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Improving communication in general aviation through the use of noise cancelling headphones

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ABSTRACT

General aviation pilots are required to receive and provide instructions over the radio and this is often in a noisy environment. Therefore, the main aim of the present research was to investigate an aspect of the effects of noise on communication performance in general aviation. Specifically, the present research tested the beneficial effects of noise cancelling headphones in order to reduce miscommunication errors. Since English is the international language of aviation, the present study also examined the effects of noise cancelling headphones with non-native English speakers. Employing a repeated measures design with two independent variables (hearing condition and audio condition) and one between groups independent variable (native language), the results revealed the beneficial effects on noise cancelling headphones on performance. The results also highlighted differences between native and non-native English speakers. These results are discussed from both an applied and theoretical perspective.

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1. Introduction

The effect of noise on performance is widely studied. Noise (auditory), otherwise referred to as unwanted sound has been shown to: affect mood (Vastfjall, 2002), cause hearing impairment (Daniel, 2007; Cruickshanks et al., 2010), induce stress (Taffinder et al., 1998), cause fatigue (Picard et al., 2008), alter health state (Gangwisch et al., 2006), negatively impact memory (Sorqvist, 2010), and increase error rate (Weinger and Ancoli-Israel, 2002). Within General Aviation (GA) it is the latter of these that is of particular concern. Moreover, pilots in GA are exposed to noise generated from the power source which is commonly located directly in front of the cockpit as well as radiated from the surfaces of the cockpit enclosure (Antunano and Spanyers, 2000). In an attempt to reduce the effect of external noise on communications, GA pilots and their passengers commonly use a headphone that includes some capacity to reduce external noise.

General aviation headphones can be divided into two categories based on the method of hearing protection provided. Passive noise reduction headphones offer hearing protection by providing well designed and good fitting cups that seal around the ear to reduce noise entering the ear canal. Active Noise Reduction (ANR) or noise cancelling headphones attempt to reduce the noise level at the ear canal by producing a sound that is 180° out of phase with the original sound so that the combination leads to a cancellation of the noise (Nelson and Elliott, 1992). This active noise cancellation is more effective in the lower frequencies of sound. Commonly, ANR headphones are also designed to include passive noise reduction, which is more effective at the higher frequencies. However, there appears to be limited research examining the effectiveness of these headphones in GA in order to reduce the effect of noise on pilot performance. Therefore, the main aim of the present research was to examine the effectiveness of ANR headphones in improving individuals' performance in terms of communication in the presence of noise typical of that experienced in a GA cockpit.

Miscommunication in GA within Australia has been highlighted as a series safety concern (Civil Aviation Safety Authority – CASA 2009; Estival and Molesworth, 2009, 2012). In a pen and paper study with over 80 GA pilots from various aerodromes in eastern Australia, Estival and Molesworth (2012) found that pilots felt 'communicating with other pilots' to be the most difficult communication task. This was rated above other tasks such as 'remembering what you have to say' (rated 2nd), 'reading back' (rated 4th) and 'saying what you have to say' (rated 5th). Pilots rated 'communicating with Air Traffic Control (ATC)' as the third most difficult. According to Estival and Molesworth, pilot-to-pilot

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communication is particularly challenging because of the background noise present for both the transmitter and the receiver.

In an earlier and smaller study with 36 pilots, pilots also rated the issue of pilot-to-pilot communication as problematic (Estival and Molesworth, 2009). However, qualitative comments elaborating on this problem centered on communicating with non-native English speaking pilots. This problem does not appear to be unique to GA, as an earlier study targeting commercial pilots and air traffic controllers identified similar trends (EUROCONTROL, 2006). Controller accent was rated as the leading contributing factor for communication errors with ‘frequency changes’ and ‘call-signs’ (51% and 34% respectively). However, the extent to which this problem is compounded by noise remains unknown. What is clearer is that as the signal to noise ratio decreases, performance in terms of intelligibility decreases (Killion et al., 2004). According to Shimizu and colleagues, the effect of noise on performance is exacerbated for non-native speakers (Shimizu et al., 2002). Therefore, increasing the signal to noise ratio by reducing noise has the potential to alleviate miscommunication errors.

Noise cancelling technology has shown promise in reducing the negative effects of noise on performance in aviation. Within the laboratory, ANR technology employed in military helmets have been shown to attenuate as much as 6 dB of A-weighted noise when compared to passive style ear muffs (Pääkkönen and Kuronen, 1998). During flight, these helmets have been shown to attenuate as much as 8 dB of A-weighted noise compared to passive noise reduction helmets. Subjective reports from pilots reflect favourably on ANR technology with pilots claiming that ANR technology made radio communications louder and more clear (Pääkkönen et al., 2001). Similar results have been obtained in the passenger sector of commercial aviation. Moreover, in a study examining intelligibility differences between passive headphones and ANR headphones, Molesworth and Burgess found that using ANR headphones increased the recall and accuracy of information presented (Molesworth and Burgess, 2013).

