Importance of High Frequency Audibility on Speech Recognition With and Without Visual Cues in Listeners with Normal Hearing

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INTRODUCTION

Objective

To examine the impact of visual cues, speech materials and age on the frequency bandwidth necessary for optimizing speech recognition performance in listeners with normal hearing.

Question 1:

- How do visual cues impact the frequency bandwidth necessary for listeners to optimize speech recognition performance?

Question 2:

- How does the speech material affect the bandwidth necessary for optimizing speech recognition performance?

Question 3

- How does age affect the bandwidth necessary for optimizing speech recognition performance?

METHODS & PROCEDURES

Using a randomized crossover design, speech recognition of 30 adults (mean age 39.5 yrs) and 30 children (mean age 9.5 yrs) all with normal hearing was assessed using speech perception tests that were low-pass (LP) filtered and presented in quiet and noise.

Speech Materials

Three speech perception tests were used:

- The Multimodal Lexical Sentence Test (MLST) (Kirk et al., 2012) assessed sentence recognition in auditory-only (AO) and auditory-visual (AV) modalities.
- The University of Western Ontario Plurals Test (UWO) (Glista & Scollie, 2011) assessed phoneme detection.
- The Maryland CNC (Peterson & Lehiste, 1962) assessed isolated single word recognition.

Condition	Frequency band
FBW	250-12 kHz
LP 630 Hz	250-630 Hz
LP 800 Hz	250-800 Hz
LP 1 kHz	250-1000 Hz
LP 1200 Hz	250-1200 Hz
LP 1600 Hz	250-1600 Hz
LP 2000 Hz	250-2000 Hz
LP 2500 Hz	250-2500 Hz
LP 3100 Hz	250-3100 Hz
LP 4000 Hz	250-4000 Hz
LP 5000 Hz	250-5000 Hz
LP 6300 Hz	250-6300 Hz
LP 8000 Hz	250-8000 Hz

METHODS & PROCEDURES

Filtering

Thirteen low-pass (LP) filter conditions of each material were randomly presented to the participants in noise at the first session and in quiet at the second session.

Scoring

- Tests were scored based on number of target words correctly repeated and reported as a percentage.
- Ten percent below the performance at full bandwidth was considered to be optimal performance (see curve fitting).

Curve Fitting

Raw data were fitted with a Boltzmann function to determine the frequency bandwidth required to optimize performance.

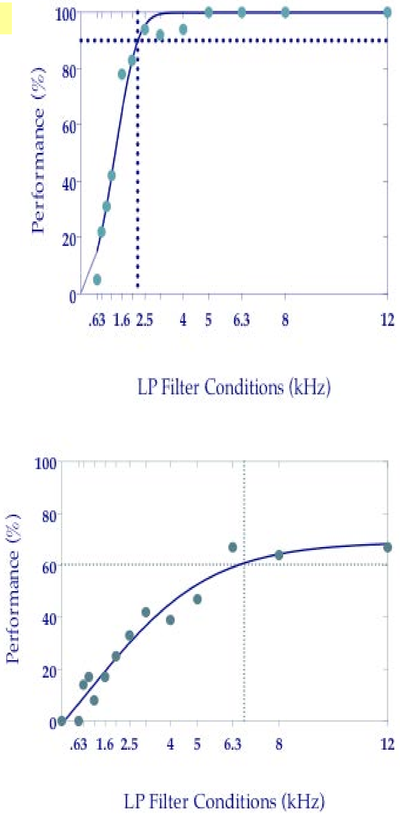

Figure 1a & b. Minimum bandwidth was determined by a best-fit sigmoidal curve to the raw data of each participant in quiet (left) and noise (right).

	Children (Q)		Adults (Q)		Children (N)		Adult (N)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
MLST AO	1861	942	1628	439.8	4614	2764	3916	1289
MLST AV	1336	1079	1152	962.7	4768	3122	2613	1355
UWO	5724	1288	4534	1198	7399	1693	6674	1461
CNC	3444	1233	1877	468	5749	1704	4277	1630

Table 2. Mean bandwidth and standard deviation for groups across test and listening condition.

