Fatiguing effect of in-cabin aircraft noise on cognition
Noise research

• Aircraft flyover noise - plethora of research
  – Long-term memory,
  – Reading ability,
  – Comprehension, and
  – Episodic memory.

(Clark et al., 2005; Haines et al., 2001)

• Little is known about in-cabin noise; even less relating to noise and fatigue
Accident report - 1997

Korean Air Flight 801

- CVR evidence indicated that the captain was tired. At the beginning of the approach, the captain made unsolicited comments related to fatigue (p. 149).

- According to his family, the captain slept his normal sleep routine in the days before the accident and had an opportunity to receive adequate rest (p. 149).
Korean Air Flight 801

- The accident occurred after midnight (about 0042) in the flight crew’s home time zone (which is 1 hour behind Guam local time) (p.148).

- On the basis of the time of day, statements recorded on the CVR, and sleep and fatigue research, the Safety Board concludes that the captain was fatigued, which degraded his performance and contributed to his failure to properly execute the approach (p. 150).
Asiana Airlines Flight 214

- Therefore, the NTSB concludes that the flight crew was experiencing **fatigue**, which likely degraded their performance during the approach (p. 86).

- There is no evidence that any of the pilots began their duty period with a preexisting sleep debt or fatigue (p. 85).

- The human body cannot adapt to transiting 8 time zones in the span of 10 hours; therefore, all three pilots were likely fatigued as a result of circadian disruption (p. 86).
Fatigue defined

Biological drive for recuperative rest

(Williamson et al., 2011. p. 499)
Major causes of fatigue

1. Time of day of operation
2. Long duration of wakefulness
3. Inadequate sleep
4. Pathological sleepiness (sleep apnea)
5. Prolonged work hours

(Åkerstedt, 2000. p. 395)
Not as clear as 1st thought

Combination of:
1. Time of day (circadian rhythm), and
2. Sleep deprivation (time since last slept)

(Williamson & Friswell, 2011)
Prevention

Individuals
• Modifying personal lifestyle to allow for adequate sleep.

Organisations
• Modifying rosters or providing opportunity for sleep (or rest).
In-cabin noise levels

Range of aircraft
• B747
• B737
• A321
• MD80
• ATR

[Bar chart showing noise levels during taxi, take-off, and cruise phases for different aircraft types]
In-cabin noise levels

Octave Band Centre Frequencies, Hz
Noise research – continuous noise

- 2hrs of 51 dBA of open-plan office noise

→ Degrades memory for words,
→ Increase self-reported levels of tiredness, and
→ Reduced motivation.

(Jahncke et al., 2011)
Noise research – continuous noise

- 3hrs of 55 dBA of open-plan office noise

↓ Reduced work rate by 3%, and

↑ Increased self-reported fatigue levels.

(Witterseh et al., 2004)
### Australian Standards – recommended noise levels

<table>
<thead>
<tr>
<th>Room Type</th>
<th>Recommended</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Board and conference rooms</td>
<td>30</td>
<td>40</td>
</tr>
<tr>
<td>Cafeterias</td>
<td>45</td>
<td>50</td>
</tr>
<tr>
<td>Call centres</td>
<td>40</td>
<td>45</td>
</tr>
<tr>
<td>Computer rooms</td>
<td>45</td>
<td>50</td>
</tr>
<tr>
<td>Corridors and lobbies</td>
<td>45</td>
<td>50</td>
</tr>
<tr>
<td>Design offices</td>
<td>40</td>
<td>45</td>
</tr>
<tr>
<td>Draughting offices</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>General office areas</td>
<td>40</td>
<td>45</td>
</tr>
<tr>
<td>Private offices</td>
<td>35</td>
<td>40</td>
</tr>
<tr>
<td>Public spaces</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>Reception areas</td>
<td>40</td>
<td>45</td>
</tr>
<tr>
<td>Rest rooms and tea rooms</td>
<td>40</td>
<td>45</td>
</tr>
<tr>
<td>Toilets</td>
<td>50</td>
<td>55</td>
</tr>
<tr>
<td>Undercover carparks</td>
<td>55</td>
<td>65</td>
</tr>
</tbody>
</table>

