Evaluating hearing-aid signal processing in a way that is indicative of real-life performance

= ecologically valid

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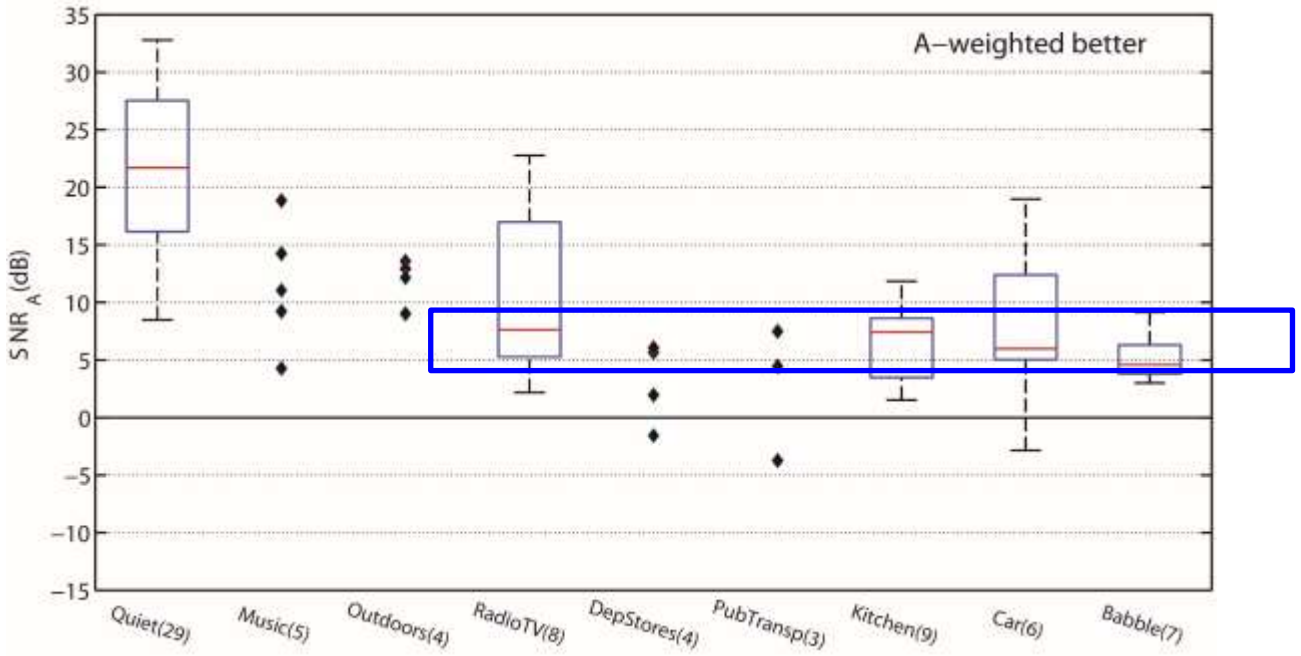
Introduction, previous work at ORCA Europe

- Auditory ecology – ”The relationship between the acoustical environments experienced in everyday life and the perceptual demands of different people in these environments” (Gatehouse et al. 1999; Jensen and Nielsen 2005)
- Estimation of realistic signal-to-noise ratios



- Common Sound Scenarios (CoSS) framework

Common Sound Scenarios (CoSS) framework

Intention	Speech communication						Focused listening				Non-specific			
Task	2 people		More than 2 people		Through device		Live sounds		Through media device		Monitoring surroundings		Passive listening	
	Two people having a conversation		Several people having a shared conversation		Two or more people having a shared conversation through a communication device		Focused listening to sound without being able to control the sound source		Focused listening to sound while being able to control the sound source		Conscious or unconscious screening of sound of relevance to current activity		Unconscious perception of environmental sounds, without relevance to current activity	
Scenario	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	#14
Occurrence														
Difficulty														
Importance														
Scenario	Conversation at home	Conversation on metro	Meeting in an office	Car ride with family	Phone call at home	Mobile call in the street	Lecture	At a concert	Watching TV	Listening to car radio	Vacuum cleaning	City walk	Relaxing with a book	Relaxing on train

Wolters et al. JAAA 2016

Traditional Laboratory Tests and CoSS

Focused listening			
Live sounds		Through media device	
Focused listening to sound without being able to control the sound source		Focused listening to sound while being able to control the sound source	
#7	#8	#9	#10
Lecture	At a concert	Watching TV	Listening to car radio

ORCA Europe exploration of test methods

- Ecological Momentary Assessments (EMA)
- Guided Sound Walk
- Live Evaluation of Auditory Preference (LEAP)

