Interview with visually impaired and blind pedestrians

The traffic conditions, which were investigated in this study, were described by visually impaired and blind pedestrians as dangerous situations

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Perception allows us to gather information regarding our environment using sensory inputs and to identify events and objects in this environment. Therefore, each sound can be regarded as information carrier.

In the context of road safety, the vehicle sounds are useful for pedestrians to detect the vehicles. In addition to the detection, various vehicle sound properties may indicate the operating condition or the place of the vehicle.

The results of an investigation of the National Highway Traffic Safety Administration show that hybrid vehicles cause more crashes than conventional vehicles (NHTSA, 2009).

Sandberg, ICA 2010

The objective of this study is to compare the detectability of conventional, hybrid and electric vehicle sounds.

Crossing street

- Question: When I can not cross the street? (Reaction time measurements)

- Vehicles with internal combustion engine
- Vehicles with the actuator powered electrically
- Spectral and temporal properties - Vehicles with internal combustion engine
- Synthesized sounds

Although these ambient noises have a character of an ordinary road traffic noise, they don’t consist of any exceptional instationary events.
Ambient noise recordings

Ambient: Traffic noise
- very low
- low
- high
- very high

Artificial head recordings in a side street

Database

- Vehicle exterior sounds:
  - car approaches with partial load acceleration with shift-operation
  - 14 representative cars with internal combustion engine from different brands with different motorization
  - 8 gasoline, 6 diesel
  - Mixture of old (> 8 years) and new (< 8 years) cars

Aim of the car selection: Broad spectral range with different temporal characteristics

Exterior sound recording path

Artificial Head
Height (Ears): 165 cm

Electric and Hybrid Vehicles without Sound Generator

Chevrolet Matiz (Electric)
Nissan Leaf (Electric)
Mitsubishi i-MiEV (Electric)
Opel Ampera (Electric)
Toyota Prius (Hybrid)
Audi Q5 (Hybrid)
Test stimuli (synthesized sounds)

*Basis: Fz170 Audi TT 3.2 quattro*

Participants

**Number: 37 Participants** (27 sighted, 10 visually impaired; Mean age: 34 years)

Test design

Reaction time measurement

A pedestrian standing on the curb waiting to cross a one-way street when there may be vehicle approaching from the left.

**Question 1:** When do you hear an approaching car?

- Presentation of vehicle approaching as well as engine start sounds with 4 different ambient sound conditions
- Signal duration: Pass-by app. 5 s, Engine start 2.5 s
- Randomised time delay (2 s to 4 s)

Results of the listening test

Vehicle approaching – Reaction time measurement

**Ambient - high**
Results of the listening test
Vehicle approaching – Reaction time measurement

Ambient - high

- Pedestrians detect the sound of electric vehicles (without sound generator) much later than the sound of vehicles with internal combustion engines.
- While the sound of an internal combustion engine vehicle can already be detected at a distance of approximately 36 meters, the sound of an electric vehicle can be detected at a distance of approximately 14 meters.

Reaction time measurement
Vehicle with internal combustion engine

Results of the listening test
Vehicle approaching – Reaction time measurement

Detection time / s

very low | low | high | very high

Ambient
Correlation: Reaction time – Sound pressure level at detection

There is no correlation between the reaction time of the pedestrians and the sound pressure level of the vehicle sound which is essential for the detection.

One-third octave band levels at detection – Vehicle approaching

- Ambient, left channel, 57 dB (A)
- Vehicle sounds, left channel, 500 ms (250 ms before and after the detection)

Vehicles with internal combustion engine, synthesized

It is completely sufficient for detecting the sound of a vehicle from ambient, if individual one-third-octave bands (low or high frequencies) are prominent.

Conclusions

- Pedestrians detect the sound of electric vehicles (without sound generator) much later than the sound of vehicles with internal combustion engines. While the sound of an internal combustion engine vehicle can already be detected at a distance of approximately 36 meters, the sound of an electric vehicle can be detected at a distance of approximately 14 meters.
- There is no correlation between the reaction time of the pedestrians and the sound pressure level of the vehicle sound which is essential for the detection.
- It is completely sufficient for detecting the sound of a vehicle from ambient, if individual one-third-octave bands (low or high frequencies) are prominent.
- Synthetic sounds which are based on the engine speed can be detected as well as the sounds of internal combustion engine vehicle sounds. The same holds true even if the synthetic sounds provide a 10 dB lower SPL than the sounds of internal combustion engine vehicles.
- Engine start sounds can be detected by the pedestrians at a distance of approximately 30 meters - already during the starter sound phase.
Stimuli

Sounds:
- Vehicle with ICE from the idle (ICE-I)
- Vehicle with ICE with engine start (ICE-ES)
- Synthesized sound from the synthesized idle (S-I)
- Synthesized sound (S)
- Vehicle with the actuator powered electrically (Mitsubishi Imiev) (E)

Participants

Number: 54 Participants (37 sighted, 18 visually impaired)
Conclusions Parkslot

- A vehicle with the actuator powered electrically (without sound generator) will be very late (3 sec.) detected
- A vehicle with ICE will be detected already in 1 sec.
- A synthesized sound will be detected in 1.3 sec.

Situation: Crosswalk - Stopping Vehicle

Listening test:
A vehicle is approaching the crosswalk – Slowing/Stopping situation
Subject should press the button, if she/he thinks that the vehicle is stationary.

Stimuli

Sounds:
- Vehicle with ICE slowing and idling (ICE-I)
- Vehicle with ICE with engine stop (ICE-ES)
- Synthesized sound slowing and idling (S-I)
- Synthesized sound (S)
- Vehicle with the actuator powered electrically (Mitsubishi Imiev) (E)
Conclusions - Crosswalk

- The stopping time of the electric vehicle is not estimable using its sound
- The stopping time of the vehicle with synthesized sound is clearly perceptible

Thank you very much for your attention!

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