(AS/NZS 2107, 2000)
# Australian Standards – recommended noise levels

<table>
<thead>
<tr>
<th>6 PUBLIC BUILDINGS</th>
<th>Recommended</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airport terminals—</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Departure lounges</td>
<td>45</td>
<td>55</td>
</tr>
<tr>
<td>Luggage despatch and collection areas</td>
<td>45</td>
<td>55</td>
</tr>
<tr>
<td>Passenger check-in areas</td>
<td>45</td>
<td>50</td>
</tr>
<tr>
<td>Art galleries</td>
<td>40</td>
<td>45</td>
</tr>
<tr>
<td>Auditoriums—</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cabarets and theatre restaurants</td>
<td>35</td>
<td>40</td>
</tr>
<tr>
<td>Concert and recital halls</td>
<td>See Note 5</td>
<td>See Note 5</td>
</tr>
<tr>
<td>Conference and convention centres—</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without sound reinforcement—</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Up to 50 persons</td>
<td>35</td>
<td>40</td>
</tr>
<tr>
<td>From 50 to 250 persons</td>
<td>30</td>
<td>35</td>
</tr>
<tr>
<td>With sound reinforcement</td>
<td>35</td>
<td>45</td>
</tr>
<tr>
<td>Drama theatres (see Notes 5 and 8)</td>
<td>25</td>
<td>30</td>
</tr>
<tr>
<td>Exhibition areas</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>Cinemas (see Notes 5 and 8)</td>
<td>30</td>
<td>35</td>
</tr>
<tr>
<td>Opera halls</td>
<td>See Note 5</td>
<td>See Note 5</td>
</tr>
<tr>
<td>Theatres for operetta and musical plays</td>
<td>See Note 5</td>
<td>See Note 5</td>
</tr>
</tbody>
</table>

(AS/NZS 2107, 2000)
Noise research – continuous noise

(Molesworth et al., 2014)
Current study – Aim

1. Does in-cabin aircraft noise at 80 dBA for 83 min degrade recognition memory?

2. Do active noise attenuation headphones (attenuate noise by 20 dBA) mitigate these effects?

3. Is there a relationship between language background and the effects of in-cabin aircraft noise on recognition memory?
Current study – Participants

- 84 university students (48 female)
- 42 non-native English speaker
- Average age = 22 years
- All with normal hearing
Current study – Procedure

3 groups

1. No noise (quiet)

2. No hearing protection + 80dBA noise

3. Noise cancelling headphones + 80dBA noise
Current study – Procedure

- Watch animated video – subtitles
- 80dBA of reproduced aircraft noise for 83 minutes
- Complete recognition memory test:
  1. Prior, and
  2. After noise
Recognition Memory Test

• 90 seconds of information about aircraft
• Example:
  “it has a double-bubble fuselage design and according to the manufacturer this provides passengers with an extraordinary amount of personal space”.

The same sentence appeared in the written script, except with three options for one word.

“it has a double-bubble fuselage configuration/ design/ uncertain and according to the manufacturer this provides passengers with an extraordinary amount of personal space”.

UNSW AVIATION
Current study – Results
Current study – NS vs. ESL

Main effect for language background \((F(2, 78) = .567, p = .570, \eta_p^2 = .014.)\)
Summary

- 80dBA of reproduced aircraft noise for 83min degraded recall performance
- Noise cancelling headphones alleviated some of the effects*

*Noise cancelling headphones reduce noise by ~ 20bBA
Summary

- Prolonged exposure to noise can be fatiguing
- Noise adversely affect recognition memory
- Recognition memory is used extensively in pilot operations
  - ATC instructions
  - Checklists
  - Decision-making
Noise and Fatigue - why

2 theories (similar effects)
1. All sounds are processed
2. Stimulates arousal

= Cognitively taxing
Noise and Fatigue – cognition

• All sounds are processed cognitively, including, noise and the target sounds
• The processing of noise consumes limited capacity of working memory
• Consumes energy resulting in depletion of resources.
• Results – reduction in performance
Noise and Fatigue – increase arousal

• Noise stimulates arousal
• Increased arousal is cognitively taxing
• Consumes energy resulting in depletion of resources.
• Results – reduction in performance
Noise and fatigue - summary

• Precise reason – unknown
• Noise is fatiguing
• Adversely affects performance
• Working memory vulnerable to noise effects
Thank you

Questions?

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