

## Introduction

- For hearing impaired people, ecological communication situations are typically characterized by positive SNRs and almost full intelligibility. Nevertheless, the perceived effort varies across individuals and listening situations [1,5]
- Spare working memory (WM) capacity is found to be one limiting factor in speech understanding in noise [4]. In challenging listening situations, parts of the WM capacity are needed for the processing of sounds and less capacity is left for recalling information of a conversation.
- Previous research in hearing aid users found improved WM abilities when processing requirements was reduced by a noise reduction algorithm [2,3]. The Sentence Final Word Identification task (SWIR) has been used to measure speech understanding and WM capacity in hearing aid users [2,3].
- Pupillometry is a valid method to quantify listening effort required in speech understanding. Furthermore, the pupil diameter is associated with task load and cognitive processing, as it enlarges with increasing task difficulty [6].

### Objectives:

- Can we use the Sentence Final Word Identification task (SWIR) in German speaking CI users?
- Can listening effort objectively be measured by means of pupillometry during the SWIR test in CI users?
  - How is listening effort represented in the pupil size while performing the SWIR?

## Methods

- Sentence Final Word identification Test (SWIR; Ng et al. 2015) in German
- 5 CI users and 4 NH controls
- CI users: speech performance in the HSM in quiet (mean=100%) and in 10 dB SNR stationary noise (mean=72.01%)

Tab. 1: Experimental conditions

Recall	3 vs. 6 sentences	Noise reduction
Yes	3	No
Yes	6	No
Yes	6	Yes
No	3	No
No	6	No

### Example of German SWIR:

#### – Repeat final word

- Kämm dir bitte noch deine **Haare!**
- Wollen wir einen Teppich **kaufen?**
- Die Straße war sehr **befahren.**
- Das Wildschwein wird **geschossen.**
- Iss noch ein Stück **Torte.**
- Morgen will ich unsere Fenster **putzen.**
- Ihr wolltet doch bei mir **anrufen!**



#### – Recall final words

- 7 List per condition (i.e. 35 lists in total)
- Each list consisted of either 6 or 3 sentences
- Noise reduction (ideal binary masking) was applied on the stimuli in some conditions
- All processing automatics of the speech processor were turned off (only audibility)
- Sentences were presented free field in 4 - talker babble noise
- SNR was adjusted during training
  - CI user: start at 12dB SNR up to 15 dB SNR (mean= 10.2 dB)
  - NH: start at 3 dB SNR (mean= 0.75 dB)

#### • Pupil data:

- Corrected for blinks
- Baseline corrected

"...Haare, befahren, ... umm!"

## Preliminary Results

	Repeat [Mean (SD)]	Recall [Mean(SD)]
CI	83.14% (5.3)	57.12% (8.83)
NH	92.72% (5.22)	86.84% (9.67)

Tab.2 : Behavioral results of speech understanding and recall

Fig. 1: Averaged (5 CI user and 4 NH controls) and baseline corrected pupil dilatation in mm for 3 sentences

