age. The experiments described here are a subset of those in an ongoing project investigating the effects of aging on temporal processing across three modalities: auditory, visual and tactile. Here, we present only auditory data. We begin with a more detailed presentation of the most recently gathered auditory data on the forward and backward masking of short vowels. After presentation of these temporal-masking data, we tie these results to those obtained on temporal-order and gap-detection tasks reported at prior meetings.

Temporal Masking Method & Results

Stimuli

- Processed 4 male vowels in "pot, pet, pit, put" to have F0 = 100 Hz
- Vowels edited to be 40 ms long and RMS normalized (83 dB SPL)
- All stimuli low pass filtered at 1800 Hz (reduced effects of high-frequency hearing loss)

Listeners

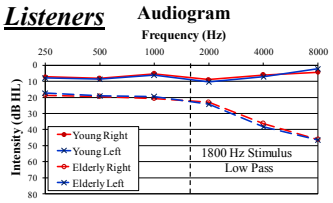

Figure 1

	Young (N=14)	Elderly (N=76)
Age	18 - 29 yrs (M=24)	60 - 88 yrs (M=70)
Female/ Male	11 / 3	43 / 33

Masking conditions (8 tasks)

- Two Maskers, 200 ms long: (1) speech shaped noise; and (2) pattern masker generated by adding fragments of 4 vowels
- Forward or backward masking (see schematics above right)
- Noise or pattern mask
- Higher vs. lower masker level (**re: 83 dB SPL target vowel**)
  - Forward masking: 87 dB SPL (**4 dB**), 93 dB SPL (**10 dB**)
  - Backward masking:81 dB SPL (**-2 dB**), 87 dB SPL (**4 dB**)

Procedures

- Each listener screened to identify vowels at 90% level
- Familiarization tasks preceded all 8 masking conditions
- Responses : Four large buttons labeled "POT", "PET", "PIT", "PUT"
- Measured SOA in ms (Stimulus Onset Asynchrony for backward masking; Stimulus Offset Asynchrony for forward masking)
- Method: Adaptive tracking for 50% & 71% correct levels in 4 ms steps

Results

SOA for each of 8 masking conditions averaged over 6 blocks, 3 at 50% and 3 at 71%, yielding thresholds at 61% correct performance.

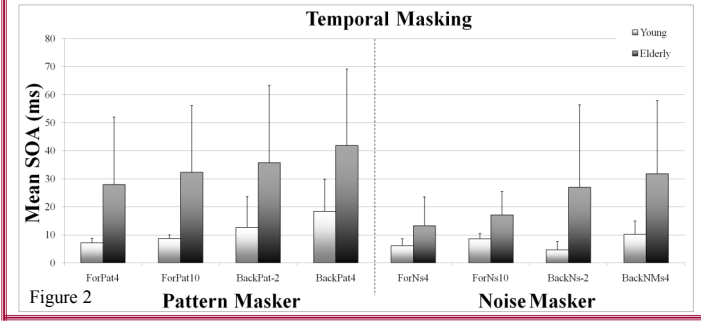

Figure 2

Integrating Masking with Other Measures

Group Data

In earlier phases of this project, three other auditory tasks were completed by our listeners and have been reported at previous meetings of the ASA. Besides hearing threshold measures, temporal processing was assessed by a gap detection task in noise and four temporal order tasks using the same vowel stimuli. The figure below indicates schematically the different tasks. Results from older adults for the four low-level masking (green), temporal order (red), gap detection (blue), and hearing threshold (orange) tasks are presented in Figure 6. For each of the four tasks there was a significant effect of age group, with the older adults performing worse than the young adults.

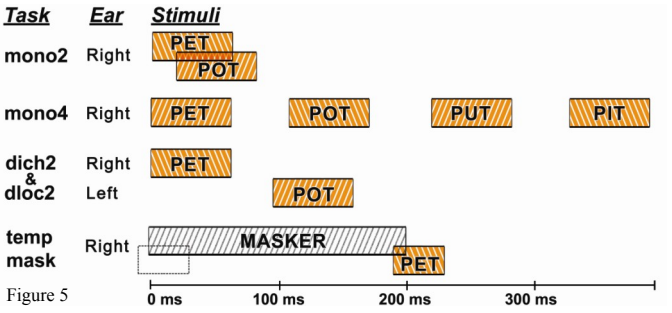

Figure 5

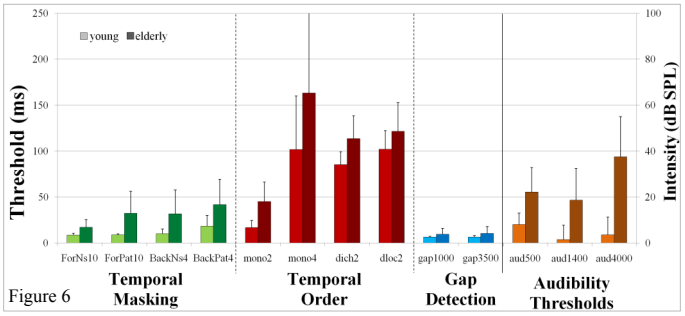

Figure 6

Individual Data

The correlation matrix below provides Pearson-r correlation coefficients between various pairs of the 13 variables and age for each of the 76 older adults. The results for the smaller group of young adults were not included in these analyses. Within the correlation matrix, within-task correlations are illustrated by the color-coded boxes, corresponding to the tasks in Figure 6. In all cases, significant ($p<.01$) correlations are shown in bold font. Most of the within-task correlations are moderate and significant, regardless of task.

