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Improving intelligibility at a safety critical point: In flight cabin safety

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ABSTRACT

The present study was designed to examine the impact of noise cancelling headphones on the intelligibility of auditory information, specific to the aviation industry. The majority of airlines in western countries prohibit the use of personal electronic devices which includes the use of noise cancelling headphones during the take-off and landing phase of flights. This blanket rule, may negatively impact on passengers' ability to hear and remember important safety related information (i.e., pre-flight safety brief). 25 participants (12 male), with an average age of 25.96 years, all with 'normal' hearing were asked to listen to five different audio briefs under five different experimental conditions presented in an environment designed to simulate an aircraft cabin environment. Each experimental condition varied based on a combination of noise cancelling headphones (active or inactive), music (present or absent) and sound source (headphones or external speaker). At the conclusion of each audio condition, participants were asked to complete a cued recall task. The use of noise cancelling headphones improved participants' ability to hear and recall information in a situation similar to those where pre-flight safety briefs are presented. The results indicate the use of noise cancelling headphones, without any conflicting in ear audio signal, aided participants' ability to hear and recall information. The findings suggest if the recall of safety information, including emergency procedures are crucial to passenger safety, authorities and airlines alike should reconsider the current restrictions on the use of noise cancelling headphones during those stages of flight when safety briefings are provided.

1. Introduction

Advancements in technology have facilitated the creation of smaller and more versatile personal electronic devices (PEDs) which all contribute to our more mobile society. Take for example a typical mobile telephone for which common features include camera, calendar, address book and audio player. Noise cancelling headphones which reduce external noise intrusion for the wearer, can be considered as PEDs and are the focus of the present research.

For the aviation industry, PEDs have been a contentious issue (NASA, 2001; Federal Aviation Administration – FAA, 2010). According to Vasquez et al. (2009) PEDs have the potential to interfere with on-board electronic equipment such as navigation and communication aids. Specifically, PEDs may cause problems when their emitted electromagnetic fields interfere with on-board electronic equipment (Vasquez et al., 2009). A review of incidents reported between 1986 and 1999 from the Aviation Safety Reporting System (ASRS) revealed 85 incidents (none fatal) were attributed to the use of PEDs during flight (NASA, 2001). An incident was defined as an abnormal event; irregular or something different. However a US House of Representatives hearing into the use of cell phones and other transmitting PEDs (T-PEDs) on aircraft heard that attempts to duplicate such events under controlled conditions have failed (Committee on Transportation and Infrastructure, 2005). Berg (2005) contends that it is highly likely that PEDs have been used to explain an otherwise undiagnosed incident. Nonetheless most western countries including Australia, Canada and the United States impose restrictions on the use of all PEDs (transmitting and non-transmitting) in aircraft based on such concerns. The Civil Aviation Safety Authority (CASA) in Australia has provided directives to the airlines which result in limiting the operation of all PEDs on-board aircraft (CASA, 2001); namely the prohibition of the use of PEDs prior to take-off and during the landing phase of flight.

PEDs are numerous and include, mobile telephones, computers, audio players (e.g., mp3 players), shavers, electronic readers (e.g., ipads), pagers, as well as noise cancelling headphones. It is the latter of these PEDs that is the main focus of the present research. The prohibited use of noise cancelling headphones during the taxi phase of flight was raised by a concerned member of the voluntary Asia Pacific Flight Cabin Safety Working Group (APCSWG). Specifically, a commercial passenger on a member state airline was

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informed that he would be refused carriage if he continued to use his noise cancelling headphones during the taxi phase of flight, solely because it was a PED, albeit non-transmitting. Despite being a PED, the passenger claimed the noise cancelling headphones had an important safety implication, namely it reduced the noise generated from the engines, thereby allowing him to better hear and understand the safety brief. The headphones were not employed to listen to any external source such as music. Therefore, and not negating the potential of this PED to cause electromagnetic interference, the main aim of this project is to examine whether the use of noise cancelling headphones during the taxi phase of flight could facilitate an individual's ability to recall important safety information (e.g., in flight safety brief).

1.1. Active noise cancelling headphones

There are a variety of types and brands of noise cancelling headphones designed to reduce unwanted noise using the technique of active noise cancellation. This technique involves generating a sound that is 180 degrees out of phase with the noise signal. In theory, the addition of these two signals results in an absence of noise (Nelson and Elliott, 1992). In practice, the active cancellation is more effective in reducing lower frequency noise below a few hundred Hertz (Elliott, 2007) but even then does not result in no sound. To use this technique, active noise control headphones incorporate a microphone within the headphone that detects the intrusive noise. This signal is then processed through a sophisticated signal processing technique within the headphones and the out of phase signal is produced at the ear. Most active noise control headphones also allow for the production within the headphone of a sound signal such as music which can then be enjoyed with less disturbance from unwanted low frequency noise in the surrounding area.

