QRTV-08-02

Status Report on Activities in Japan regarding the Guideline on Measures against Quietness issure of HV, etc.

18-20 October 2011

JASIC

MLIT activates for issue of quiet vehicles

- Japan federation of the blind and vehicle users demanded to take some measures against the quietness of these vehicles.
- This issue was discussed at the Diet.

  ⇨ It is required immediately by the social demand to take measures of those vehicles as soon as possible.

MLIT set up “Study Committee” on the quietness of HVs, in 2009.

- The Study Committee decided to emit a sound from vehicles as a realistic measure for visually-handicapped people .
- At the end of January 2010, the Study Committee summed up the conclusions of discussions and reported it to MLIT. (Committee Report)
- MLIT published a proposed solution based on the Committee Report. (Guideline)
- The Guideline stats the requirements of the Approaching Vehicle Audible Systems (AVAS).

Scope

AVAS shall be installed in “Hybrid vehicles that can run only on electric motors”, “Electric vehicles” and “Fuel-cell vehicles”.

The point at issue : Which types of vehicles are needed measures.

Discussion of the issue:

Following vehicles were assumed to require measures against quietness.

(a) HVs with EV-mode and EVs
(b) HVs without EV-mode
(c) ICEVs with idling stop system
(d) Quiet general ICEVs

- **At Workshop, ICEVs were noticed by most participants even when it run at low speed.**
- **(b) HVs without EV-mode (ex. Honda Insight) was found to be as noticeable as ICEV by the Workshop, because the engine is activated at the start.**

Conclusion of the issue:

- **AVAS shall be installed in “Hybrid vehicles that can run only on electric motors”, “Electric vehicles” and “Fuel-cell vehicles”.**

Future activates

This time guideline's positional relation to the Regulation in force and the concept of its standardization in future.

- Seeing to the issues over the present status and the penetration rate of HIV, triggered the necessity to go up for enabling a quick action to strike out counter-measures, resulting in the guideline summarized from considerations.
- Before it goes to mandatory installation of AVAS on the new vehicle, verification of social acceptability, setting-up of regulation figures based on a prospective of technological development, organization of a testing method, and the consideration of timing for the mandatory installation are needed. However, regarding the vehicles already developed and on sale at the moment, it needs to be considered with alteration of the existing structural layout and/or the fabrication process taken into account. Therefore, at present, the standardization of AVAS installation has been passed on to next possible opportunity.
- **From now on, the standardization process is scheduled to start, in accordance with the verification of technological and social acceptability and other related matters.**

Nissan's Audible Vehicle Alerting System (AVAS)

Heather Konet
Nissan Technical Center, North America

8th Meeting of QRTV, Baltimore MD
October 18, 2011

Overview of the Presentation

- Concept
- Specifications
- Activities during development
- Background research
- Conclusions

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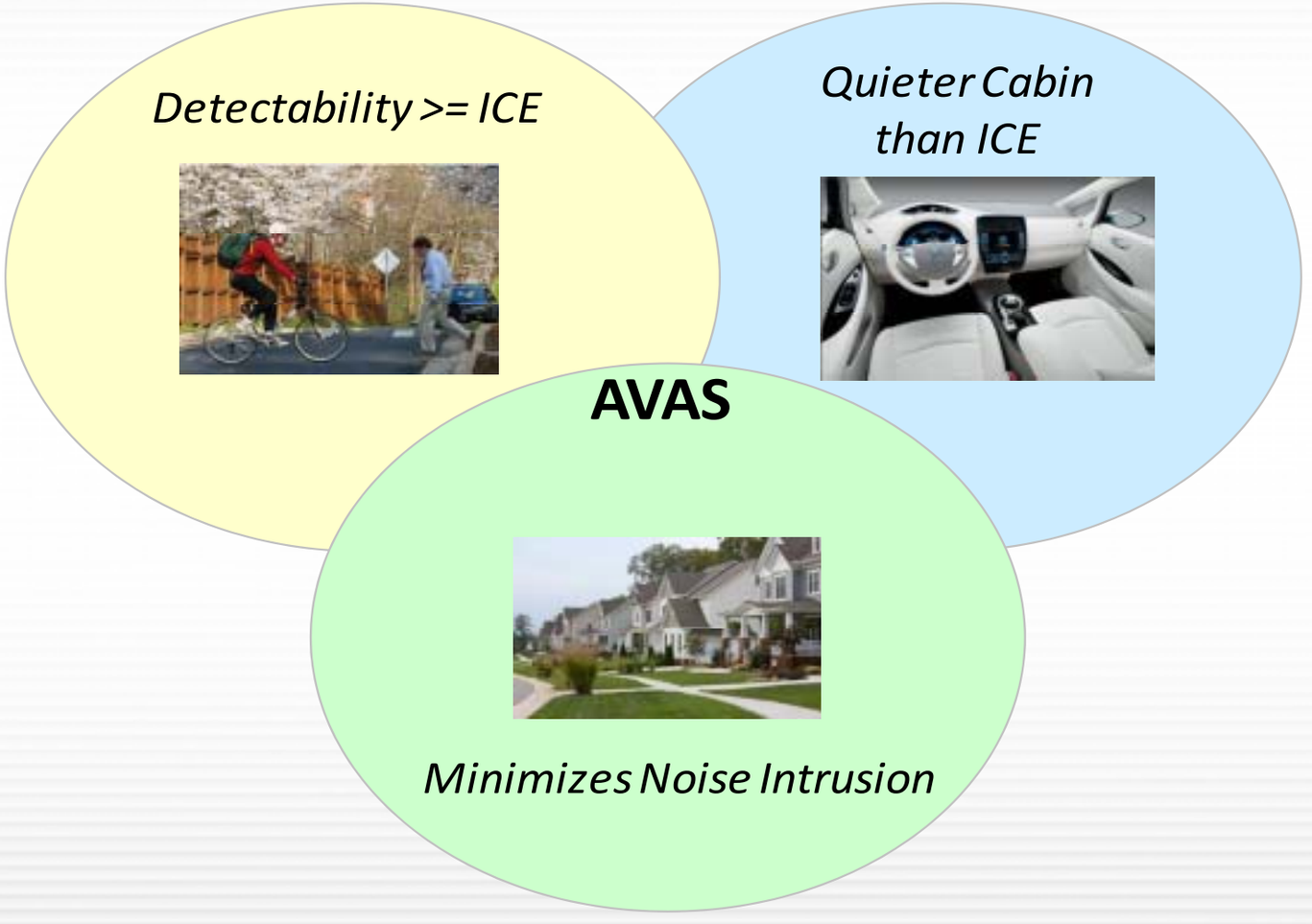
Balanced Solution

- Nissan's AVAS system implemented on the 2011 LEAF was developed based on Japanese Guidelines for balanced performance to meet needs of all Stakeholders



Nissan AVAS Design Concept

(red: Japanese guideline)

	Pedestrian	Driver	Neighborhood
1. Sound associated with Vehicle	☑	☐	☐
2. Sound pitch proportional to vehicle speed	☑	☐	☐
3. Easily audible for pedestrian (young and elderly) under various ambient sounds, yet maintaining a quiet environment for driver and neighborhoods	☑	☑	☑
Twin peak concept			
4. Similar sound level as conventional ICE	☑	☐	☑
Sound pressure level; 55dB(A)			
5. Futuristic sound	☐	☑	☐

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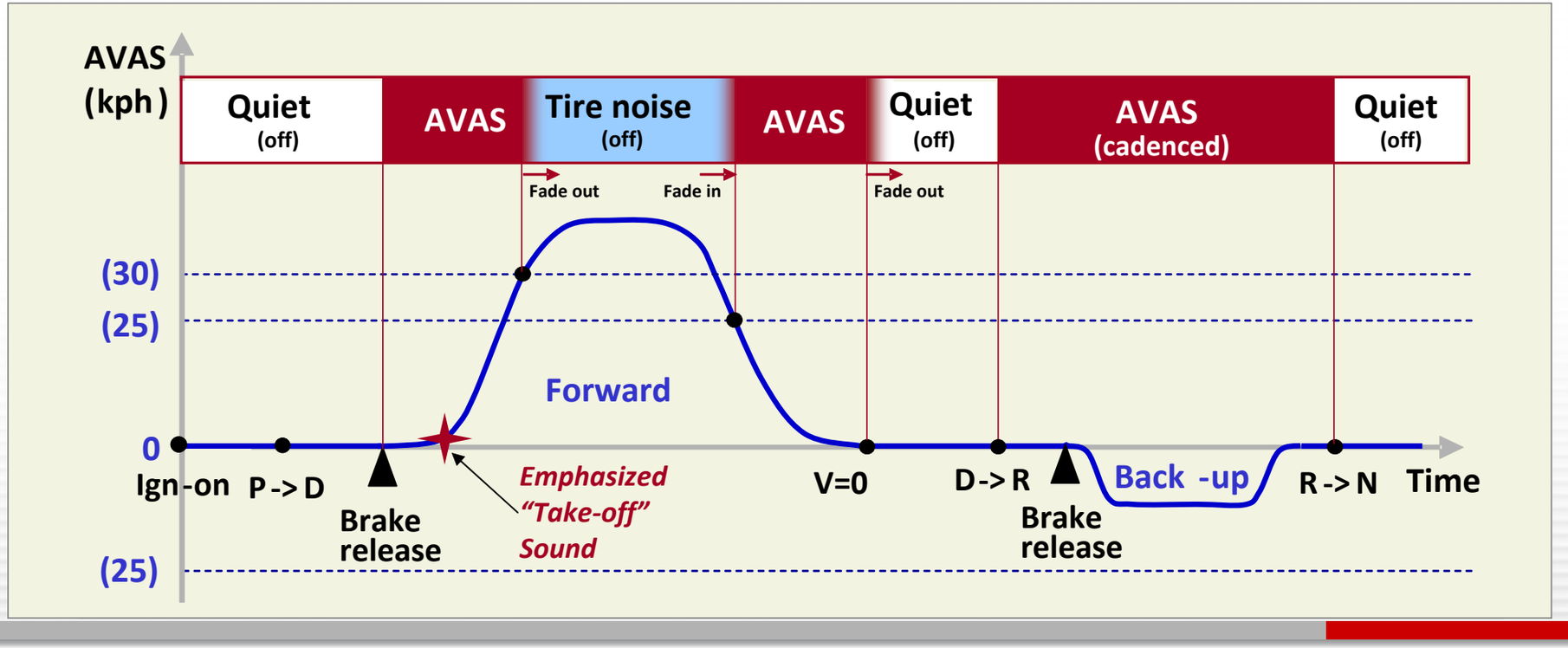
Implemented Activation Procedure

- Sound activation procedure for AVAS adheres to Japanese Guidelines

  - *No sound while stopped*
  - *D-position & brake release -> forward sound starts*
  - *Emphasized "take-off" sound to provide cue that vehicle is starting to move*
  - *Over 30 kph fades out, below 25 kph fades in*
  - *R-position -> cadenced backing-up sound starts*

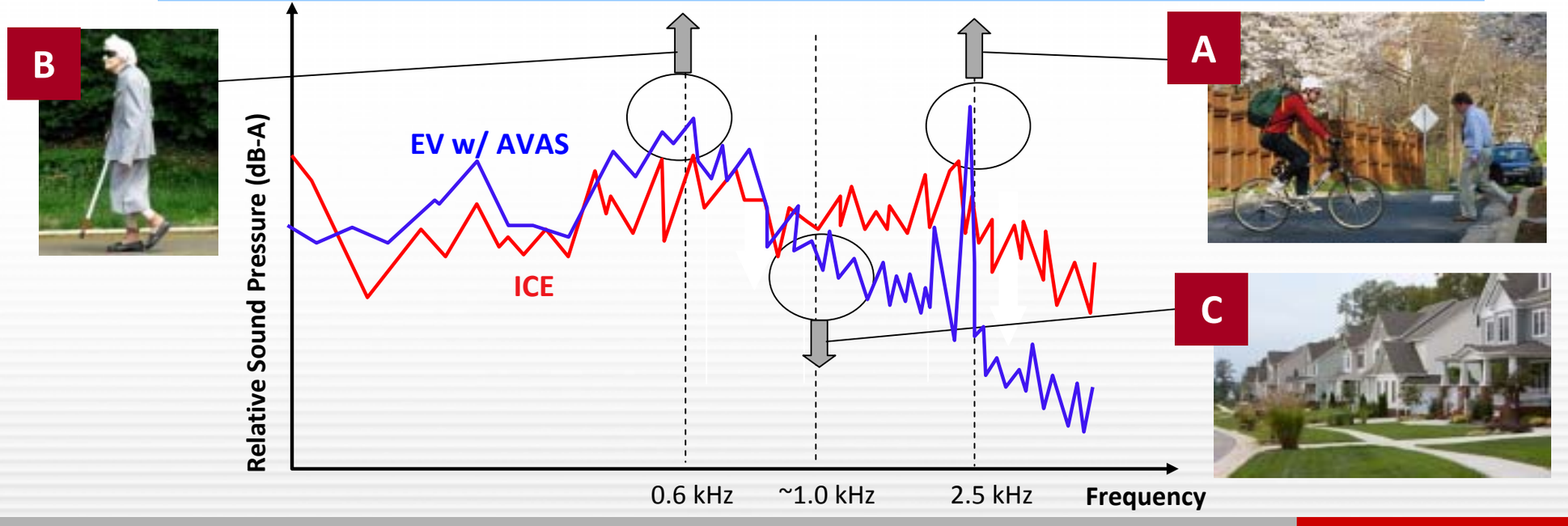


Nissan's "Twin Peaks" AVAS Sound Strategy

A *Outstanding peak frequency between 2 kHz and 5kHz is effective for providing good detectability for sighted pedestrians*

