Vehicle Noise: Loudness Ratings, Loudness Models and Future Experiments with Audiovisual Immersive Simulations

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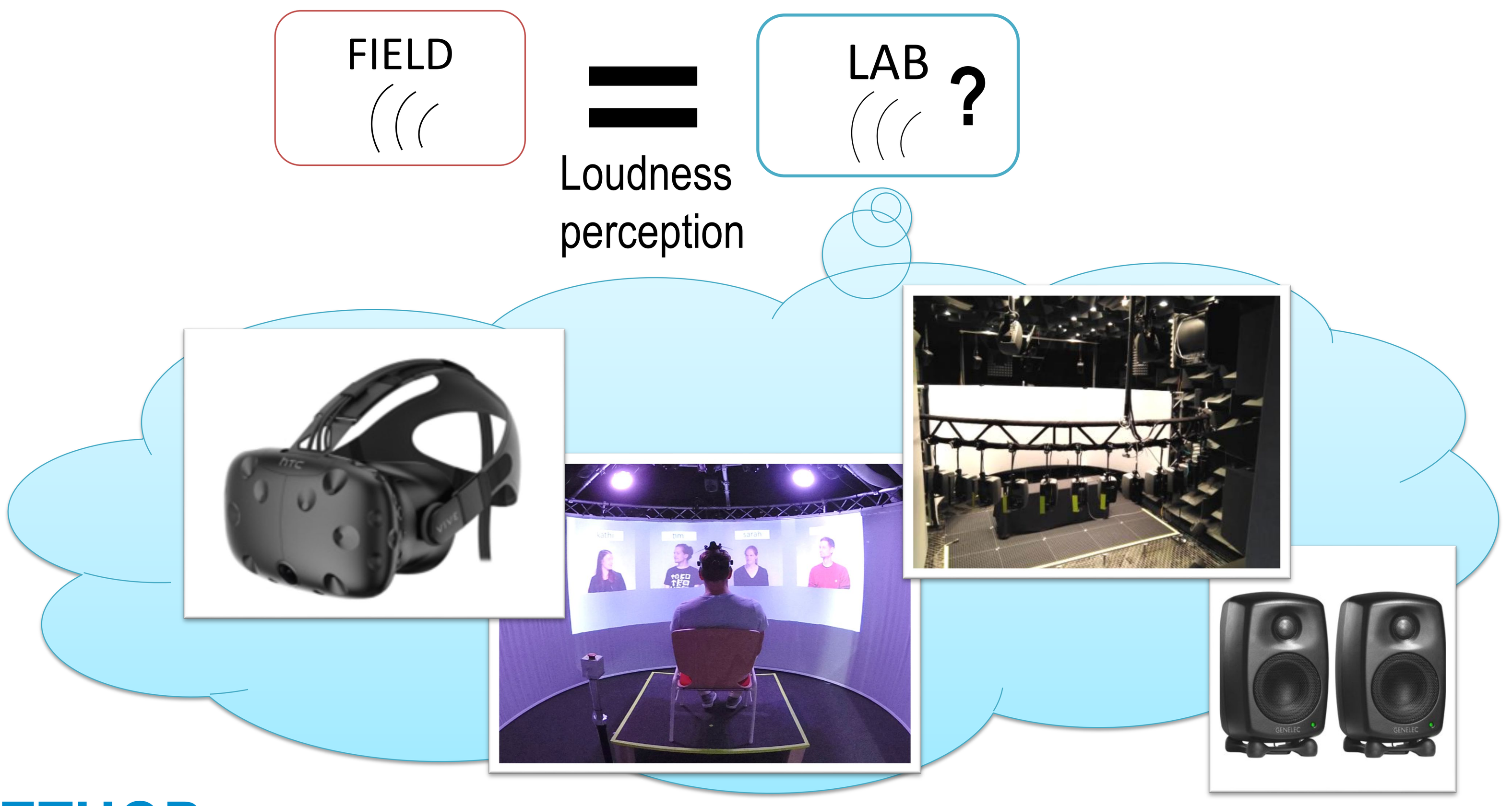
Motivation

- Hearing aid users complain about loudness.
- Clinical audiological methods don't reflect real-life situations (Mueller and Bentler 2005).
- How should the laboratory be to reflect reality?

