

# Benefits of Fitting Bilateral BAHS: Impact on Auditory Working Memory

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## Introduction

Bone anchored hearing systems (BAHS) have successfully been used for many years as a recommended treatment for conductive hearing losses, mixed hearing losses and single-sided deafness in both adults and children. Bilateral treatment should be considered for candidates with symmetrical bilateral conductive or mixed hearing losses. The effect of bilateral BAHS treatment has been evaluated in previous studies in terms of tone detection, speech intelligibility in quiet and in noise, localization, spatial release from masking, as well as via numerous questionnaires (see Janssen et al. 2012 for a review). This is the first study to investigate whether there is a benefit of bilateral fitting on auditory working memory.

## Objectives

The objective of this ongoing study is to evaluate the benefits of bilateral implantation in adult bone-anchored users in terms of spatial resolution abilities and auditory working memory.

Additionally, the aim is to investigate the performance that is perceived daily by the bilateral users via a questionnaire.

## Method

### Study design

This single-blinded study consists of two visits of about 2 hours each in duration:

- Visit 1: Audiometry, Fitting (Unilateral and Bilateral), Minimum Audible Angle (MAA) test
- Visit 2: SWIR test, Speech, Spatial, and Qualities of Hearing questionnaire (SSQ12; Noble et al., 2013)

### Conditions

#### Unilateral condition:

- One brown Ponto 3 SuperPower on the test side;
- One white Ponto 3 SuperPower (inactive).



#### Bilateral condition:

- Two black Ponto 3 SuperPower.



### MAA test

Spatial resolution was tested with a MAA test (Litovsky et al. 2006; Dun et al. 2013).

#### Stimuli and procedure:

- Broadband pink noise (0.5 s) presented either to the Right or Left loudspeaker.
- 10 repetitions for each angle.
- Sound levels are randomized (60, 65, 70 dB SPL).
- Right/Left discrimination task.
- The percentage of correct responses is calculated for each angle.
- MAA score = the smallest angle to obtain 80% correct on the psychometric curve fitted to the data.

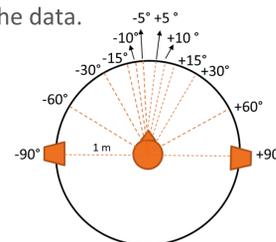


Figure 1 Sketch of the loudspeaker setup used in the MAA test.

### SWIR test

Auditory working memory was evaluated via the Sentence-final Word Identification and Recall test (SWIR; Ng et al. 2013, 2015).

#### Stimuli and procedure:

- Target sentences presented at 0° (fixed level of 70 dB SPL). 4-talker babble presented at ± 90° and ±135° at a fixed level to obtain 95% correct last-word discrimination.
- After each sentence, the participant has to repeat the last word. After a full list of 7 sentences, the participant has to recall as many last words as possible.
- 5 lists per condition (random order).

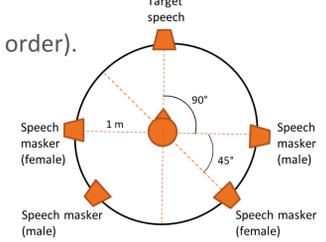


Figure 2 Sketch of the loudspeaker setup used in the SWIR test.

## Results

### Test persons characteristics

- 26 patients enrolled (13 males; 13 females):
  - 24 patients completed the study (PP population)
- Mean age: 55 years (min: 23 years; max: 74 years)
- 8 patients with bilateral conductive hearing loss; 16 patients with bilateral mixed hearing loss.

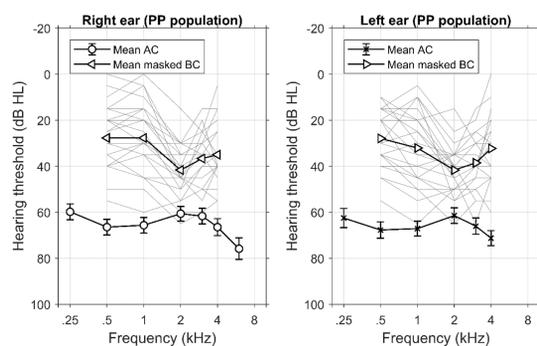


Figure 3 Mean air-conduction (AC, ± standard error) and bone-conduction (BC) hearing thresholds for the right and left ears. Individual BC thresholds are depicted in grey.

