

Binaural speech recognition for normal-hearing and hearing-impaired listeners in a competing voice test

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A new competing voices test based on male and female HINT sentences has been run on normal-hearing and hearing-impaired listeners. Different cue placements and spatial conditions were used and significant effects were found from both.



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Background

Competing voices are part of the everyday challenges for a hearing aid user. Users mention e.g. restaurant settings and watching TV while someone in the room is talking. In order to test the performance of hearing aids in this user scenario, a new type of speech test has to be developed.

Compared to traditional speech tests, a competing voices test should have two or more targets that are equally important. We have recently investigated a number of suitable candidates [1] and on this basis selected a test for further work based on HINT sentences spoken simultaneously by a female and a male. The listener was cued on a monitor to repeat both sentences or one of them (male or female), in the latter case this cue could be either before or after the presentation.

This poster investigates the binaural effects in the test by comparing diotic and dichotic presentation. Furthermore, the effect of cueing before or after the presentation was investigated.

Requirements to test

- To simulate having attention on and switching between two talkers.
- Two equally important competing voices
- Identical energy in the targets: signal-signal ratio (SSR) := 0 dB
- Be realistic and doable for elderly hearing-impaired listeners.
- Be efficient and re-usable across multiple test devices, e.g. hearing aids.
- Achieve scores away from floor (0%) and ceiling (100%), ideally around 50%.

Dual sentences

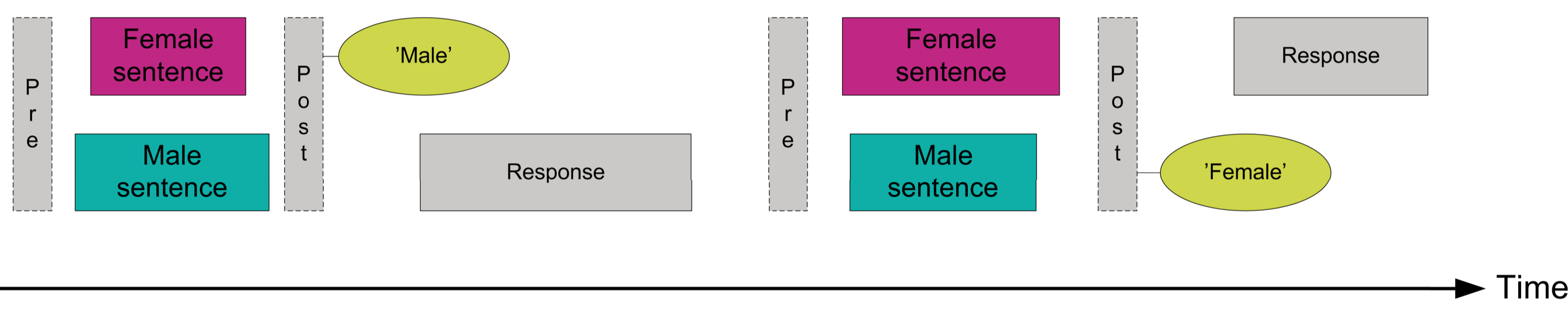


Figure 1. Timeline of the dual sentences test.



Figure 2. Visual cues used in the 'dual sentences' test. The 'male'/'female' cues are displayed either before ('pre') or after ('post') the sentence pair is played. The 'both' cue is displayed during the entire sentence list.

Aim of current study

To mature and confirm 'dual sentences' test from [1], with special focus on the questions:

- Are test results still useful with the use of identical speech material (female HINT)?
- What is the effect of cueing (pre-post-both)?
- What is the effect of binaural presentation modes? And is the test sensitive enough to detect this?
- Are the two talkers (male and female) equal with respect to word recognition?

Methods

Speech material:

The new aspect of the present test, compared to the 'dual sentence test' in [1] was to use new female HINT recordings (HINT-F) along with the existing male HINT (HINT-M):

- New recordings were made while listening to existing HINT-M material, in order to mimic the original speaking style.
- All sentences were RMS equalized.
- Sentence gains from HINT-M were then applied to approximate 50% word scores across sentences. Ideally, a new intelligibility equalization process [3] should have been done.
- No spectral matching of HINT-F to HINT-M was done, so both long-term spectra were unchanged.
- For a given trial, two different lists were chosen for HINT-M and HINT-F. The order of lists was balanced across all listeners.

Listeners:

- 4 normal-hearing listeners (< 20 dB HL)
- 9 hearing-impaired listeners with moderate, sloping losses. Hearing losses were compensated linearly using the CAMEQ gain rule.

