Spatial Release from Masking for horizontally and vertically distributed noise sources and the definition of the better ear

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INTRODUCTION

Spatial Release from Masking (SRM) is the improvement in speech intelligibility when moving an interferer away from the target speech. SRM is dominated by two perceptual processes; Better Ear Listening (BEL) & Binaural Unmasking (BU).

Using a speech-shaped noise interferer, there is up to 10 dB SRM when separation takes place in the horizontal plane, with BEL contributing more than BU (Bronkhorst & Plomp, 1988). Little attention has been paid to vertical SRM, but Ter-Horst *et al,* (1993) used two speech-shaped noise interferers symmetrically displaced at the front (0°) and side (90°) & reported up to 4 dB and 9.5 dB SRM, respectively.

AIM

The reported SRM in the front vertical plane appears larger that what would be expected, considering vertical cues are governed by pinna resonance cues (Saberi *et al*, 1991). We replicated the free-field study of Ter-Horst *et al,* (1993) with a virtual simulation using headphones. Comparison is made with predictions of a model proposed by Lavandier & Culling (2010).

METHODOLOGY

i) Stimuli

Speech-shaped noise interferers were generated using Gaussian noise and filtered with a finite impulse response designed to match the long term speech spectrum (Moore & Glasberg, 1983).

Harvard IEEE sentences (Rothauser *et al*, 1969) were filtered with Head Related Impulse Responses (HRIRs) to provide two directions of target speech; front (0°) and side (90°).

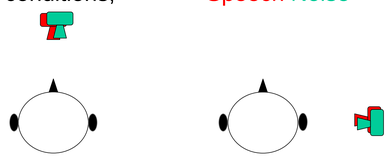
ii) Participants

10 undergraduate students were recruited, all reported normal hearing and English as their first language.

iii) Procedure

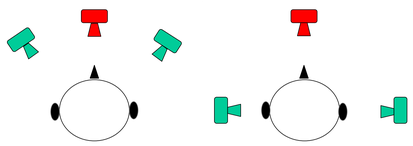
12 conditions. Each using 10 sentences, each sentence having 5 key words. 2 trial runs for familiarisation with the task. Two reference conditions needed to analyse the improvement (SRM) in 4 horizontal and 4 vertical conditions. Target-interferer ratio low, increased by 4 dB until 2-3 words heard. Target reduced by 2 dB in 3 or more correct, and increased by 2 dB if 2 or less correct.

Reference conditions; Speech Noise



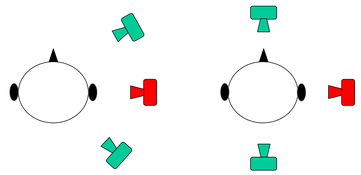
Front co-located Side co-located

Horizontal front conditions;



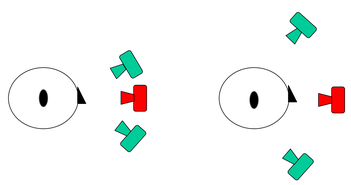
FH45 FH90

Horizontal side conditions;



SH45 SH90

Vertical front conditions;

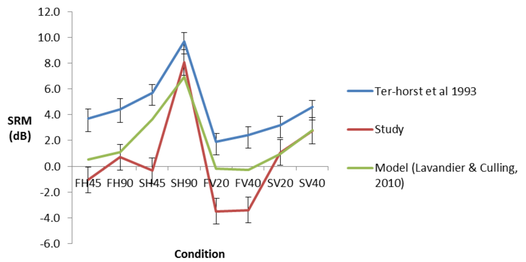


FV20 FV40

Vertical side conditions;

SV20 SV40

RESULTS



Significant correlations between: current data and the model (r=0.89, n=8, p<0.003) RMSE of 2.3; model and Ter-Horst *et al.* data (r=0.97, n=8, p<0.005) RMSE of 2.6; current data and Ter-Horst *et al* (r=0.90, n=8, p<0.002) RMSE of 4.3.

DISCUSSION

The elevated SRM reported in Ter-Horst *et al* (1993) may be due to their use of correlated noise in their symmetrically displaced interferers. This can lead to interference effects (comb filtering), which would permit improved SRM (Noble & Perrett, 2002).

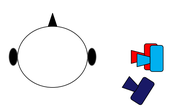
FOLLOW-UP STUDY

Why is there a difference between model and data at SH45? When speech at 90° (right), model predicts listeners use left ear (highest signal-to-noise ratio, SNR). *Question*: Which ear do listeners attend to when the ear with the higher target level has the poorer SNR?

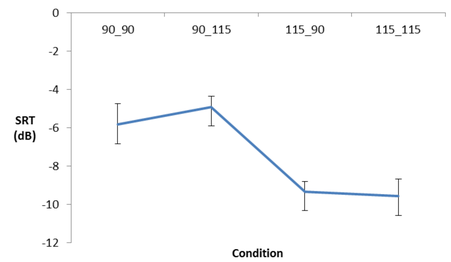
METHODOLOGY

Same stimuli used, but speech presented at 90° (right) and HRIRs for the noise from 90° or 115°, independently selected for each ear. Noise level at left ear is higher for 90° than for 115°. Noise HRIR at which ear determines SRT? 3 participants so far.

Conditions:



RESULTS



First number of the condition represents the left ear interferer HRIR and the second number represents the right ear interferer. HRIR at left ear determines SRT.

DISCUSSION

Previous work has shown that monaural sensation level has no effect on word recognition in quiet or in the presence of continuous noise but a significant effect when using interrupted noise. Performance increases with increasing SNR (Stuart & Phillips, 1997). However, it appears speech intelligibility as a function of target level and signal to noise ratio across the ears (i.e. binaural) remains unexplored.

This study indicates that SRM is, as predicted by the model, limited in the mid-sagital plane, but substantial in the coronal place. It confirms that listeners exploit the ear with the better SNR and not with the higher target level.

REFERENCES

Bronkhorst, A., & Plomp, R. (1988). The effect of head-induced interaural time and level differences on speech intelligibility in noise. *The Journal of the Acoustical Society of America*, *83(4)*, 1508–1516.

Lavandier, M., & Culling, J. F. (2010). Prediction of binaural speech intelligibility against noise in rooms. *The Journal of the Acoustical Society of America*, *127*(1), 387–99.

Moore, B., & Glasberg, B. (1983). Suggested formulae for calculating auditory-filter bandwidths and excitation patterns. *The Journal of the Acoustical Society of America*, *74*(3), 750–753.

Rothauser, E., Chapman, W., & Guttman, N. (1969). IEEE recommended practice for speech quality measurements. IEEE Transactions on Audio and Electroacoustics, *17*, 227–246.

Saberi, K., Dostal, L., & Sadralodabai, T. (1991). Free-field release from masking. *The Journal of the Acoustical Society of America*, *90*(3), 1355–1370.

Stuart, A., & Phillips, D. (1997). Word recognition in continuous noise, interrupted noise, and in quiet by normal-hearing listeners at two sensation levels. *Scandinavian Audiology*, *26*, 112–116.

Ter-Horst, K., Byrne, D., & Noble, W. (1993). Ability of hearing-impaired listeners to benefit from separation of speech and noise. *Australian Journal of Audiology*, *15*(2), 71–84.