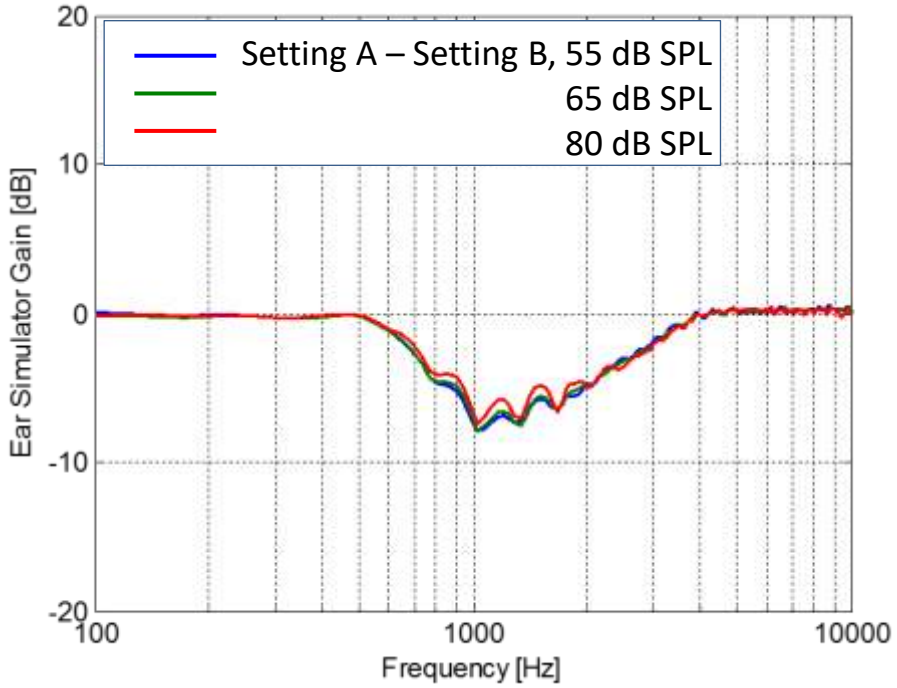
Test procedure: Comparison of *preference* for different hearing-aid signal-processing schemes

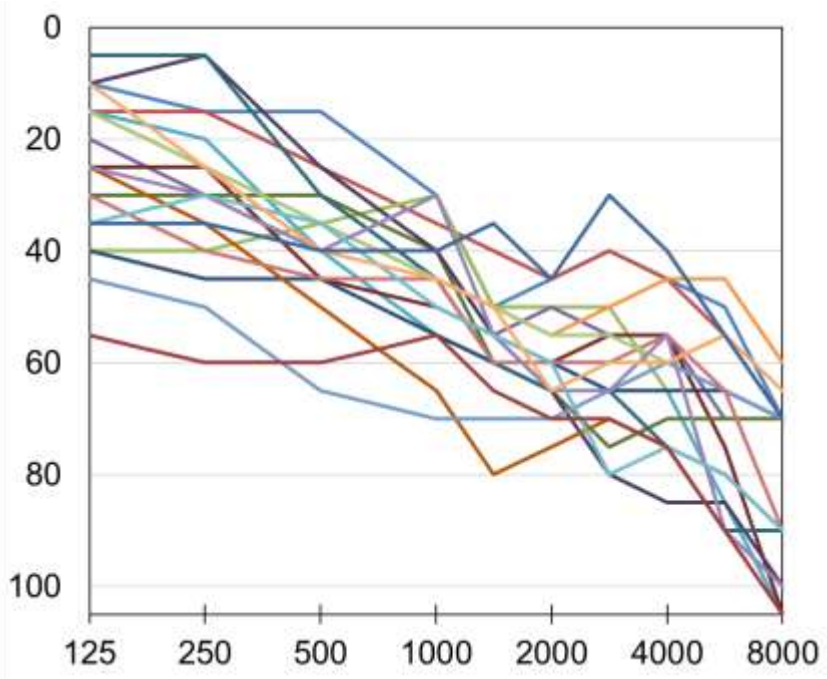
- Paired Comparisons
- Multiple Comparisons

Unsupervised field test – EMA

EMA: Method

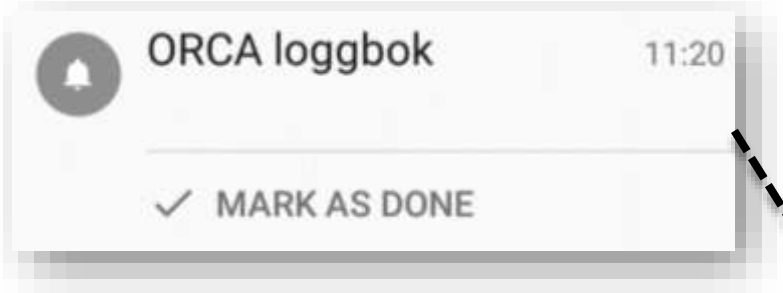
- Paired comparisons between two hearing-aid settings in two hearing-aid programs
- 19 elderly hearing-impaired participants (avg 74 years)
- 10 day field-trial period
- Prompted responses every 2 h plus self-initiated responses