Test design:

Full factorial design using the following factors and levels:

- 3 cues: Pre, Post, Both
- 3 spatial modes: Separate (dichotic), sum (diotic) and male phase reversed to one ear.
- 2 replications

...for a total of 18 trials in two hours.

Training

4 training trials were run before test.

References

- [1] Bramsløw, L., Vatti, M., Hietkamp, R., & Pontoppidan, N. H. (2014). Design of a competing voices test. International Hearing aid Conference (IHCON) 2014. Lake Tahoe, CA, USA.
- [2] Nielsen, J. B., & Dau, T. (2011). The Danish hearing in noise test. International Journal of Audiology (IJA); 50, 202-208
- [3] Nielsen, J. B., & Dau, T. (2009). Development of a Danish speech intelligibility test, IJA; 48, 729-741.
- [4] Studebaker, G.A. (1985): A "rationalized" arcsine transform. Journal of speech and hearing research; 28, 455-462.

Acknowledgements

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Results

Analysis

Word scores (%) were rau-transformed for better linearity [4]. Analysis was done using 3-factor factorial repeated-measures ANOVA and Tukey HSD post-hoc. All effects are tested against the within-subject variance from replication, thus learning effects cannot be tested separately.

Normal-hearing (NH) listeners

- All four NH listeners had scores close to 100%.
- Still significant effects ($p < 0.005$) of cue and spatial mode: Pre > Post, Both and Separate > Sum, Male_rev (data not shown).

Hearing-impaired (HI) listeners

Effects of cue (Figure 3)

- Pre > Post, Both: Pre cue has higher word score (74%) than Post and Both (51 and 49%).

Effects of binaural mode (Figure 4)

- Clear effect of separate presentation (71%) vs. sum and male_reversed (49 and 54%).
- No binaural unmasking effect from reversing phase of male to one ear.