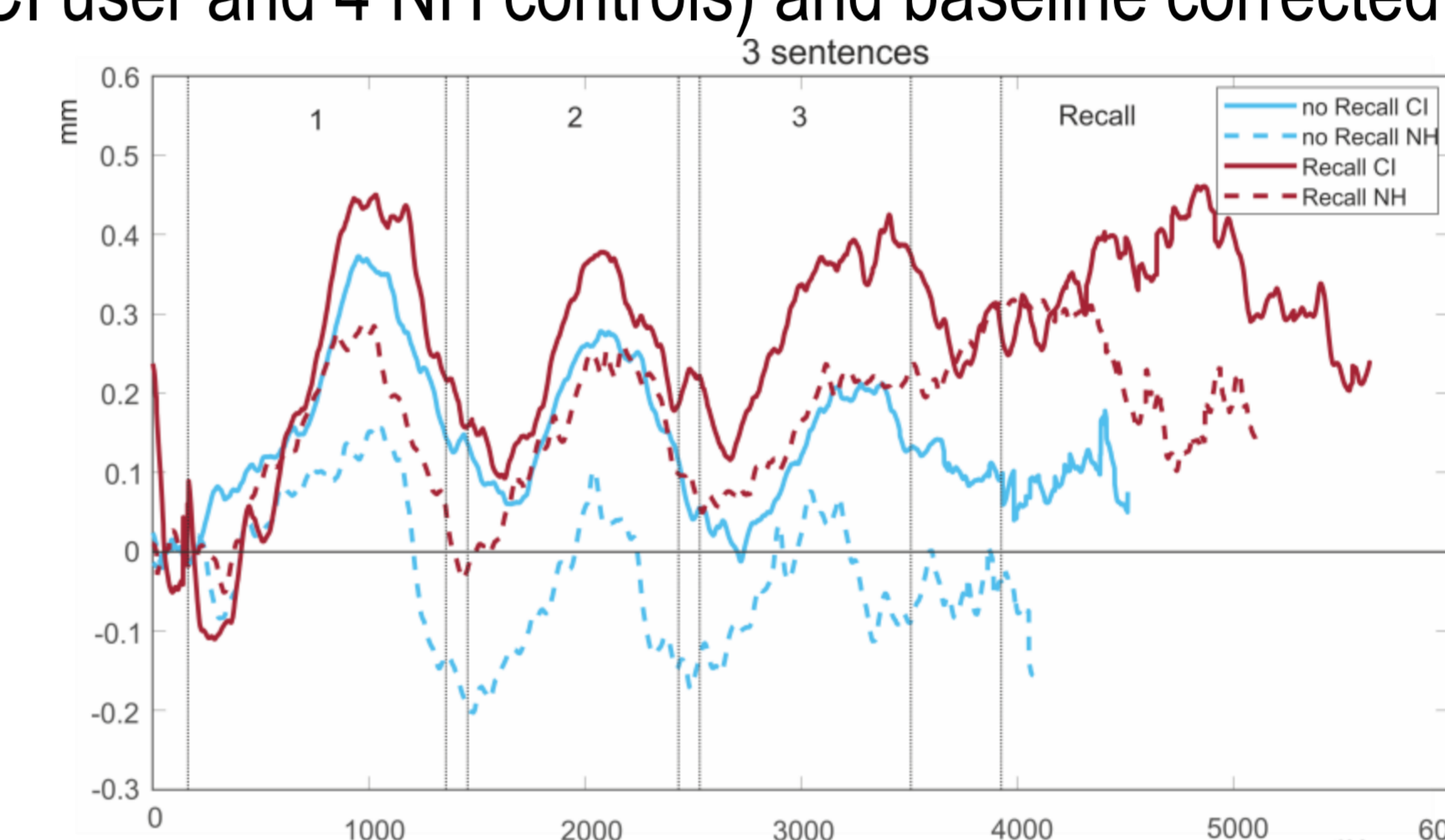
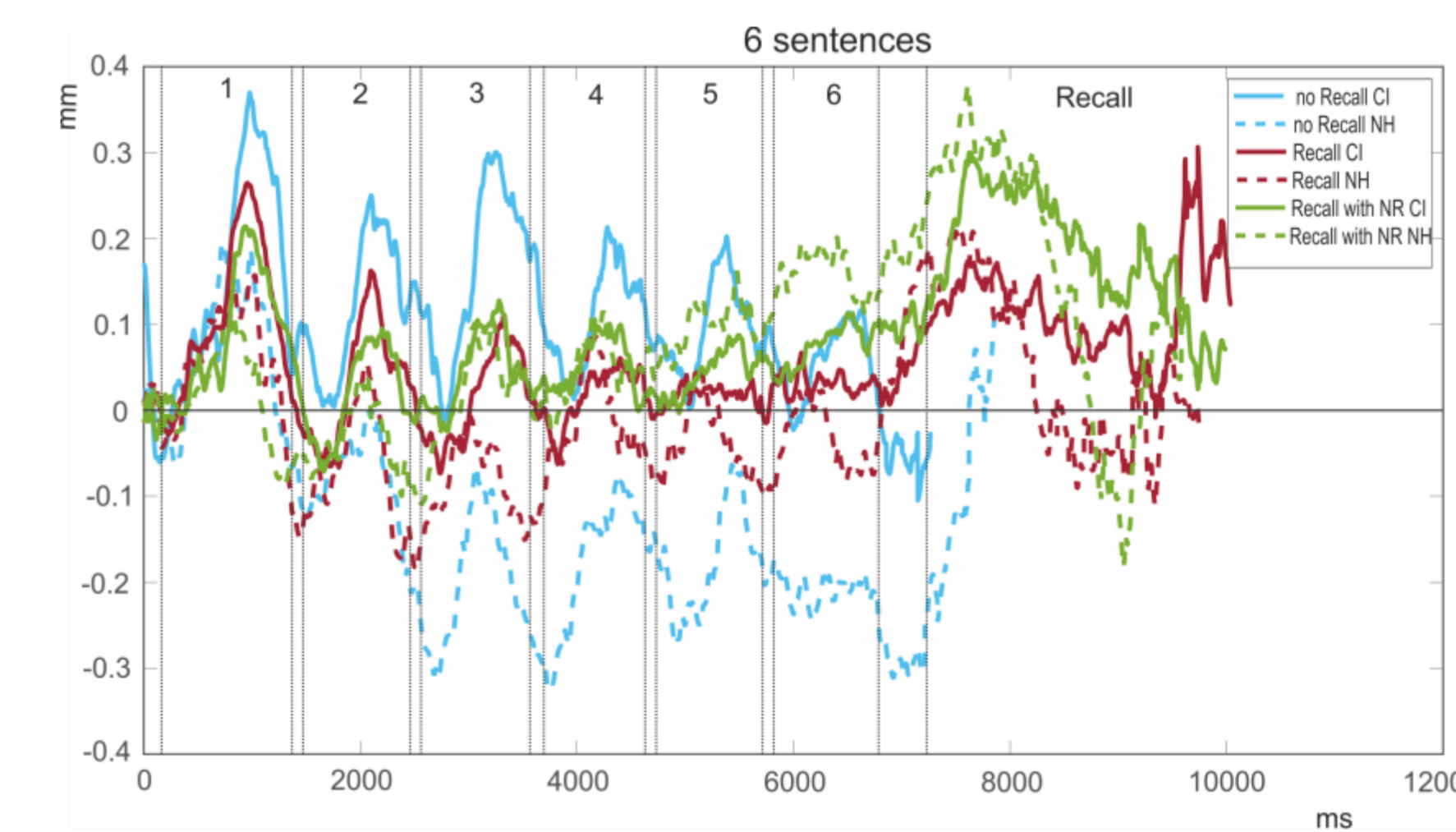