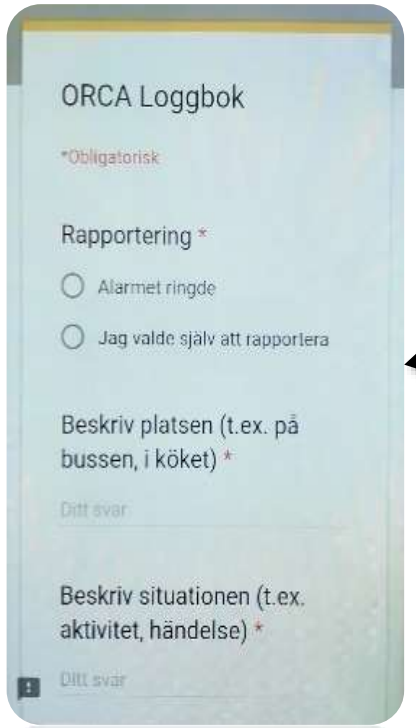


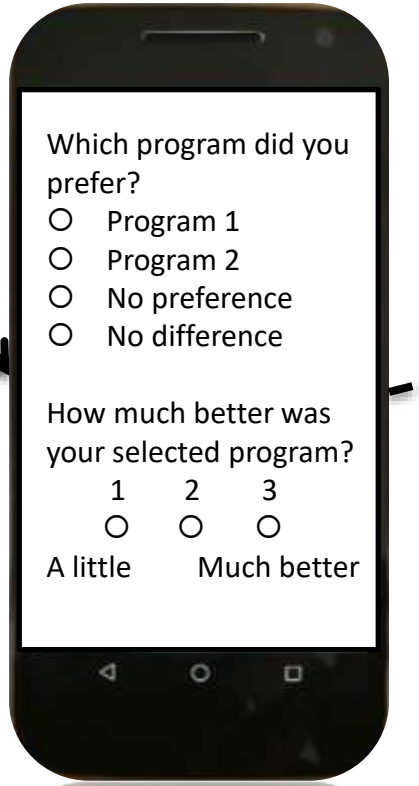
Setup

Reminder



Questionnaire



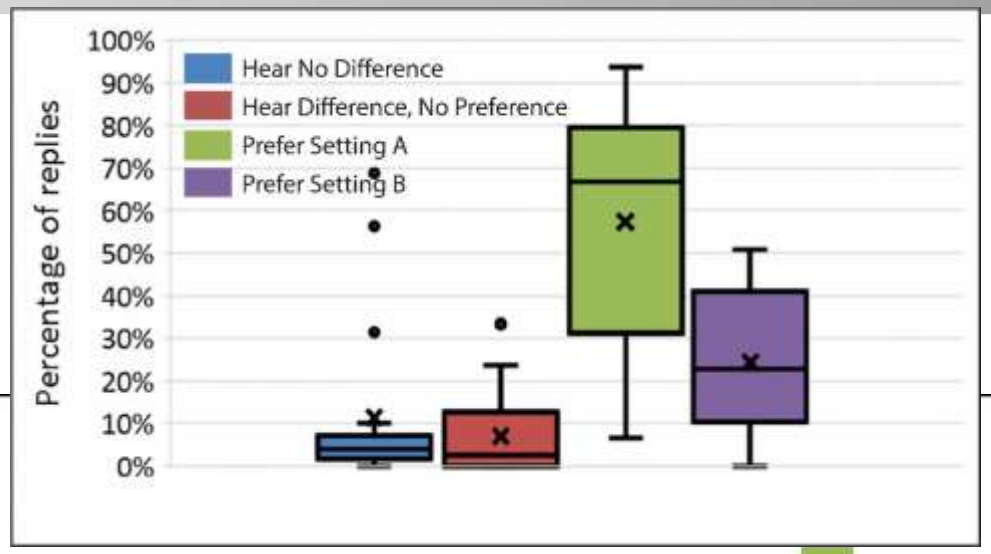


Hearing aids

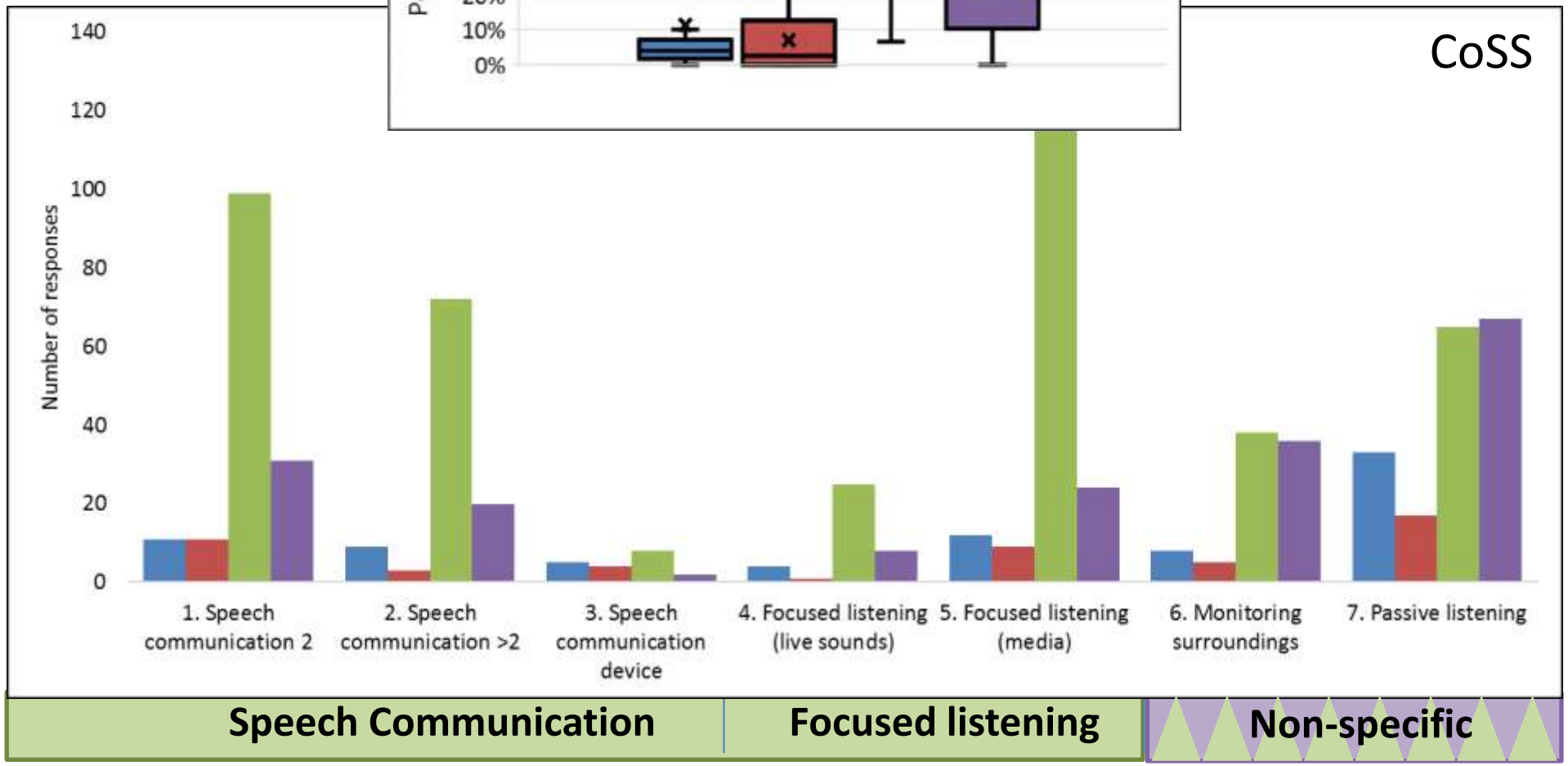