Related Work

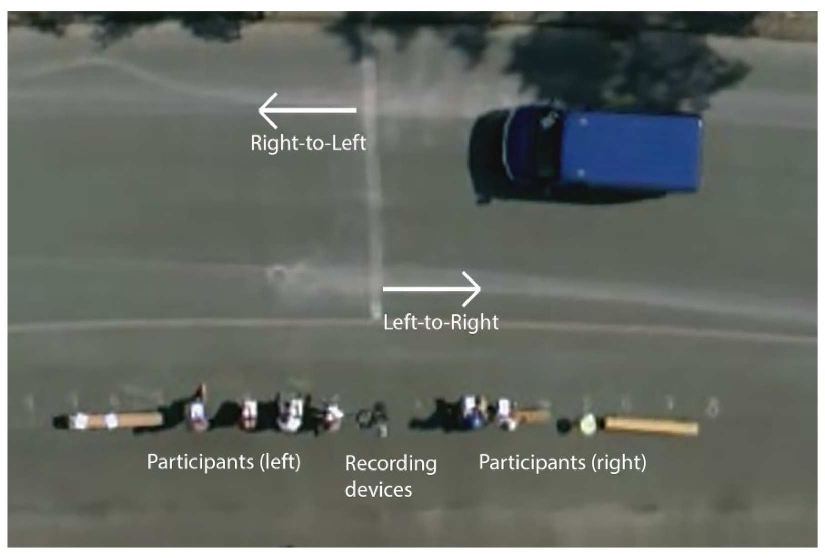
- Lower loudness preference in the laboratory than the field (Smeds et al. 2006).
- Loudness studied in the laboratory (Heeren et al. 2003, Appell 2002) to predict loudness perception and ratings.
- Visual cues play a role in the laboratory. Sounds are perceived less loud with visual cues (Fastl 2004).

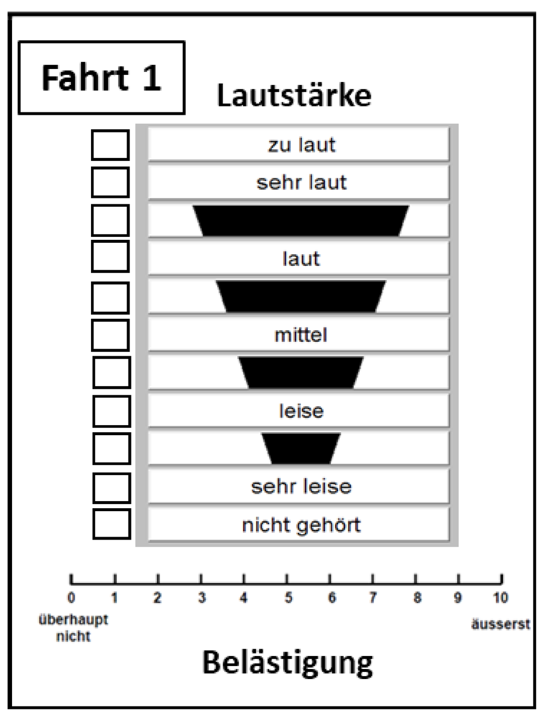


Method

- Loudness and annoyance ratings of vehicle noise in the field:
  - 4 different vehicles (car, motorbike, van, street sweeper)
  - 5 driving urban actions (stand by, accelerate, 30 km/h, 50 km/h, break to stop) and 3 for the street sweeper (stand by, brushes on, brushing forward).
  - 72 rated driving actions per participant.

- Participants:
  - 19 NH listeners (9 female, mean age 50 yrs, SD: 19.2, PTA=3.8 dB HL, SD: 4.7).
  - 20 HI (12 female, mean age 72 yrs, SD: 12.0, PTA=38.5 dB HL, SD: 6.8) with NAL-NL2 and trueLOUDNESS (Oetting et al. 2018).
- Categorical Loudness Scale (CLS) and ICBEN numerical annoyance scale (0-10).

