



**Hearing well and being well – a strong scientific connection**

**Clinical implementation of a listening effort measure (ACALES) - [Melanie Krüger](#)**

*November 14–16, 2019 | Frankfurt am Main, Germany*

## Listening effort

**“the deliberate allocation of mental resources to overcome obstacles in goal pursuit when carrying out a listening task.” (Pichora-Fuller et al., 2016)**

- An important factor in cocktail party situation
- Various measurement methods: objective (e.g. pupillometry, EEG) and subjective (scales and questionnaires).
- The practical effect of subjective methods: individual evaluation of the benefits of hearing systems in acoustically demanding everyday situations.



# Adaptive Categorical Listening Effort Scaling

- A = Adaptive  
CA = Categorical  
L = Listening  
E = Effort  
S = Scaling
- Subjective rating of listening effort
- Responses were given on a 13-step scale with an extra category “only noise”



# Adaptive Categorical Listening Effort Scaling

- Speech in background noise
  - Matrix sentences test with the structure:  
name – verb – numeral – adjective – object.

German: Tanja – kauft – acht – nasse – Messer.

English: Alan – gives – eight – dark – toys.

- Three sentences in a row
  - First sentence: First impression of the listening situation
  - Second sentence: Initial information about the perceived listening effort
  - Third sentence: Final decision about the perceived listening effort

# Adaptive Categorical Listening Effort Scaling

- Background noise
  - stationary e.g. Olnoise
  - fluctuating e.g. IFFM
  - complex scenarios e.g. restaurant
  
- Task

„How much effort is required for you to follow the speaker?“

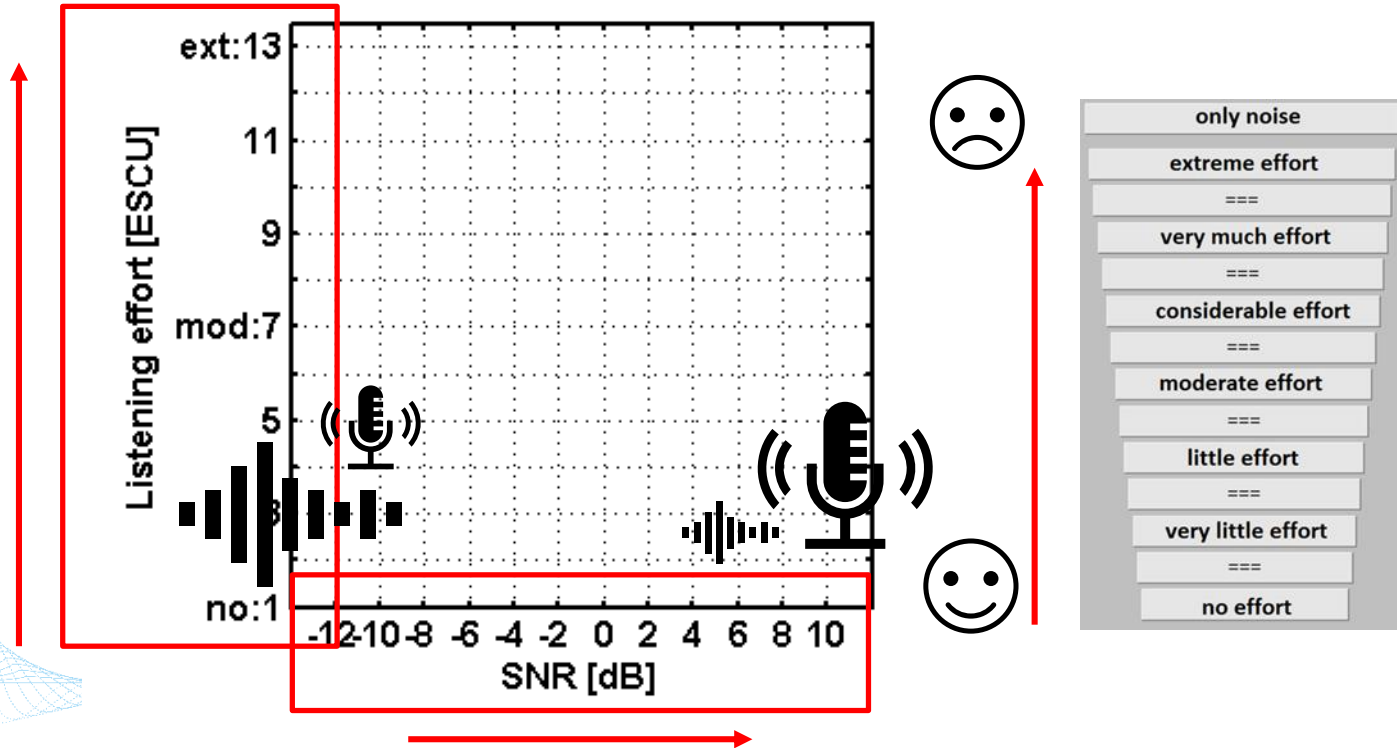
# Adaptive Categorical Listening Effort Scaling

- The ACALES method is divided into three phases (Krueger et al., 2017):

## 1. Determination of boundaries for „no effort“ and „extreme effort“

# Adaptive Categorical Listening Effort Scaling

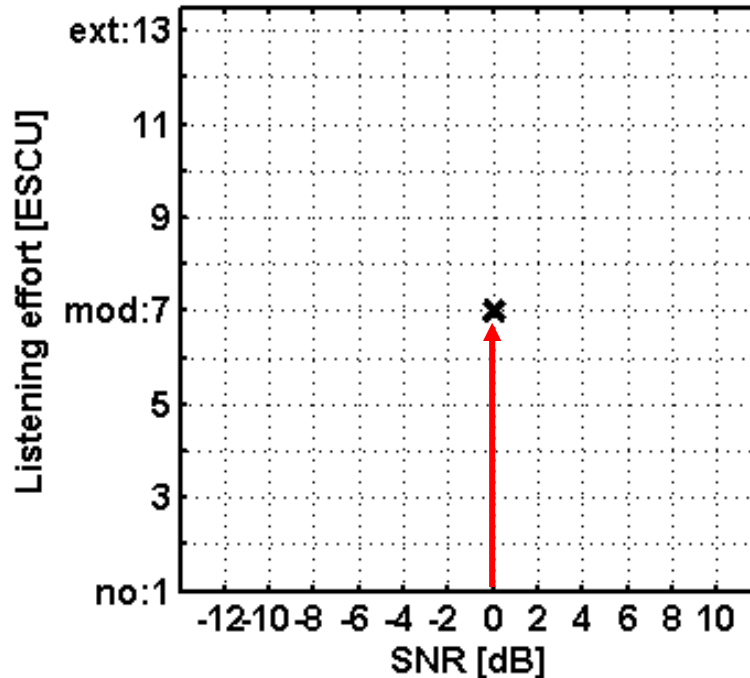
1. Determination of boundaries for „no effort“ and „extreme effort“