B *Outstanding peak under 1 kHz frequency to help provide good detectability for majority of sight impaired people*

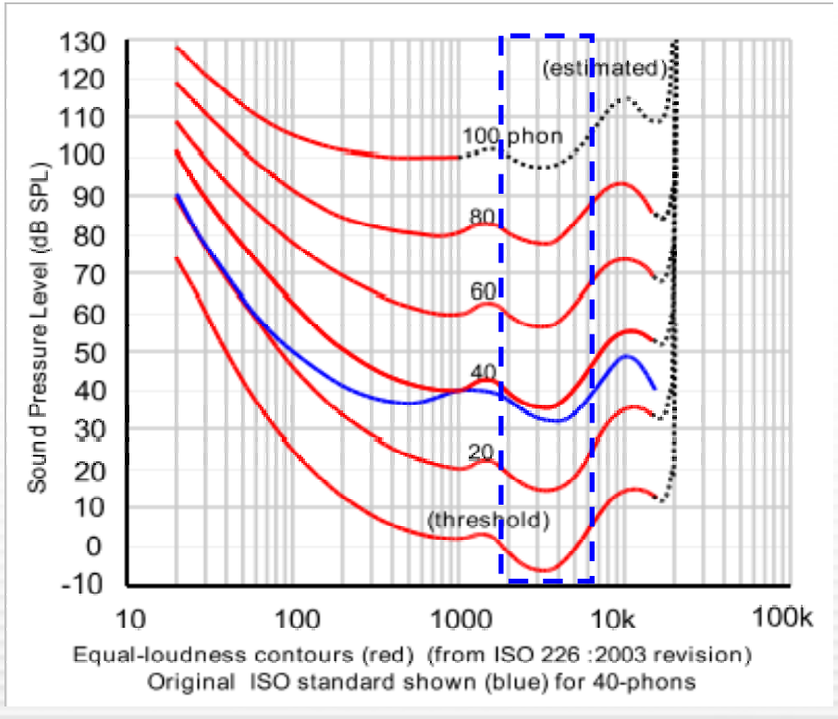
C *Frequency peaks at the 'shoulders of the 1 kHz peak' will allow an overall lower sound pressure level while maintaining effectiveness and a quiet environment for driver and community*



AVAS for Sighted Pedestrian

- For persons with normal hearing, the ear is most sensitive to frequencies between 2 and 5 kHz due to the resonance of the ear canal and the transfer function of the ossicles of the middle ear.

A *Outstanding peak frequency between 2 kHz and 5kHz is effective for providing good detectability for sighted pedestrians*



Equal-loudness contours (red) (from ISO 226 :2003 revision)
Original ISO standard shown (blue) for 40-phons

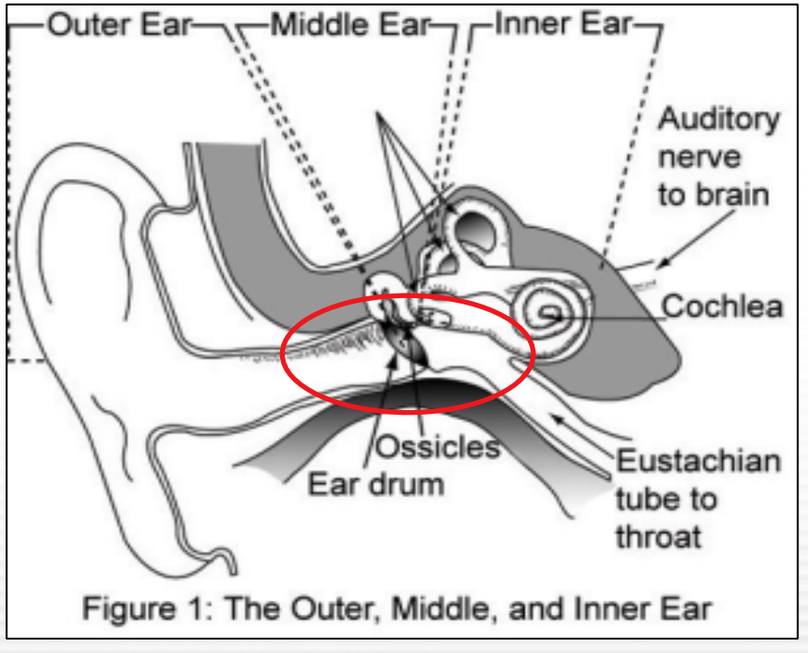


Figure 1: The Outer, Middle, and Inner Ear

Source: ISO Equal Loudness Curves (ISO 226):2003

AVAS for the Majority of Visually Impaired

- More than 70% of visually impaired are over 60 years old.
- Elderly persons more than 60 years old generally have difficultly detecting sounds higher than 2kHz due to age related hearing loss.

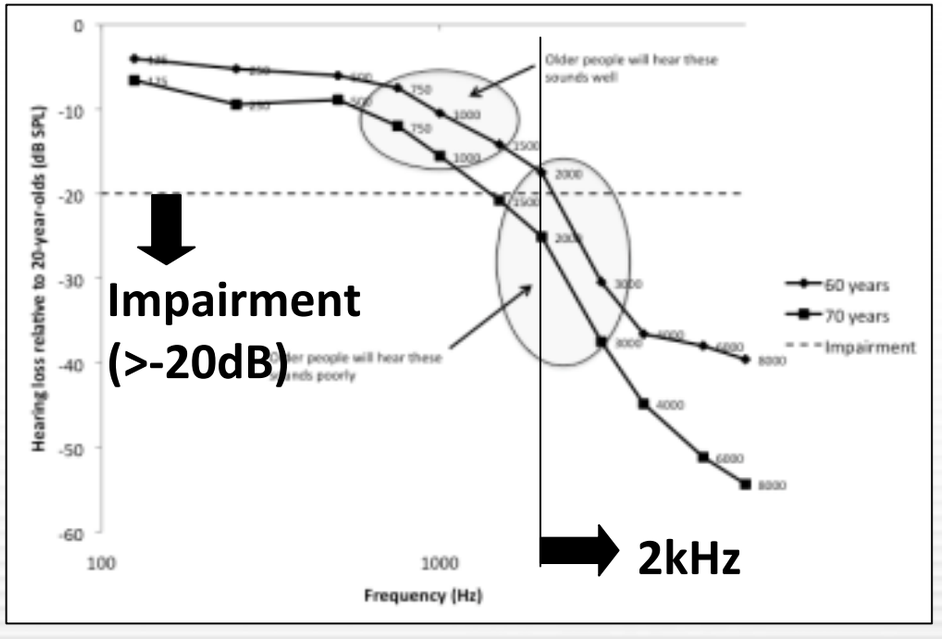
B *Outstanding peak under 1 kHz frequency to help provide good detectability for majority of sight impaired people*

	Population of Visually Impaired	Impaired over 60 years old
	1.64 million	72%
	4.30 million	70%

"Visually Impaired" includes people with "Legal Blindness" and "Low Vision"

Japan Data: Brant, M. Yamada et al (2010) Ophthalmic Epidmiology, 17(1), 50-57

US Data :elderly visually impaired population: National Eye Institute (NEI)
total blind + low vision: Lighthouse International data

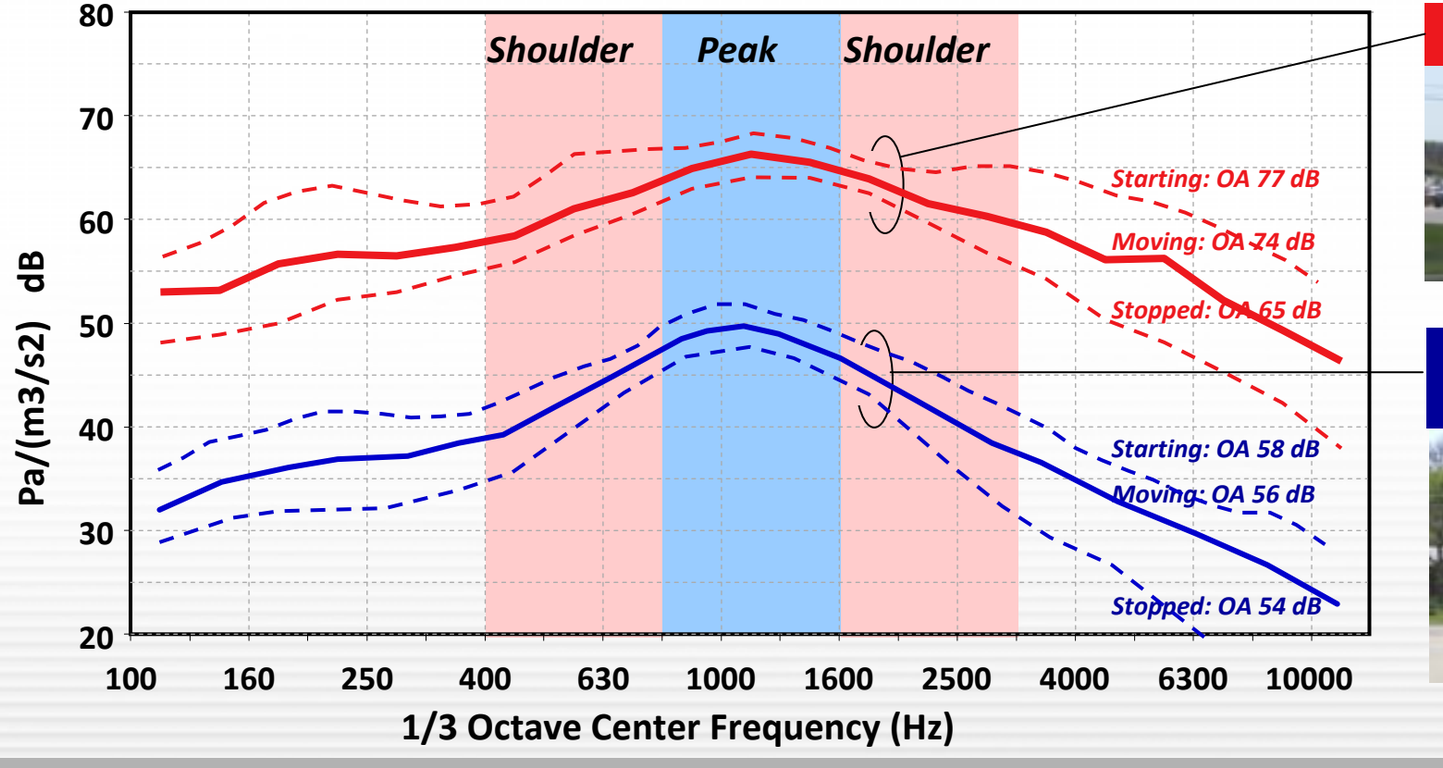


Source: Brant, L.J. & Fozard, J.L. (1990). Journal of the Acoustical Society of America

AVAS for Neighborhood Community

- Ambient noise measurements taken at different locations in Detroit.
  - *Ambient noise peaked at approx.1kHz for each traffic condition*

C *AVAS frequency peaks at the 'shoulders of the 1 kHz peak' will allow an overall lower sound pressure level while maintaining effectiveness and a quiet environment for driver and community*



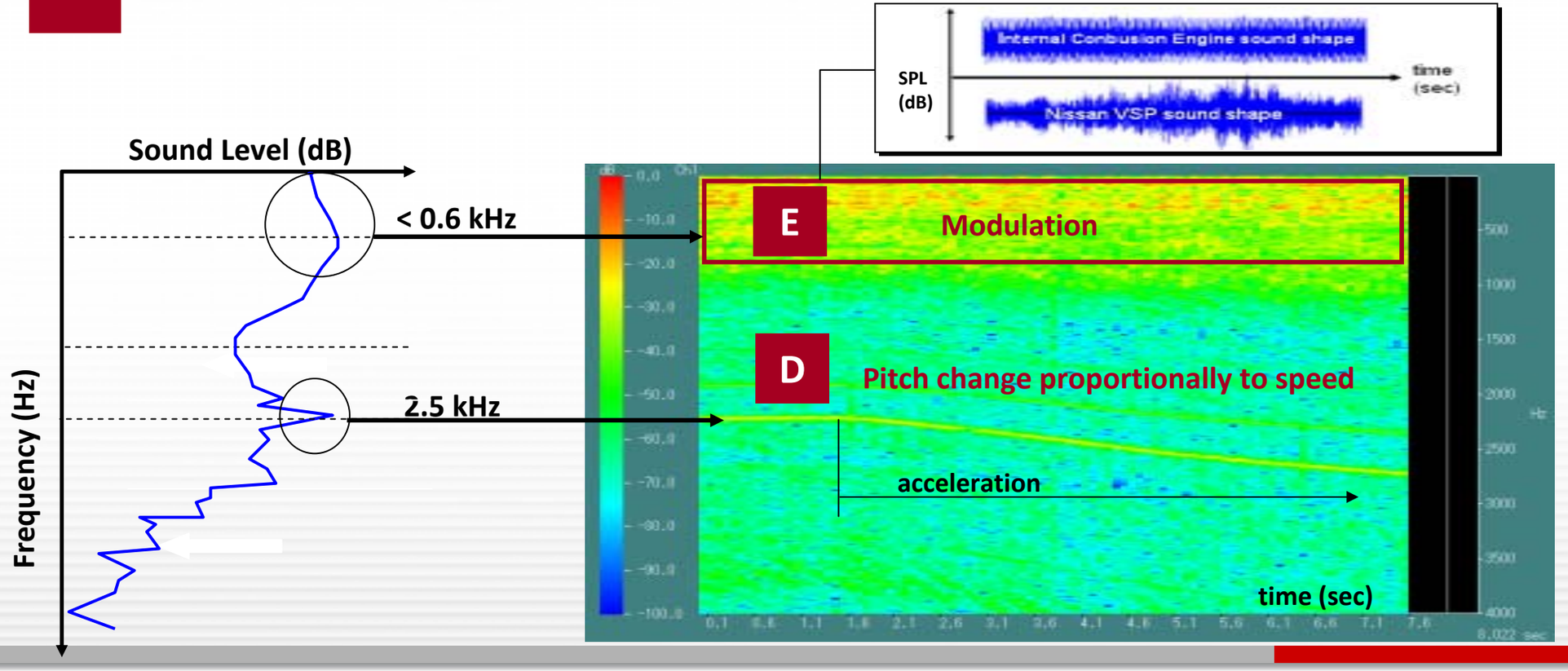
Busy Intersection

Neighborhood Near Busy Intersection

Implemented Time Domain Features

- "Twin Peaks" sound also includes time domain characteristics

D	*Pitch shifts proportionally to vehicle speed – use pure tone to help detect the pitch change and vehicle behavior (acceleration and deceleration)*
E	*Modulation of ICE dominant frequency (<0.6kHz) – simulate engine 'firing' beat, to enhance recognition as a vehicle and help tracking in ambient noise*



