Instrumentation to measure cyclist noise exposure: Considerations for study design with smartphones and sound level meters

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research on active transportation
react

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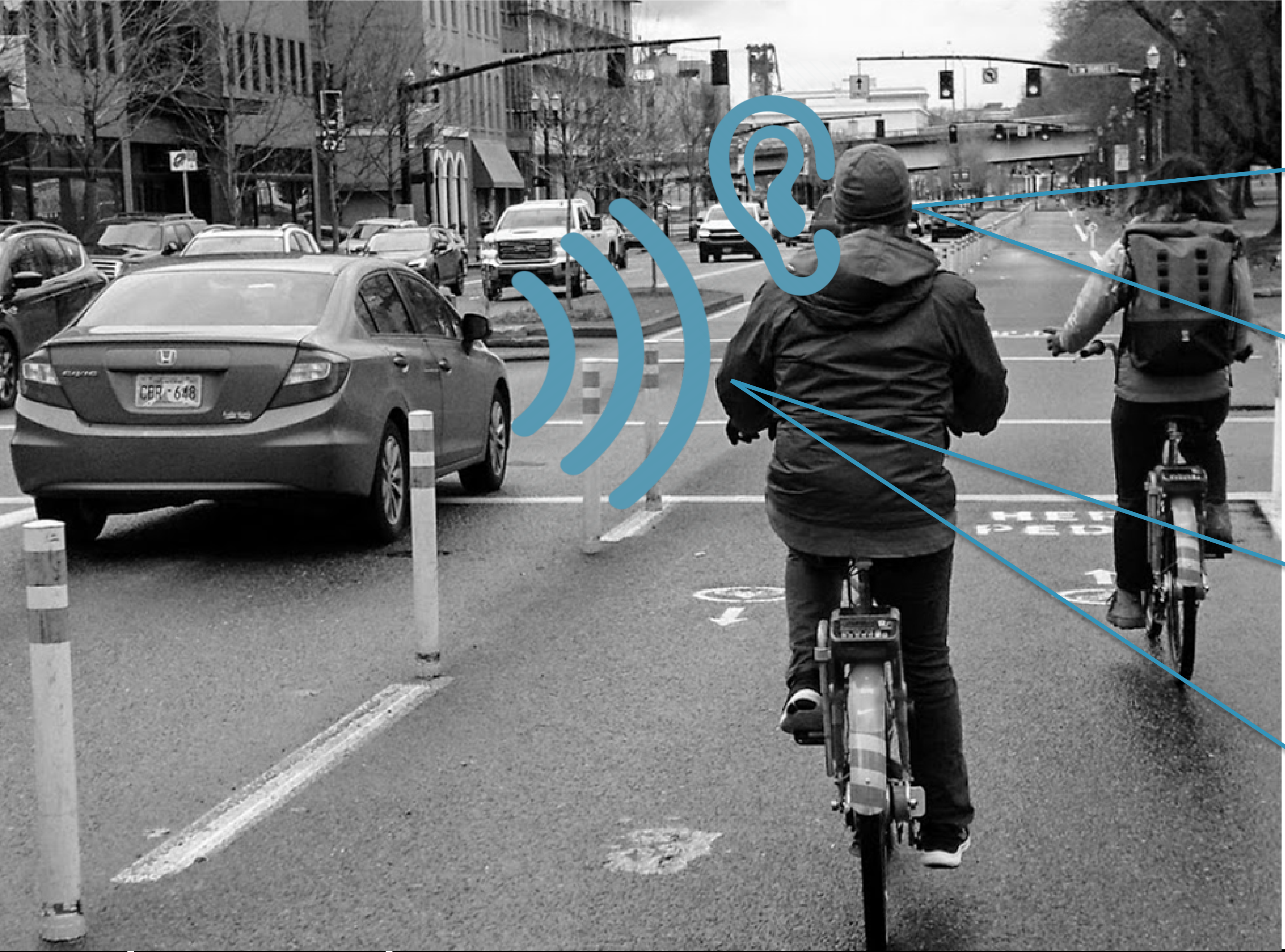
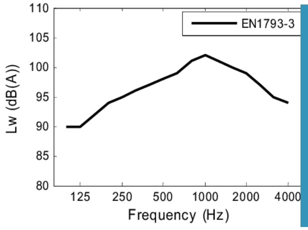


Environmental hazard (noise exposure)

