A Self-Controlled Trial to Evaluate the Use of Active Hearing Defenders in the Engine Rooms of Operational Naval Vessels

M Ong, J T L Choo, E Low

ABSTRACT

Introduction: Active Hearing Defenders are established hearing protectors with in-built electro-acoustics that shut-off ambient noise while allowing effective communication between users.

Methods: A blinded, self-controlled trial was conducted among naval servicemen to compare the effectiveness of two types of active hearing defenders (Howard-Leight Thunder™ and COM-55) in relation to passive hearing defenders in an operational environment.

Results: Subjects felt that the active hearing defenders were more comfortable, durable, and that the active hearing defenders helped them work better. When subjects were tested with a speech discrimination battery (Central Institute of the Deaf, Spondee Word lists), there was a significant difference (p value of 0.04, using the Kruskall-Wallis ANOVA test) between the two active and the passive defenders. However, no significant difference was found between the two types of active hearing defenders.

Conclusion: Active hearing defenders are an acceptable and efficacious means of hearing protection in noisy environments.

Keywords: active hearing defenders, hearing conservation programme, noise induced deafness, passive hearing defenders, speech discrimination battery

INTRODUCTION

Noise-induced deafness (NID) is the leading occupational disease in Singapore(1,2). Controlling noise levels at its source is regarded to be the best way of preventing noise-induced deafness in industry. However, such controls are not always feasible and it has been recommended that suitable hearing protectors be employed as part of a Hearing Conservation Programme to reduce the incidence of noise-induced deafness(3). Noise mapping studies were done on board Republic of Singapore Navy ships in 2000. The noise levels in the engine rooms were found to be consistently above 85 dBA(4) at normal cruising speeds. Servicemen working in the engine rooms of ships in the Republic of Singapore Navy are therefore at risk of developing high-frequency hearing loss as a result of exposure to high noise levels(5), and are required to wear good hearing protectors when working in the engine room.

Earplugs and earmuffs have been widely used. However, these cut down all types of noise, both wanted and unwanted noise, such that users are unable to hear others speak and communication at work becomes a problem. This compromises safety and also often results in users removing the ear protectors periodically in order to hear others speak. The use of active hearing protectors allows effective communication(6) by selectively filtering out certain types of noise (e.g. loud impulse noise or harmful level of noises of certain frequencies) thus allowing speech sounds to be heard better. There are two types of active hearing defenders, namely: active level dependent protectors and active noise canceling protectors.

Active level dependent hearing protectors allow sound at non-harmful levels to be processed at unity gain. However, if ambient noise levels are above 85 dBA, the circuitry is clamped down so that the user receives the full protection of the hearing defender. Active noise cancellation inverts the phase of the noise to cancel it(7). Variants of the two types which selectively attenuates noise of different frequencies are also available. Two sets of active hearing defenders, the Howard-Leight Thunder™ and the COM-55, were procured for evaluation. The COM-55 is an active level dependant hearing protector whereas the Howard-Leight Thunder™ is a active noise canceling protector which is able to selectively reduce lower frequency of noise.

The objectives of the study were to evaluate the subjective comfort, durability, user acceptance, speech reception and noise reduction capability of the active hearing defenders versus the passive hearing defenders;
and to evaluate the objective speech reception capability of the active hearing defenders versus the passive hearing defenders.

**METHODS**

The trial was carried out on four ships of different classes, chosen based on operational availability. A total of 18 servicemen who worked in the engine room were selected for this study. While out at sea, these personnel had to conduct periodic rounds in the engine room to monitor and operate the various mechanical devices in the engine room. All were men, regular servicemen in the Navy, and their age ranged from 20 to 25 years old. The study group had no prior history of noise-induced deafness, and had normal pure-tone audiometry (8,9) done a few days prior to the trials. The trial was conducted at sea to test the performance of the hearing defenders under operational conditions during which the ship was running at normal cruising speed. The trial was carried out over a period of six weeks from 5th December 2001 to 21st January 2002.