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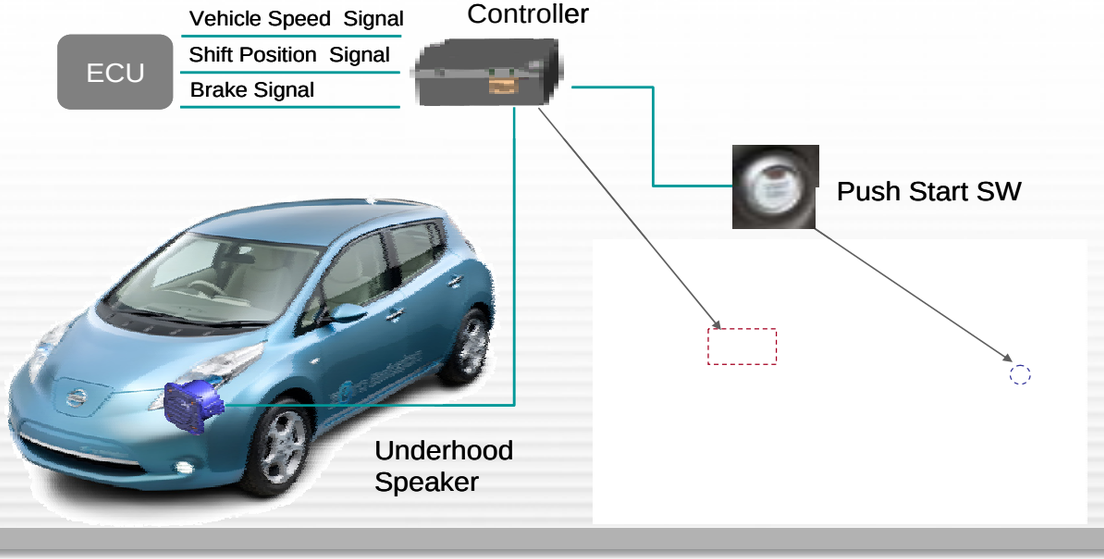
Meetings with the Visually Impaired

- 2007-2009 – Understand needs, develop basic design

-Meetings with the visually impaired in collaboration with MLIT Study Committee

-Development of basic hardware, control logic and sound files based on Japanese Guidelines



Refinement, Forward Sound Development

- 2009-2011 – US based research in close collaboration with Japan

-Meetings with the visually impaired at Detroit Institute of Ophthalmology (DIO) and the Western Pennsylvania School for Blind Children (WPASBC)





-Research with network including 5 Universities focused on forward AVAS sound

Vanderbilt University Medical Center (VUMC)	Western Michigan University (WMU)	University of Idaho (U of Idaho)	Wayne State University (WSU)	University of Michigan Transportation Research Institute (UMTRI)
Dr. Dan Ashmead	***Dr. Dae Kim***	***Dr. Ben Barton***	***Dr. Li Hsieh***	***Dr. John Sullivan***

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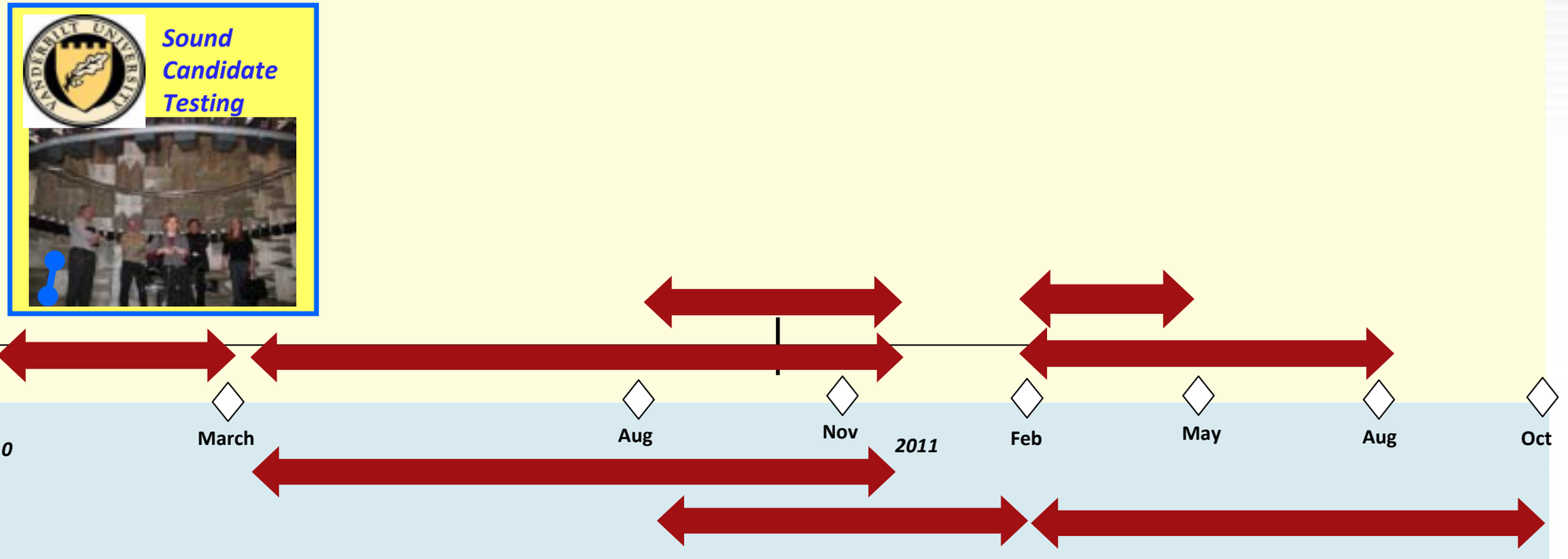
US Research Strategy

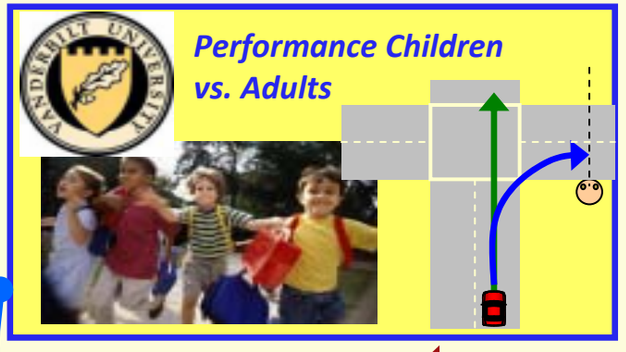
Acoustic Psychology and Real World Performance



Cognitive Psychology and Neuroscience

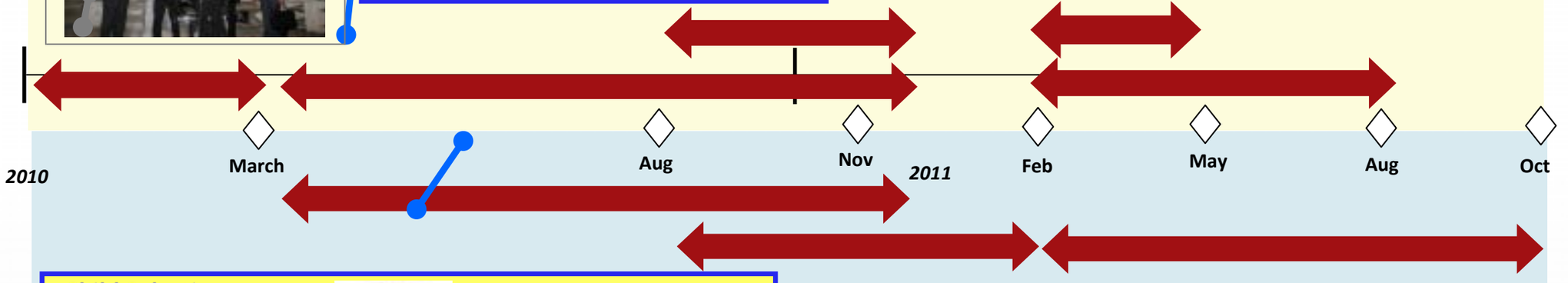
US Research Strategy

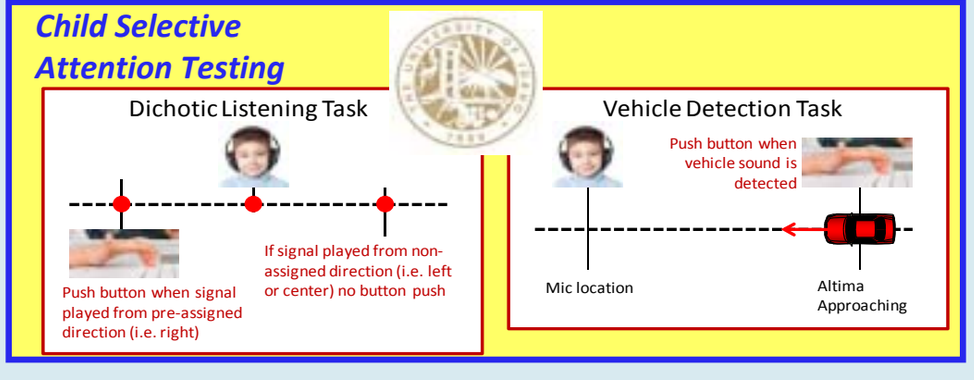
Acoustic Psychology and Real World Performance



Next phase of VUMC testing results showed no statistical difference between AVAS sound and ICE for all age groups

Overall, children required the vehicle sound to be set at a higher dB-A level than adults to complete the listening tasks





U of Idaho results suggest that children's worse VUMC performance due to less developed selection attention

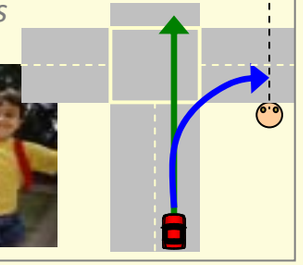
Cognitive Psychology and Neuroscience

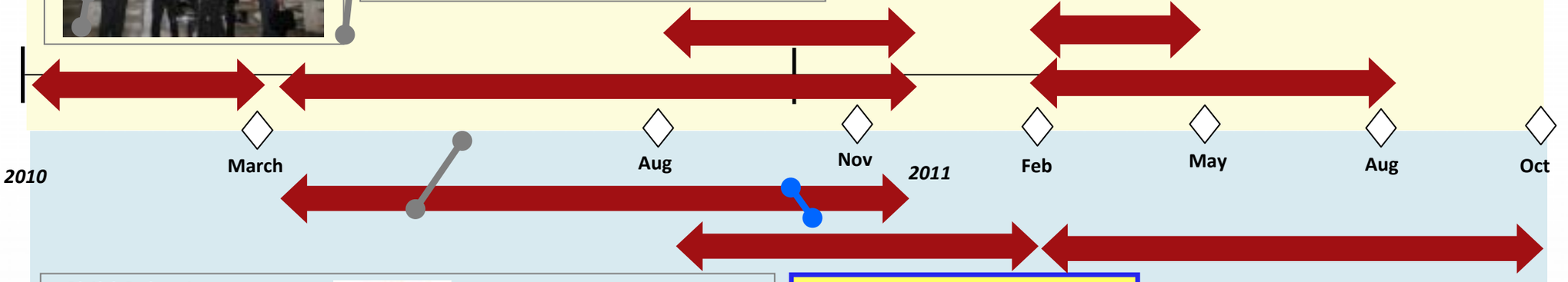
US Research Strategy

Acoustic Psychology and Real World Performance

Sound Candidate Testing

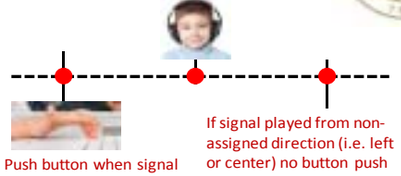
Performance Children vs. Adults



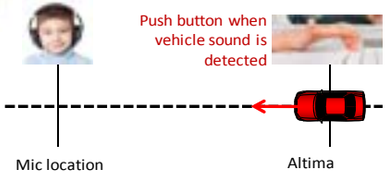


Child Selective Attention Testing

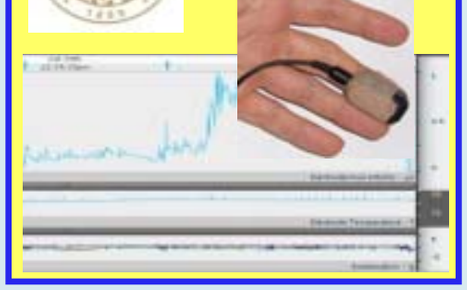
Dichotic Listening Task



Vehicle Detection Task



Driver Stress Testing



U of Idaho results show manual AVAS systems result in significantly more driver stress than automatic AVAS systems

