The Effects of Noise Cancelling Headphones on Performance

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Background

Asia Pacific Cabin Safety Working Group

- Passenger uses Active Noise Reduction headphones during pre-flight safety brief
- Legislative concern – PED may interfere with safe operation of aircraft - communication and navigation equipment (CASA AC 91-050(0) 2001)

- Passenger claims – allows him to hear safety brief better (increases signal to noise ratio)

Oral Briefing

- "Operator ensure that all passengers are orally briefed…." (CASA, CAO 20.11.14).

- "PIC….passengers been orally briefed…" (FAA, Sec. 135.117).

Assumption

- Passengers can hear audio information

Or at least

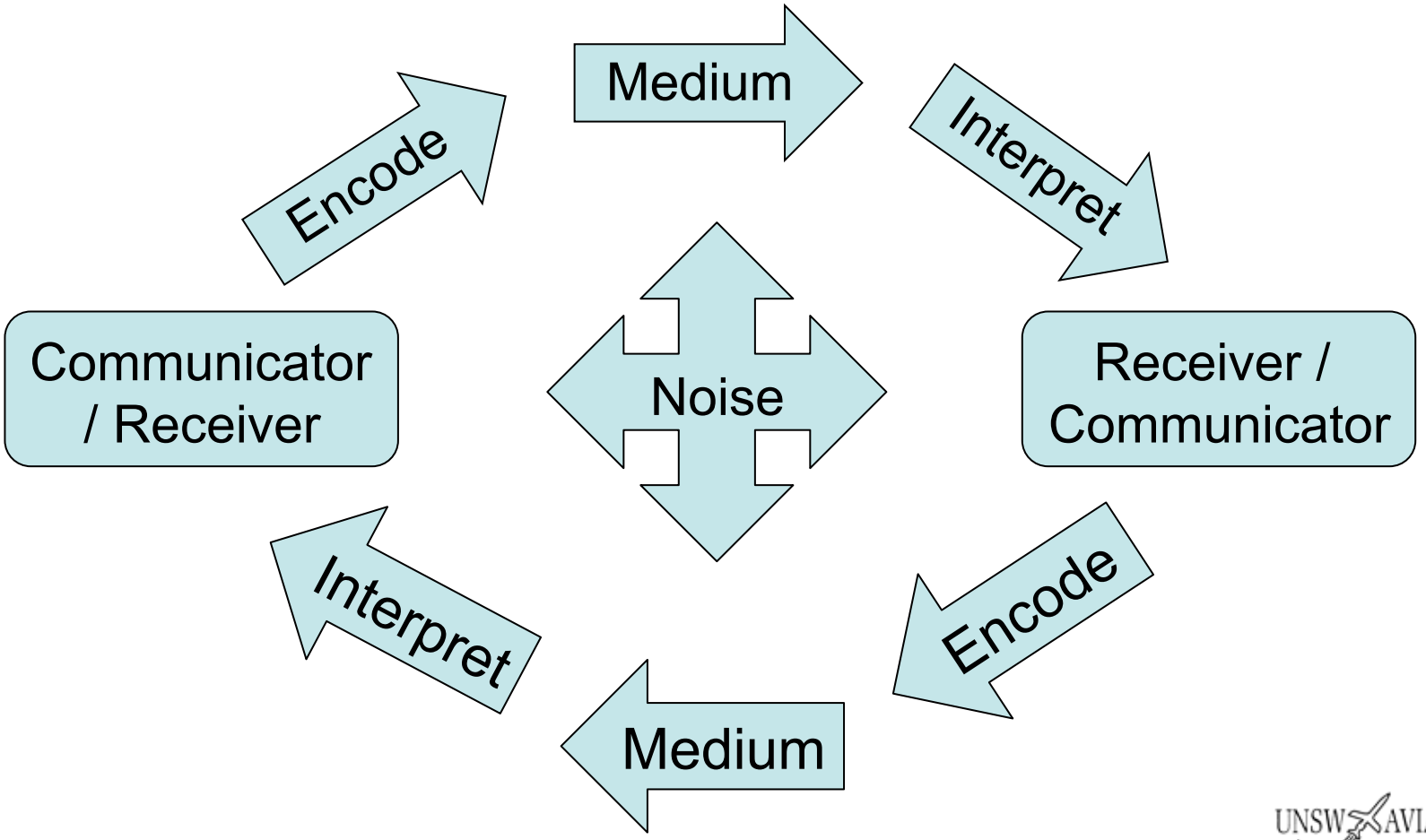
- Provided an opportunity to hear the information

Opportunity to Hear

Effective Communication

- Sender
- Receiver
- Message to communication
- Often forgotten
  - Purpose of communication/ intended outcome – Educate or Behavioural change

Communication



Noise

- Noise defined – Any stimuli that is unwanted

- It may be unwanted because:
  - Unpleasant
  - Harmful
  - Distractor

Audio Noise and Performance

- Audio Noise defined - Any sound stimuli that is unwanted (Antunana & Spanyers, 2000)