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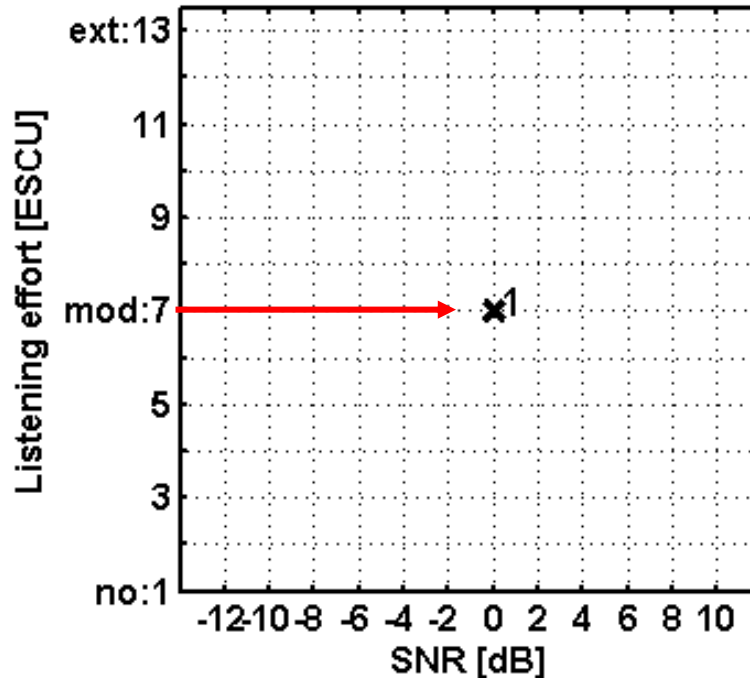
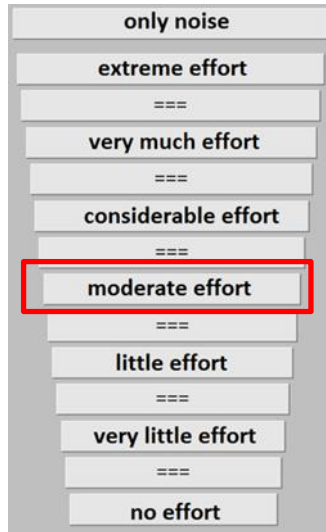
only noise
extreme effort
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very much effort
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considerable effort
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moderate effort
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little effort
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very little effort
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no effort