Remote control

Results (stored in cloud)

Results



CoSS



Laboratory test – LEAP

LEAP (Live Evalution of Auditory Preference)

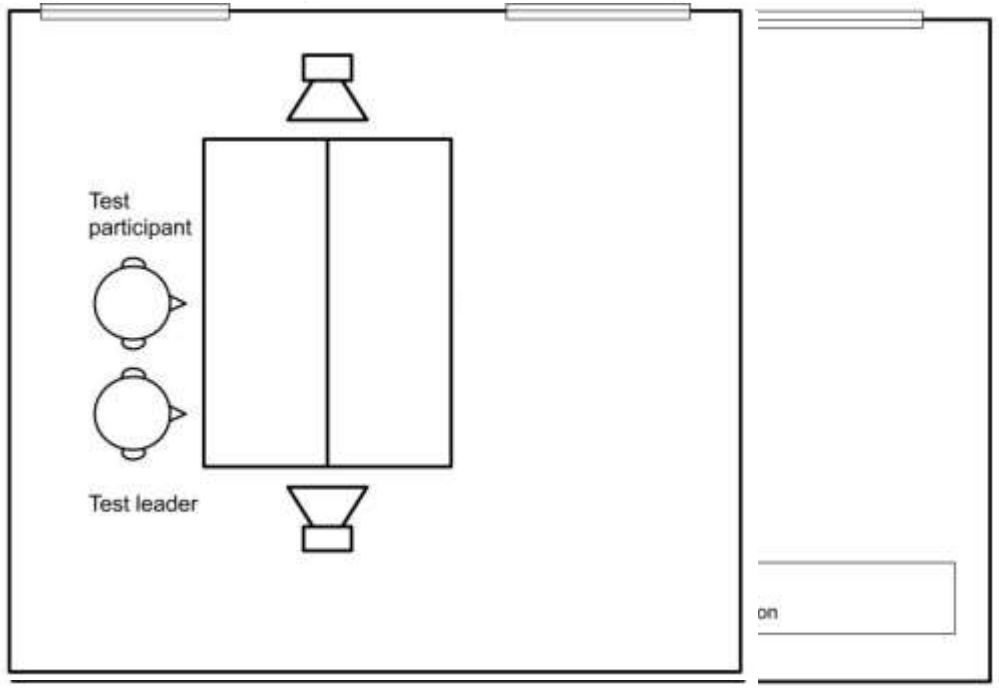
Range of realistic scenarios (regarding tasks)

