Sound detection of electric vehicles by blind or visually impaired persons

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Overview

- Motivation / Project Task
- Probands
- Test Setup
- Test Results
- Summary
BASt Research project
Acoustical perceptibility of Electric Vehicles by blind persons

- Are Electric Vehicles perceptible?
  - For pedestrians, particularly blind and visually impaired people
    - as single vehicle
    - as part of traffic mix
    - on which relevant speed ranges
- Which options exist to increase the perceptibility?
  - synthetic sound
  - synthetic sound adaptive to situation
  - others
Probands

- Twelve participants (7 male, 5 female), all blind or visually impaired
- Average age: 56 years (SD = 10 years)
- All probands are taking part in road traffic daily
- Eight have no experience with EV or HEV, three reported negative experience or irritations
Proband’s interviews – critical situations

- large junction
- road crossing without traffic light
- green arrow signs for right turning vehicle
- crossing junctions with roundabouts
- road crossing with center island
- bicycles
- only two probands reported problems with vehicles equipped with start / stop- systems
- three probands stated to cross the street if they hear a vehicle, but they assess the vehicle far enough away or travelling with low speed
- Nine probands are waiting or communicating with the driver
Test Setup - Vehicles

• Comparative study of different vehicles with different engines (Nissan Leaf – Electric Vehicle, Lexus IS 250 – „quiet“ Internal Combustion Engine vehicle, Mercedes 190 – „loud“ ICE)

• Study of different traffic situations (pass by test with 1 or 2 vehicles at different speeds+accelerating tests), overall 57 tests
Test Setup – Test Configuration

- Test site of BASSt [highway background noise of 52-55 dB(A)]
- 80 m straight lane to the probands
- Digital video camera in a distance of 50 m from travelled lane
- Light tableau with one light per proband (switched on by pressing key button)
Test Setup – Test Configuration

- Recording of the sound pressure level by 2 near field- (3 m to center of travelled lane) and 1 far field- (7,5 m to center of travelled lane) microphone
- Vehicle speed measurement
Test Setup – Scenarios

- Pass by tests with constant speed (10, 20, 30 km/h)
- Two vehicles side by side (20 km/h)
- Accelerating from a distance of 5 m and 10 m

- Probant’s task: press key button when perceiving the vehicle

- Two vehicles, one following the other, with constant speed (10, 20, 30 km/h)

- Probant’s task: press key button when perceiving the first vehicle, when perceiving the second vehicle release the key button and press it again
Test Results

Pass by tests at about 20 km/h

Nissan Leaf

Lexus IS 250

Mercedes 190
Test Results

Detection distance pass by tests at about 20 km/h

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Lexus IS 250  MB 190  Nissan Leaf
Test Results

Comparison stopping distance <-> detection distance pass by tests at about 20 km/h
stopping distance at 20 km/h = 7.48 m (a=8 m/s²)

25%- quantile
25% of probands did not perceive the vehicle yet

mean value
Test Results

Sound pressure level pass by tests at about 20 km/h (near field microphone 3 m to center of travelled lane)
- Nissan Leaf and Lexus IS 250 about 60 dB(A)
- Mercedes 190 about 66 dB(A)
Test Results

Pass by tests at about 10 km/h

Nissan Leaf
Test results

detection distance pass by at about 10 km/h
Test Results

Comparison stopping distance <-> detection distance pass by at about 10 km/h
Stopping distance at 10 km/h = 3.26 m (a=8 m/s²)

25%- quantile mean value
Test results

sound pressure level pass by tests at about 10 km/h (near field microphone 3 m to center of travelled lane)

- Nissan Leaf not measurable!
- Lexus IS 250 about 55 db(A)
- Mercedes 190 about 64 dB(A)
Test Results

Comparison of pass by tests of the Nissan Leaf at 10, 20, 30 km/h

30 km/h

20 km/h

10 km/h

Nissan Leaf constant speed, 30 km/h

Nissan Leaf constant speed, 20 km/h

Nissan Leaf constant speed, 10 km/h
Test Results

Pass by tests with two vehicles, one following the other, at about 20 km/h

Mercedes 190, Nissan Leaf

Nissan Leaf, Mercedes 190
Test Results

Detection distance pass by tests with two vehicles at about 20 km/h

![Graph showing test results for various vehicle combinations.]

- 50% Bereich
- Mittelwert
- Median

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Test Results

pass by tests with two vehicles, one following the other, at about 20 km/h

- The first vehicle was detected in nearly the same distance as the vehicle in the single vehicle pass by test
- The second vehicle was everytime later detected than the same vehicle at single pass test (masking)
- If the second vehicle is much louder than the first, the first vehicle can be missed (Test 19 ?) [But anyway under this condition nobody would step on the road.]
Test Results

Accelerating tests

Nissan Leaf, distance 5m

Nissan Leaf, distance 10 m

Nissan Leaf
accelerating from 5 meters

Nissan Leaf
accelerating from 10 meters
Test Results

Accelerating

- The vehicle was detected directly when it starts (tyre noise under torque)
- But remember, the Nissan Leaf emits no noise when standing
Summary

- There are cars with ICEs today which are nearly as quiet as EV.
- Requirements from MLIT- Guideline (no siren, no bird twitter, no bell ringing etc.) are consistently expedient.
- 'Uncontrolled' free sound design with the possibility to use individual or personalized sounds or 'lifestyle'- sounds is not acceptable.
- Leave the door open for other technical solutions in future.
Thank you for your attention!

Special thanks to the blind organisation and to the blind probants