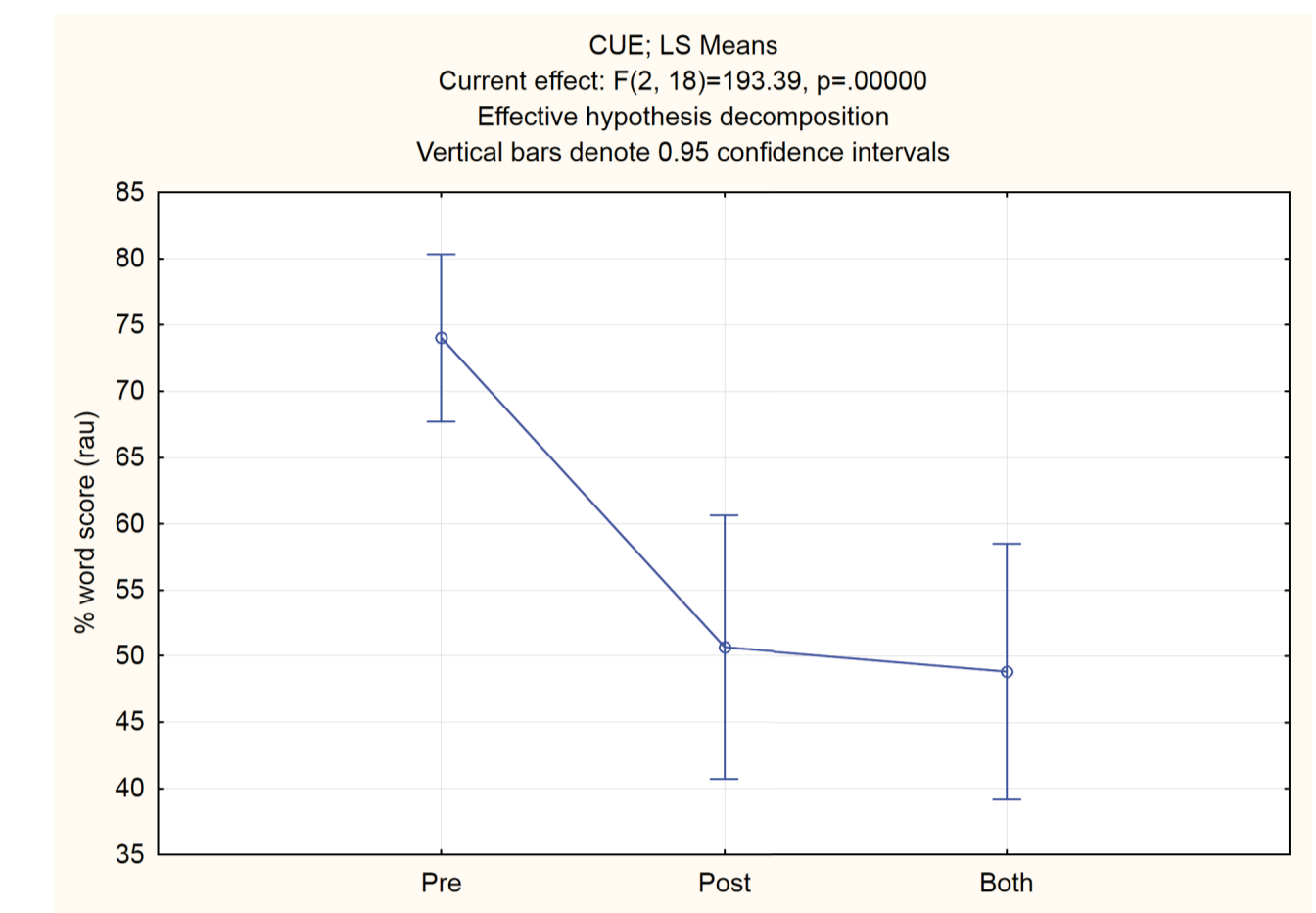


Figure 3. The cue effect, HI listeners.

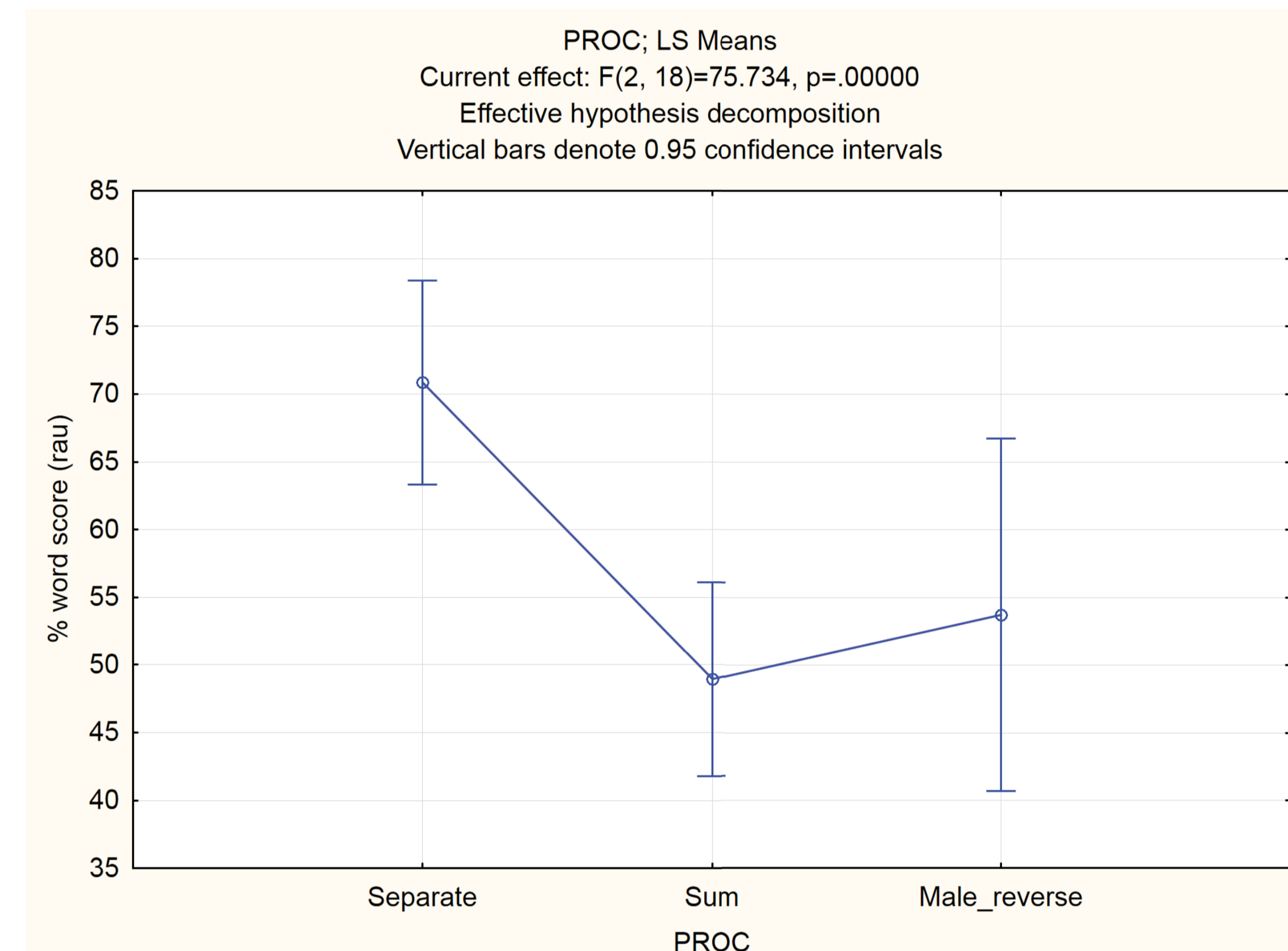


Figure 4. The effect of binaural mode, HI listeners.