Particular focus on real communication

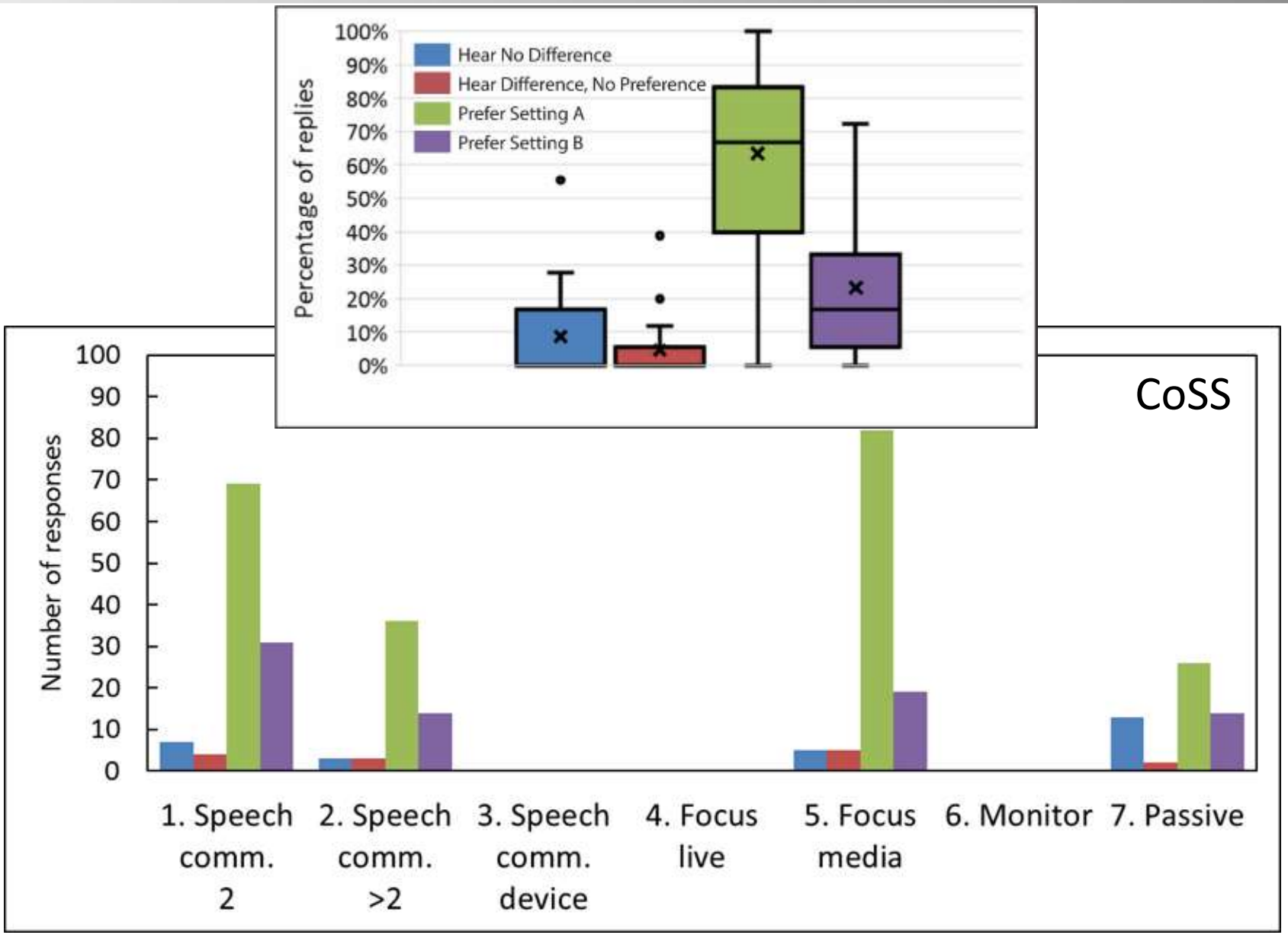
LEAP: Method

Same test participants, same hearing aids, same gain difference, similar smartphone questionnaire as in the EMA study

- 6 mandatory test scenarios
    1. Communication 2 people in “quiet”
    2. Communication 2 people in car noise
    3. Communication 3 people in restaurant noise
    4. Focused listening to TV
    5. Focused listening to radio
    6. Passive listening, paper work
- Up to 6 individually selected test scenarios
    - Max 2 important
    - 2 challenging
    - 2 common situations
- 3 presentations of each test scenario