During the trial, each serviceman was required to wear the COM-55 hearing defenders for one hour, the Howard-Leight ThunderTM hearing defenders for one hour, and conventional ear protectors for one hour. We attempted some blinding whereby they were not told of the differences between the three types of hearing defenders. However, no attempt was made to disguise the three defenders so that they had looked identical.

The passive attenuation of the three hearing defenders were similar, ranged from 21dB to 24dB, and were not deemed to be a confounding factor.

While wearing the three types of hearing protectors, their word recognition and hearing acuity were tested objectively using a speech discrimination battery, the W-1 Spondee Word lists (Central Institute for the Deaf)(10). This battery consisted of 36 bi-syllabic words used by audiologists and is designed to test speech reception. As all the subjects had normal hearing, bi-syllabic words were used rather than phonetically balanced words. This was because bi-syllabic words had equal stress placed on each syllable, homogeneous with respect to audibility, and were therefore easier to administer clinically. On the other hand, phonetically balanced words are more useful for speech discrimination for words of different frequencies, and more suitable for assessment of hearing impairment and the usage of hearing aids.

Table I. Subjective assessment of hearing protectors.

<table>
<thead>
<tr>
<th></th>
<th>COM - 55 hearing defenders</th>
<th>Howard-Leight Thunder hearing defenders</th>
<th>Conventional passive hearing defenders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is the hearing protector that you used comfortable?</td>
<td>7.19</td>
<td>7.00</td>
<td>5.92</td>
</tr>
<tr>
<td>Are the hearing defenders durable?</td>
<td>6.73</td>
<td>6.96</td>
<td>6.54</td>
</tr>
<tr>
<td>Can the hearing protectors reduce noise effectively?</td>
<td>6.88</td>
<td>7.15</td>
<td>6.19</td>
</tr>
<tr>
<td>Do the hearing protector help you work better?</td>
<td>6.81</td>
<td>6.77</td>
<td>6.08</td>
</tr>
<tr>
<td>Can you hear your colleagues speak while wearing the hearing protectors?</td>
<td>5.27</td>
<td>5.12</td>
<td>4.27</td>
</tr>
<tr>
<td>On a scale of 1 to 10, how would you rate the hearing protectors?</td>
<td>6.81</td>
<td>6.66</td>
<td>5.65</td>
</tr>
</tbody>
</table>

Table II. Objective testing with hearing protectors in ship engine room using a speech discrimination test.

<table>
<thead>
<tr>
<th></th>
<th>COM - 55 hearing defenders</th>
<th>Howard-Leight Thunder hearing defenders</th>
<th>Conventional passive hearing defenders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Missile gun boats (MGB)</td>
<td>3.6'</td>
<td>3.6</td>
<td>1.0</td>
</tr>
<tr>
<td>Patrol vessel (PV)</td>
<td>5.7</td>
<td>7.0</td>
<td>4.3</td>
</tr>
<tr>
<td>Landing ship tanks (LST)</td>
<td>8.8</td>
<td>11.2</td>
<td>3.0</td>
</tr>
<tr>
<td>Overall performance</td>
<td>10.2</td>
<td>10.1</td>
<td>4.3</td>
</tr>
</tbody>
</table>

1 Average number of words identified correctly during the speech discrimination test

To ensure that the tests were properly administered and to prevent observer bias, two medical orderlies (medics) administered the tests onboard all four vessels. The medics were trained to repeat the words at the same intensity and with the same stress placed on each syllable. As the words used were already chosen with a homogeneous stress of each syllable, their task was made easier. The same two medics were used across the different ships. The words were read by the medics to the subject at an arm’s length with the subjects facing away from the medics to prevent
because the numbers assessed was small, or that there
hearing defenders. This could have either been
difference was found between the two types of active
and the passive defenders. However, no significant
of 0.04) between the two active hearing defenders
showed that there was a significant difference (p value
SPSS and the Kruskall-Wallis ANOVA test. The results
was analysed. Statistical analysis was conducted using
discrimination test obtained for each of the three sets
between the three sets, the mean score of the speech
showed that both types of active hearing
defenders performed better in both subjective and
objective assessments, compared to the older passive
hearing defenders.

