Assessing the Effectiveness of Acoustic Vehicle Alerting Systems (AVAS) for Pedestrians with Visual Disabilities

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Technological University of the Shannon: Midlands Midwest

NDA
Údarás Náisiúnta Míchumais
National Disability Authority

Taighde Éireann
Research Ireland

IARIA

About the Presenter

Research Ireland Postdoctoral Fellowship (2024/25) hosted at the National Disability Authority, Dublin, Ireland.

Academic at Technological University of the Shannon, Limerick, Ireland.

Researcher at Lero – the National Centre for Software, Limerick, Ireland

PhD in Computer Science (Auditory interfaces and Inclusive Design) - University College Cork, Ireland

Head of Delegation and National Chair of Standards Committees under the National Standards Authority of Ireland

Research Interests & Ongoing Projects

Interactive Systems & Creative Informatics Research Groups

- Team of postgraduate researchers and academic peers
  Technological University of the Shannon - Ireland

Current projects:

- Electric Vehicle Acoustics Survey
- Accessibility in Public Transport
  The Centre for Excellence in Universal Design, NDA, Ireland

Collaborations:

- Irish Centre for High-End Computing
- HEAnet, Ireland
- University of Jyväskylä (Finland)
- Häme University of Applied Sciences (Finland)
- University College London (UK)

Introduction & Motivation

- Rapid growth of quiet Electric Vehicles (EVs) → reduced auditory cues
- Heightened safety risk for pedestrians relying on sound, especially those with a visual disability
- UNECE Reg. No. 138 mandates Acoustic Vehicle Alerting Systems (AVAS)
- Effectiveness of AVAS in real-world scenarios remains uncertain

AVAS Regulations & Technical Background

- UNECE Reg. 138 & EU Reg. 2019/2144 require AVAS < 20 or 30 km/h (depending on region)
- ISO 16254 defines test methodology (min. SPL, frequency content, stationary tone)
- Design flexibility allows unique ‘sonic branding’ → potential safety trade-offs
- Need for psychoacoustic criteria aligned with pedestrian needs

EVA Survey Design

Online survey optimised for screen-reader accessibility

Distributed via disability orgs, road-safety mailing lists & social media

9 Likert statements (5-point scale), focusing on safety, detectability & usability

Ethical approval: Technological University of the Shannon

Participants & Data Preparation

Total responses collected: 86 → cleaned dataset: 54

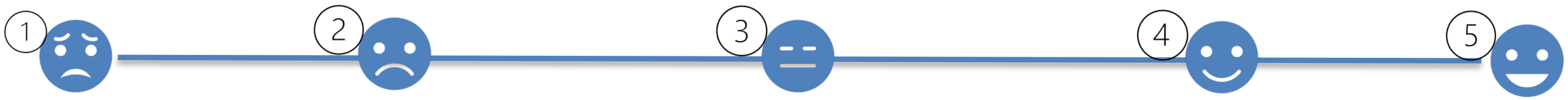
Groups: 33 No Disability (ND); 21 Visual Disability (VD)

Age ≥18; self-reported visual status; anonymised (no Personal Info or computer IP requested or captured)

Data analysed using R version 4.4.2 (dataset in CSV format)

Likert Items

#	Statement
L1	I feel safe when I think there might be an EV close by.
L2	It is easy to notice an EV approaching because of its sound.
L3	Sounds made by EVs help me understand what the vehicle is doing
L4	I feel confident I understand an EV's next action based on its sound.
L5	I can react quickly to the sound of an EV when necessary.
L6	I find the sound of EVs pleasant.
L7	It takes little effort for me to listen to an EV's sound and understand what it is doing.
L8	I believe that the sound from all electric cars will be a positive thing for noise levels in busy cities and towns.
L9	Imagine you are standing on a busy street with lots of electric cars making sounds. Do you think it would be easy or hard to know when it is safe to cross the road?