# Adaptive Categorical Listening Effort Scaling

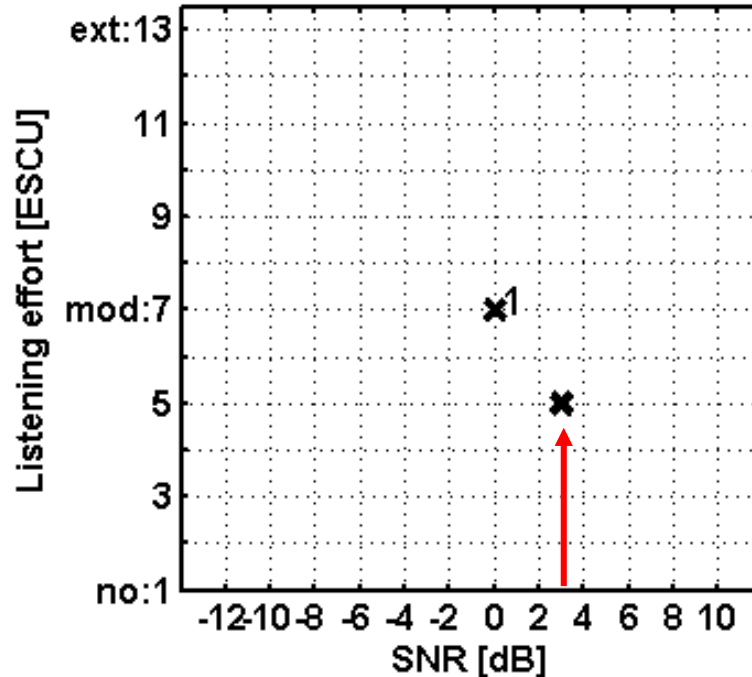
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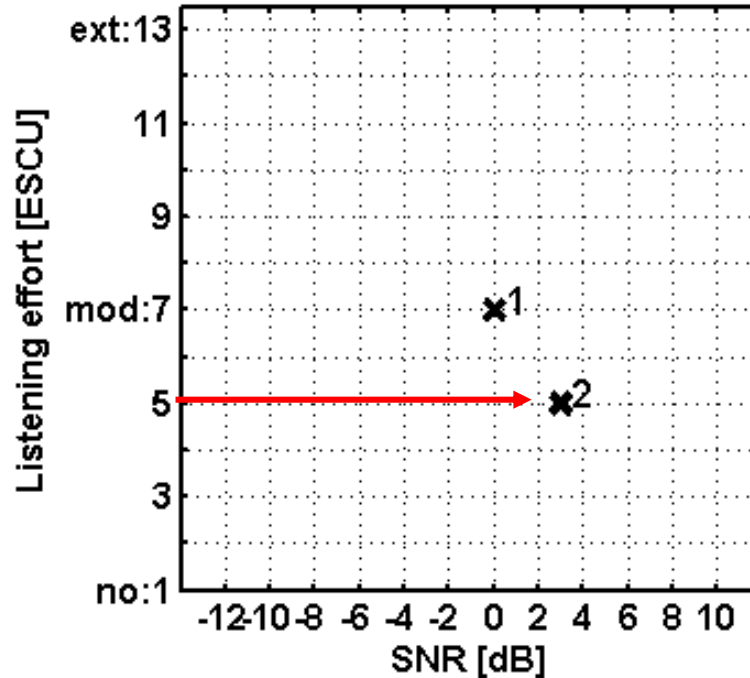
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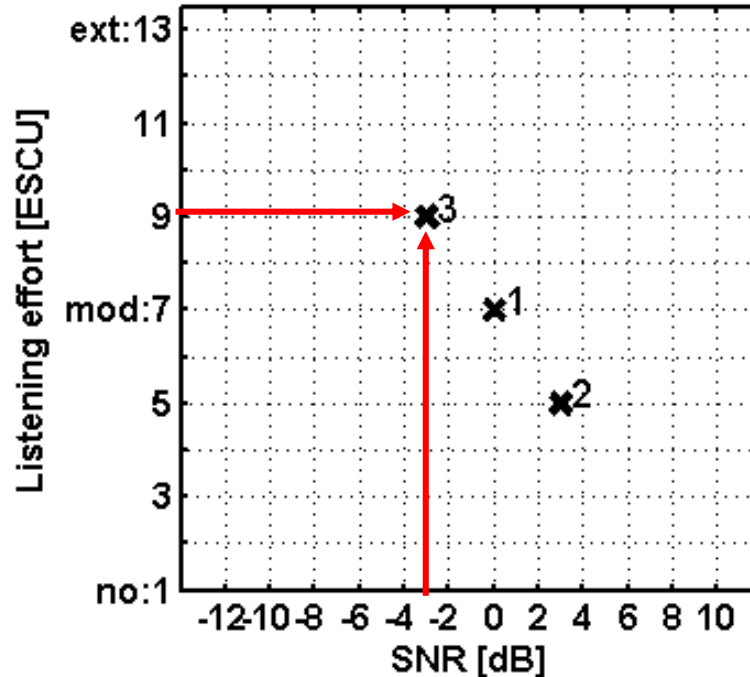
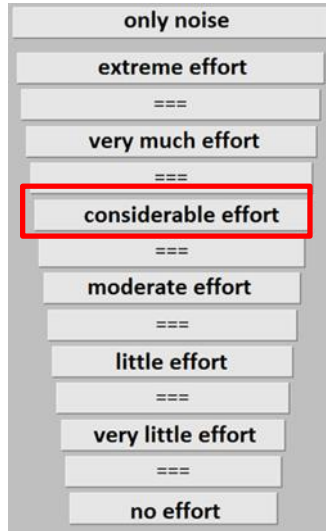
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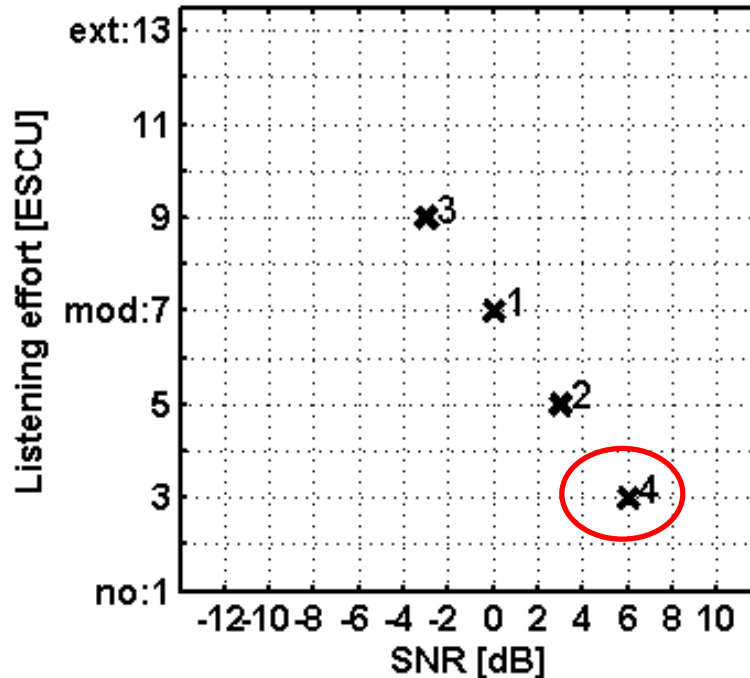
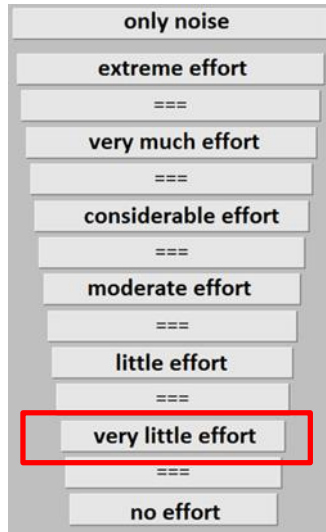
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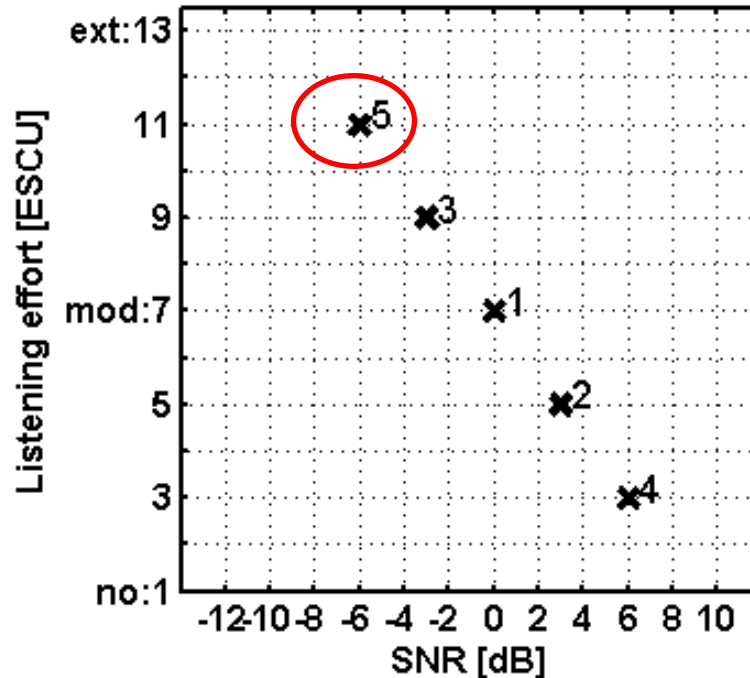
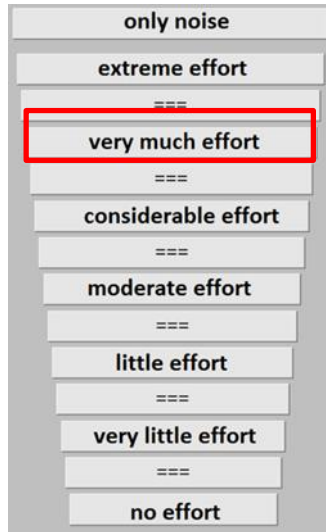
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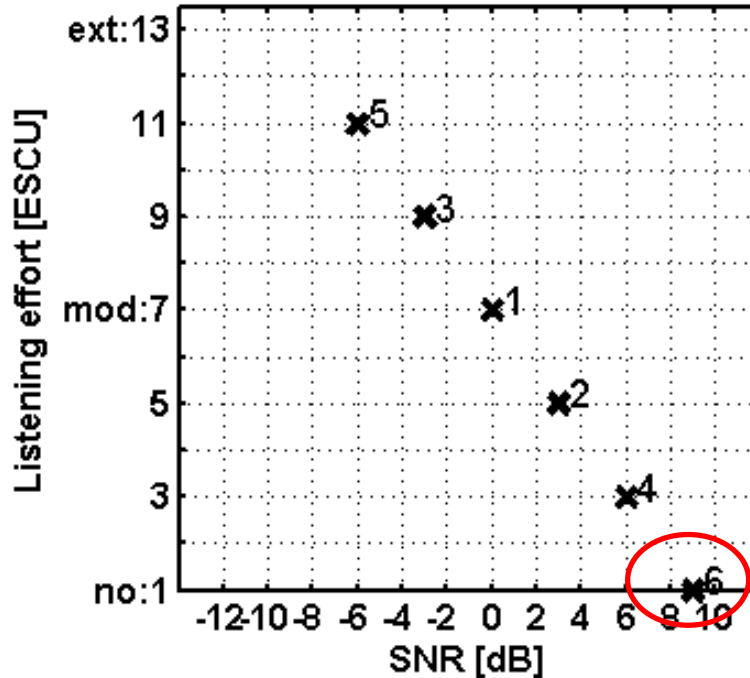
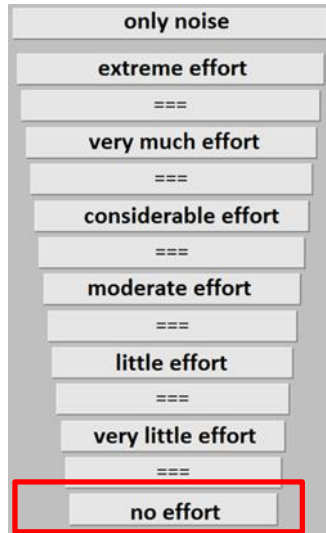
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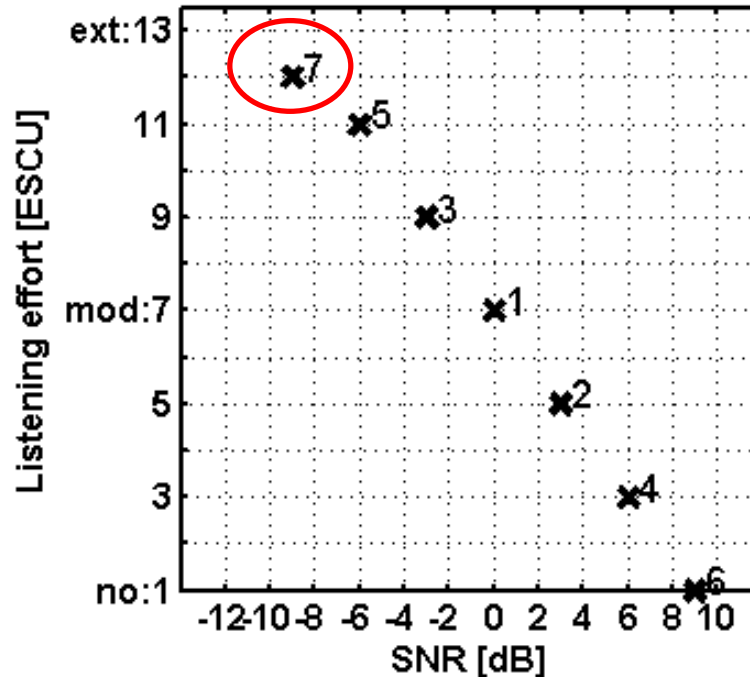
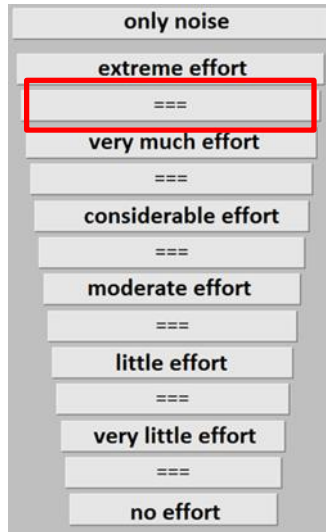
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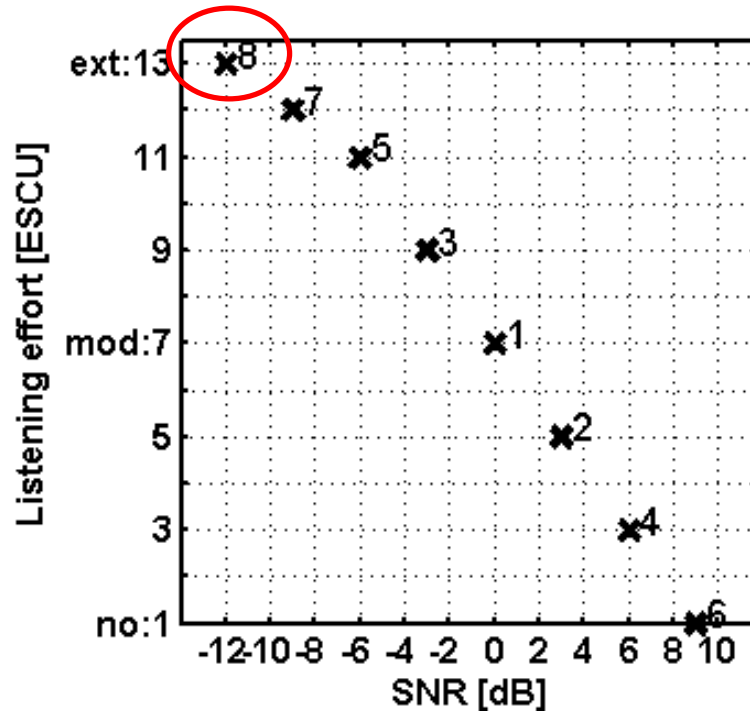
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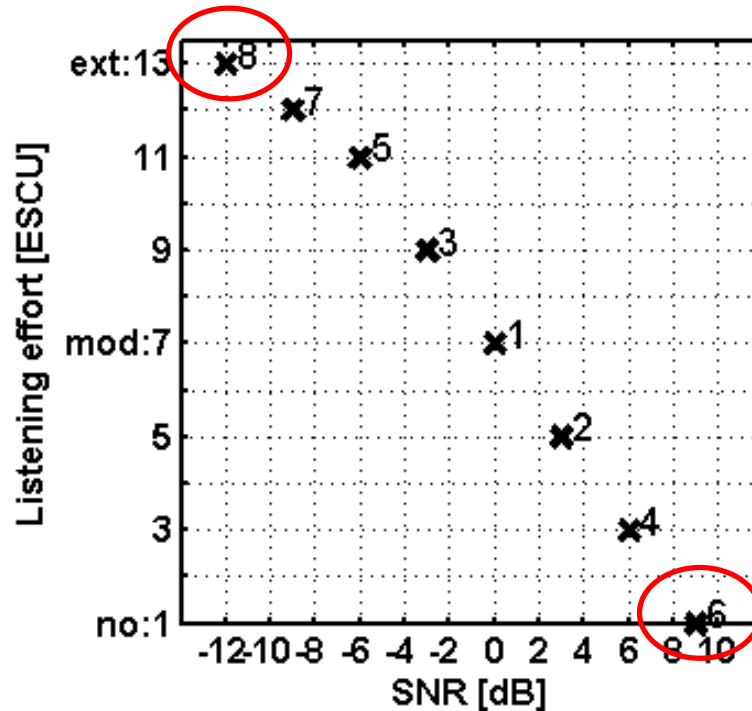
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# Adaptive Categorical Listening Effort Scaling