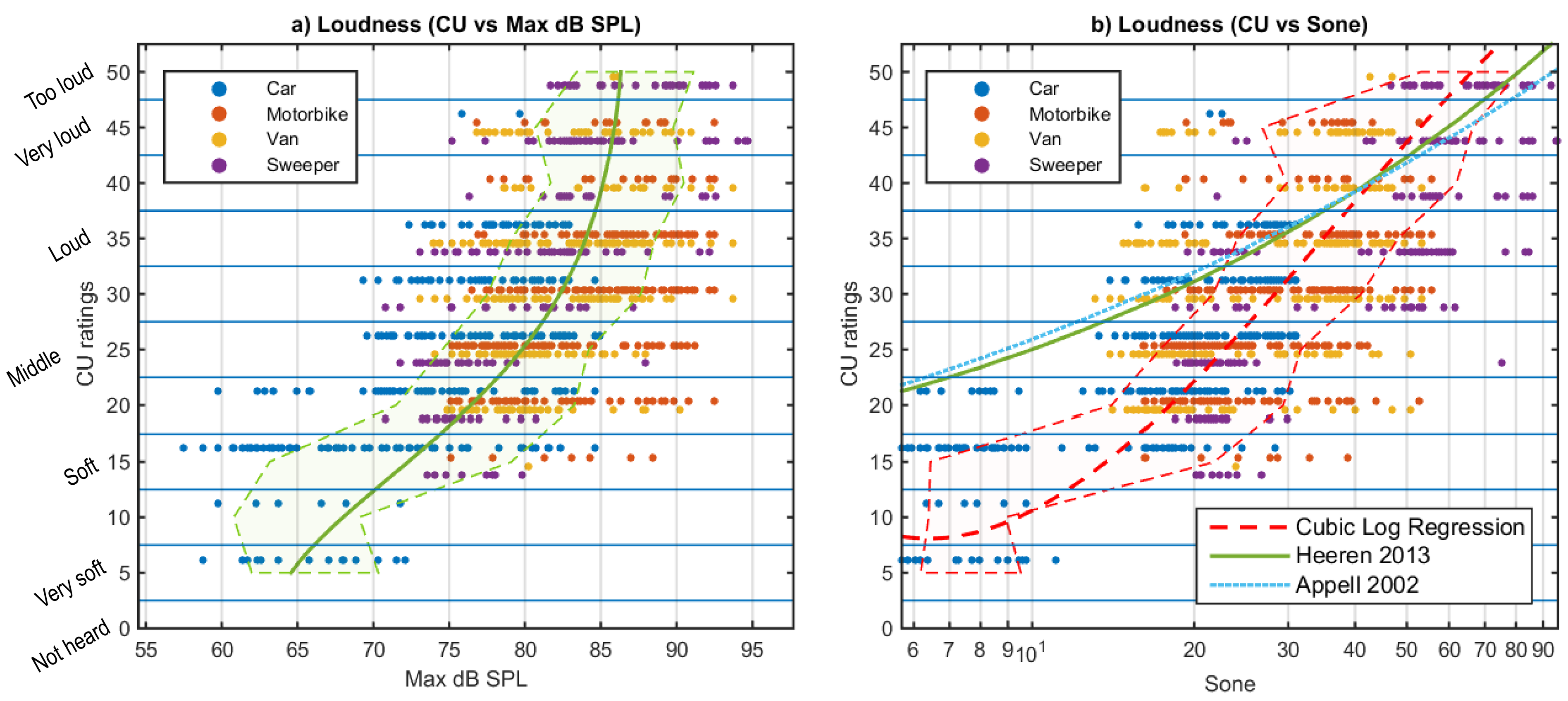




- Field experiments recorded with a 360º camera (Xiami Mi Sphere Camera), a tetrahedral microphone (Core Sound TetraMic) and a level meter.
- Stimuli available at https://gerardllorach.weebly.com/work.html

