

QUANTIFYING THE EFFECT OF IN-CABIN NOISE ON COGNITION

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Abstract

Noise, defined as loud or unwanted sound is ubiquitous in the cabin of a commercial aircraft during flight. While the health effects of noise above the noise damage threshold are well known, little is known about the effects of noise at levels typical during flight. What is known, is that all sounds, including unwanted sound (i.e., noise), are processed cognitively. The cognitively taxing nature of noise has the potential to adversely affect cognition, and by extension, performance in safety critical domains such as aviation. This paper presents the findings of three separate research studies designed to examine the effect of noise on cognition. Employing sound scientific methodologies, the research reveals noise at levels common during the cruise phase of a commercial flight (i.e., 75dBA), adversely affects recognition memory. Working memory, including linguistics, grammatical reasoning and mathematical problem solving appear to be immune from the noise effect. The noise effect, however, was most pronounced for non-native English speakers. Incentives, in the form of monetary reward failed to offset the adverse effect of noise on cognition. These findings have important implications for the aviation industry, and highlight the importance of reducing as much as possible, noise levels within the cabin, and the need for robust redundancies to capture or mitigate the negative effects of noise on pilot cognition.

Keywords: Aircraft Noise, Safety, Human Factors, Cognition, Memory

1. Introduction

Noise is defined as sound that is unwanted [2]. The effect of noise on human health is well documented [11]. In regard to protection of hearing in the workplace from excess noise, international and national legislation and regulations define noise limits to protect hearing in the workplace (i.e., 85 to 87 dBA for 8 hours; [5]). For exposure to community noise, international and national regulations and guidelines provide guidance limits for a range of noise sources (typically 40 to 55 dBA in the home) to reduce health effects, such as annoyance, sleep disturbance, and cardiovascular disease [13]. However, there is limited research examining the effect of noise on factors other than human health, such as cognition and performance [14].

Great efforts are made by aircraft manufacturers to reduce the noise both for the crew and passengers but there is a limit to how much the noise levels can be reduced with current technology and materials. Thus an understanding of the effect of noise on cognition and performance is important, since in aviation, noise levels within an aircraft during cruise are reported to be as loud as 80dBA, while during taxi noise levels typically average 65dBA [3, 7, 10]. In-cabin aircraft noise can be described as pervasive and insidious due to its prolonged, continuous and unavoidable existence. However, there is limited research examining the effect of noise inside aircraft on cognition and performance, while being below the threshold for workplace noise and risk of hearing damage. Therefore, the aim of the present paper is to present the results of three studies that have directly examined the effect of in-cabin aircraft noise (reproduced in a simulated environment) on cognition, including, working memory, attention, reaction, and decision-making.

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All sounds, including noise are processed cognitively [4]. This is evident through the 'Cocktail Party Effect' where an individual can detect a single voice in a noisy environment, and at the same time attend to perceived relevant information such as their name. Humans process all sounds in working memory [1]. Working memory is known to be limited in capacity. The processing of noise, namely unwanted or distracting sounds, therefore, is cognitively taxing [6]. The effect of noise on cognition is more pronounced for individuals whose native language is not aligned with the target stimuli [12]. In high hazard or safety critical environments, such as aviation, where not all personnel are native English speakers (the language used throughout aviation), ensuring key personnel, such as pilots and crew are free from unnecessary burdens is important.

This paper summaries the findings of three studies that examine the effect of simulated in-cabin aircraft noise on cognition, such as working memory, recognition memory, attention and decision-making.

2. Findings

2.1 Comparison Between Effects Noise and Blood Alcohol Level

'Molesworth, Burgess and Zhou' [8] examined the effect of simulated in-cabin aircraft noise (broadband noise) at 75dBA, on individuals' recognition memory, working memory and reaction time. The results were compared to the effects of a widely known and common metric for the same skill, namely blood alcohol concentration. This effect was examined for both native English speakers and non-native English speakers. Thirty-two participants completed the research, half of which were non-native English speakers. Using a mixed repeated measures design, the results revealed 75dBA of simulated aircraft noise affected recognition memory only. The detriment in performance was more pronounced for non-native English speakers than native English speakers. They also compared performance effects of broadband noise at 75 dBA and performance with a blood alcohol concentration (BAC) level of 0.05 and 0.10. The effect of noise at 75 dBA was found to reflect performance detriments equivalent to a BAC intoxication level of 0.05.

2.2 Comparison Between Effects of Broadband and Babble Noise

'Molesworth, Burgess and Wilcock' [9] examined the effect of simulated in-cabin aircraft noise (broadband noise) and noise typically present in workplaces or at a cafeteria (i.e., babble) at both 55dBA and 65dBA, on individuals' recognition memory (measured using cued recall task) and three types of working memory, namely linguistics (measured using a Letter Span Task – LSPAN), grammatical reasoning (measured using a grammatical reasoning task) and mathematical problem solving (measured using a C-Span task). Forty participants completed the research, half of which were non-native English speakers. Using a mixed repeated measures design, the results failed to reveal any effect with 'babble' noise at either noise level and for either recognition memory or any of the three working memory conditions. Noise effects were present with simulated in-cabin aircraft noise, however, limited to only 65dBA and for recognition memory only. 65dBA of broadband noise degraded recognition memory by as much as 15%.

2.3 Effect of Noise on Dynamic Decision-Making Performance

'Zhou, Molesworth, Burgess and Hatfield' [15] examined the effect of simulated in-cabin aircraft noise (broadband noise) at 75dBA on individuals' dynamic decision-making performance, and whether monetary incentives and sex moderate the effect. Dynamic decision-making is a process of making multiple independent decisions, where the outcome of the proceeding decision affects the state and factors of the subsequent decision. Effective dynamic decision-making is particularly important for safe operations within safety critical workplaces such as aviation, medicine and firefighting. Forty-eight participants completed the research, half of which were female. The monetary incentive was based on a quota scheme, with the upper limit for the incentive payment set at AU$100. Using a mixed repeated measures design, the results revealed that in ambient noise, males' dynamic decision-making performance was superior to their female counterparts, while in simulated in-cabin

aircraft noise, this sex difference disappeared. In other words, the presence of broadband noise eliminated any performance improvement observed for males in the ambient condition. Incentives, in the form of monetary reward had no effect on dynamic decision-making performance, nor was there an interaction between noise and monetary incentives.

3. Conclusion

In-cabin aircraft noise is ever present for pilots, cabin crew and passengers. While the effect of noise at levels known to cause hearing damage are well known, its effect on cognition and performance at a level reflective of the work environment for pilots and cabin crew remain largely unknown. The above-described research highlights the detrimental effect of in-cabin aircraft noise on cognition, such as recognition memory and dynamic decision-making. Simulated in-cabin aircraft noise at levels as low as 65dBA, reflective of the taxi phase of flight, was found to adversely affect recognition memory. At 75dBA, the same noise adversely affected recognition memory and removed any sex advantage seen for males with dynamic decision-making. The noise effect was also more pronounced for non-native English speakers, and this effect was equivalent to being intoxicated with a BAC of 0.05. These finding illustrate the need to continue efforts to reduce noise levels within the cabin of an aircraft and improve the auditory environment in which pilots and cabin crew operate. They also indicate that there needs to be particular attention during training to raise the awareness of the effect of noise, and operational systems are designed to mitigate any negative cognition and memory effects from noise.

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