Driving by the seat of your pants!
A multisensory approach to capturing driver attention

Charles Spence
Crossmodal Research Lab.
Department of Psychology
Oxford University

Wickens (1984, 1992, 2002…)

Spence & Read (2003)

Structure of human processing resources
• Note separate resources for auditory & visual I-P
• Hugely influential model in field of ergonomics
Driver Inattention

- Inattention one of leading causes of car accidents, estimated to account for 26-56% of all road traffic accidents
- Increased technology in cars (mobile phones, satnav, email…) means this problem can only get worse!
- Given the development of radar detection systems, what’s the best way to alert drivers to potentially dangerous events?

The challenge: To demonstrate that cognitive neuroscience can help to design multisensory warning signal for drivers that are significantly better that a smart (i.e., intuitive) engineer can come up with.

Alerting Sounds

(Oyer & Hardwick, 1963)

• Most common cause of accident (25% of accidents) = front-to-rear-end collision
• BUT: You are likely to be involved in a FTRE accident every 25 years or so
• Hence, most of the time such warning signals will be false alarms (FAs)
• People don’t like irritating warning signals especially when they’re frequently FAs. Often such warning signals disabled!

Isherwood et al. (2004)

If you lose these senses you lose your sense of living
Jan de Vries

The Five Senses

1) HEARING
2) TASTE
3) TOUCH

Urgency

Unpleasantness

Urgency

Unpleasantness

1 2 3 4 5 6 7

1 2 3 4 5 6 7
Time to impact!

If a warning signal is presented too early, it is likely to be judged as annoying or else to represent a false alarm.

Optimal window in which to present a warning signal.

Warning signal presented too late to be effective.

We need intuitive warning signals that will prime the likely response.

Latest point at which a warning signal can facilitate a crash avoidance response.

Moment of impact.

Driving task: Upon hearing auditory cue, check windscreen & rearview mirror, decide if there is a potential collision, & accelerate / brake / make no response.

Rapid Serial Visual Presentation task. Occasional target digits presented every 2-6 sec simulating attention-demanding situation.

- Spatially non-predictive car horn sound
- Spatially predictive car horn sound
- Spatially predictive verbal cue: ‘front’ / ‘back’

Ho & Spence (2005): JEP:Applied

- Warning beep
- Verbal cue
- Spatial auditory cue
- Auditory icon
- Spatial auditory icon (car horn sound)

Ramsay & Simmons (1993): Some drivers listen to music at 85-130 dB.
Benefits of Tactile Signals
• Skin (18% of body mass) currently not used (much) while driving so tactile signals won’t overload driver
• Unaffected by background noise
• Automatically attention-capturing but not irritating. Claimed to be intuitive
• Good for presenting directional cues
• Personal to driver; Technology cheap

Ho, Tan, & Spence (2005)

So what’s really going on here?

Video

Peripersonal vs. Extrapersonal Space

Electrical microstimulation of the polysensory zone in the monkey elicits stereotypical defensive movements such as movements of the monkey’s arm behind its back, or complex defensive posture involving a facial squint, a head turn, and the arm and hand moving to a guarding position (taken from Graziano et al., 2004).
Transport Research Laboratory Driving Simulator (Crowthorne, Berkshire, UK)

**Ho, Reed, & Spence (2006)**

![Graph showing RT vs. Shortest headway](image)

- RT: 0.0
- Shortest headway: 16.0

Brake lights disabled!

**Ho, Reed, & Spence (2007)**

![Bar chart showing Mean RT](image)

- Vibrotactile: Off 600, On 700
- Auditory: Off 600, On 800
- Audiotactile: Off 600, On 800

**Suetomi & Kido (1997)**

Estimate that 500 ms reduction in braking reaction times would reduce front-to-rear-end collisions by up to 60%!

**Fitch et al. (2007)**

Compared drivers’ ability to verbally localize direction (8 in total) of warning signals on road:
- Auditory (32%; 2.8 sec)
- Tactile (86%; 2.4 sec)
- Audiotactile (81%; 2.4 sec)

Results highlight driver difficulty in localizing sounds inside car. No multisensory enhancement effect observed.
Conclusions

• Warning signals should be intuitive
• Spatial auditory icons (e.g., car horn sound) provide an effective means of capturing driver attention
• Tactile cues can also be used to direct attention & alert driver to road hazards
• Spatially co-localized multisensory warning signals (e.g., auditory + tactile) best. They provide automatic interrupt

Neuroscience-inspired design

• Spatial coincidence can be critical
• Multisensory > unisensory signals
• Near-rear peripersonal signals
• Asynchronous warning signals to simulate distance/optimal distance?
• BUT: High incidence of warning signals in studies reported so far, &
• What about compensatory behaviour?

Crossmodal Research Lab
University of Oxford
http://www.psy.ox.ac.uk/xmodal/

Alerting Smells?
Increasing interest in use of smell to:
– Alert drowsy drivers
– Relax stressed drivers
– Enhance the driving experience
(Ho & Spence, 2005)