1. Determination of boundaries for „no effort“ and „extreme effort“

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# Adaptive Categorical Listening Effort Scaling

- The ACALES method is divided into three phases (Krueger et al., 2017):

## 1. Determination of boundaries for „no effort“ and „extreme effort“

„no effort“ (1 ESCU) at 9 dB SNR

„extreme effort“ (13 ESCU) at -12 dB SNR



# Adaptive Categorical Listening Effort Scaling

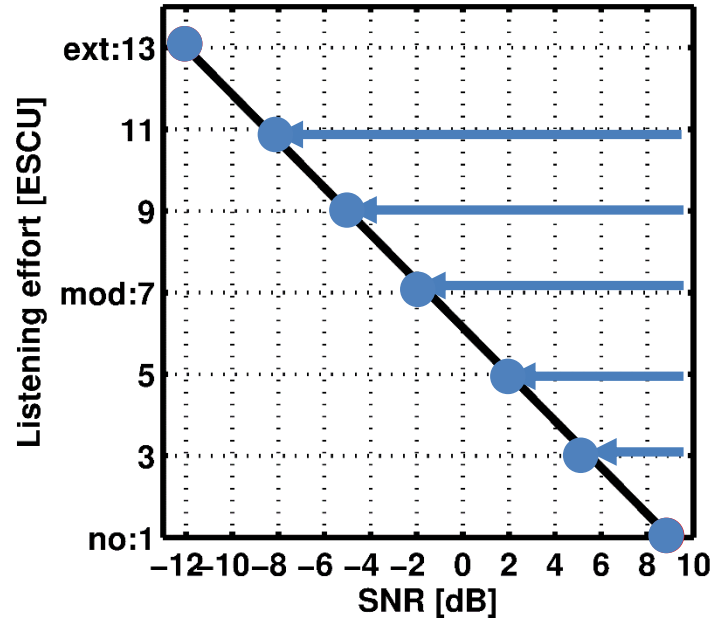
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1. **Determination of boundaries for „no effort“ and „extreme effort“**  
„no effort“ and „extreme effort“
2. **Estimation of SNR for categories**



# Adaptive Categorical Listening Effort Scaling

## 2. Estimation of SNR for categories



# Adaptive Categorical Listening Effort Scaling

- The ACALES method is divided into three phases (Krueger et al., 2017):

- 1. Determination of boundaries for „no effort“ and „extreme effort“**
- 2. Estimation of SNR for categories**



# Adaptive Categorical Listening Effort Scaling

- The ACALES method is divided into three phases (Krueger et al., 2017):

1. **Determination of boundaries for „no effort“ and „extreme effort“**
2. **Estimation of SNR for categories**
3. **Recalculation of boundaries and SNRs**



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A close-up photograph of a person's hand cupped behind their ear, symbolizing listening or hearing. The hand is positioned to the left of the ear, with the fingers spread and the palm facing the ear. The ear is on the right side of the frame, and the person's dark hair is visible at the top right. The background is plain white.

**Preliminary study with CI users**

# Methods

	Speech intelligibility	Listening effort
Test	Oldenburg sentence test (OLSA)	Adaptive categorical listening effort scaling (ACALES)



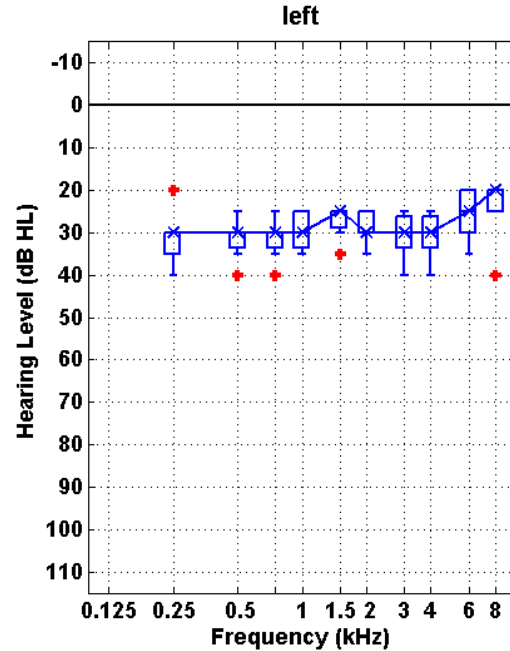
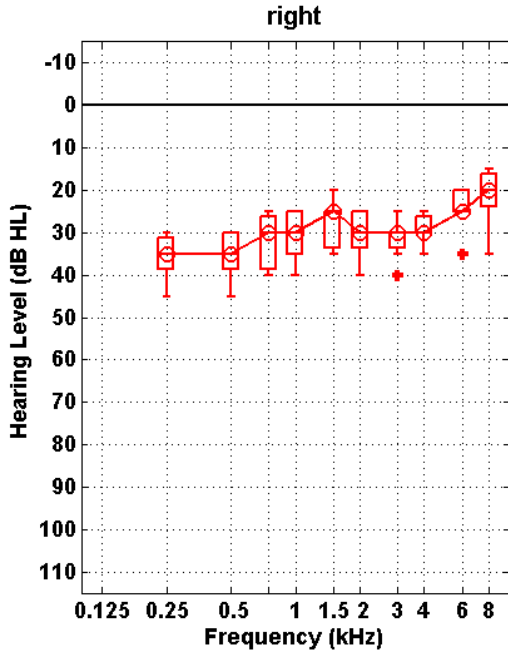
	Speech intelligibility	Listening effort
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Task	Repeat all recognized words  Example: „Peter sold two cheap toys.“	„How much effort is required for you to follow the speaker?“  <u>Test material:</u> Three sentences of the Oldenburg sentence test in a row.

