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

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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.

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 $L_{\mathrm{Aeq,1min}}$ 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

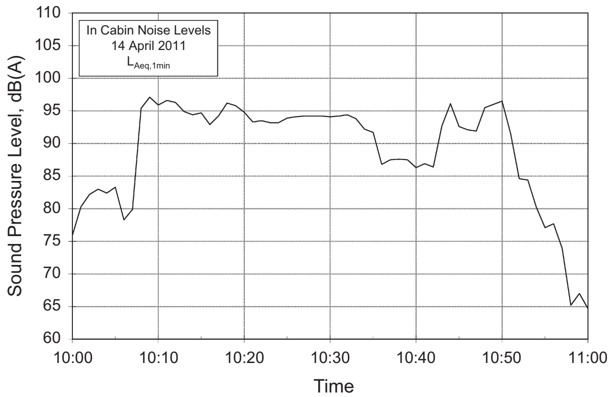

Fig. 1. $L_{Aeq,1min}$ values for the 1 h flight in the Cessna 172 from departure through cruise to landing.

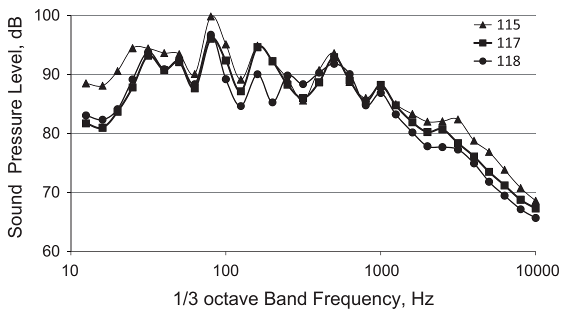

Fig. 2. Frequency spectra in terms of the 1/3 octave bands from three samples obtained during 1 h flight in Cessna 172.

tested individually and initially asked to read the information sheet and complete the consent form, followed by the demographics questionnaire (age, gender, and native language). Following this, participants were provided with two different listening tasks and two different headphone conditions (presented in a counterbalanced order) along with a quiet baseline condition (half of the participants completed the baseline condition prior to the experiment while the other half completed this after the experiment). In the monosyllabic word test, participants were asked to listen to the recorded speech stimuli, which consisted of 50 phonetically balanced monosyllabic words (e.g., ace, end, his, jump, shoe, wood) with the carrier phrase "You will say ...". Participants were provided approximately 3 s to state the word they just heard. All words were recorded for analysis (words recorded on the Sony handheld digital recorder). This was repeated for both headphones conditions.

For the aviation phrase task, participants were asked to listen to the prerecorded aviation phrases, which consisted of 50 aviation ATC instructions. For example, "Tango Hotel Oscar – Climb to **7500**, watch for traffic at 9 O'clock", or "Juliet **Hotel** Kilo – Traffic 2 O'clock, climb to **3000** feet report passing 1000". Items given in bold in these examples were removed and participants had to recall these items.

Between each phrase participants were given approximately ten seconds to complete the accompanying fill-in-the-blanks answer sheet (written). Each fill-in-the-blanks exercise contained the aviation phrase with between one and two random words missing. This was repeated in both headphones conditions. For both audio conditions (monosyllabic and aviation phrases), participants were allowed to set the desired volume level, consistent with what occurs presently within the aviation industry.

The audio (monosyllabic and aviation phrases) and listening (noise cancelling and non-noise cancelling) conditions were presented in a counterbalanced order, as per a Latin squares experimental design. During each listening task (except the quiet baseline condition) continuous aircraft noise was produced from the sound source. This was produced from the digital audio file recorded in the Cessna 172 during flight (recorded using NGARA sound acquisition system), as referred to above. The level at ear of the subject was adjusted to be comparable with the level measured during the flight. In cockpit noise for a Cessna 172 was chosen because this type of aircraft is widely used as a training aircraft in general aviation within Australia. In fact, a search of the Civil Aviation Safety Authority's (CASA) aircraft register database revealed there are more Cessna 172s in Australia than any other GA aircraft. At the conclusion of the study, participants were thanked for their time and provided with a $20 bookshop gift voucher.

3. Results

3.1. Pre-test screening

Prior to analysing the results in relation to the main aim it was important to determine if any participant had a hearing deficit that would negatively impact on the results. Since prior to obtaining any pilot licence, all applicants need to undergo extensive health tests, including a hearing test, only those participants who were not pilots were tested. Using a software based audiometric screening procedure, the results revealed all participants had hearing within what is considered the 'normal' range (i.e. any loss in either ear at any frequency considerably less than 20 dB(A)).