I disagree a lot
L9: Very difficult

I disagree just a little
L9: Difficult

I don't know
L9:Neither difficult or easy

I agree just a little
L9: Easy

I agree a lot
L9: Very easy

Descriptive Results: Medians & IQRs

Median & IQR computed for each group and Likert item

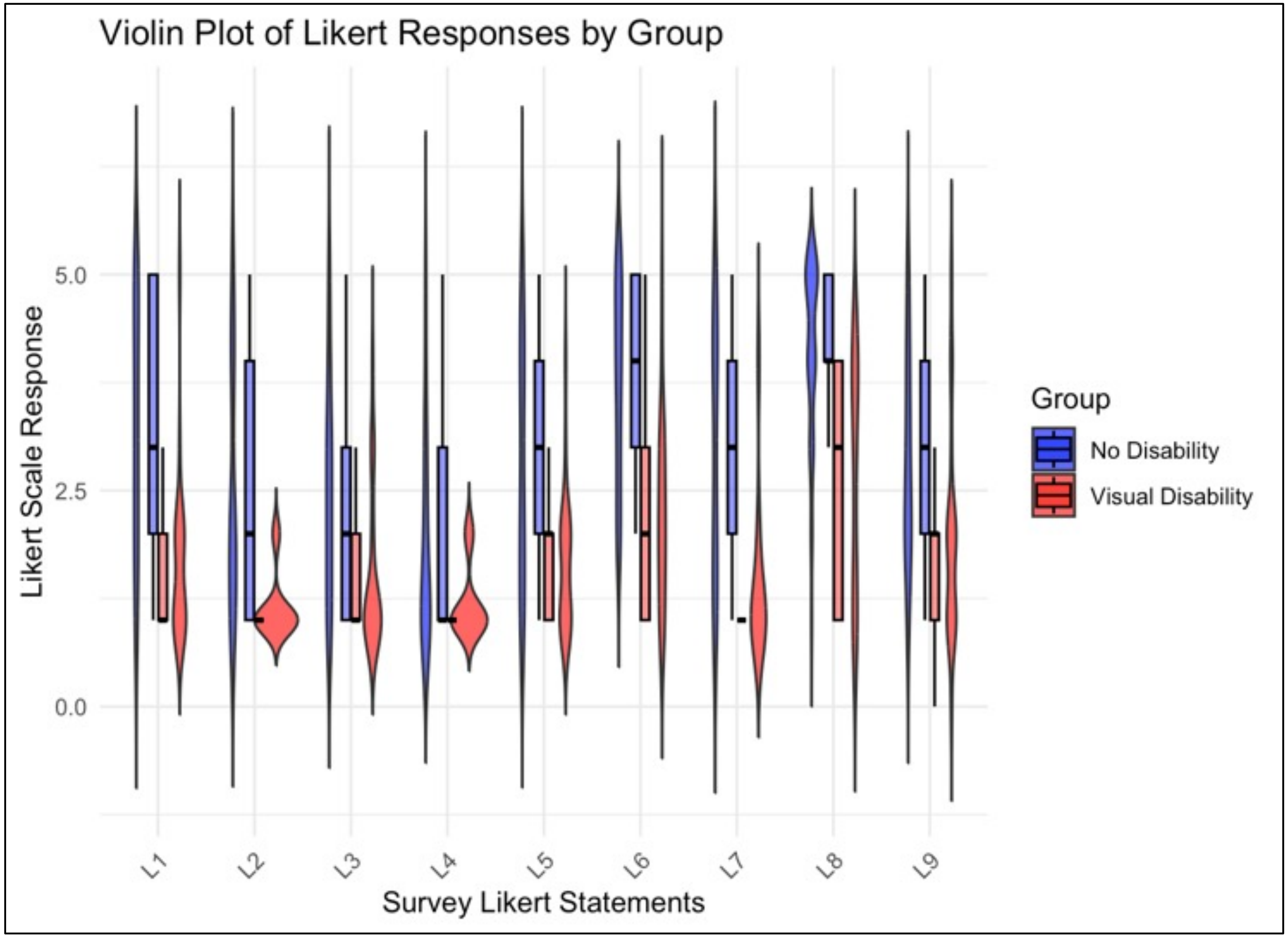
VD group reported lower medians on most statements → strong disagreement

ND responses more neutral/positive with broader spread

Statements L1, L2, L3, L7 showed largest median gaps

* ND = No Disability group
* VD = Visual Disability group

Violin plot showing Likert-scale response distributions for ND and VD groups across nine statements.



Key Disparities & Effect Sizes

Significant Difference

Absolute median difference & Cliff's Delta calculated

Strongest disparities: L1 (safety), L6 (pleasantness), L7 (interpretation effort)