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	<u>Background noise:</u> Fluctuating „International Female Fluctuating Masker“ ( <b>IFFM</b> ) Stationary background noise of the Oldenburg sentence test ( <b>Olnoise</b> )	

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Result	Threshold for score of 50% (SRT)	Subjective listening effort

# Participants

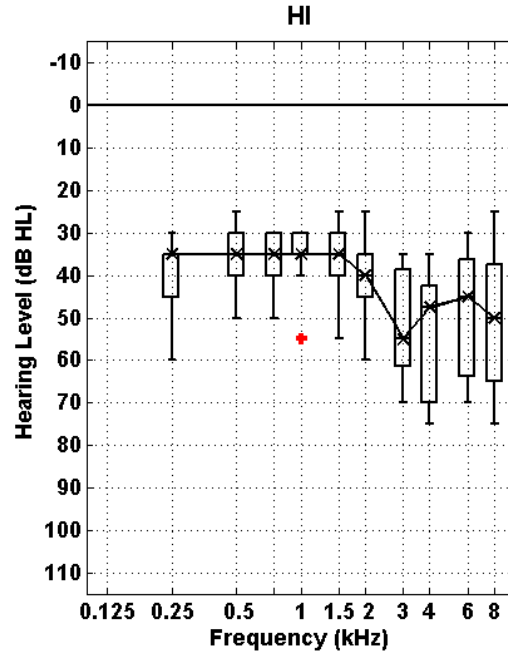
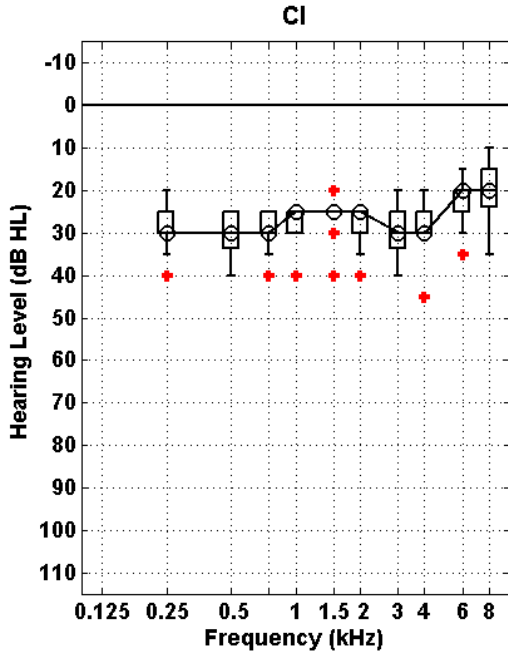
## Group 1: Participants with bilateral CI provision



- Aided free field audiogram separated by ears
- Aided threshold around 30 dB HL

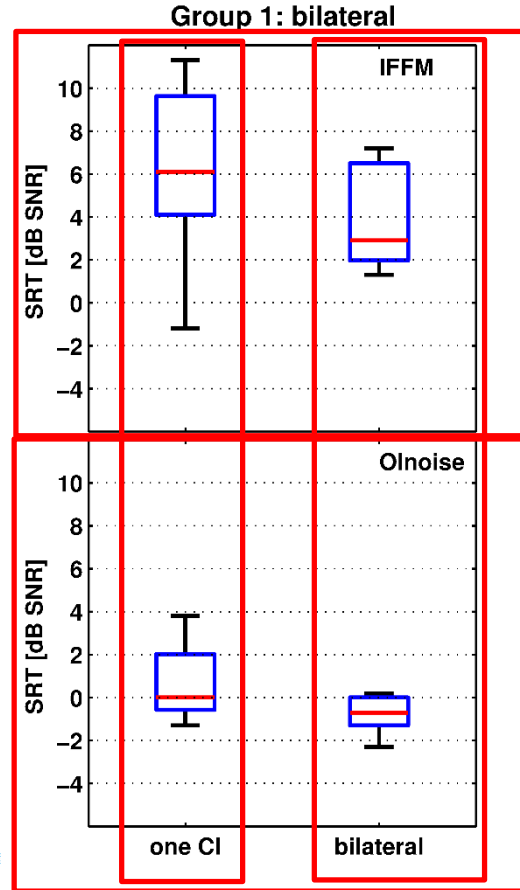
# Participants

## Group 2: Participants with bimodal provision



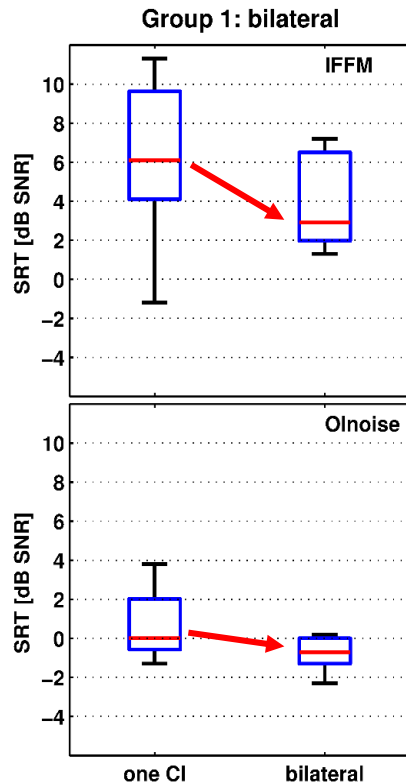
- Aided free field audiogram separated by ears
- CI threshold of the better ear around 30 dB HL
- HI threshold up to 1.5 kHz around 30 dB HL and a wider spread for higher frequency