Fig. 2: Averaged (5 CI user and 4 NH controls) and baseline corrected pupil dilatation in mm for 6 sentences



## Preliminary Summary

- This first data show promising results, data acquisition will be continued. In total 25 CI users and 25 NH controls will be tested.
- The preliminary results of speech understanding and recall indicate that the SWIR test can be tested in German speaking CI users in ecological valid listening situations. It appears that NH show less listening effort and therefore more processing capacity is available for the recall.
- First descriptive results reveal an increase in pupil size at the end of each sentence and during recall. This indicates higher listening effort at the end of each sentence and before and during recall.
- In general, pupil dilation seems to be increased for conditions where a recall is required. An increased pupil size at the end of a list might indicate that more cognitive resources and higher involvement of WM is required for recalling.
- The descriptive increase of absolute pupil dilation between noise reduction "on" vs. "off" might already indicate a benefit of the noise reduction on listening effort.
- In all conditions, NH controls display lower pupil dilation compared to CI users suggesting that listening overall was less effortful for the NH controls.
- The 6 sentences condition shows a descriptive decrease of pupil size across the sentences, whereas for the 3 sentences the pupil size does no decrease. This decrease is more pronounced in CI users, which might imply that CI users tend to reach their cognitive capacity limit earlier than NH controls.

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