Having established all participants had no hearing deficit, data from the audio tests (monosyllabic and aviation phrases) were analysed. The number of correct answers on the aviation phrase tests was calculated. The maximum score a participant could obtain on the aviation phrase test was 75. For the monosyllabic word tests, audio recordings were first reviewed by the main researcher. Any recording that was not clear was then reviewed by an independent researcher. 100% consensus was achieved. A 10% sample of all recordings was then reviewed by a second independent researcher to ensure data integrity. In terms of the monosyllabic word test, the maximum score a participant could obtain was 50.

3.2. Audio tests

Scores from the two different audio conditions (monosyllabic words and aviation phrases) under two different hearing conditions (noise cancelling and non-noise cancelling headphones) were analysed using a mixed repeated measures analysis of variance (ANOVA), with native language as the between groups factor (native English and non-native English language). However, prior to the conduct of this analysis, it was important to ensure that the ANOVA test assumptions were not violated. Employing the Interquartile Range technique (1.5 $\times$ IQR rule for outliers) to identify potential outliers, as proposed by Moore et al. (2012), it was determined that three from the six data sets contained potential outliers (score/s more than 1.5 $\times$ IQR above the third quartile or below the first quartile). The data points in question were transformed through a process involving the next highest score less one, as recommended by Tabachnick and Fidell (2013). In total seven scores were transformed and included one from the Baseline Monosyllabic condition, two from the Non-Noise Cancelling Monosyllabic condition and four from the Monosyllabic Noise Cancelling condition. With the ANOVA test assumptions satisfactory, and alpha set at .05, the results revealed a main effect for 'hearing condition', $F(1,30) = 6.11$, $p = .02$, $\eta^2 = .169$, whereby using the noise cancelling headphones produced a higher average score ($\bar{x} = 49.50$, S.E. = 1.08) compared to the non-noise cancelling headphones ($\bar{x}$ = 47.25, S.E. = 1.34).

No main effect was evident for ‘audio condition’, $F(1,30) = .241$, $p = .63$, $\eta^2 = .008$, neither was there an interaction between the variables (hearing condition and audio condition), $F(1,30) = .81$, $p = .38$, $\eta^2 = .026$. However, the tests of between-subjects effects revealed a statistically significant difference between native language, $F(1,30) = 5.14$, $p = .03$, $\eta^2 = .146$. Native English speakers were able to recall and repeat on average more correct words ($\bar{x}$ 50.94, S.E. = 1.60) than their non-native English speaking counterparts ($\bar{x}$ = 45.81, S.E. = 1.60).

As illustrated in Table 1, the results suggest that for native English speakers, the monosyllabic words were easy to identify and repeat (average percent correct = 97.58%), almost irrespective of hearing condition. Non-native English speakers also found the words relatively easy to identify and repeat $\bar{x}$ = 94.92%). However the aviation phrases were found to be more difficult than the monosyllabic words as shown by percentage correct for both groups. When comparing between groups, it is clear that the native English speakers ($\bar{x}$ = 69.94%) found these easier than their non-native English counterparts ($\bar{x}$ = 59.66%). This suggests differences between groups in terms of English Language proficiency.

As can also be seen in Table 1, when presented with aviation phrases in the presence of noise the native English speakers were able to recall more correct words using noise cancelling headphones (74.42%) than in the quiet condition without any headphones (baseline condition; 67.75%). In order to determine if these results reflect normal fluctuations around the mean or are indeed different, a paired sample test was employed. With alpha adjusted to .017 (Bonferroni adjusted .05/3) due to the repeated use of the dependent variable, and assumptions of normality met, the results failed to reveal a statistically significant difference between the baseline condition and the noise cancelling condition, $t(15) = -2.16$, $p = .048$. At first glance, this result appears to reflect positively on noise cancelling headphones as it suggests that they reduce the effect of noise to a level where performance is comparable to a situation where no noise is present. However, given that performance in the non-noise cancelling condition was similar (0.08% difference) to the performance in the baseline condition (no noise and no headphones), if the same analysis was to be performed between the non-noise cancelling condition and baseline condition, a similar result and hence conclusion could be drawn. What is clearer however, is the advantage of noise cancelling headphones over non-noise cancelling headphones in the presence of noise for native English speakers, $t(15) = -2.79$, $p = .014$.