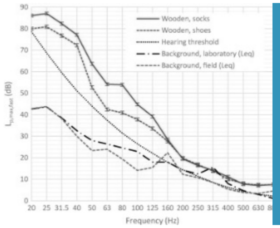
Stress/discomfort
- Noise
- Traffic

Proxy for other exposure
- Air pollution
- Crash risk

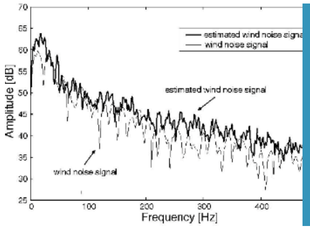
Probe for noise mapping



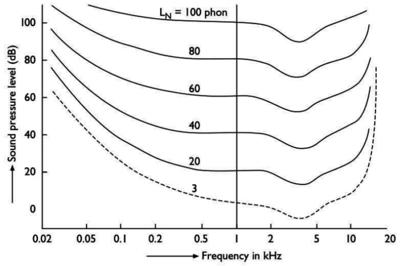
Traffic generated noise



Other urban noise sources



Wind & bicycle generated noise

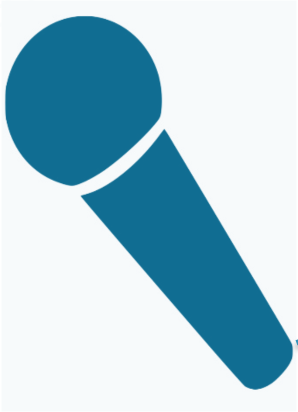


Physiological perception

Cognitive perception

Physiological response

Affective response



Measured sound level

?

1. Ambient/riding noise
2. Total/traffic noise
3. Objective/perceived noise

Literature (~30 on-road studies)

- Mixed results for noise correlation with traffic, stress markers, crash risk, air pollution, and built environment
- Usually A-weighted noise
  - Low freq measures better proxy for vehicles (esp. trucks) & pollution
- Inconsistent mic placement (shoulders, handlebars)
- No consideration of air/riding speed (confounding?)
- Usually SLM, but starting to use smartphones (w/o field validation) for broader, lower-burden sampling

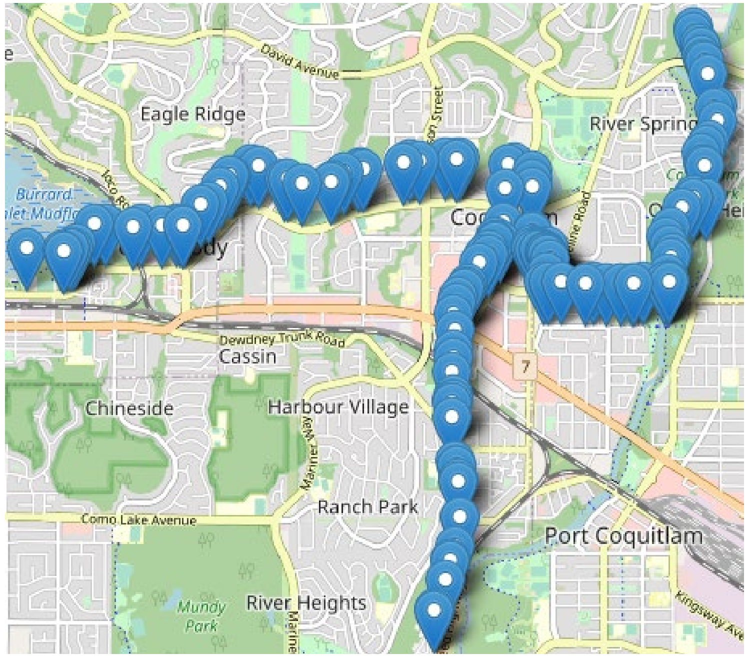
Study objectives

Impacts of instrumentation on *in situ* cyclist noise measurement

1) Smartphone accuracy (vs. SLM)
2) Effects of:
   - Mic placement & windscreen
   - Travel/air speed
   - Frequency weighting
   - Temporal aggregation