Cognitive Psychology and Neuroscience

US Research Strategy

Acoustic Psychology and Real World Performance

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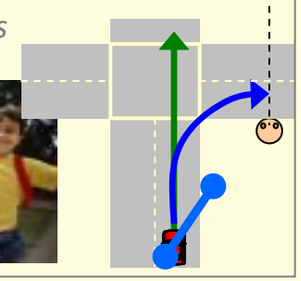
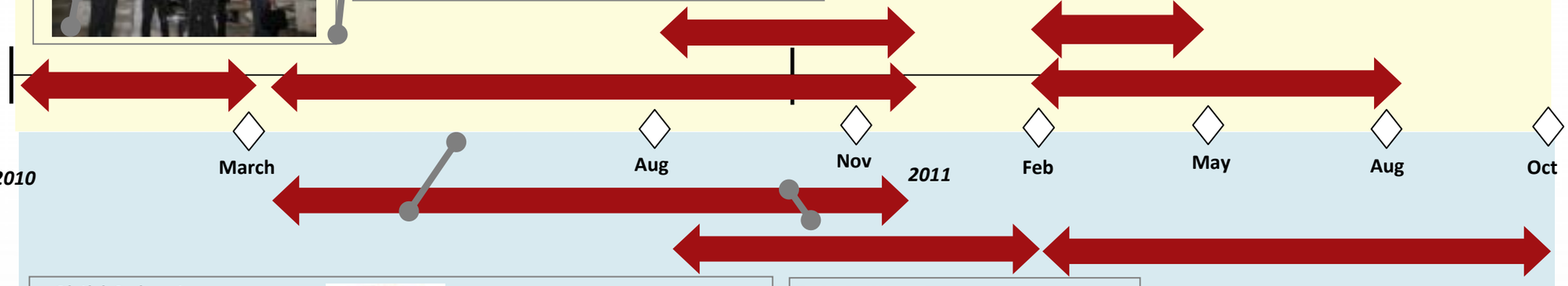


Testing w/ Visually Impaired



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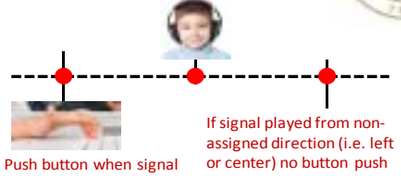

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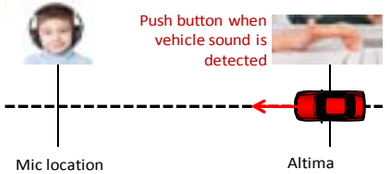
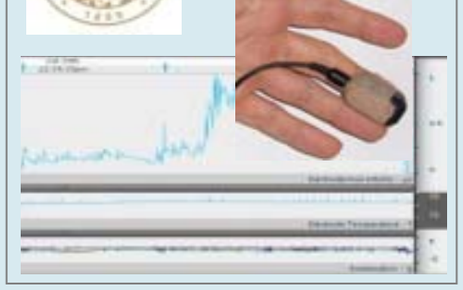


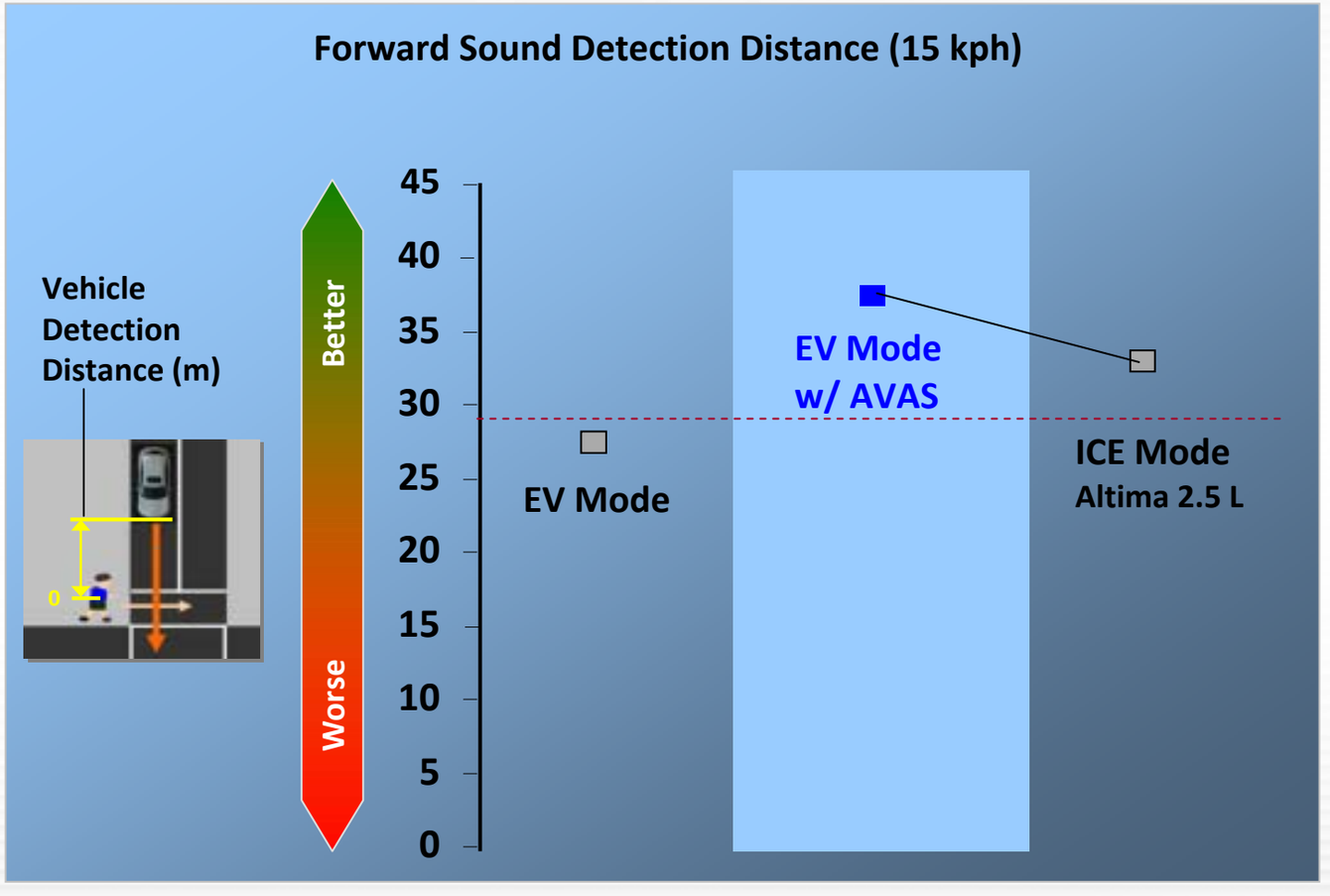
Driver Stress Testing

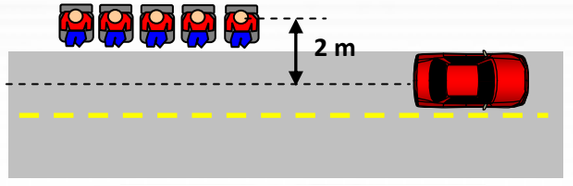


Cognitive Psychology and Neuroscience

WMU Approach Detection Results (Forward)

- No statistical difference between AVAS sound and ICE





Crossing Distance (corresponds to 6.9 s)

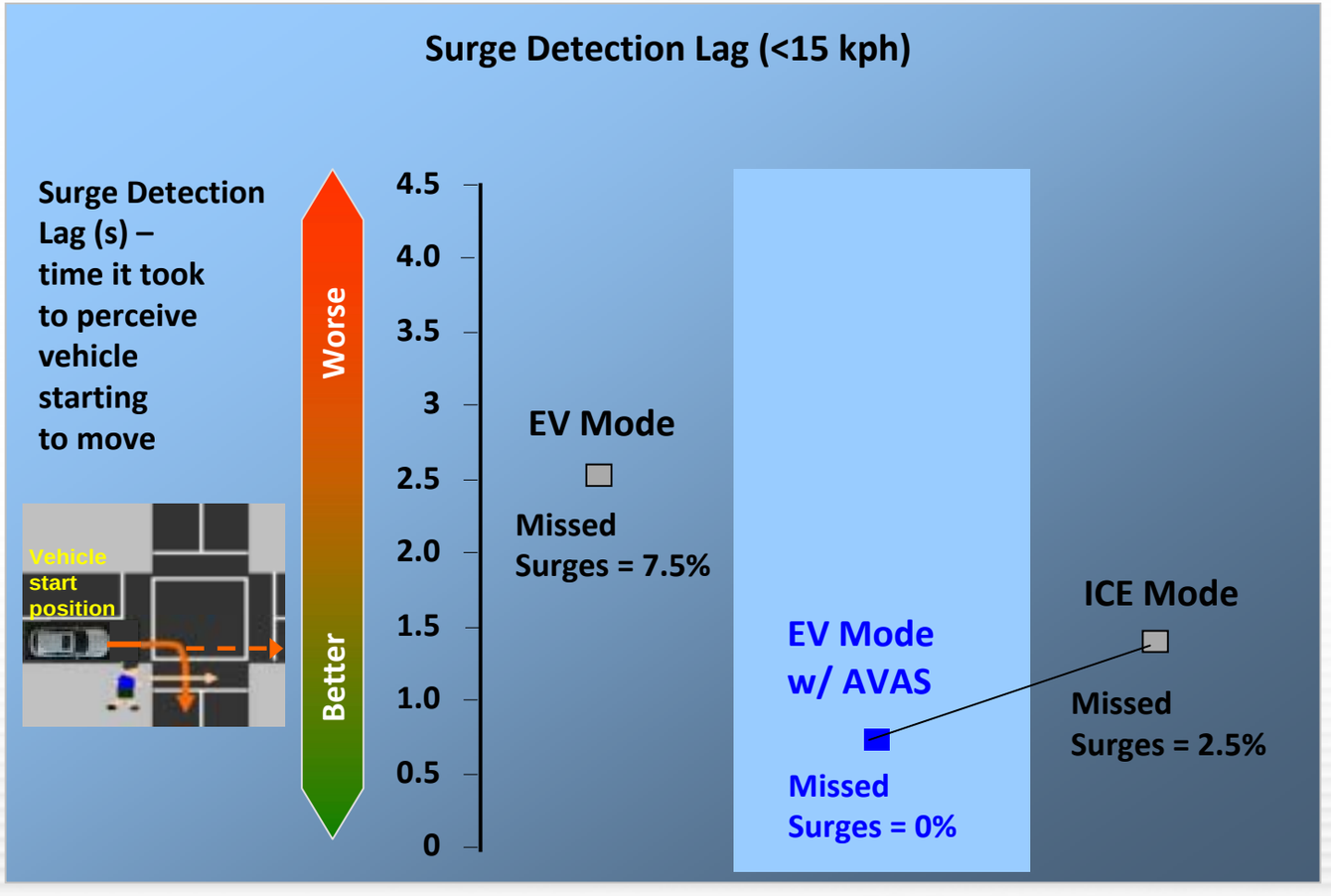
6.9 s crossing time is DOT FHA standard

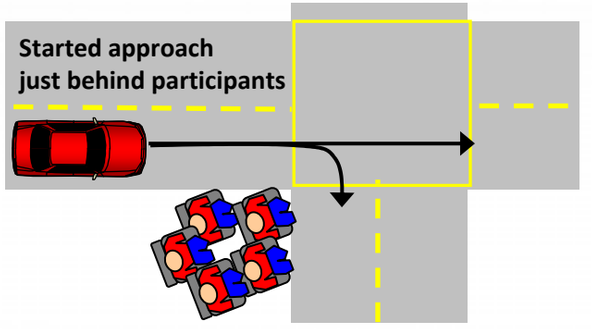
U.S. Department of Transportation
Federal Highway Administration

Participants = 14 visually impaired adults. Ambient = 48.7 dB-A (parking lot). No difference between AVAS and ICE at alpha = .017 (p = .059).