Cliff's Delta ≈ 0.60 → large practical effect

Similarities

Shared low scores on L4 (predicting EV actions) across both groups

Correlation Insights

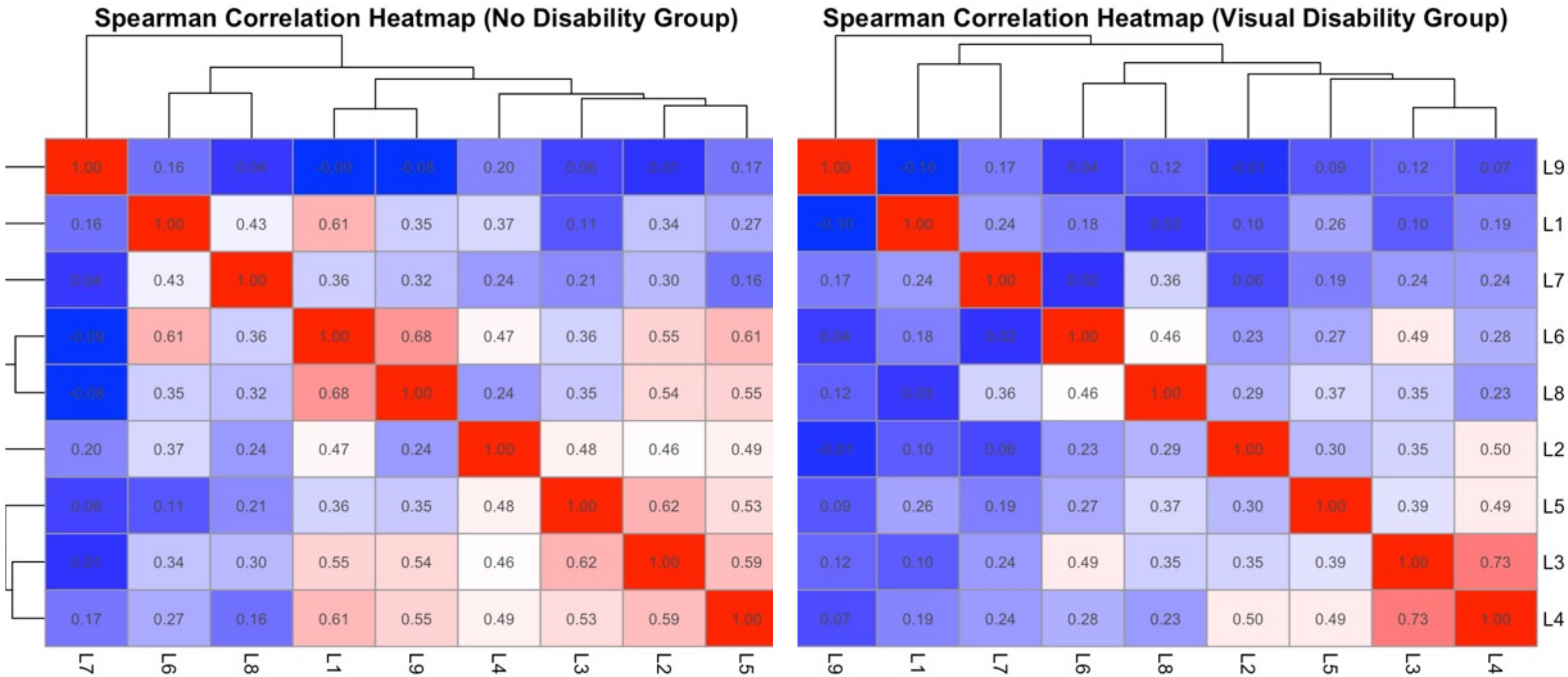
Spearman correlations visualised via heatmaps (ND vs VD)

ND: Safety (L1) ⟷ Detectability (L9) strongly linked ($\rho = 0.68$)

VD: Understanding cues (L3) ⟷ Confidence in actions (L4) very strong ($\rho = 0.73$)

Distinct perceptual networks suggest different cue-integration strategies

Spearman correlation heatmap for ND and VD groups
Characteristic difference between the groups



Inferential Analysis

Mann-Whitney U: significant group differences on all 9 items ($p < 0.05$)

Largest effect sizes on L1, L2, L6, L7 ($r \geq 0.50$)

PERMANOVA: being a member of a group (be that ND or VD) explains 27% of overall variance ($p < 0.001$)

Evidence supports systematic AVAS shortcomings for visually disabled pedestrians

Key Findings & Implications

- AVAS insufficient for safe navigation by visually disabled pedestrians
- Sighted pedestrians show mixed perceptions influenced by visual cues
- Uniform negative ratings in VD group highlight urgent design deficiencies
- Regulatory frameworks lack psychoacoustic performance metrics

Conclusion & Next Steps

- Reassess AVAS design with inclusive, ecological psychoacoustics principles
- Develop universal-design sound profiles prioritising safety over branding
- Future EVA phases: controlled auditory experiments & longitudinal studies
- Collaboration invited: multi-modal safety research, EV manufacturers

Merci beaucoup!

Go raibh míle maith agaibh!