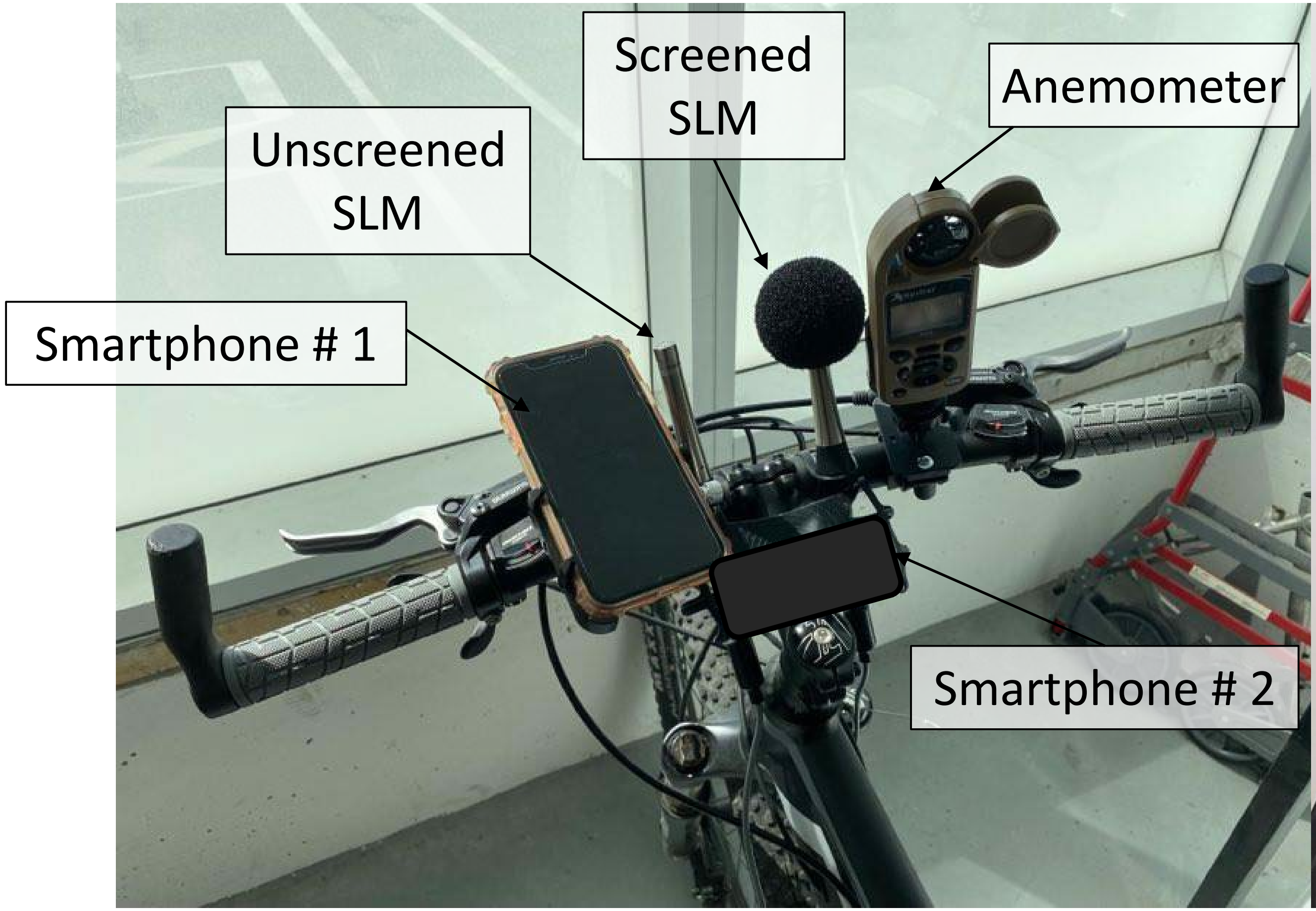
Data collection

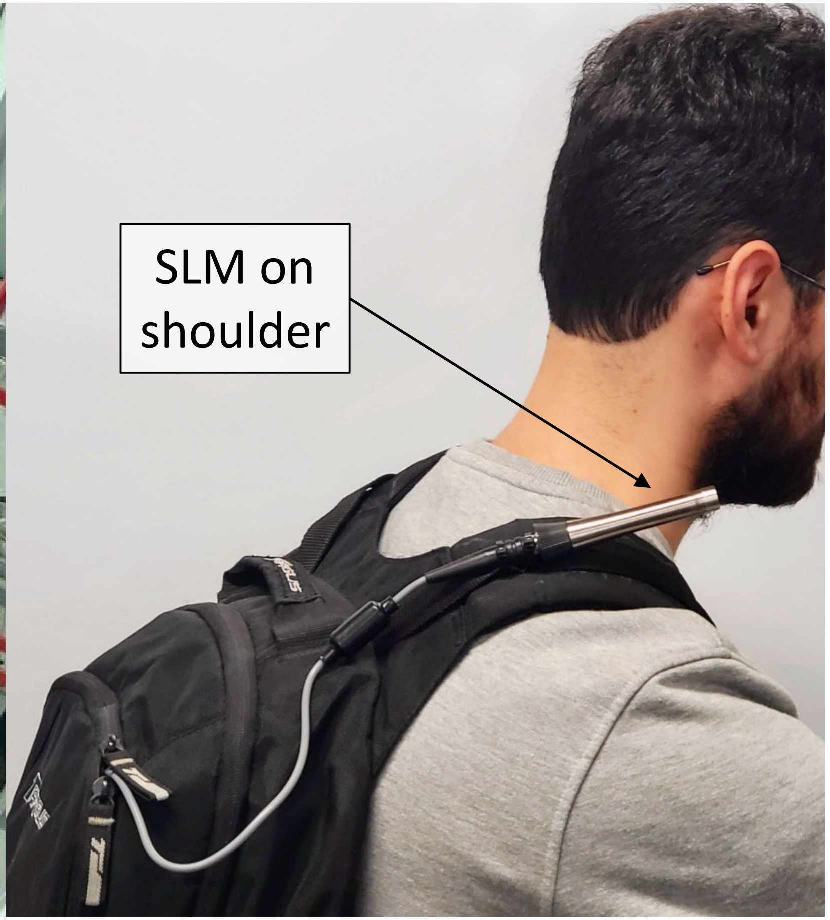
- Paired instrument comparisons on-road
  - –1-sec sound levels synced with GPS
  - –A & C weightings
- 24-km route on 3 days in June 2021
  - –Typical cycling facilities (lanes and paths)
  - –Mostly flat for consistent pedalling
  - –Single hybrid bicycle, single rider
- 18,300 1-sec observations (after cleaning)
  - –Mean 66 dB-A (Peak 120 dB-A)