# Results: Speech intelligibility



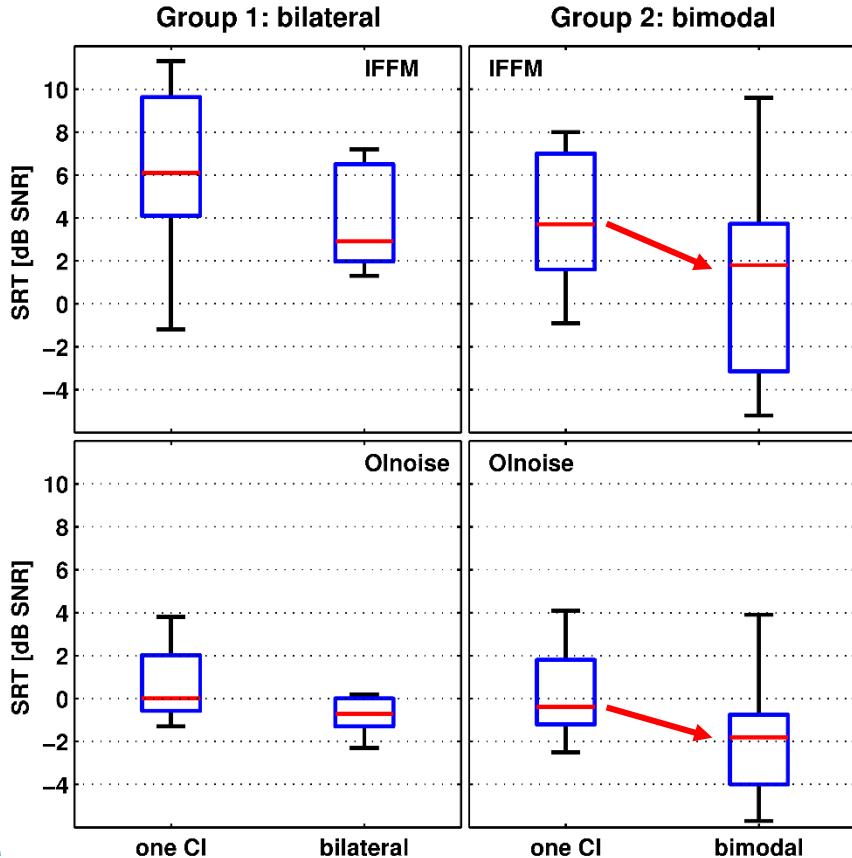


# Results: Speech intelligibility



- Group 1: bilateral  
Improvement of 3.2 dB (IFFM) and  
0.7 dB (Olnoise)

# Results: Speech intelligibility



- Group 1: bilateral

Improvement of 3.2 dB (IFFM) and 0.7 dB (OInoise)

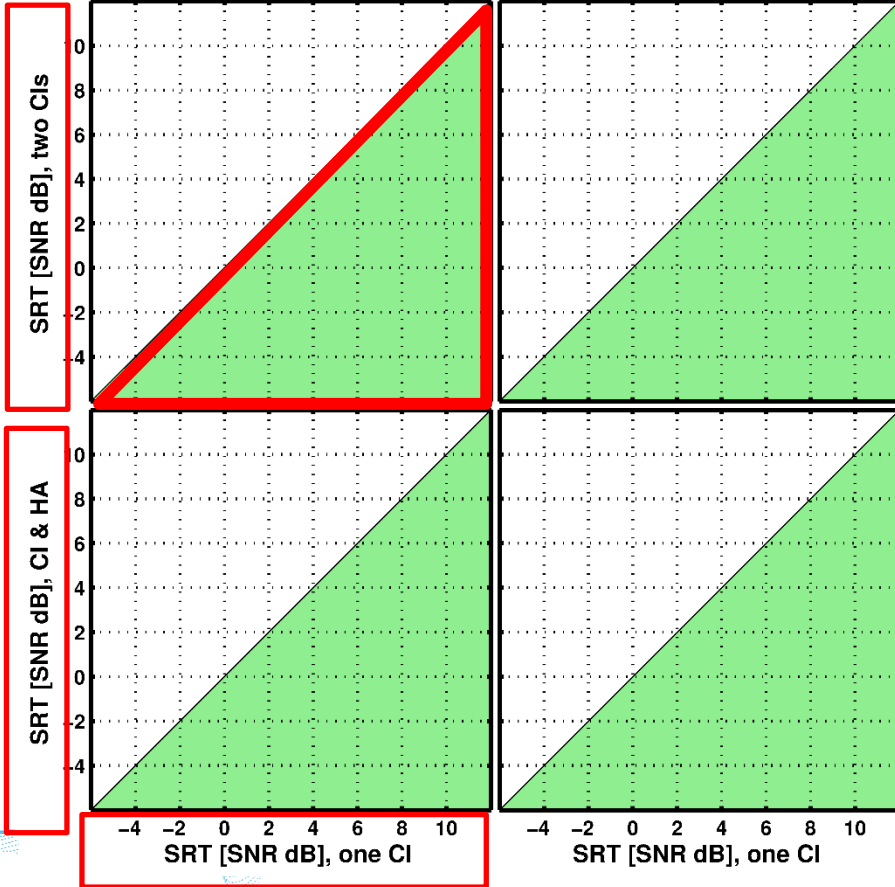
- Group 2: bimodal

Improvement of 1.9 dB (IFFM) and 1.5 dB (OInoise)

# Results: Speech intelligibility

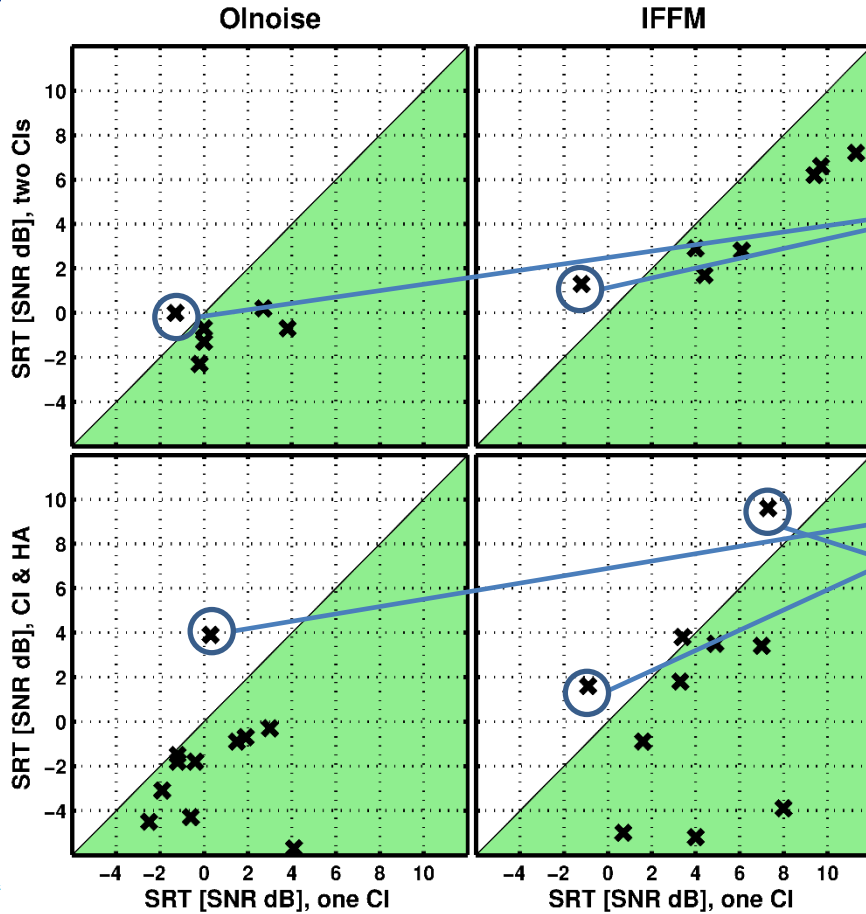
Olnoise

IFFM



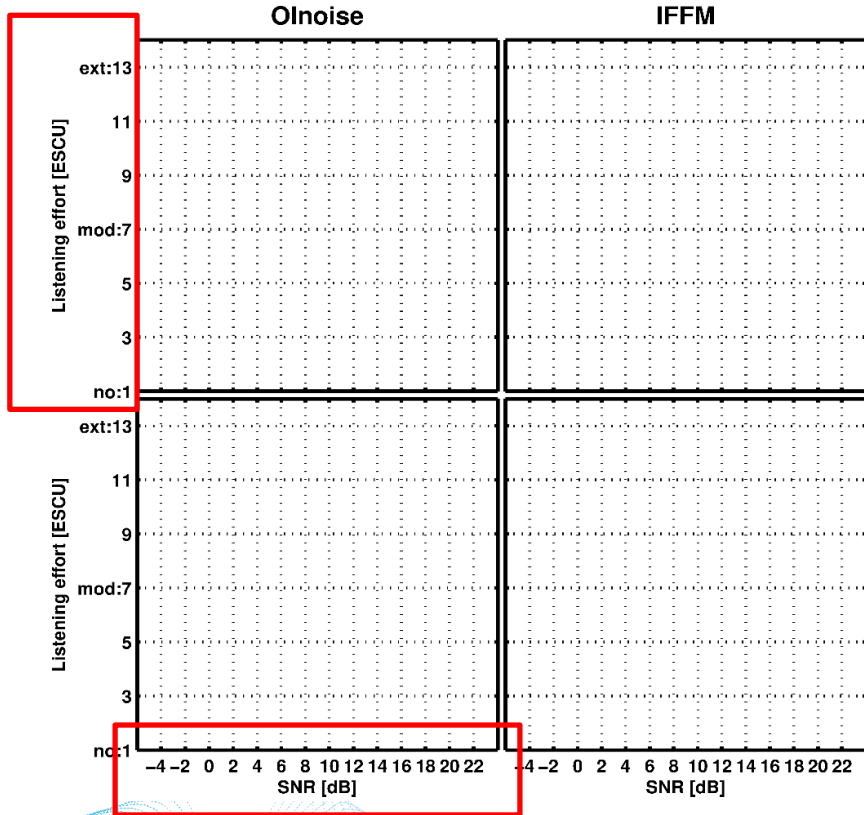
Speech intelligibility is better with a bimodal or bilateral provision

