Fatiguing effect of noise in aircraft on cognitive and motor performance

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ABSTRACT

Pilots, cabin-crew and their customers are exposed to varying levels of aircraft noise throughout each flight. Aircraft noise, as little as 65 dBA which is present during the taxi phase of a commercial flight, is known to adversely affect individuals' performance in terms of information recall. However, what remains unknown is the effect of aircraft noise, comparable to that experienced in the cabin of a commercial aircraft, on motor performance as well as other cognitive functions. This research sought to examine this by testing working memory, simple reaction time and vigilance after exposure to in-cabin simulated aircraft noise at 80 dBA for 83 minutes. The results do not give any clear indication of a reduction in performance for such noise exposure over that time period.

INTRODUCTION

There has been an aim by manufacturers of passenger aircraft to achieve a 'quiet cabin' for the comfort of staff and passengers. Some reductions in the internal cabin noise have been achieved with the adoption of noise control technology. However it will take some time for all current passenger aircraft to be replaced, so until then cabin crew and passengers will spend long periods in an environment which is not likely to cause hearing damage but is well above acceptable noise levels for most work and relaxation activities.

Measurements by the authors in the passenger cabins of a range of current aircraft including Boeing 747, 737, MD80, Embraer, and ATR turbo propeller commercial aircraft during cruise were found to range from 74 to 85 dBA depending on aircraft type, operation and seat location. During take-off and landing the noise levels would be higher than these values measured during some climbing but mainly cruise. These levels are in agreement with the findings of Ozcan and Nemlioglu (2006). For comparison the guidance for acceptable noise levels for general offices is 40 and 45 dBA (Standards Australia, 2000). So for passengers seeking to work during the aircraft journey or undertake tasks immediately after the journey, the background noise during cruise is at least 30 dB higher than would normally be considered acceptable for a typical working environment.

A number of studies have investigated the effect of different levels of noise and the type of noise on performance and to a lesser extent on fatigue (eg see Banbury, et al, 2001). For example Saeki et al (2004) showed some effect of noise on fatigue and on performance in noise levels of only 55 dBA presented for reasonably short times; 6 min for some tests. Conversely Smith et al (2003) showed little or no effect from noise at 72 dBA for 70 hours on subjective indices relating to the fatiguing effect of noise or on various measures of performance. In their paper on the effects of noise of

various durations (20 to 240 minutes), Ryherd and Wang (2007) undertook a range of studies using noise levels ranging from 39 to 51 dBA but with different spectral content. Their findings showed little between the noise conditions, but some differences in perception. They also commented that

> "*While intuition and previous research would suggest that the time length in which a task is to be performed is important, the pool of research examining the impact of time length of exposure to noise on performance and annoyance is limited and contains conflicting results*."

It is clear from the diversity of findings that it is important to define the context and the intention of the study as these have influence on the type of noise that is presented, the duration of the noise and the tasks undertaken either during or after the exposure to the noise. The study reported in this paper was related to the aviation context. It sought to investigate the effects of fatigue on performance for subjects exposed to a noise representative of an aircraft cabin over a period comparable to a moderate flight time and to assess if there was any benefit from the use of noise cancelling headphones in that noise environment. Previous studies by Molesworth and Burgess have shown the benefits of the use of noise cancelling headphones in such noise levels (for example Molesworth et al 2013)

METHOD

The study was approved in advance by the UNSW Ethics Panel prior to commencement. A one-way factorial design was used incorporating continuous noise as the independent variable (no noise, noise at 80 dBA, and noise at 80 dBA with the use of Sennheiser px 450 active noise attenuation headphones). To replicate the type of noise in an aircraft cabin, the noise source was a broadband noise with no distinguishing characteristics. For the no noise condition, the noise level inside the room with only computers operating was found to be, in terms of $L_{eq,1min}$, 38 dB(A).

The dependent variables were performance on three different tasks: a working memory task examining both forward and backward digit recall, a reaction time task and a vigilance task. For all statistical procedures, test assumptions of normality and homogeneity of variance were examined and corrected if required; alpha was also set at .05.

Seventy-two university students (39 female), with an average age of 22.3 (SD= 3.87) years participated in the research. All participants were checked first to ensure that their hearing was within what is considered the 'normal' range (i.e. any loss in either ear at any frequency less than 20 dB(A)). Participants were then asked to complete three experimental tests (working memory, reaction time and vigilance test), presented in a counterbalanced order. After the three tests, they watched a video with subtitles and no audio, followed by a final test sequence, involving the same three tests that were conducted prior to the video. At the completion of the last test they were reimbursed with a $40 bookshop gift voucher. The total duration of the study was approximately two hours.