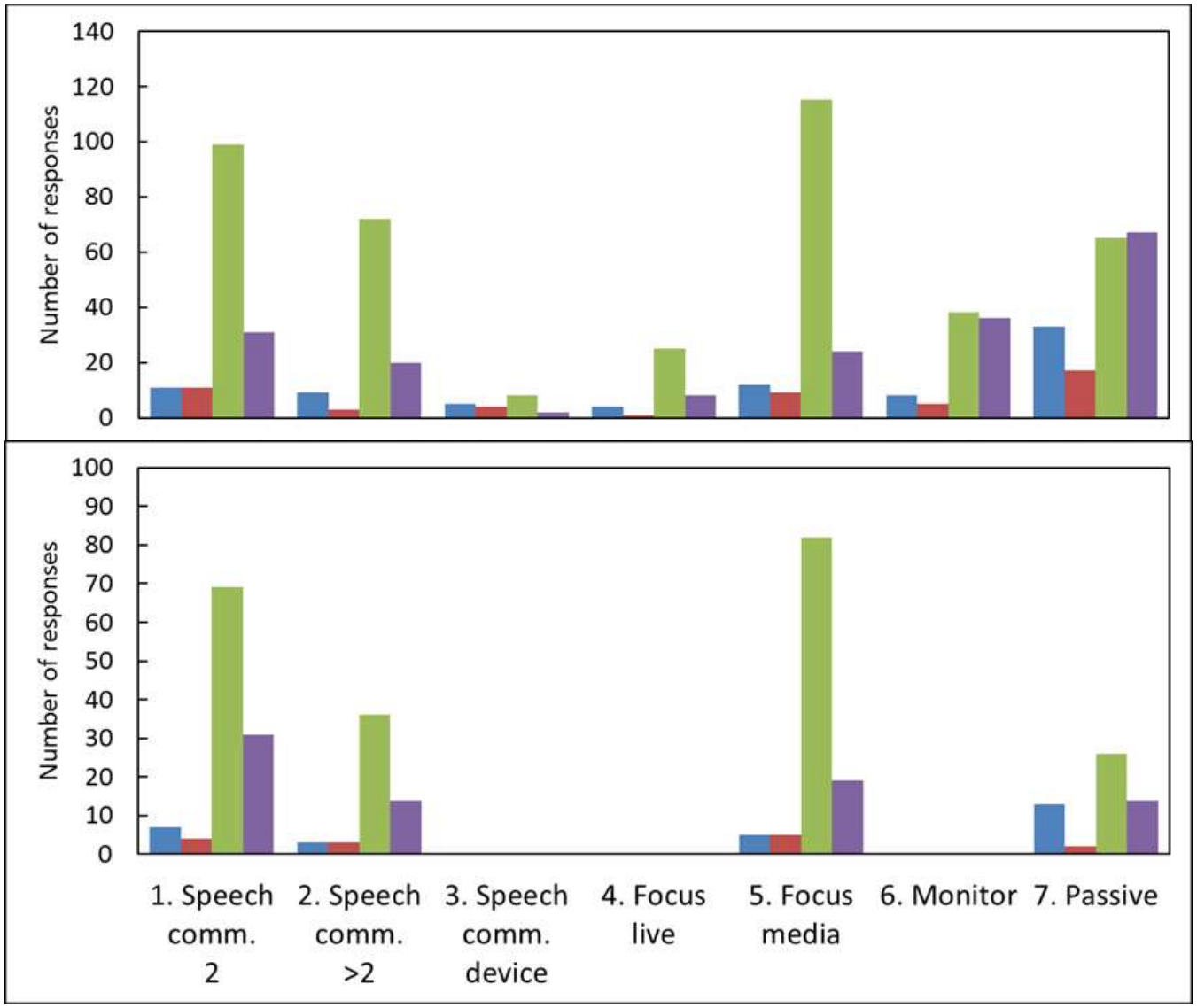
Results LEAP (Lab)