WMU Turning Perception Results (Surge Detection)

- AVAS sound performed statistically better than ICE
- Participants missed 0% AVAS surge trials, but missed 2.5% of ICE surge trials (likely due to AVAS emphasized “take-off” sound and no idle sound)

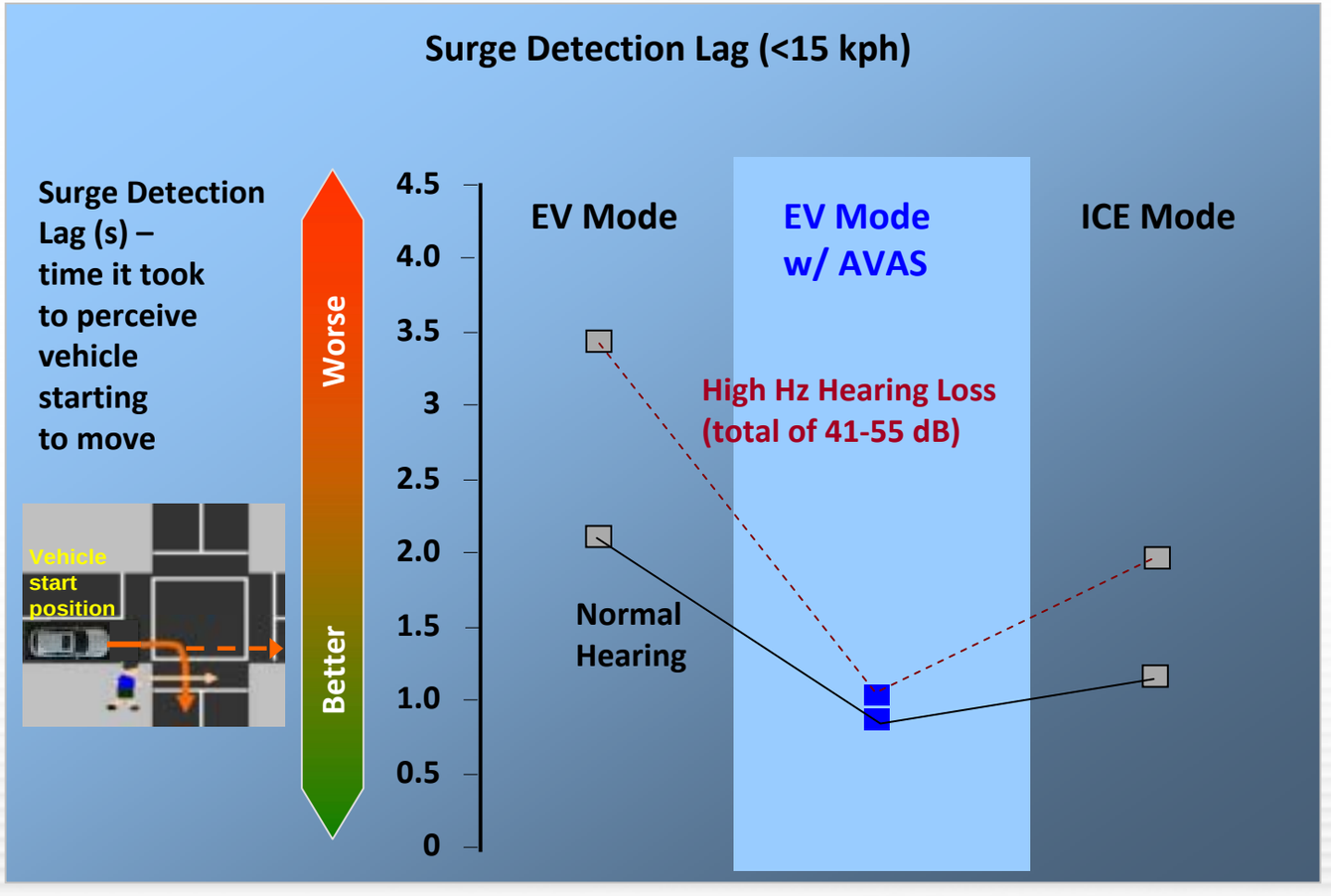


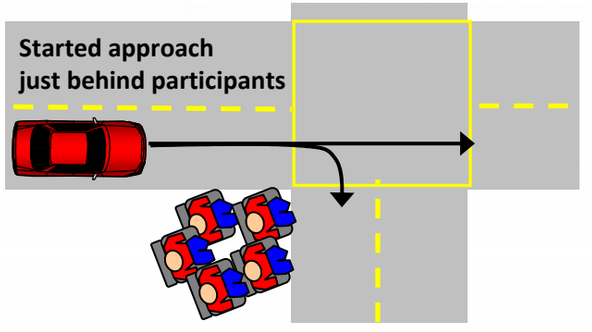


Participants = 15 visually impaired adults. Ambient = 48.7 dB-A (parking lot). AVAS performed better than ICE at alpha = .017 (p < .001).

WMU Turning Perception Results (Surge Detection)

- For AVAS, 3 participants with high Hz hearing loss achieved approximately the same performance as 12 participants with normal hearing

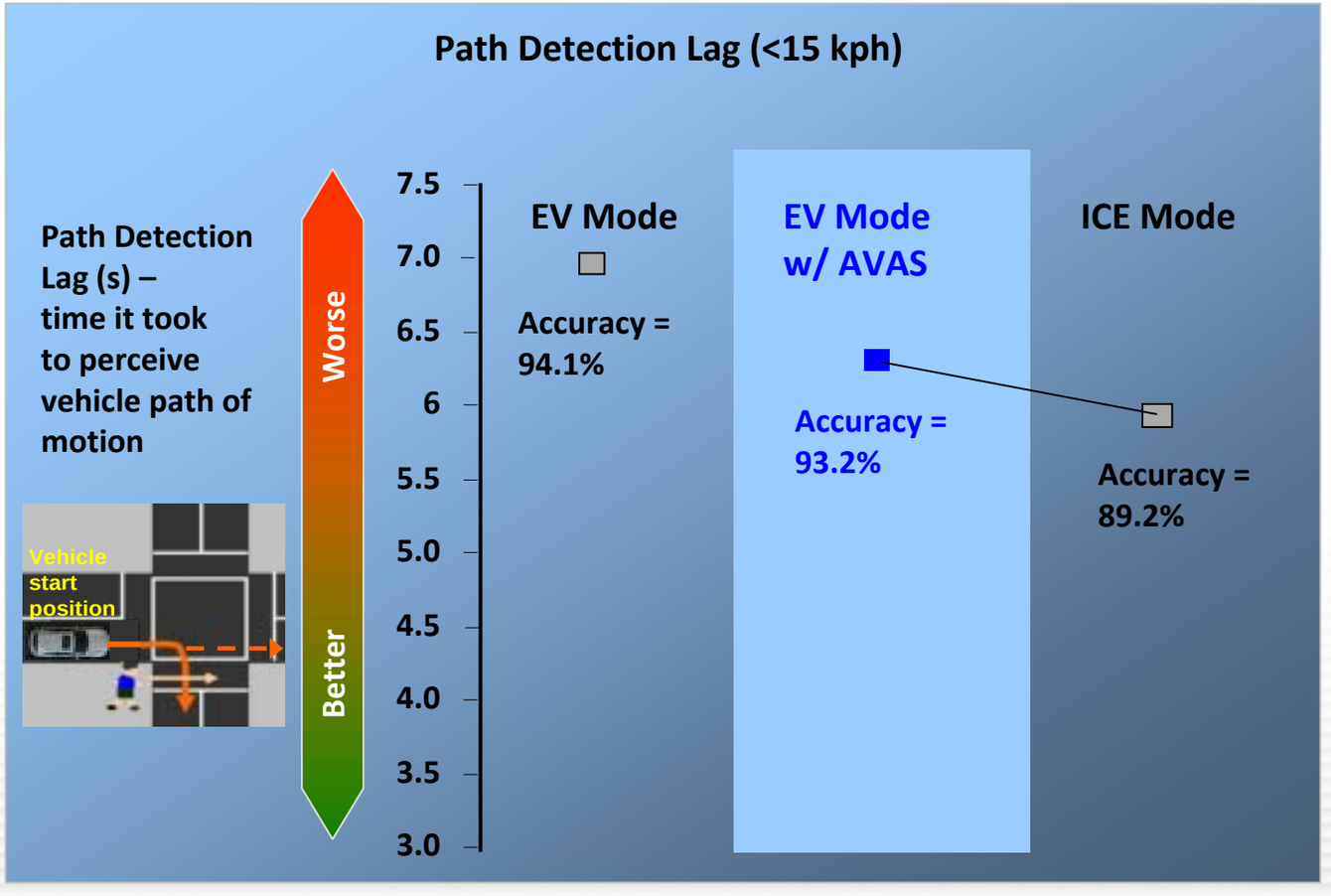


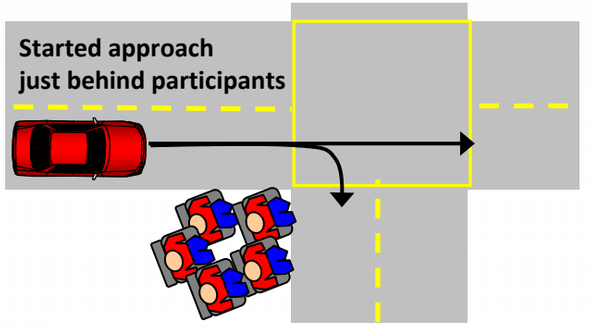


Participants = 15 visually impaired adults Ambient = 48.7 dB-A (parking lot). No inference to population due to small participant group.

WMU Turning Perception Results (Path Detection)

- No statistical difference between AVAS sound and ICE for Path Detection Lag (and Path Detection Accuracy)





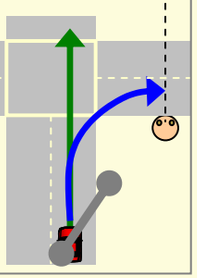
Participants = 15 visually impaired adults. Ambient = 48.7 dB-A (parking lot). No difference between AVAS and ICE at alpha = .017 (p =.032).

US Research Strategy

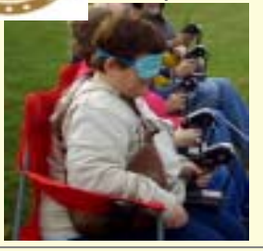
Acoustic Psychology and Real World Performance

Sound Candidate Testing

Performance Children vs. Adults



Testing w/ Visually Impaired

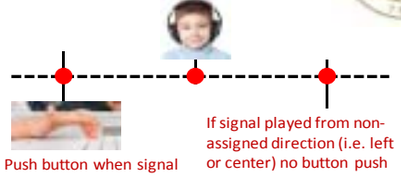


Pedestrian Crash Incident Analysis

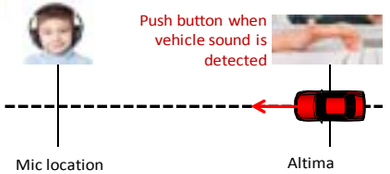
2010 **March** **Aug** **Nov** ***2011*** **Feb** **May** **Aug** **Oct**

Child Selective Attention Testing

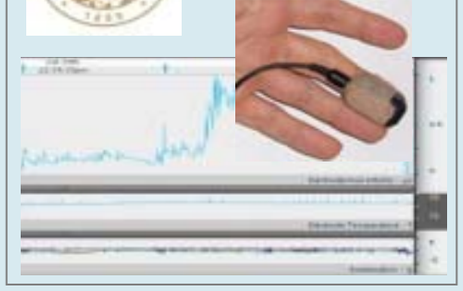
Dichotic Listening Task



Vehicle Detection Task



Driver Stress Testing



Cognitive Psychology and Neuroscience

US Research Strategy

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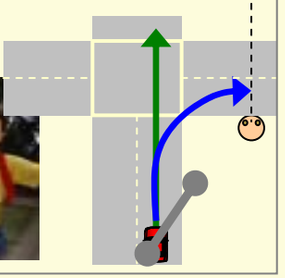

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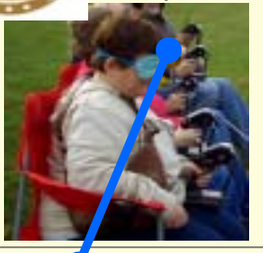

Nissan LEAF Customer Survey

Pedestrian Crash Incident Analysis

2010 | March | Aug | Nov | 2011 | Feb | May | Aug | Oct

Child Selective Attention Testing

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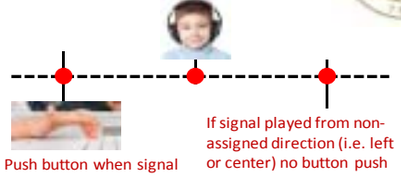

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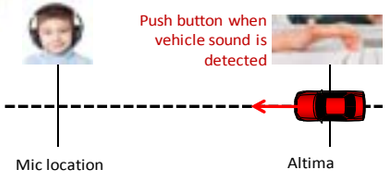
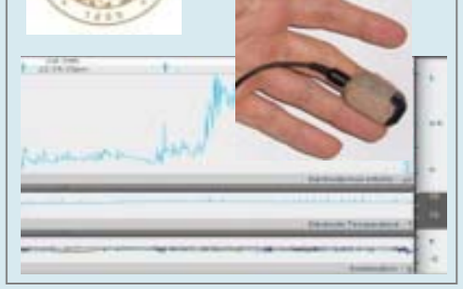