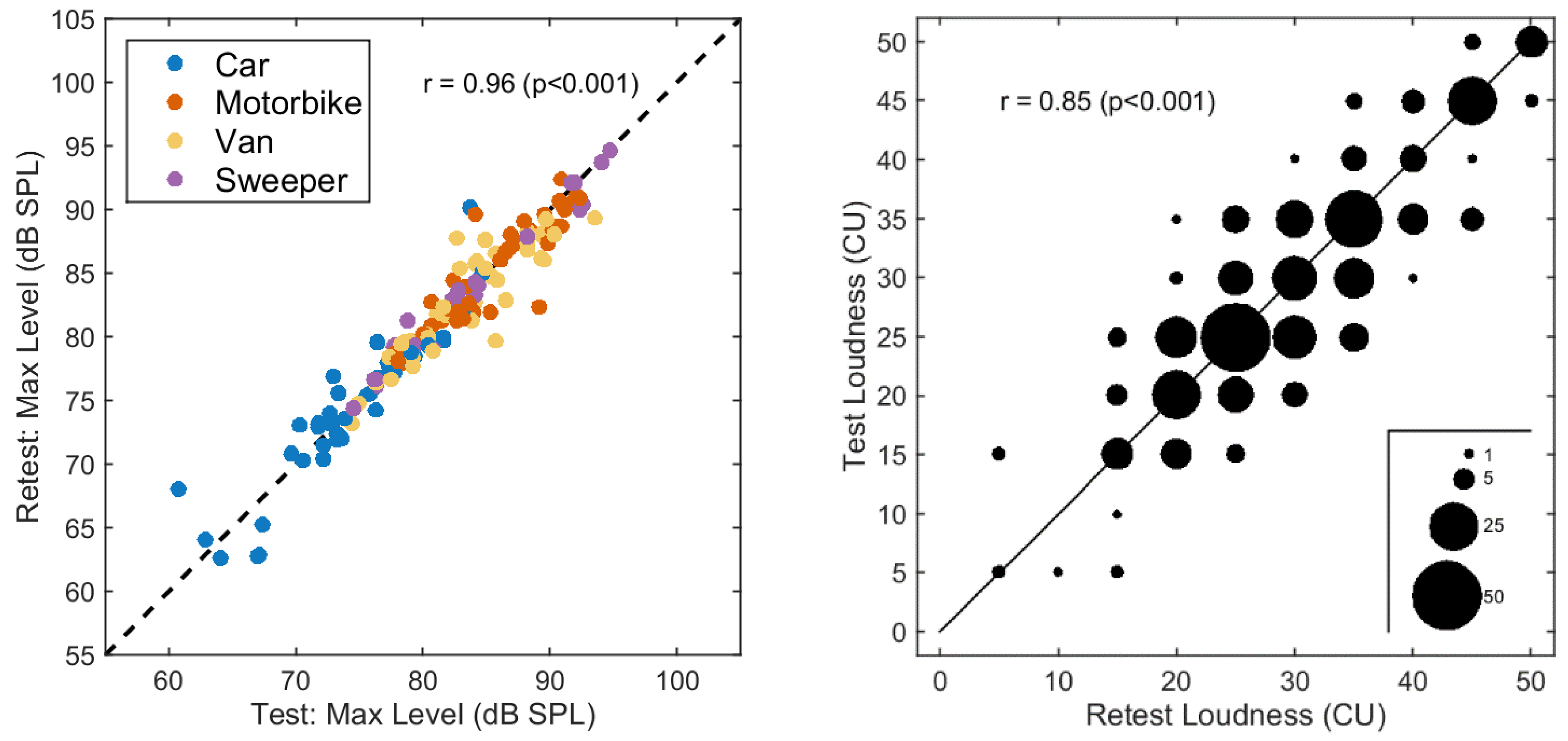
Results

Loudness ratings (NH = 15)



- Stimuli distribution from ~57 to ~95 dB SPL
- The loudness models (ANSI S3.4 2007 and N5 percentile) with the transformation formula from Heeren et al. (2013) predicted higher loudness ratings in CU compared to the field ratings for up to 40 sone.

Test and Retest driving and individual variability (NH = 15)



- Low variability between repeated driving actions.
- High test-retest reliability in the CU ratings

Conclusion

- Ratings in the field were lower than predicted for stimuli below 40 sones.
- Annoyance ratings were highly correlated to loudness ratings (r = 0.82, p<0.001).
- Little variation in the driving actions and consistent ratings of the participants.

Future Laboratory Experiments

- Reality replication (in progress):
  - Same acoustic levels with different laboratory conditions, e.g., mono, stereo, first-order-ambisonics; desktop screen, head-mounted display, CAVE.
  - Preliminary results presented at International Hearing Instruments Developer Forum 2019 (slides available at https://gerardllorach.weebly.com/work.html).
- Level adjustment:
  - Participants choose the gain of the stimuli to match reality.

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