3.3. Pilots vs. non-pilots

Since the origins of this project stem from aviation and the challenges pilots experience communicating during flight, a series of ANOVA were performed in order to determine if the pilots in the present study performed similar to the non-pilots. Due to the small samples size, a series of non-parametric ANOVA alternates were performed, the Mann–Whitney U Test. The first test involved comparing between groups (pilots vs. non-pilot) on the two baseline tests. Recall, baseline tests were performed using both the monosyllabic and aviation phrases in order to provide some indication of performance in the most ideal condition. With alpha set at .05, the results failed to reveal a statically significant difference between group (pilot vs. non-pilot) and score on the monosyllabic test as well as the aviation phrase test for native English speakers, smallest z (N = 16) = 5.50, p = .059 (see Table 2). However, a statistically significant difference was revealed between group (pilot vs. non-pilot) on the aviation phrase test for non-native English speakers, z (N = 16) = 12.50, p = .044 (see Table 3). No differences were observed between groups on the monosyllabic test for non-native English speakers, z (N = 16) = 22.00, p = .297.

In order to determine if this difference observed on the baseline test with the aviation phrases, was reflected in both test hearing conditions (noise cancelling and non-noise cancelling), a further two Mann–Whitney U Tests were performed. With alpha set at .025 (Bonferroni adjusted .05/2) the results revealed a statistically significant difference between group in the non-noise cancelling condition z (N = 16) = 5.00, p = .005. The mean rank for pilots was 11.44 (N = 9) and for non-pilots 4.71 (N = 7). No statistically significant results were observed in the noise cancelling condition, z (N = 16) = 23.00, p = .367. These findings indicate that non-native English speaking subjects who are not pilots understand aviation specific phrases better when using noise cancelling headphones.

Finally, a series of correlational analyses were performed using the two baseline tests to examine if a relationship exists between performance on the two tests and years speaking English for the non-native English speakers. The results of two Pearson product-moment correlations failed to reveal a significant relationship between performance with monosyllabic words and years speaking English, $r(16) = -.047$, p = 854, and between performance with aviation phrases and years speaking English, $r(16) = .610$, $p = .138$. These results were consistent with the pilots in this group, $r(9) = .001$, $p = .997$ (monosyllabic), $r(9) = .293$, $p = .444$ (aviation phrases). These results suggest that the years in which the individuals had spoken English had little impact on their performance. A result which could be an artefact from the experiment, namely the sample from which the population was drawn (English speaking university with English language proficiency entry requirements).

4. Discussion

The benefits of noise cancelling headphones have been demonstrated in commercial aviation for use with passengers during the pre-flight safety brief (Molesworth and Burgess, 2013; Molesworth et al., 2013). The benefits of noise cancelling technology extends beyond commercial aviation and includes other noisy environment such as manufacturing (Berger, 2002; Pääkkönen et al., 2001). However, there appears to be limited research about their use within general aviation. General aviation is typically characterised (although this is changing) by old aircraft. Within Australia, the average age of an aircraft employed in general aviation for training is 24.2 years (BITRE, 2010). These older aircraft typically have less noise control measures, hence resulting in the transmission of noise directly into the cockpit. As illustrated in the present research, noise levels inside a commonly used training aircraft during cruise average 95 dB(A). This is as high as some military jet turbine aircraft (Pääkkönen and Kuronen, 1998), 10 dB(A) above the recommended 8 h workplace noise exposure limit of 85 dB(A) (Economic Council, 2003) and 50 dB(A) above the recommended

Table 1
Percentage (not raw score) correct response on the two word tests plus the baseline test distributed across native language background.

	Native English (N = 16)			Non-native English (N = 16)		
	Baseline (%)	Non-noise cancelling (%)	Noise cancelling (%)	Baseline (%)	Non-noise cancelling (%)	Noise cancelling (%)
Monosyllabic	98.38	96.25	98.13	96.25	92.00	96.50
Aviation	67.75	67.67	74.42	60.33	58.83	59.83

Table 2
Correct response (presented in percentages) for native English speakers on the two word tests plus the baseline test distributed across aviating background.

	Pilots native English ($N = 13$)			Non-pilots native English ($N = 3$)		
	Baseline (%)	Non-noise cancelling (%)	Noise cancelling (%)	Baseline (%)	Non-noise cancelling (%)	Noise cancelling (%)
Monosyllabic	98.62	97.38	98.00	97.33	91.33	98.67
Aviation	71.59	74.05	78.36	51.11	40.00	57.33

Table 3
Correct response (presented in percentages) for non-native English speakers on the two word tests plus the baseline test distributed across aviating background.