Driver Stress Testing

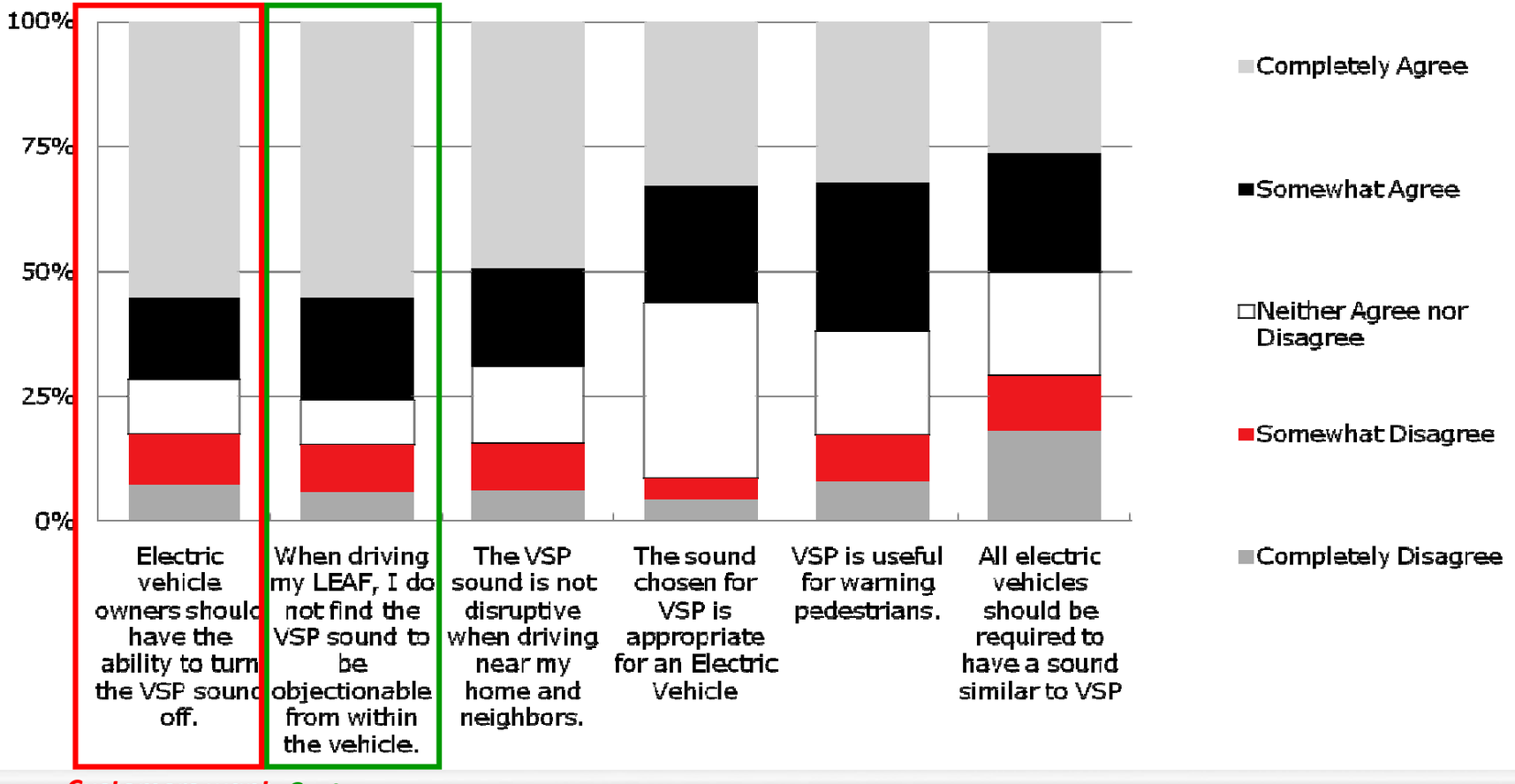


Cognitive Psychology and Neuroscience

AVAS Acceptance – Customer Survey

- Approximately 85% of customer do not find AVAS disruptive from within the vehicle or disruptive to their neighborhood/community, regardless they want the ability to turn it OFF

Response to Attitudinal Statements

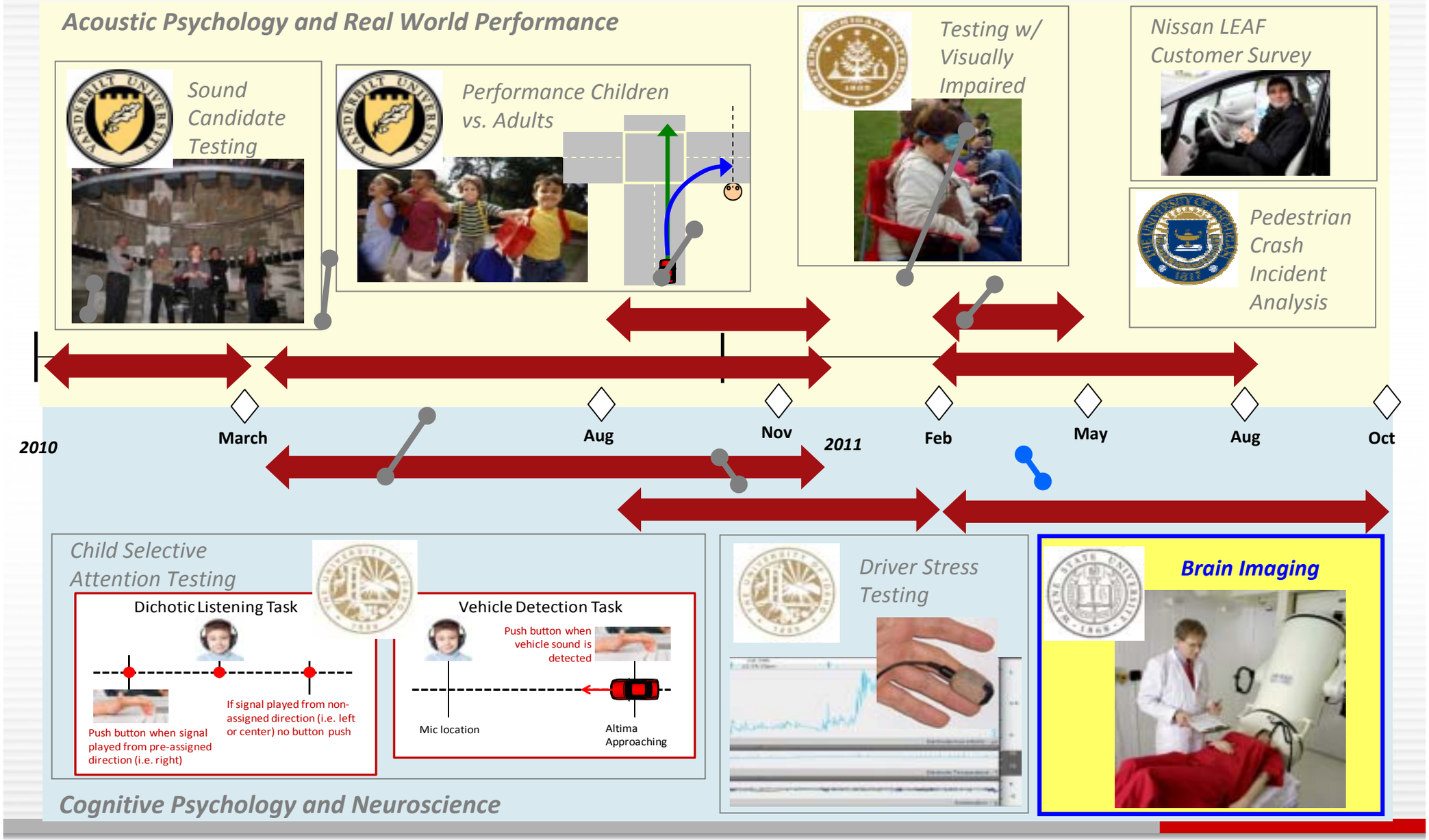


Customers want ability to turn AVAS off

Customers are accepting of Nissan AVAS

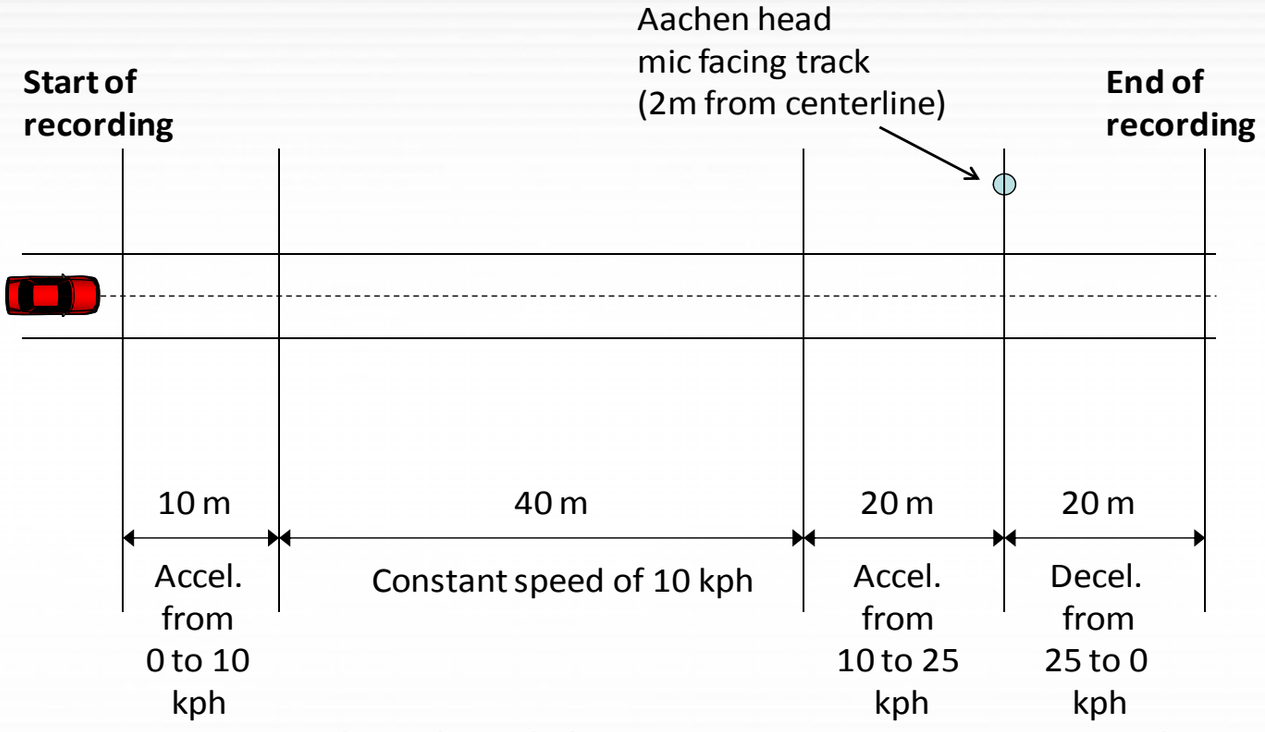
Over 100 LEAF customers surveyed

US Research Strategy



Brain Imaging – AVAS vs. ICE

- 2 recordings were made at AZ test track: 2011 Versa 1.8l and 2011 LEAF w/ AVAS



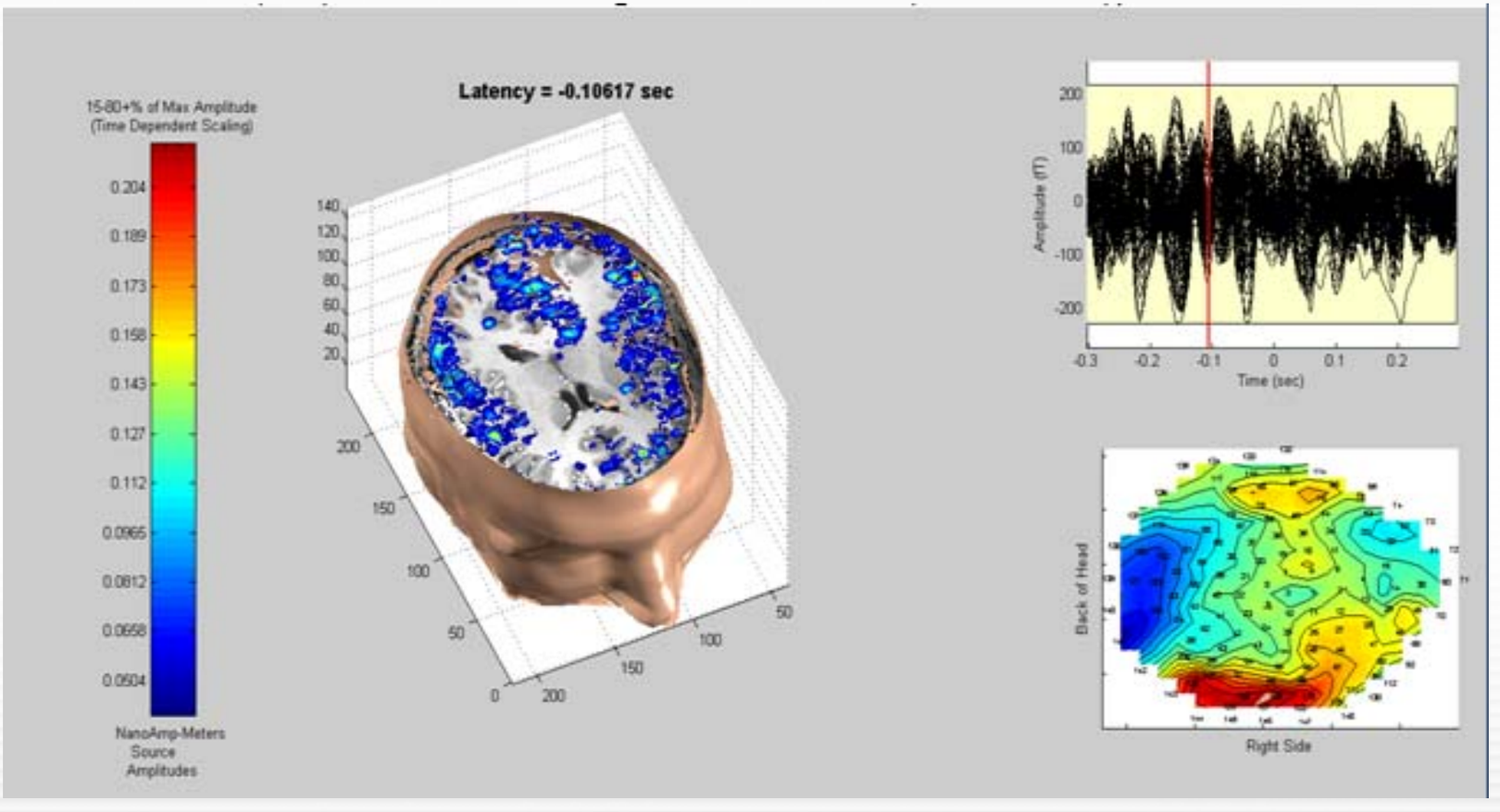
- Recordings were presented via headphones to 21 participants undergoing EEG and MEG
- Channels were swapped to simulate right and left approach conditions, 2 ambient noise conditions: 1-no ambient noise added, 2-ambient noise added
- For both EEG and MEG testing each participant had 120 trials

(2 vehicles x 2 approach directions x 2 ambient conditions x 12 repetitions) + 24 control noises = 120 trials

Ambient noise = whitenoise file synthesized to match spectral frequency profile of traffic noise, set at 10% max SPL measured in vehicle recordings
Versa and LEAF sound recordings achieved same peak SPL at time vehicle passed Aachen head). Telemetric data confirmed that vehicle position vs. time was the same.