Comparison Field – Lab

Field EMA

Lab LEAP



Hear No Difference

Hear Difference, No Preference

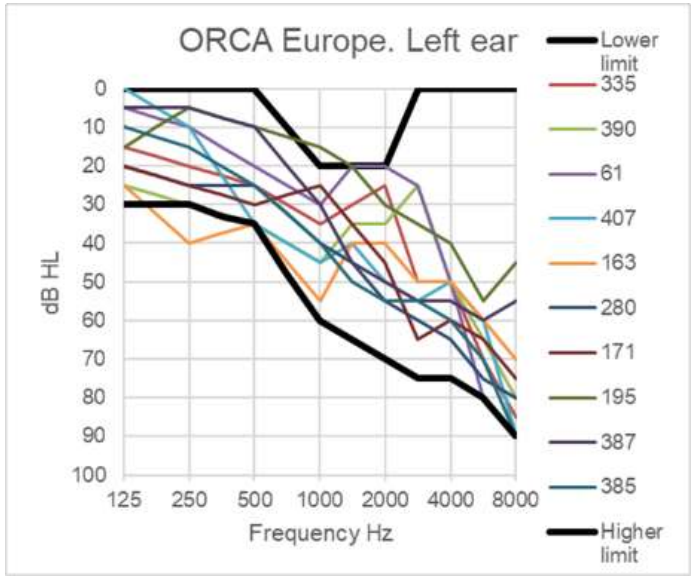
Prefer Setting A

Prefer Setting B

Guided walk

Guided walk

- ”Bringing LEAP out into the field”
- Similar gain difference as in previous studies
- Now 4 hearing-aid settings in 4 hearing-aid programs
- 10 test elderly test participants (avg 73 years)
- Compare settings
  - Test participants changed programs using an app
  - Test leader filled out a logbook using pen and paper
  - Test participants also encouraged to describe sound characteristics of the different programs and why they selected a particular program
  - The walks were recorded
- 18 stops during the guided walk
- Typically 5 minutes per decision, in total 75-105 minutes



Stops during the walk (examples)

Indoors ORCA Europe premises

- Conversation in a reverberant hallway

Outdoors

- Conversation in a calm back yard
- Conversation in a quiet/busy street

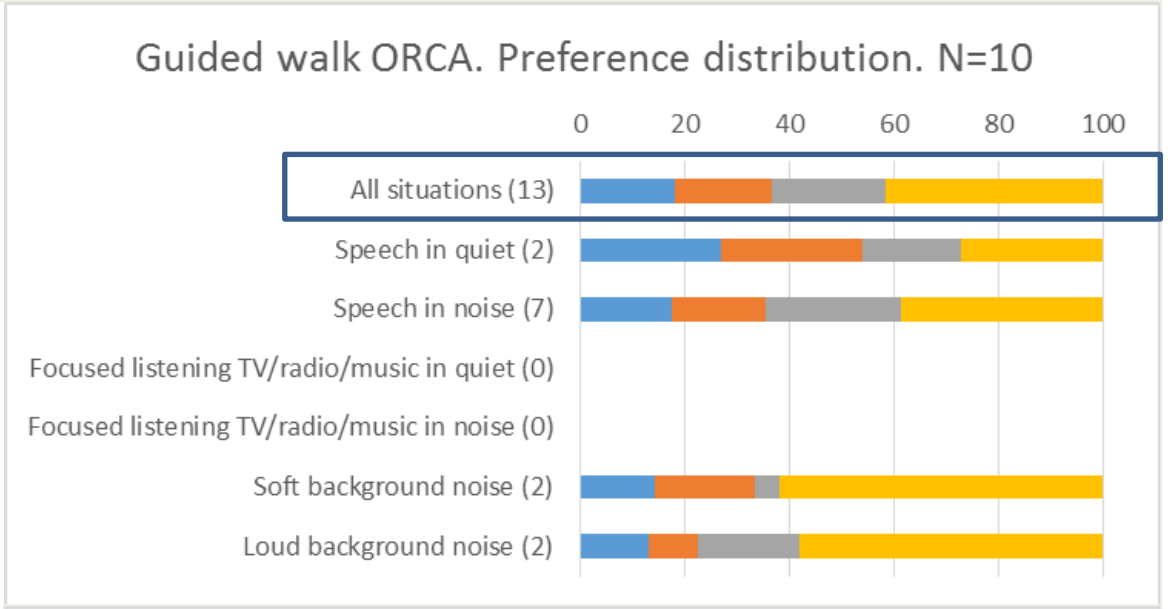
Transport and train station

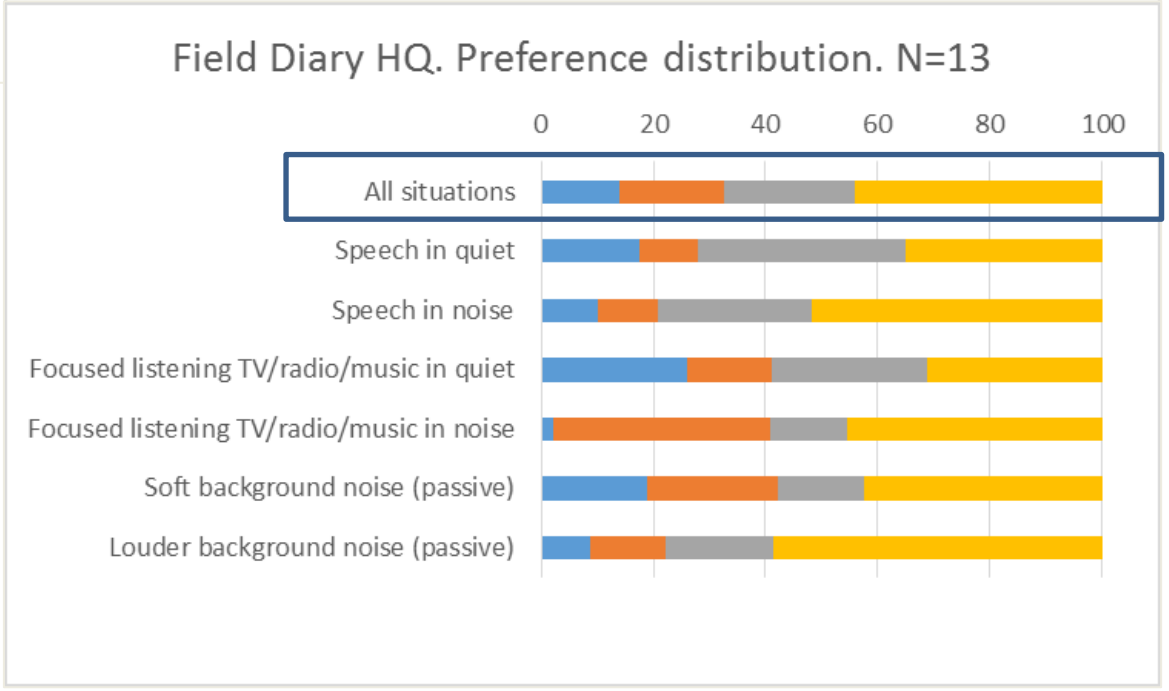
- Conversation at a train station
- Conversation at a bus