# Results: Speech intelligibility

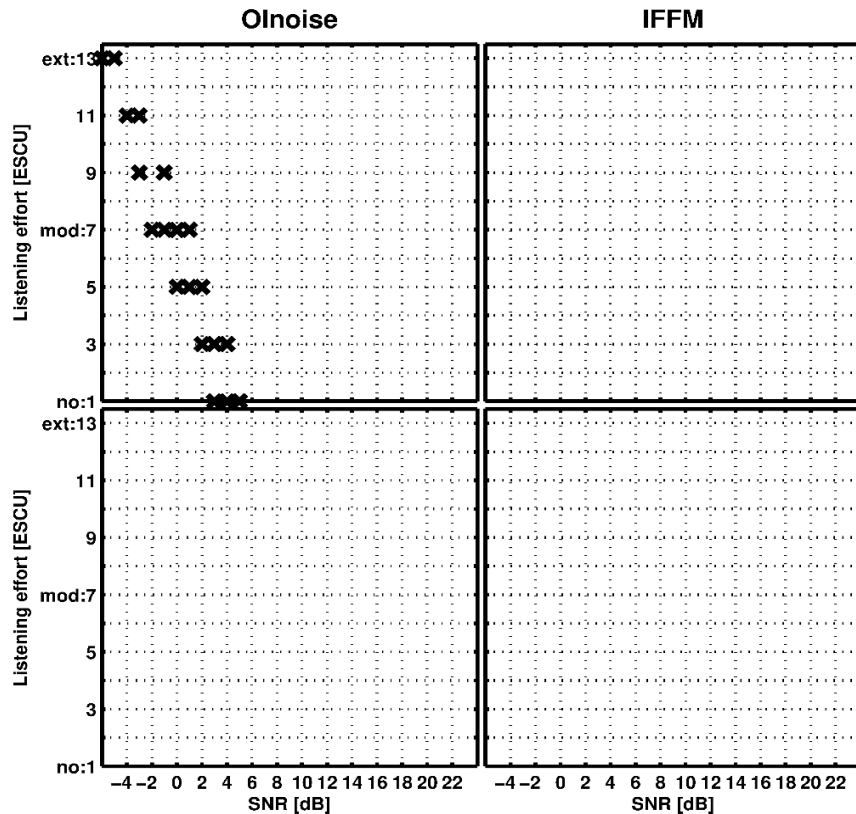


- Group 1: bilateral  
Two participants with no benefit of the bilateral provision
- Group 2: bimodal  
Participant #15 has no benefit of the bimodal provision in both noises  
Another participant with no benefit

# Results: Listening effort

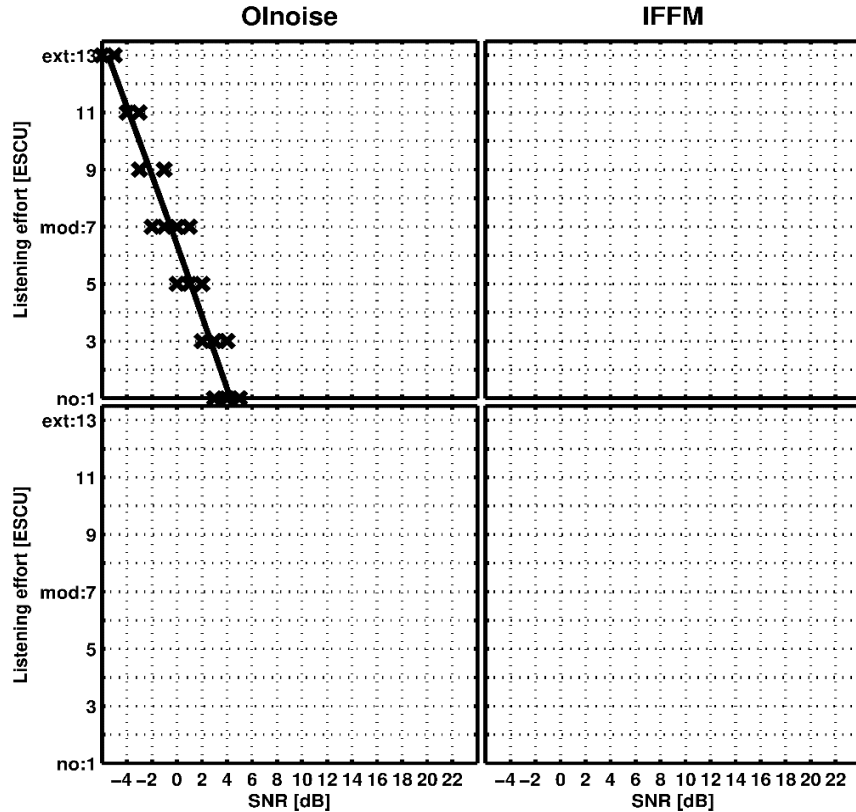


# Results: Listening effort



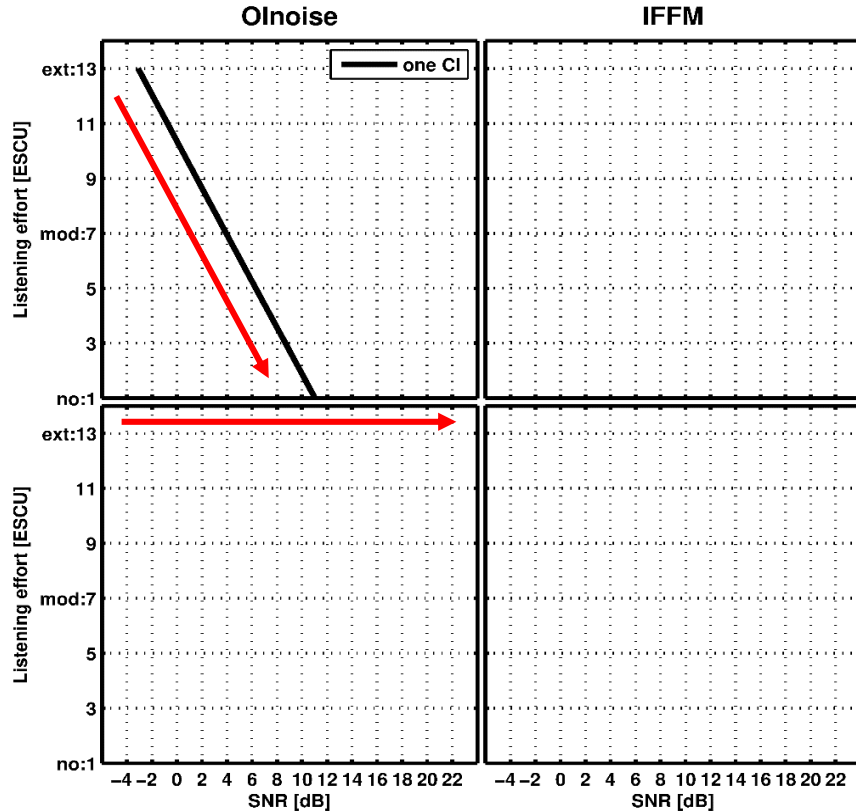
Measurement data of one participant

# Results: Listening effort



Measurement data of one participant with the corresponding listening effort function