### MAA test results (N = 24)

- Mean performance in the Bilateral condition was at least **20 percentage points better** than in the Unilateral condition at all angles (see Fig. 4A).
- The median\* of the MAAs (Fig. 4B) obtained from the curve fitted to the individual data was:
  - Bilateral condition: **3.6°** azimuth;
  - Unilateral condition: **75.0°** azimuth.

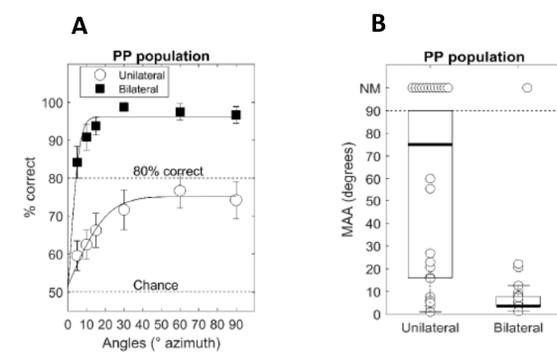


Figure 4 A: Mean performance (± standard error) in the right/left discrimination task and psychometric function fitted to the mean data. B: Angle to obtain 80% correct for each patient (NM: not measurable). The MAA was NM for 12 patients in the Unilateral condition and for 1 patient in the Bilateral condition. \* Note that the box plot and the median are obtained assuming NM = 90°.

### SWIR test results (N=24)

- Mean masker level = 65 dB SPL (mean SNR = +4.9 dB).
- Overall, no significant difference in recall performance between the two conditions (total recall bilateral = **57.23%**; total recall unilateral = **55.03%**). There was a significantly higher performance in the bilateral condition than in the unilateral condition for two out of the five repetitions (lists).

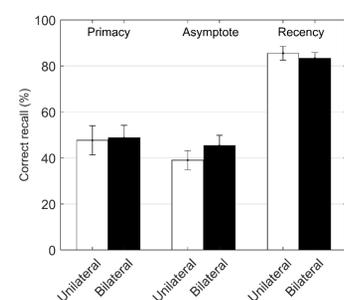


Figure 5 Percentage of words correctly recalled, for sentences at different serial positions (first two sentences: primacy; three middle sentences: asymptote; last two sentences: recency).

### SSQ12 questionnaire (N=24)

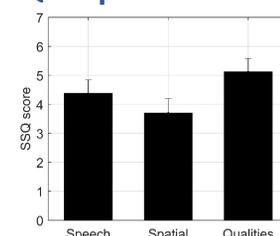


Figure 6 Mean scores in the SSQ12 (± standard error), in relation to the use of bilateral BAHS in the patient's everyday life. Scale from 0 ('Not at all') to 10 ('Perfectly').

## Discussion

When wearing only one BAHS, 50% of the patients could not reach 80% correct in the MAA test (Fig. 4B). All these patients had a poor PTA AC at the unaided side (>65 dB HL), not allowing any use of interaural time and level differences. However, performance in the MAA test improved by 20 percentage points when wearing both BAHS, and patients needed, on average, only 3.6° azimuth to obtain 80% correct.

Interestingly, performance in the MAA test for the bilateral condition did not correlate with self-reported performance in everyday life, while recall performance in the SWIR test did (Fig. 7).

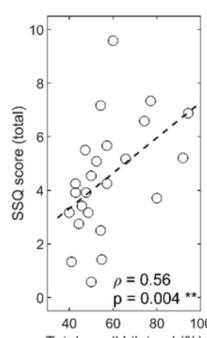


Figure 7 Individual scores in the SSQ12 as a function of the recall performance in the SWIR test.

## Conclusions

Results from 24 patients with bilateral conductive or mixed hearing loss suggest a large benefit in spatial resolution when wearing two bone-anchored sound processors. Performance with two BAHS was, on average, greater by 20 percentage points than performance with only one BAHS at all tested angles. Additionally, there was no overall benefit of bilateral fitting on auditory working memory, despite observing a benefit in two out of five repetitions of the SWIR test. Performance in the SWIR test was also correlated with the users' self-reported performance in everyday life, such that users with higher recall ability reported to achieve better performance in real life. These findings highlight the need of providing bilateral treatment to BAHS users with a symmetric conductive or mixed hearing loss.

#### References

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