Instrumentation

- iPhone
- TSI Quest SoundPro
- Kestrel Weather Meter





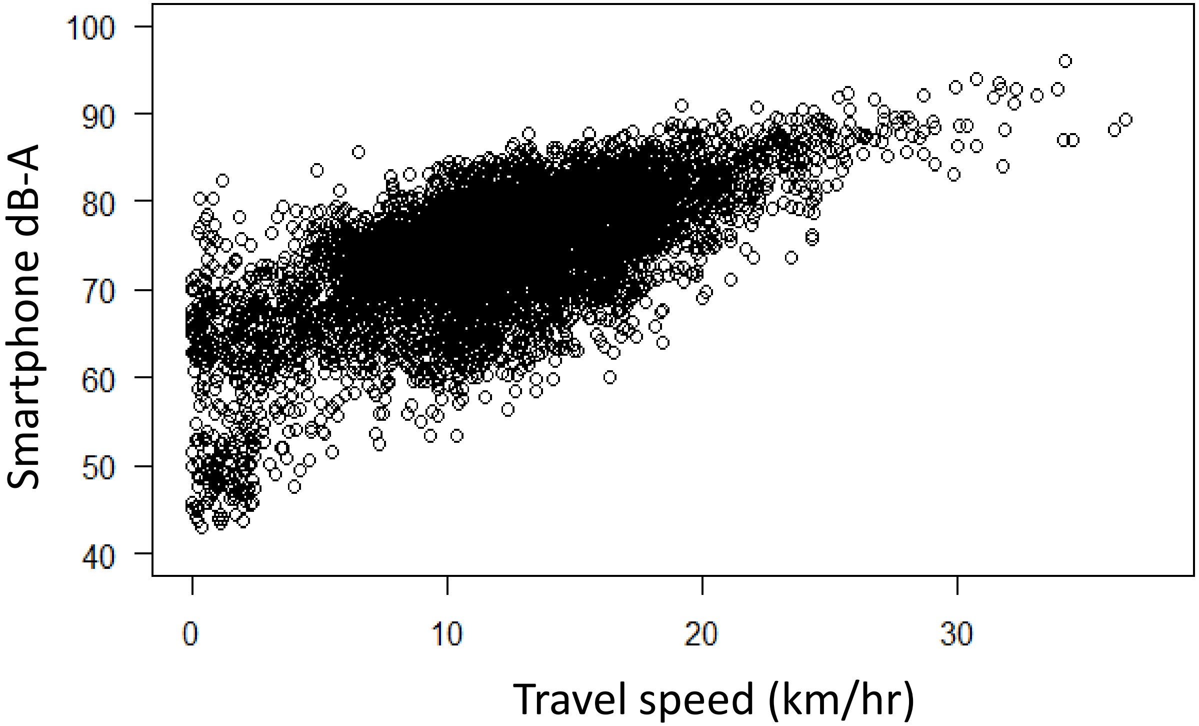
Paired comparison results

Comparison	Weighting	Mean difference (dB)	Mean absolute % difference
Unscreened vs. screened SLM	A	0.3	4%
	C	2.8	5%
Shoulder vs. handlebar SLM	A	-1.3	9%
	C	-1.7	7%
Smartphone vs. unscreened SLM	A	4.2	12%
	C	-2.8	5%

(typical precision thresholds of 1-2 dB)

Effects of travel & air speed

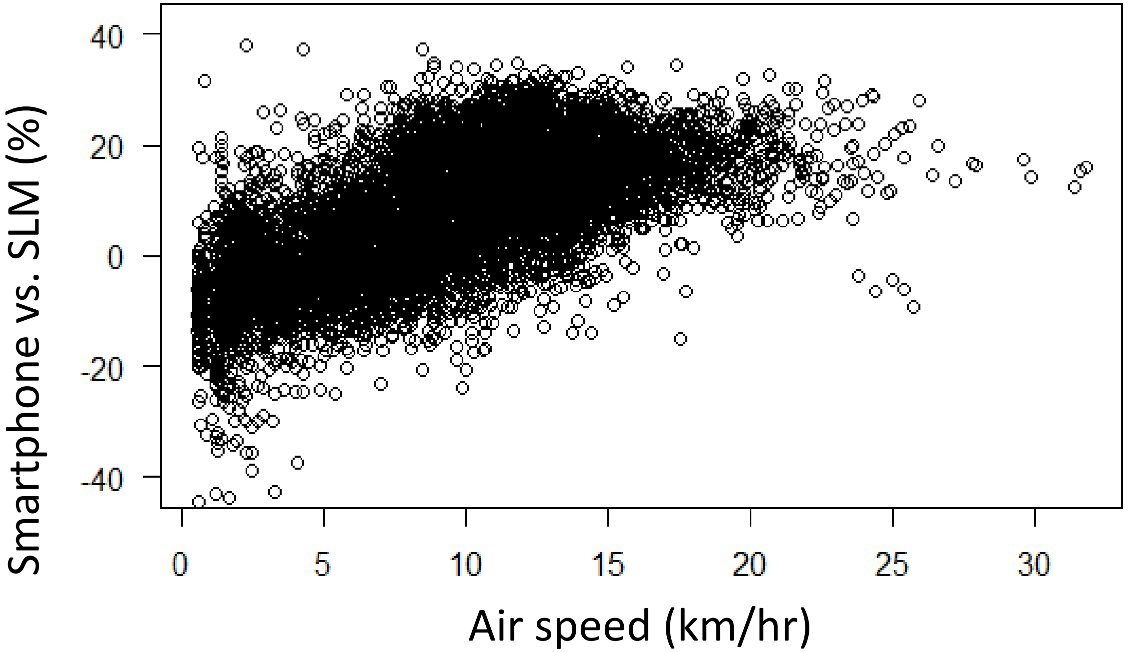
- Noise increases significantly with:
  - –Travel speed: ~0.2 dB per km/hr
  - –Air speed: ~0.7 dB per km/hr
- More for:
  - –Smartphone vs. SLM
  - –Unscreened vs. screened SLM



Speed and smartphone accuracy

Mean error increases significantly with:

- –Travel speed: ~0.3% per km/hr
- –Air speed: ~0.6% per km/hr



Conclusions

- SLM windscreen has a small effect on dB-A, and moderate effect on dB-C
  - Windscreen effect increases with speed
- Mic placement has a moderate effect on noise
- Smartphone moderately accurate for dB-C (not -A)
  - Also more consistent across speeds

Recommendations

- Cycling noise studies
  - Base instrumentation on objectives & accuracy
  - Consider speed effects on measured noise
- Future research
  - Frequency weighting for perceived traffic noise
  - Characteristics of bicycle-generated noise
  - Other instrumentation: phones, apps, mounting, mics, etc.

a place of mind
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