# Results: Listening effort

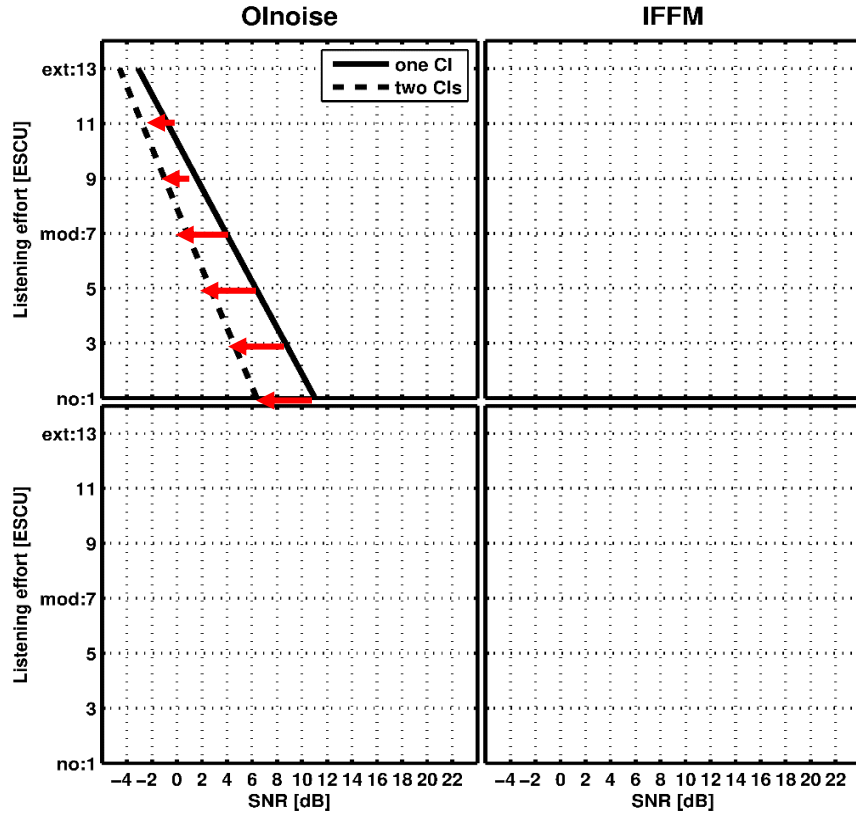


Averaged listening effort function  
for the measurement condition  
„one CI“

With increasing SNR the perceived  
listening effort decreases

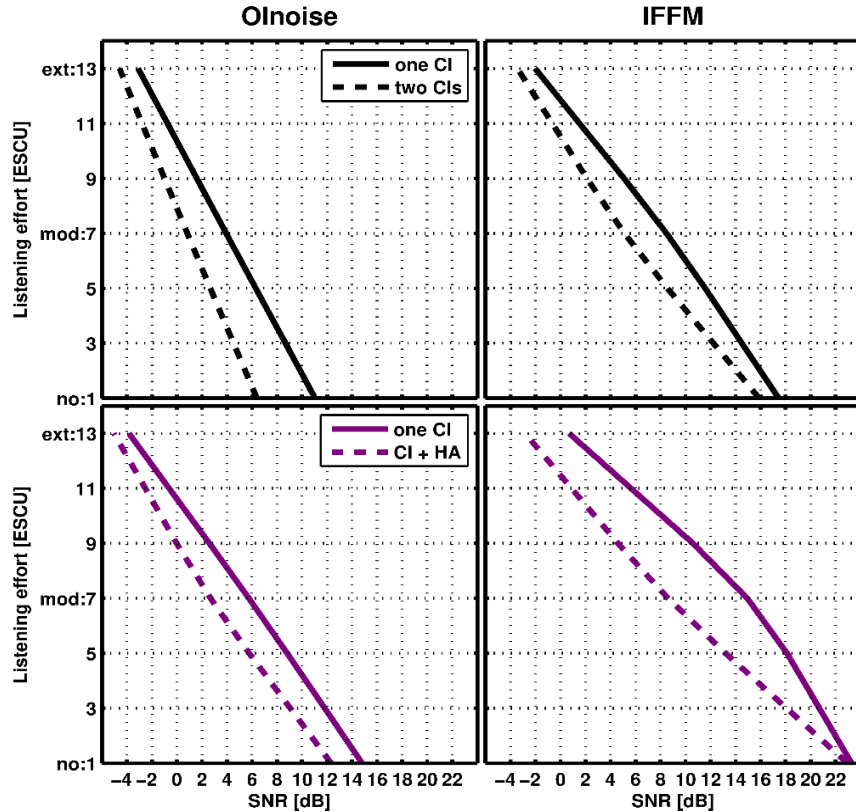


# Results: Listening effort



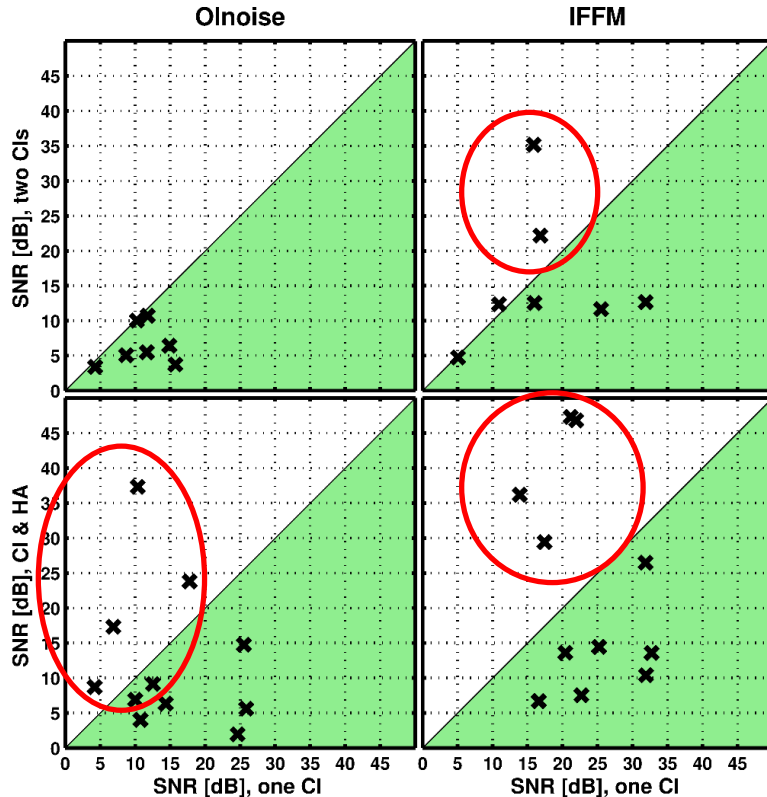
- Group 1: bilateral  
Reduced listening effort with two CIs

# Results: Listening effort



- Group 1: bilateral  
Reduced listening effort with bilateral provision
- Group 2: bimodal  
Reduced listening effort with bimodal provision

# Results: Listening effort



- Group 1: bilateral
  - All participants have a benefit with a bilateral provision in Olnoise
  - Two participants with increased listening effort in IFFM
- Group 2: bimodal
  - Four participants with increased listening effort in Olnoise and IFFM

# Summary

- ACALES is fast and easy.
- The adaptive scaling method can be used with CI users.
- ACALES is able to detect differences between CI only and bilateral or bimodal provision.
- It is not possible to make predictions about improvements in listening effort based on benefit in speech tests.
- **Why do some CI users get a benefit from bilateral or bimodal provision and others do not?**



# Outlook

- How does the perceived listening effort differ between the participants?
- Longitudinal study in cooperation with Evangelisches Krankenhaus Oldenburg (Universitätsklinik für Hals-Nasen-Ohren-Heilkunde)





# Thank you for your attention!

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