- Effects:
  - cause hearing impairment (Daniel, 2007; Cruickshanks et al., 2010)
  - induce stress (Taffinder, McManus, Gul, Russell, & Darzi, 1998)
  - cause fatigue (Picard et al., 2008)
  - alter health state (Gangwisch et al., 2006)
  - negatively impact memory (Sorqvist, 2010)
  - increase error rate (Weinger & Ancoli-Israel, 2002)

Active Noise Reduction Technology

Pseudo name

- Noise cancelling headphones

In Theory

- Produces a sound that is 180 degrees out of phase with the original sound
- Two sounds combined cancels noise (Nelson & Elliott, 1992).

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The Effects of Noise on Performance

- Recognised by World Health Organisation (WHO), Hearing protective required when employees are subjected to occupational noise > 90 dB(A).

- NOHSC - 85dB(A) for no more than 8 hours (NOHSC: 1007, 2000)

- AS/NZS 2107 office noise ~ 40-45 dB(A)

Noise, Cognition and Performance

- Stimuli processed
  - Explicitly, and
  - Implicitly

- Explicit = distractor + consumes cognitive resources
- Implicit = consumes limited cognitive resource

Present Research

Context

- Commercial aviation
- Headphones banned during taxi phases of flight
- Engines operational
- Pre-flight safety brief provided
- Noise affects the intelligibility of the message

In other words,

- Decreases signal to noise ratio

Dual Task Research

Aim

1. Examine differences in performance between two commercially available headphones
2. Examine the effects of noise cancelling headphones on concurrent task performance (commercial aviation)

Participants

- 36 (23 male)
- Average age 20 years
- Normal hearing (tested)

Design

- Balanced Latin square design (6 x 6)
- DV – correct # on fill-in-the-blanks test (max 12)
- Aircraft noise 65 dB(A)
- Audio briefs 70 dB(A)
- Concurrent task – maths question summing to < 20
  - E.g., 3 + 7, 5 + 12, 19 – 2, 14 – 8
- Baseline maths test (instructed to perform similar)

Experimental Conditions

Audio Condition	1	2	3 NC1	4 NC2	5 NC1	6 NC2
Single Task	✓		✓	✓		
No Headphone	✓	✓				
Dual Task		✓			✓	✓
NC Active			✓	✓	✓	✓
Brief through speaker	✓	✓				
Brief through headphone			✓	✓	✓	✓
Wideband noise	✓	✓	✓	✓	✓	✓

Results

- No differences between headphones (single – 3 & 4 or dual task 5 & 6) *largest F, F(1, 35) = .048 , p = .494.*
- Single task - NC (7.85) compared to no-NC (5.72), F(1, 35) = 14.93, p < .001.
- Dual task - NC (6.47) compared to no-NC (5.36), F(1, 35) = 13.18 , p = .001.

**Fewer questions answered in dual task than baseline

No difference in error rate (baseline and dual task)**

Results Cont…

- NC (7.85) in single task compared to NC in dual task (6.47), $F(1, 35) = 27.32$, $p < .001$.
- NC (6.47) in dual task compared to single task but no headphones (5.72), $F(1, 35) = 1.89$, $p = .184$.

- Beneficial effects of NC are nullified if user elects to engage in 2nd task
- However, performance no worse than not using headphones (current situation in commercial aviation).

Summary

- No diff between NC headphones
- NC better in single task
- NC better in dual task
- With NC, performance better in single task than dual
- ***NC dual task = no-NC single task ***

- Noise impairs performance
- Increasing the signal to noise ratio improves performance

Summary

- 4 separate studies (to date)
- NC headphones repeatedly better than no headphones
- No difference – NC dual task vs. no headphones
- No difference – NC masking low vs. no headphones

- Noise impairs performance
- Increasing the signal to noise ratio improves performance

Applied Perspective

The challenges for airlines:

- Does a non transmitting PED interfere with sensitive on-board electronic equipment?
- How do you prevent passengers from listening to 'loud' music during the pre-flight safety brief?

In isolation, research suggests:

- current practice is not best practice.

Applied Perspective

- Oral briefing ≠ Informed passenger (e.g., safe)
- Oral briefing = Compliance
- Compliance < Descriptive
- Effective communication = Change in behaviour
- Noise = Distorted/Unclear message

- Reduce noise = Clearly hear (FAA, Part 121 and 135)

Future Research

Active noise reduction and:

- Native language,
- Age,
- Different environments (older or newer aircraft),
- Visual stimuli plus auditory stimuli, and
- Fatigue.

Stimulating the Senses

Human being have evolved to such a degree that we no longer adapt to changes in our environment, but rather adapt our environment to the changes in us (Bowden, 2010).

Present research indicates flaws in our adaption.

These require attention!

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Thank you

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