	Pilots non-native English ($N = 9$)			Non-pilots non-native English ($N = 7$)		
	Baseline (%)	Non-noise cancelling (%)	Noise cancelling (%)	Baseline (%)	Non-noise cancelling (%)	Noise cancelling (%)
Monosyllabic	96.89	93.78	95.78	95.43	89.71	97.43
Aviation	68.44	70.07	64.15	49.90	44.38	54.29

design sound level of 40–45 dB(A) for noise in an office (AS/NZS 2107). Therefore, the potential for noise to negatively impact on communication is a real concern. Hence, the main aim of the present study was to investigate if noise cancelling technology could reduce miscommunication within general aviation. A secondary aim of the present study was to investigate the benefits of ANR headphones for both native and non-native English speakers.

The main findings from this research indicate that when exposed to noise typical of that experienced in a GA cockpit, noise cancelling headphones improves individuals' ability to accurately identify and repeat (verbal or written) words provided verbally. The results also indicate that the benefits of this technology extend to non-native speakers, however this relationship is slightly more complex. For non-native English speakers who are not familiar with a specific dialect of a language such as aviation English, use of noise cancelling headphones improves their ability to hear and detect words, thus removing any advantage a person familiar with this specific dialect (i.e., pilots) may have.

The present research also identified the English language proficiency of non-native speakers is inferior to that of a native speaker, irrespective of the complexity of the words (monosyllabic or aviation phrases) asked to attend to. While this result is not surprising (see Nábělek and Donahue, 1984; Broersma and Scharenborg, 2010; van Wijngaarden et al., 2002) it does further highlight the importance of existing measures (i.e., standard phraseology) and redundancies (i.e., readbacks) within the aviation industry to maintain safety.

The results of the present research also highlight the disproportionate error rate with aviation phrases compared to the less complex monosyllabic words. While Cardosi (1993) found similar results when analysing controller-to-pilot transmissions over a 48 h period, it appears that the proportion of errors identified in the present research is far greater than those previously identified. Cardosi (1993) found as the complexity of the transmission increased, so did the number of communication errors. In fact, the number of communication errors more than doubled when messages contained five or more elements (8% miscommunication) compared to messages containing one to four elements (1–3% miscommunication). Similarly, Barshi (1997; see also Barshi and Farris, 2013) found a large drop in accuracy with messages containing more than three elements, with the largest drop between messages of three and four elements. In the present research, most messages had no more than three elements, and only a few had four elements, which suggests other factors such as experience, expectancy or noise may have adversely affected the results. Specifically, all pilots in the present research were relatively young and undergoing formal training at a flight training school. In addition, the messages were random and no contextual clues could have been used to provide a hint as what to expect. Furthermore, the noise level in the present study was set at 95 decibels, which is at least 10–15 decibels louder than that typically in a commercial aircraft. Nonetheless, the results from the present research highlight the importance of existing practices in aviation such as using standard phraseology and keeping the number of elements in message to a minimum.

4.1. Limitations and future research

While the results from the present study are positive, they are not without their limitations. Participants employed in the present study were recruited from two main sources, namely the student population at a university and flying schools located at one aerodrome located in Sydney, Australia. Although there is no reason to suggest this sample is not reflective of the wider population, it would however be prudent to examine this. Similarly, and as with all studies, the study could be replicated with an expanded sample base, as some subgroups within the current study had low participant numbers (i.e., Native English non-pilots).

Future research should also examine the effectiveness of noise cancelling headphones with polysyllabic words. As can be seen from the data in all three tables, a ceiling effect was present with the monosyllabic words, irrespective of noise or headphone condition. Whether increasing the difficulty of the words under examination amplifies the benefits associated with noise cancelling headphones remains unknown.

In addition, the present research employed two specific headphones; an active noise cancelling headphone and a passive noise reduction headphone. Whether these headphones are representative of other active and passive noise cancelling headphones used in aviation remains unknown.

The present research also tested individual performance under one condition, albeit a common condition within general aviation (i.e., noise produced by Cessna 172 during cruise). Whether other aircraft of a similar generation or age, or more modern aircraft produce similar levels of noise remains unknown. Hence, how these changes if at all, impact performance and ultimately safety remains unknown.

Future research should also investigate the relationship between noise and performance for older pilots. It is widely known that as individuals age their ability to detect target stimuli from competing noise decreases (Pirhora-Fuller and Souza, 2003). Hence, ANR technology may prove more beneficial for people as they age.

5. Conclusion

The present study highlights the benefits of noise cancelling headphones in industries where there is a high level of background noise such as general aviation. Importantly, this benefit appears universal across language background. In fact, the results of the present study indicate that using noise cancelling headphones as a non-native speaker reduces any advantage other non-native speakers who have specialist knowledge in the area may have. The results also highlight the importance of various techniques employed within aviation such as the use of standard phraseology, as well as redundancies such as read-backs, to maintain minimum safety standard levels.

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