Therefore, the main aim of the present study is to examine the effects of ANR headphones within GA. Since noise is said to affect non-native English speakers more than their native speakers counterparts, the present study will examine if ANR headphones improve performance similarly for both speakers. What is less ambiguous is the effects of ANR headphones on performance. Therefore, it is hypothesized that ANR headphones will reduce communication errors when compared to passive noise reduction headphones.

2. Method

2.1. Participants

32 participants (11 female) were recruited for the study. Participants were recruited from the general student population at the University of New South Wales (UNSW), UNSW Aviation flight programme and flight training schools located at Bankstown aerodrome. Participants included individuals with formal pilot licenses (22 pilots), as well as individuals from non-native English speaking backgrounds (16 participants). The mean age of the participant was 21.97 (SD = 7.66) years. All participants were reimbursed with a $20 bookshop voucher. The research was approved in advance by UNSW Ethics Panel.

2.2. Design

The study comprised of a $2 \times (2 \times 2)$ mixed methods experimental design with the addition of a baseline condition. Native language was the between groups independent variable (native English vs. non-native English), with hearing condition (active noise cancelling vs. passive noise cancelling) and audio condition (monosyllabic words vs. aviation specific words) as the two repeated measures independent variables. The baseline condition was employed to test performance in ideal conditions (quiet location). The dependent variables included the number of correct responses to the speech stimuli represented as 50 different aviation read-back scenarios (maximum possible correct 75), and the number of correct responses on 50 Central Institute for the Deaf (CID) W-22 monosyllabic phonically balanced words (maximum correct 50). All stimuli, including aviation read-back scenarios and monosyllabic word lists were presented in a balanced Latin Square design.

2.3. Materials and apparatus

The laboratory apparatus comprised of: a Lightspeed Zulu General Aviation Active Noise Cancelling Headphones, David Clark H10-80 passive noise reduction headphones, two personal computers, Bruel and Kjaer sound level meter type 2250 (used to measure sound levels in Cessna 172 during flight), Casella USA CEL-240 sound level meter (used to set sound level in research laboratory), NGARA sound acquisition system (used to record sound in Cessna 172 during flight), Sony ICD-P620 digital voice recorder, and a Logitech 5.1 surround speaker system (used to reproduce aircraft noise in laboratory).

The material comprised: an information sheet, a consent form, a demographics questionnaire, three audio files each containing 50 (total 150) different audio scenarios/statements between air traffic control and pilots (aviation phrases) relating to a phase of flight and their respective fill-in-the-blanks written tests, and three different audio files each containing 50 (total 150) monosyllabic words derived from CID W-22 monosyllabic word lists. Specifically, the aviation phrases were common flight instructions from air traffic control to pilots which always included an aircraft call sign (ABC in following example) followed by instructions. For example, ‘Alpha Bravo Charlie, descend and maintain 2000 feet’. These recordings were produced by a subject matter expert with 27 years experience in air traffic control (native English speaker). Accompanying each aviation phrase was a written dialogue of the transmission and on every odd phrase one word was missing, while with every even phrase two words were missing – total 75 items missing. The task for the participants was to complete the missing items. The research was conducted in a quiet room; noise levels in the room without participants and only computers operating were found to be at 38 dB(A).

The noise generated from a 1974 Cessna 172 during cruise was measured using a Bruel and Kjaer Sound Level Meter type 2250 and an ARL Ngara noise logger. The microphone of the noise logger was positioned near to the ears of the seated co-pilot and the noise level data stored. The values for $L_{Aeq,1min}$ for 1 h from departure through cruise to landing are shown in Fig. 1. This shows that typically the noise level during cruise was close to 95 dB(A). The sound level meter was held by the co-pilot and used to obtain samples of the frequency spectrum of the noise during the cruise. Each sample was approximately 1 min duration and the overall L_{Aeq} values were similar to those obtained during cruise from the noise logger. Frequency spectra in terms of the 1/3 octave bands from three samples are shown in Fig. 2. These spectra show the sound energy is predominantly in the frequency range below 1000 Hz.

2.4. Procedure

Participants were recruited using both internal and external advertisement within the University of New South Wales and at flying schools located at Bankstown Airport. Participants were

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