The working memory test was designed to measure the storage capacity of individual's working memory. It comprised two separate parts. The first involved presenting participants visually a series of digits one at a time and after the last digit disappeared from view, they were tasked to recall all digits. The task started with a few digits and repeated with increasing number of digits until they were no longer

recalled correctly. The backward digit task worked similarly to the forward digit task, except once the last digit disappeared from the screen participants had to recall the digits in the reverse order to which they were presented. Again the highest number of digits that were correctly recalled was the score.

The simple Reaction Time test required participants to depress the spacebar on a computer keyboard once a red circle appeared on a screen. The red circle appeared 20 times over a period of approximately 2 minutes.

The Mackworth Clock test (Mackworth 1964) studies the effects of vigilance on the detection of signals. It involves watching a moving pointer around a circle and identifying when the point makes a double jump. The number of times the circle missed a pointer was four and the duration of the test was approximately 1 minute.

Participants were randomly assigned to one of three groups (no noise, broadband continuous noise at 80 dBA without hearing protection, and broadband continuous noise at 80 dBA with noise cancelling headphones). The participants watched an animated video with English subtitles for 83 minutes. The audio volume for the video was turned down as far as possible with the control on the player. Even in the no noise condition no sound from the video sound track could be heard. At the conclusion of the video, participants completed the three tests presented in a counterbalanced order. The total time to complete the research was 2 hours.

RESULTS

One aim of the present research was to examine the fatiguing effect of noise, comparable with that in a commercial aircraft cabin over a time period typical for a short haul intercity journey. A second aim was to assess if a simple countermeasure, such as use of noise cancelling headphones, could reduce any of these effects. A mixed repeated measures ANOVA was performed on the results for the three main tests.

Working Memory: Forward Digit Recall and Backward Digit Recall

The analysis revealed no statistical difference between the scores in the before and after conditions between the three groups. That means there was no evidence of a reduction in performance of the groups exposed to the noise compared to the no noise group. In the first test, the average score for forward digit recall was 8.1 compared to 8.3 in the test after the video. The scores for the backward digit recall were 7.5 before and 8.0 after the video. So for all the groups there was a small increase in the performance after the video which may be attributed to learning the technique for the test.

Reaction Time

The analysis failed to reveal any statistical difference between the scores in the before and after conditions between the three groups. The average time taken for participants to respond was 319.9 ms in the first test and 314.0 ms in the test after the video. So for all the groups there was a small decrease in reaction time, ie a small increase in the performance, after the video which may be attributed to learning the technique for the test.

Vigilance Task

The analysis failed to reveal any statistical difference between the scores in the before and after conditions between the three groups. For all the groups there was a small increase in hit rate. In the first test, the average number of correct detections was 3.7 compared to 3.9 in the test after the video. This improved performance, after the video may be attributed to learning the technique for the test.

While the findings from the three tests showed that after the 83 minutes of the video there was no statistical difference on performance between the groups, there was some evidence for a trend towards better performance for those in the two noise exposure groups. The data in Figure 1 for the Backward Digit Recall Task shows the trend for the backward digit recall task and similar trends were observed in the data for the other tests. This would support findings that the presence of noise may have an arousal effect (Cassidy and Macdonald, 2007)

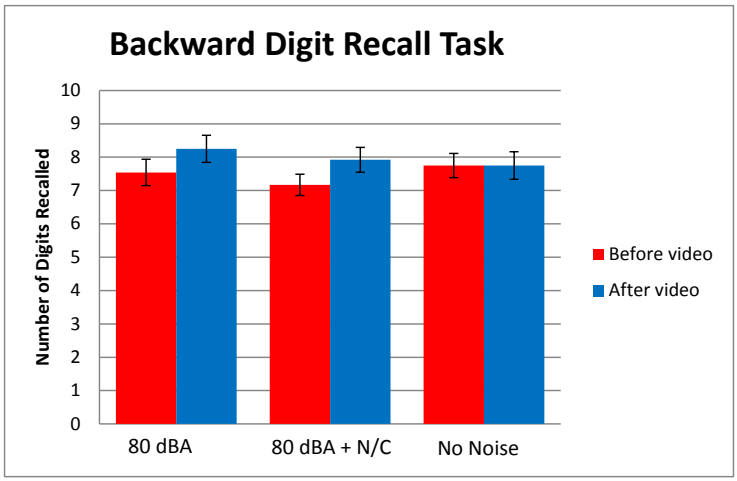

Figure 1: Comparison of results across the groups for the Backward Digit Recall Task

CONCLUSION

The main aim of the present research was to investigate the relationship between noise and fatigue on performance. The results revealed that the effect of being exposed to noise representative of that present during a short-haul inter-city flight, had no noticeable effect on the three performance measures under investigation. There was a small improvement in performance across the groups for the second test which may be attributed to learning technique. There was also a trend toward an improved performance for those exposed to the noise which may result from an arousal effect from the noise. While the subjective comments from many exposed to in-cabin noise during flights indicate a feeling of fatigue, the findings from this study show no such effect. They do however support the comments from Ryherd and Wang (2007) about intuition and conflicting results from such studies.

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