Overall Brain Activity - Coherence

- Overall MEG shows that there is no statistical difference between AVAS sound and ICE in terms of coherence (or synchronization of neutral activities across brain regions)



148 channel MEG

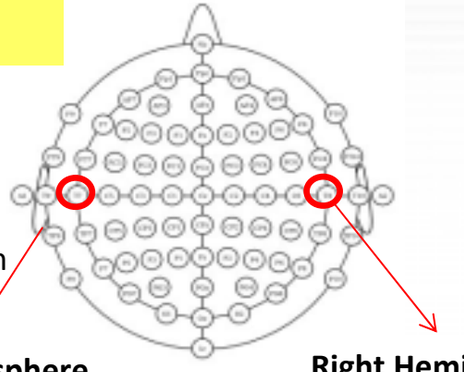
Single subject's brain network patterns during a right-approach detection of a AVAS sound without ambient noise

EEG Result – Localized Brain Activity

- EEG results show that AVAS sound was heard and comprehended at 4.5 seconds (evident by spike in 0-15 Hz brain waves or theta/alpha bands), 3 seconds sooner than ICE

No Ambient Noise

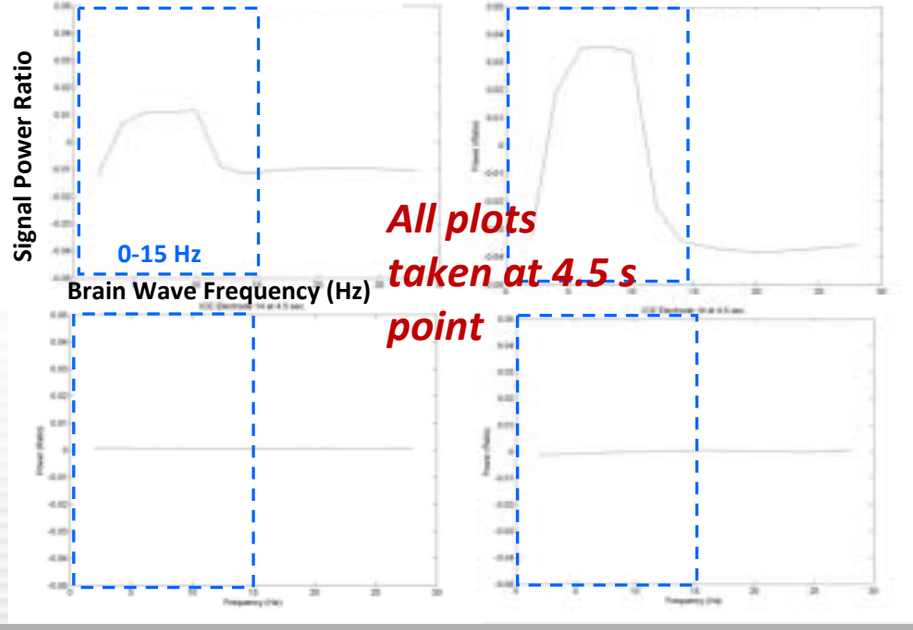
Temporal Lobe
-Auditory Cortex
-Hearing
-Auditory recognition



Left Hemisphere **Right Hemisphere**

AVAS

ICE



All plots taken at 4.5 s point

Signal Power Ratio (y-axis) = (Average of Signal Power of Left Approach trials – Right Approach Trials)/Max signal power measured

Key Results:
-Spike in signal power ratio occurs earlier for AVAS

-Left ear/right brain is more sensitive

-Spike in Signal Power Ratio is positive indicating Left Approach trials are associated with more brain activity

-Spike in Signal Power Ratio is higher in right brain hemisphere than left brain hemisphere

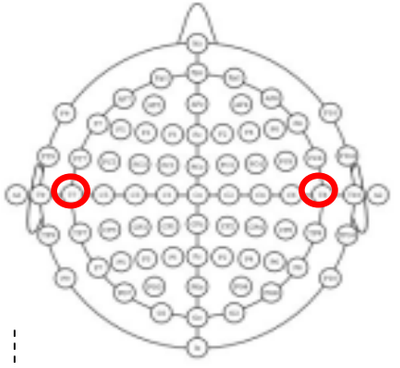
-Measured Brain Wave Frequency (x-axis) shows that activity occurs in theta (4-8 Hz) and alpha (8-13 Hz) bands – indicating that brain is actively processing stimulus

64 channel EEG – Plots reflect average of 21 participant results.
Same patterns witnessed in the frontal, pre-frontal and parietal lobes

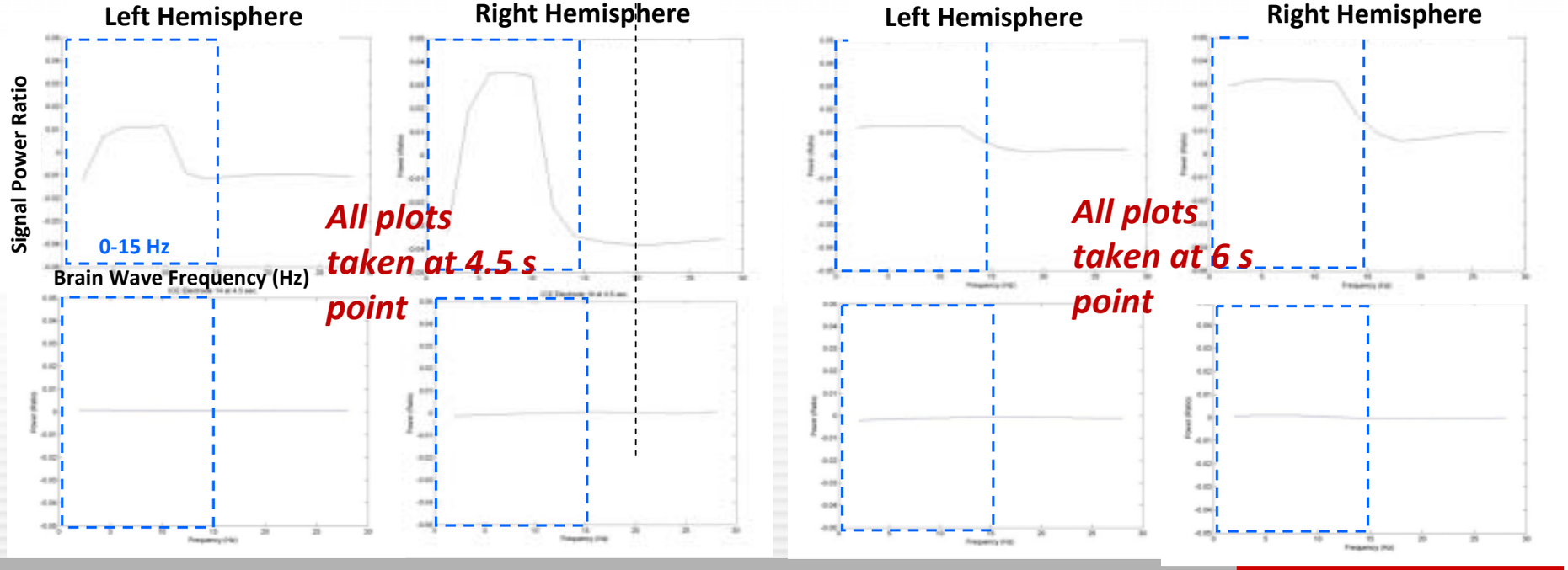
EEG Result – Impact of Ambient Noise

- When ambient noise is added, AVAS sound brain activity spike occurred later at 6 seconds and amplitude of peak was attenuated. ICE spike was not discernable with ambient noise.

Temporal Lobe
-Auditory Cortex
-Hearing
-Auditory recognition



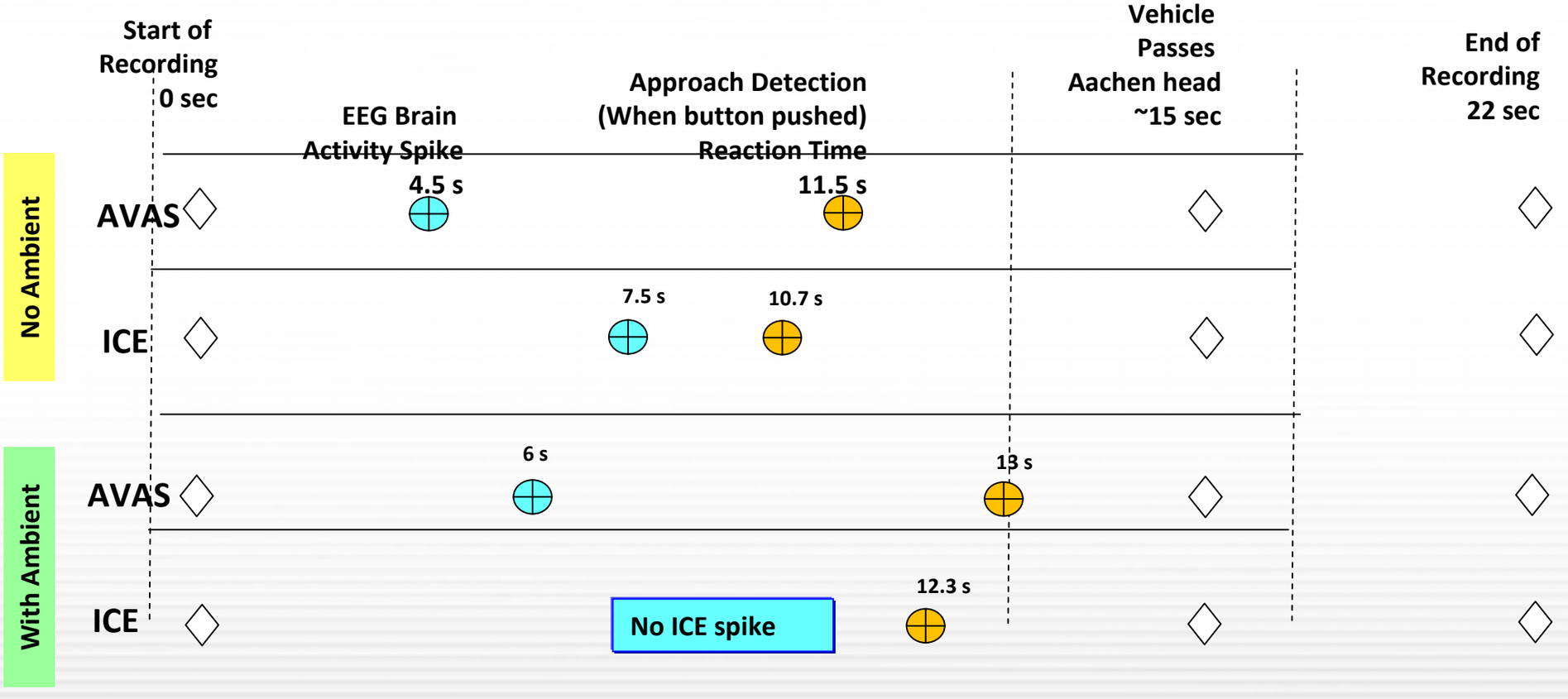
No Ambient Noise | **With Ambient Noise**



64 channel EEG – Plots reflect average of 21 participant results.
Same patterns witnessed in the frontal, pre-frontal and parietal lobes