Coffee shop

- Conversation in a coffee shop

Results


Guided walk ORCA. Preference distribution. N=10
0
20
40
60
80
100
All situations (13)
Speech in quiet (2)
Speech in noise (7)
Focused listening TV/radio/music in quiet (0)
Focused listening TV/radio/music in noise (0)
Soft background noise (2)
Loud background noise (2)

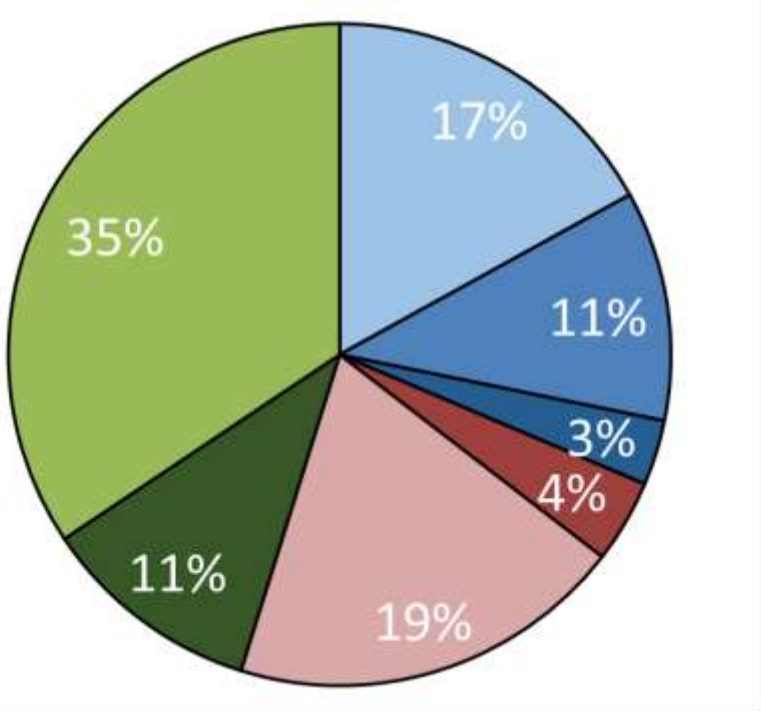

Field Diary HQ. Preference distribution. N=13
0
20
40
60
80
100
All situations
Speech in quiet
Speech in noise
Focused listening TV/radio/music in quiet
Focused listening TV/radio/music in noise
Soft background noise (passive)
Louder background noise (passive)


Setting A
Setting B
Setting C
Setting D

Discussion

EMA (field unsupervised)

+ Test participants own, relevant listening situations



CoSS task categories

- Speech comm, 2 people
- Speech comm, >2 people
- Speech comm, Device
- Focused listening, Live
- Focused listening, Media
- Monitoring surroundings
- Passive listening

Discussion

EMA (field unsupervised)

+ Test participants own, relevant listening situations
– But some specific, perhaps important situations might not occur during the test period
+ Data collection not so resource heavy for test leader
– But could be demanding for the test participants

Guided walk (field supervised)

+ Reasonable control over visited situations (could also be recorded for subsequent analysis)
– But information about performance in other situations not gathered
+ Richer data than EMA (tailored questions about the preference can be asked)
– But, more resource heavy data collection for test leader

LEAP (laboratory supervised)

+ Careful control of background noise levels and listening intention and task
– But in order to test all types of signal processing, an advanced loudspeaker setup is needed
+ Compared to traditional laboratory testing: more complex task, own voice, tailored SNR
– But, tailored SNR…

Conclusions

- (Paired) comparisons seem useful when evaluating hearing-aid signal processing in ecologically valid ways
- Here: Comparisons of preference, but other attributes can be used

- The (paired) comparison test procedure can be used in a variety of settings
  - Unsupervised field testing using EMA
  - Guided walk
  - Laboratory test LEAP
  - (Traditional laboratory test)

- Selection of setting depending on what is being evaluated

Thank you for your attention!

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