RESULTS

Question 1:

- The effect of visual cues was significant [$F_{(1, 177)}$ =10.40; p=0.0015]. That is, in general the availability of visual cues reduced required BW.

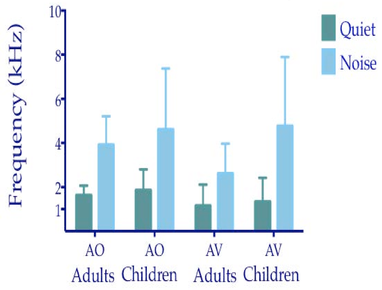

Figure 2. Group means and standard deviation for the minimum BW required for adults and children to optimize performance in quiet (Q) and noise (N) on the MLST presented in ns auditory-only (AO) and auditory-visual (AV).

Question 2:

- The main effect of speech material was significant ($F_{2, 297}$) = 131.87, p=<0.0001. That is, the more ecologically valid the speech material, the less BW required.

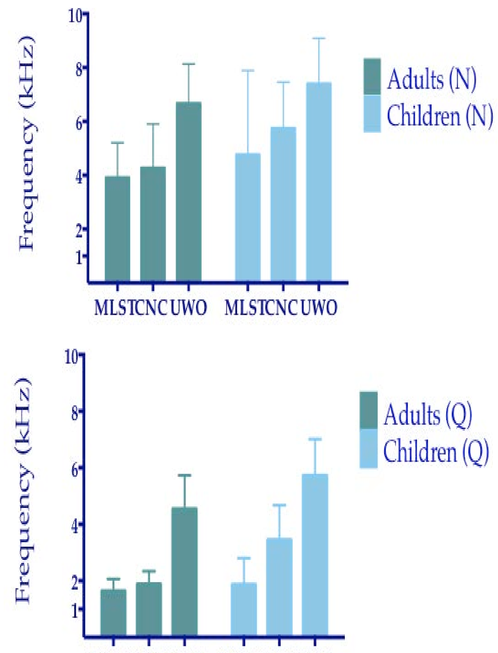

Figure 3a & b. Group means (Hz) and +/- 1SD (Hz) of the min. bandwidth that is required for optimizing performance on speech perception tests presented in auditory-only (AO) in quiet (Q) and noise (N). Adults and children required significantly less BW in quiet (Q) for all tests.

RESULTS

Question 3:

- The interaction of age and condition was also significant [$F_{(1, 177)}$ =11.09; p=0.0011] That is, children required significantly more BW than adults in noise.

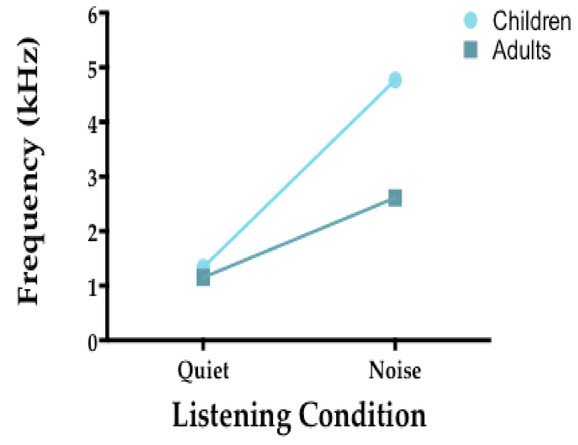

Figure 4. Although the minimum BW required for optimal speech recognition in the quiet condition was not different for children and adults, children required significantly more BW in the noise condition.

CONCLUSIONS

- Listeners require significantly less bandwidth when listening with visual cues; typical communication allows for these visual cues.
- Current hearing aids provide such BW, given the listener does not have such loss in the higher frequencies to preclude use of the available cues.

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