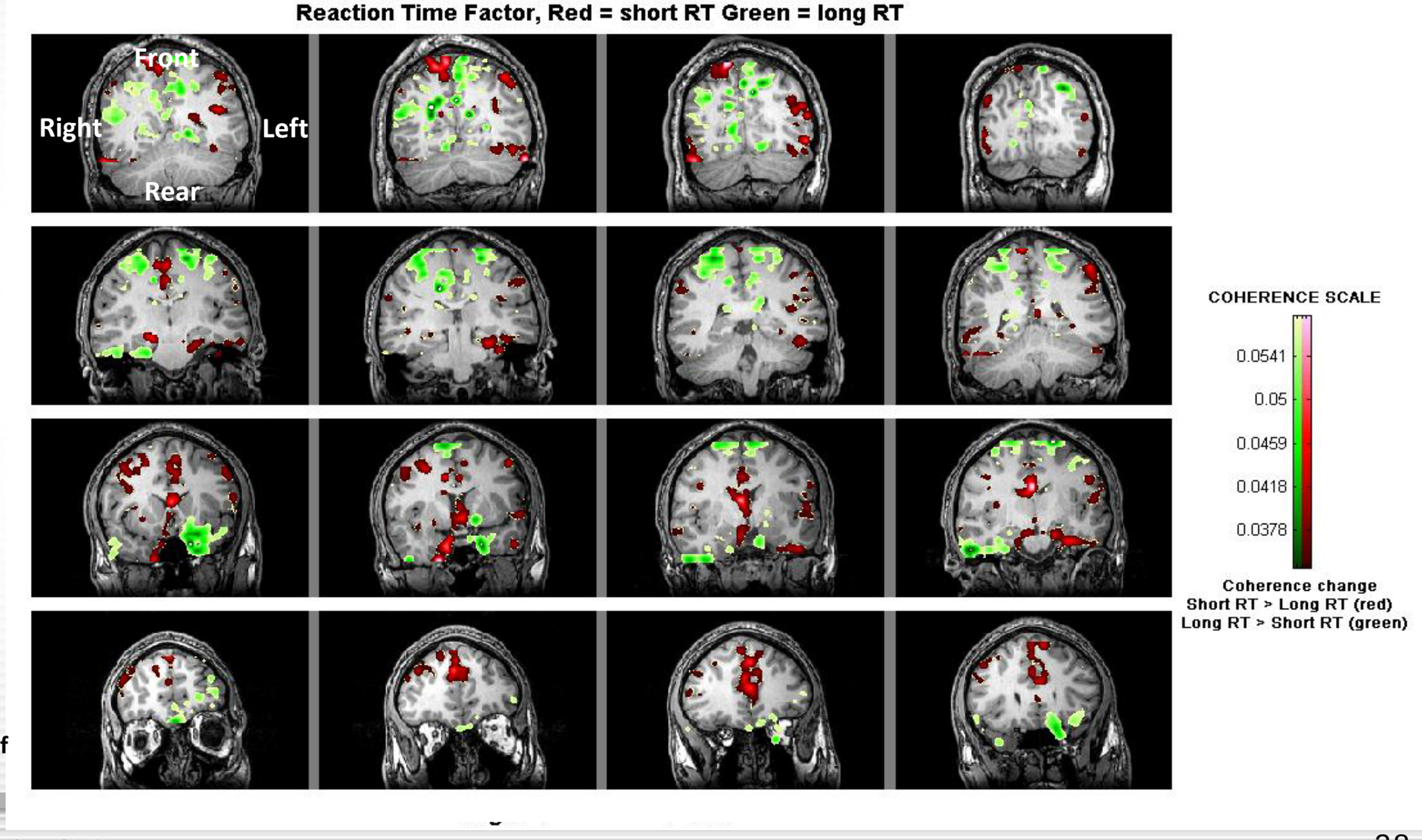
EEG vs. Approach Detection Performance

- During EEG testing participants were asked to push a button indicating when they could "detect a sound approaching" – AVAS sound had slightly longer reaction times (RT) than ICE
- This indicates that it was more difficult for participants to make a conclusive decision on AVAS sound approach, despite early brain activity (witnessed in EEG)



RT and MEG Brain Activation Areas

- Subjects with faster RT showed more coherence patterns in the brain (more synchronicity)
- Different brain area activation is associated with slow and fast RT



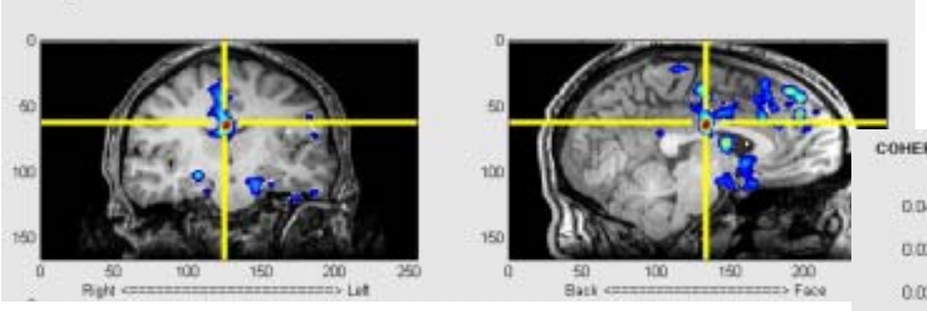
148 channel MEG

RT and MEG Brain Activation Areas

- Shorter RT are associated with activity (strong coherence) in 4 particular areas of the brain
- It's possible that sound can be designed to target activation in these brain areas for maximizing RT performance

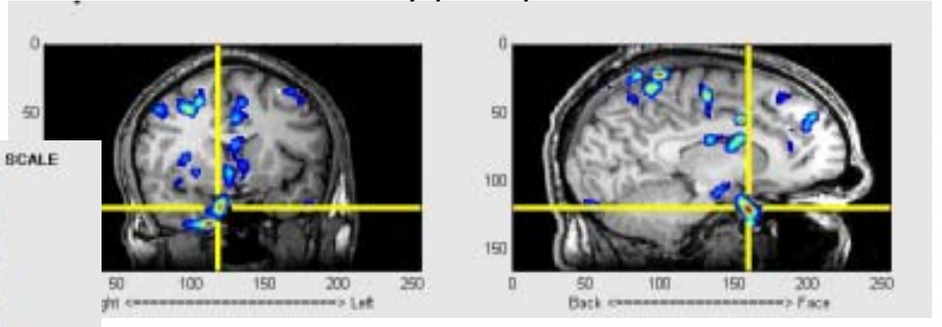
Cingulate Gyrus

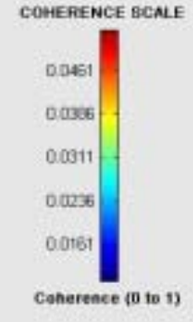
Attention, coordinates sensory input with emotion



Superior Temporal Gyrus

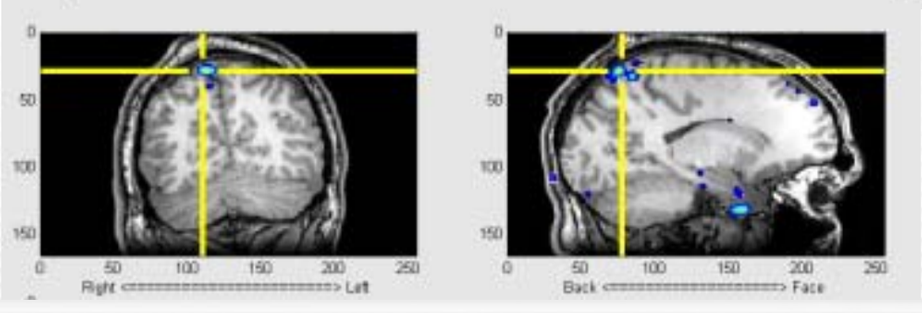
Auditory perception





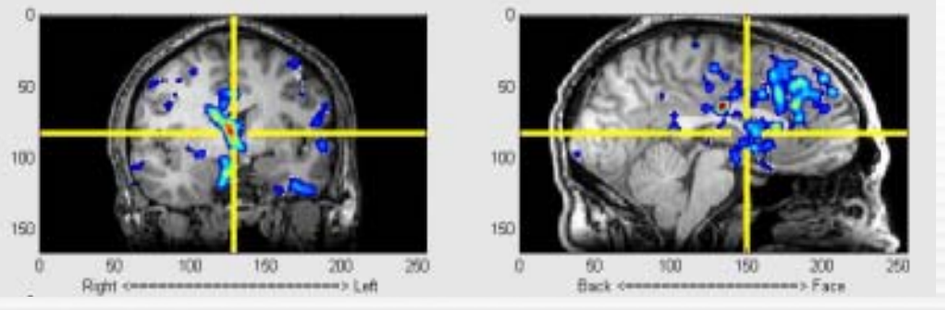
Superior Parietal Gyrus

Spatial attention, sensory-motor integration



Caudate Nucleus

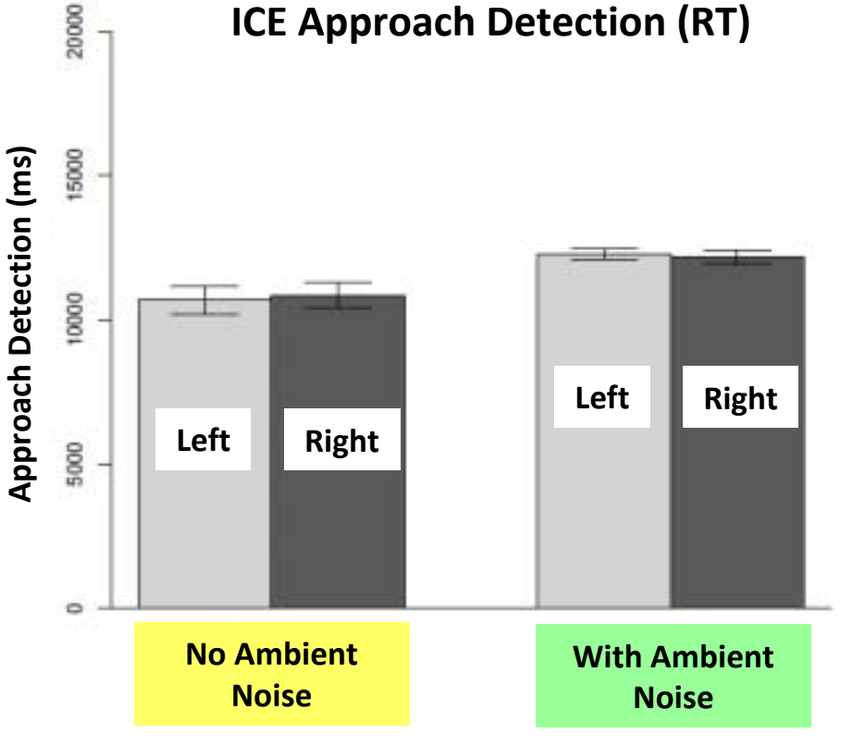
Learning, memory

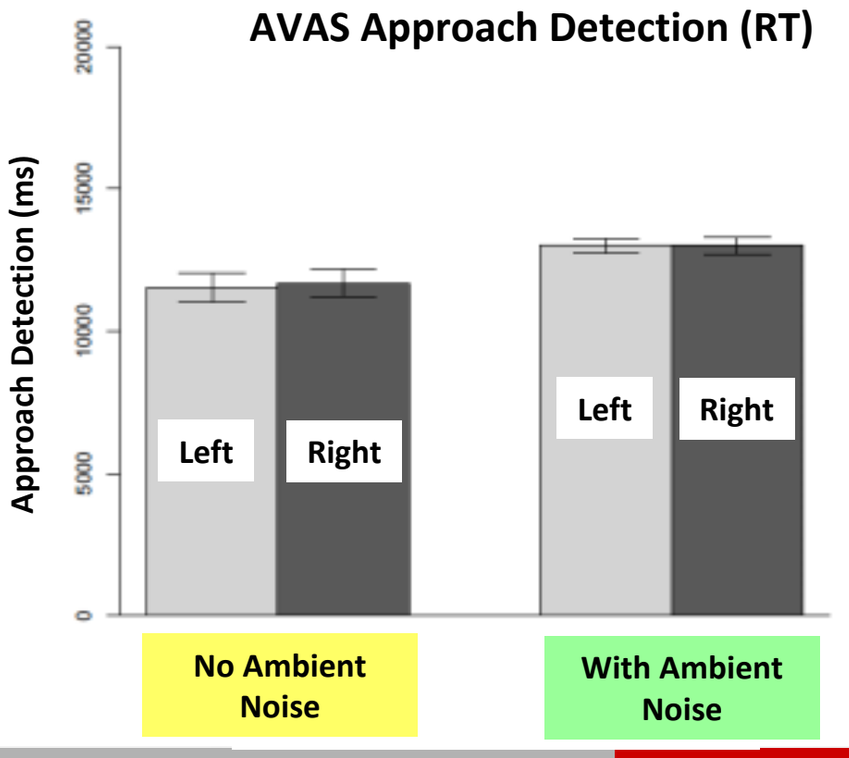


148 channel MEG

Right vs. Left Performance

- Past studies show that the brain processes sound asymmetrically
  - *-Left ear/right hemisphere is more sensitive to sound spectral changes*
  - *-Right ear/left hemisphere is more sensitive to sound temporal information*
- Despite this phenomena, there was no statistical difference between right and left approach detection RT behavioral performance for AVAS sound and ICE





Schonwiesner, et al 2005, ""Hemispheric asymmetry for spectral and temporal processing in the human antero lateral auditory belt cortex"

Conclusions

- Nissan's AVAS system implemented on the 2011 LEAF adheres to Japanese Guidelines and achieves a balance of performance, addressing needs of all Stakeholders
- Extensive fundamental research and real world study provides evidence that AVAS "twin peaks" sound achieves similar performance as ICE in pedestrian related listening tasks
- Brain imaging results suggest that AVAS "twin peaks" sound causes earlier brain activation than ICE, which could contribute to real world pedestrian performance advantages
- More investigation is needed to understand which elements of sound result in activation of areas in the brain that are associated with shorter reaction times