Removing or reducing low frequency noise in the presence of speech is potentially beneficial. The words that go together to form speech each contain consonants and vowels. Consonants affect speech intelligibility more than vowels; consonants have most of their acoustic cues over the higher frequencies (for example Stevens, 2000; Shadle, 2007). Although the active noise control technique is more effective in the low frequencies, it would be expected that the utilization of this technique would have some effect on the ability to understand the speech by reducing the upward spread of masking noise.

In contrast to active noise cancelling technology/headphones, passive noise attenuating headphones reduce external noise to the ear by filtering, as much as possible noise entering the ear. This is achieved by utilizing specially designed tight fitting cups that go around the ears. This technique proves more effective in reducing high frequency sound as opposed to low. Hence if designed accordingly, some active noise cancelling headphones can also provide passive noise attenuation. However, this is not the case with headphones at the centre of the present research which are primarily designed to provide good quality audio signal at the ear and not designed to provide hearing protection; thus do not have the features necessary to achieve passive noise reduction.

1.2. Noise, cognition and human performance

From a human performance perspective, the benefits of filtering unwanted or irrelevant noise before it reaches the ear are numerous. Noise in the form of classroom babble has been found to be detrimental to academic achievement in children (Shield and Dockrell, 2008). In adults, noise predominately in the form of speech has been found to induce fatigue, reduce concentration levels and negatively affect memory (Ingle et al., 2005; Belojevic et al., 2001). Road traffic noise has also been found to have a similar effect. Moreover, road traffic noise impairs children's ability to perform basic mathematics as well as reading speed (Ljung et al., 2009). In adults it has been found to cause sleep disturbance and even result in insomnia (Koh and Jeyaratnam, 1998). The effects of noise are even more profound for non-native speakers attempting to listen to speech presented in a second language (Shimizu et al., 2002). Similarly, noise affects older adults more than their younger counterparts (Tun et al., 2002). According to Vertegaal and colleagues, noise has been shown to have an effect on cognitive resources such as attention (Vertegaal et al., 2006), memory (Tremblay et al., 2000) and semantic processing (Smith, 1985). However, how this precisely occurs remains largely unknown.

What is known is that noise can impair performance if presented when the target stimulus is being listened to (i.e., input) or when individuals are encoding this information in memory (i.e., rehearsal; Miles et al., 1991). In contrast, noise appears to have little if any affect during the recall or application of the target stimulus. The effects of noise on encoding are also more profound if it is intense (i.e., loud; Tun et al., 2002) and/or considered a meaningful distracter such as speech (Marsh et al., 2008). However, not all tasks disrupt equally (Beaman and Jones, 1997) nor are all sounds equally disruptive (LeCompte et al., 1997; Jones et al., 1992, 2000). Moreover, Jones and colleagues identified that a sequence of sounds (discrete tones, noise burst or speech sounds) that alternate produce greater disruption (in term of information to be stored in memory) than a sequence of repeated sounds (Jones et al., 1992). Crucial to the current research is that the effects of noise on performance can be reduced or even nullified by subjecting them to degradation by filter (Vertegaal et al., 2006), such as noise cancelling headphones.

The effects of noise are potentially profound in safety critical environments such as aviation. Take for example the safety brief played to passengers during the taxi phase of flight. This brief contains safety related information specific to the type and model of the aircraft flown, important differences in aircraft that passengers need to be aware of can include, seat pitch, type of seat belt buckle (lift vs. push), and/or location of emergency exits. However, while important safety information is being provided, aircraft engines are producing irrelevant information (noise) that can be distracting. During taxi the Airbus A321, a twin jet turbine aircraft produces an average noise level of 65 decibels (dBA) in the passenger cabin (Ozcan and Nemlioglu, 2006). As a comparison, recommended noise levels for acceptable levels in areas of occupancy are listed in the Australian Standard (Standards Australia AS/NZS 2107, 2000) for a general office or reception area are 40–45 dBA, slightly higher for public spaces (40–50 dBA); both areas where speech communication is important. It is only in transit areas such as car parks where communication is less important; the recommended levels of 55–65 dBA are closer to those found in a aircraft cabin.

The main aim of the present study was to examine whether noise cancelling headphones could enhance users' cognitive processes by filtering out irrelevant information before it reaches the brain. Since the origins of this problem involved the use of a commercially available noise cancelling headphone, these headphones featured in the experimental method. Specifically, it was hypothesised that if noise cancelling headphones reduce unwanted wideband noise, then performance in both condition 1 (active noise cancelling with audio brief through headphones) and condition 2 (active noise cancelling with audio brief through external speaker) will be superior on the fill-in-the-blanks written audio test compared to condition 3 where the headphones are inactive reflecting passive hearing protection (i.e., earmuffs).

What is less clear is how performance using noise cancelling headphones compares to a situation where no headphones are used (condition 4) or when a competing audio source is played