	Temporal Masking				Temporal Order				Gap Detection		Audibility Thresholds		
	ForPat10	BackPat4	ForNs10	BackNs4	mono2	mono4	dich2	dloc	audgap1000	audgap3500	audthr500	audthr1400	audthr4000
BackPat4	**.389**												
ForNs10	**.479**	**.381**											
BackNs4	**.460**	**.446**	**.629**										
mono2	**.592**	**.405**	**.439**	**.362**									
mono4	.020	.176	.075	.195	**.435**								
dich2	**.351**	**.583**	**.328**	**.393**	**.455**	**.332**							
dloc	.136	**.305**	.191	.163	.169	.197	**.228**						
audgap1000	.257	.050	.114	.126	.216	.163	.087	.174					
audgap3500	.177	.096	.056	.063	.159	.108	.031	.181	**.649**				
audthr500	.148	-.137	.051	.134	.069	.045	-.020	-.090	.179	.242			
audthr1400	.241	.042	.251	.223	.239	.096	.188	-.050	.218	**.390**	**.667**		
audthr4000	.050	.060	.127	.131	.058	-.015	.045	-.037	.037	.230	**.233**	**.584**	
age	.227	.110	**.390**	**.403**	.179	-.103	.089	.083	.115	.069	**.324**	**.297**	.271

Poster presented at the 155th Meeting of the Acoustical Society of America, Paris, France, July 3, 2008

Anova, 2 Ages X 2 Maskers X 2 Positions X 2 Levels (Figure 2)

AGE: Elderly SOAs 3 times larger (M=32ms) than young (M=10ms)

MASK TYPE: Noise mask (M=17ms) was easier than pattern mask (M=25ms)

POSITION: Forward masking (M=17ms) was easier than backward (M=25ms)

MASK LEVEL: Lower mask level was easier (M=17ms) than higher level (M=21ms)

Performance for elderly was much more variable than for young. Relation between masking performance by elderly and age was weakly correlated (Figures 3-4).

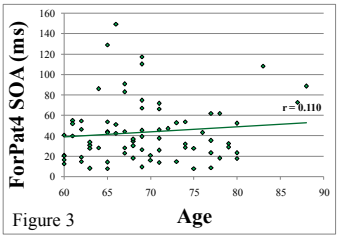

Figure 3

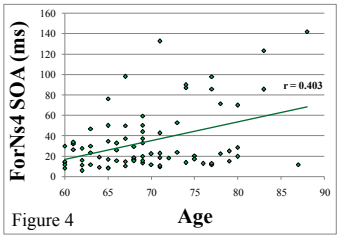

Figure 4

Summary: Temporal Masking of Vowel Identification

1. Expected results of **greater SOA** for elderly listeners vs. young, for pattern (containing vowel fragments) vs. noise masker (only energetic masking), and for higher vs. lower masker level confirmed.
2. Unexpected that forward masking much less effective masker than backward; lower SOAs even when masker level in forward task +6 dB more intense than backward.
3. Surprising results were the ability of listeners to identify vowels (61% correct level) from brief pieces of vowel even though masker 200 ms with level generally higher (+4 dB) than vowel. Young identified vowel on average from just **one pitch pulse** of vowel (10 ms). Elderly on average needed only **three pitch pulses** of a vowel (30 ms).

Examination of the remaining correlation coefficients (those not within the color-coded boxes), reveals several others that are also moderate and significant. In all but one case, these correlations were found between the measures of temporal masking and two-item measures of temporal order, all of which used the same speech stimuli ("pit, pet, pot, put"). The positive correlations suggest that those older adults with more temporal masking also required greater temporal separation between the vowels comprising a given stimulus pair to accurately identify the temporal order of the stimulus sequence.

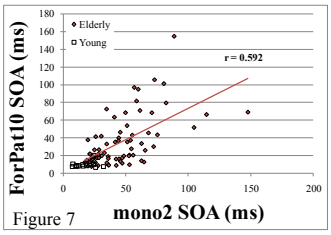

Figure 7

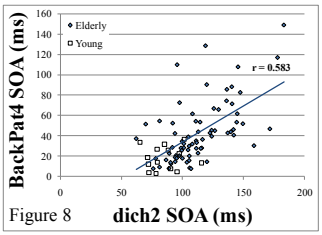

Figure 8

The data for the two strongest across-task correlations are shown in the scatterplots above. The data for the 14 young listeners have been added to these scatterplots for reference, but were not included in the computation of the correlations.

The bottom row of the correlation matrix indicates that there was generally a weak association between age and the various measures of auditory temporal processing. Scatterplots for two of these correlations were shown previously in Figures 3 and 4. Moreover, the correlation matrix shows that there was only one correlation between hearing loss and any of the ten measures of temporal processing (threshold at 1400 Hz and gap-detection at 3500 Hz). Thus, individual differences in age or hearing loss do not explain much of the variance in performance on auditory measures of temporal processing among older adults.

Work supported by: NIA R01 AG022334-02