Effects of talker (Figure 5)

- Female talker scores significantly lower than male talker scores (51% vs. 65%).
- Sentences were rms-matched but no further equalization was done.

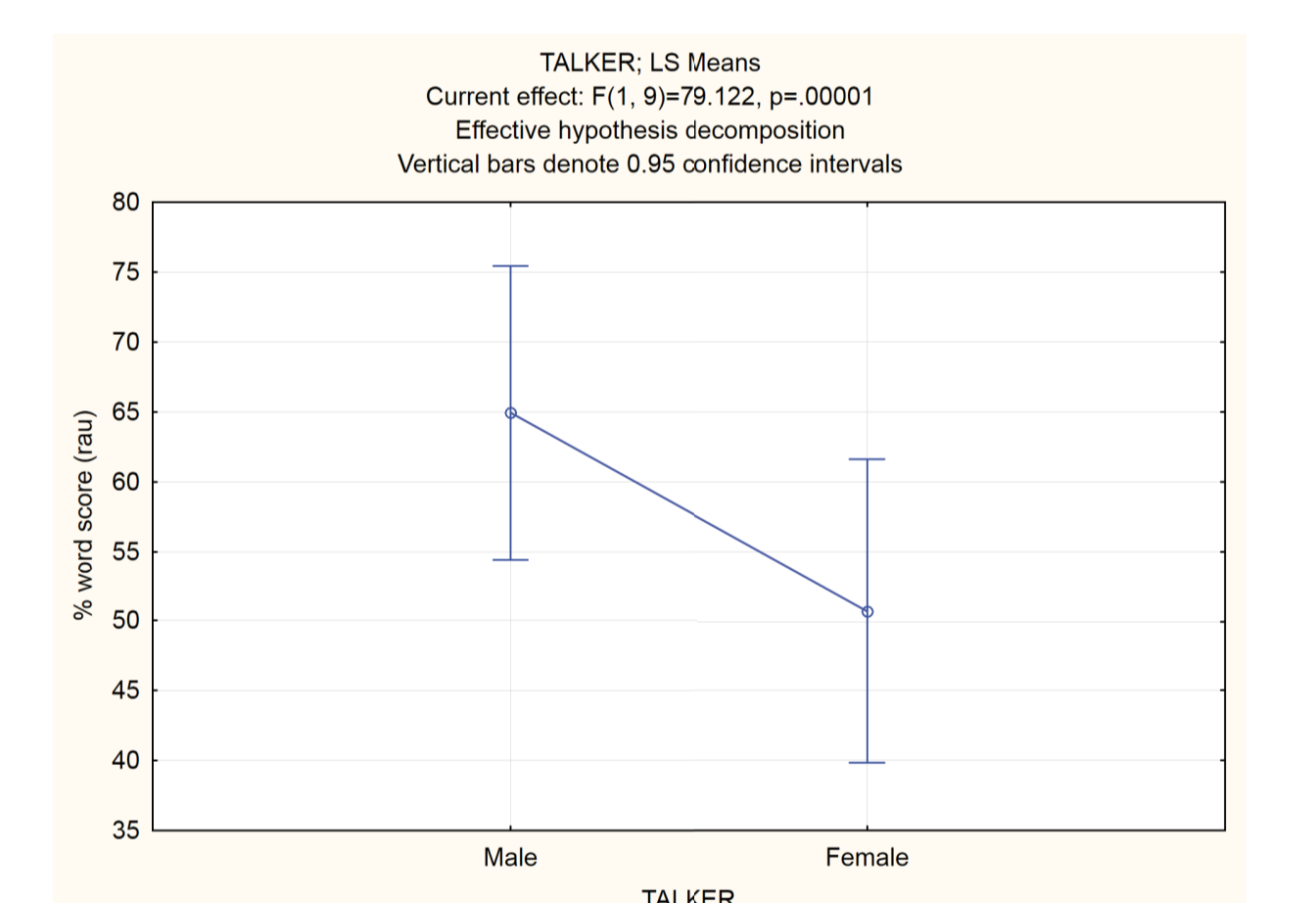


Figure 5. The talker effect.

Talker-spatial interaction (figure 6)

- Significant interaction indicates very different binaural unmasking skills across listeners.

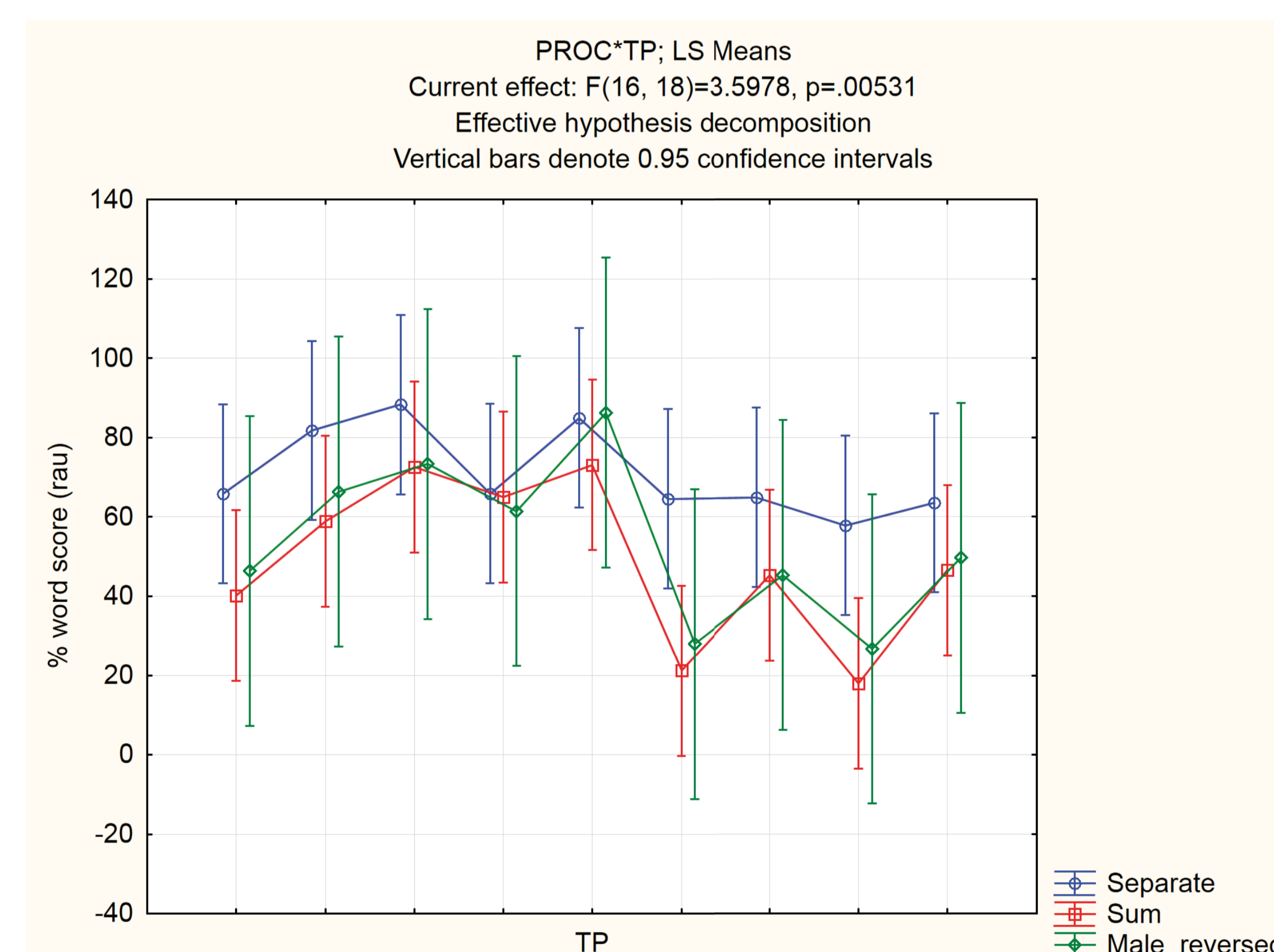


Figure 6. Interaction test person and binaural mode, HI listeners

Conclusions

The aims of the study were fulfilled:

- Test scores were around 50% for hearing-impaired listeners when using 'post' or 'both' cues. The difficulty was also judged to be reasonable by the HI listeners.
- Clear effect of cueing. Future recommendation is to use 'post' cueing as it forces dual attention and is faster to score than 'both'.
- Clear effect of spatial modes, successfully detected by the test. Phase reversal caused no unmasking.
- Some bias towards male speaker, but this effect can be separated out in the analysis.
- Learning effects of app. 6% from replication one to two could not be tested statistically.