In the objective assessment with the speech reception
battery, users averaged 10 out of 36 words correct for
the active hearing defenders compared to four out of
36 for the passive defenders (Table II). To compare
between the three sets, the mean score of the speech
discrimination test obtained for each of the three sets
was analysed. Statistical analysis was conducted using
SPSS and the Kruskall-Wallis ANOVA test. The results
showed that there was a significant difference (p value
of 0.04) between the two active hearing defenders
and the passive defenders. However, no significant
difference was found between the two types of active
hearing defenders. This could have either been
because the numbers assessed was small, or that there
was truly no real difference between the two types of
active hearing defenders. We had chosen to combine
the scores obtained for each of the hearing defenders
type for the three classes of ships together. This
was because “ship class” was not deemed to be a
confounding factor despite the different level of
noise since the active hearing defenders tested in the
MGB which had the loudest noise level also
performed better.

In the subjective testing, users felt that the active
hearing defenders were more comfortable, more durable
and more effective in reducing the noise in the work
environment. Furthermore, users felt that the active
hearing defenders helped them work better and
allowed for more effective communication with
their colleagues in noisy environments (Table I). As
this was descriptive in nature, no statistical analysis
was attempted.

RESULTS
The noise level of the engine room in the ships were
generally the same for two classes of ships, i.e. the
landing ship tanks (LST) and the patrol vessel (PV),
and varied between 98 to 103 dBA. The noise level
for the missile gun boats (MGB) were louder at
120dBA. However, in all three classes of ships, the
results showed that both types of active hearing
defenders had performed better.

DISCUSSION
Our results demonstrated that the active hearing
defenders were better than normal passive hearing
defenders in that it allowed better word discrimination.
With the active hearing defenders, users could get
only an average of 10 words out of 36 words correct,
compared to four words out of 36 words when they
used passive hearing defenders. The strength of the
study was that it was self-controlled and therefore
took into account individual variability in hearing.
However, it could have been improved if efforts were
made to blind the study group by making all three
types of hearing defender identical. The fact that
the noise level of the three classes of ships were not
identical did not confound the study and invalidate
the statistical application of the results since in all
three classes of ships, the active hearing defenders had
performed better than the passive hearing defenders.

However, although the word discrimination using
the active defenders was still better in the MGB,
it was not as good as that in the other ships (3.6 words
in the MGB versus 5.7 and 8.8 words in the PV and
LST, respectively). This would no doubt have diluted
the overall word discrimination score when using
the active hearing defenders. Sensorineural deafness
as a result of exposure to high intensity noise is
irreversible(11). Naval servicemen working in the
gine rooms of our ships are exposed to loud noise
for a long duration. Thus, to reduce disability and to
improve operational readiness, hearing protection
and hearing conservation measures are imperative.
Even though many types of hearing protectors, including
earplugs, are available to workers, their success is
confounded not only by their noise reduction rating but
also by the workers’ attitudes, comfort and durability.

Active hearing defenders are established
hearing protection devices. Although more costly
than conventional hearing protectors, the results
from this study are encouraging. In this study, active
hearing defenders have been shown to be better
than conventional ear muffs in reducing background
noise, improving hearing acuity and communication
in the noisy engine room compartment. This study
also shows that the active hearing protectors
employed were comfortable and in general, well-
accepted by their users. Although at present, cost may
be a factor in the widespread use of these hearing
defenders, it is expected that with improvements in
active hearing defenders, in particular with the size
of the circuitry, active hearing protectors will be more
affordable for industrial use.
It is conceived that the use of active hearing defenders may be extended to industries in which workers are exposed to high noise levels yet requiring frequent on-job communication between workers. These include shipbuilding and repair, metal industries and other military units such as artillery formations. Other than the employment of hearing protectors in noisy environments, it must be remembered that the prevention of morbidity from noise-induced deafness in industry depends on a range of interventions including engineering design, worker and employer education, surveillance and notification, and regular audiometric testing of workers in noisy environments\(^{(12)}\).

In conclusion, active hearing defenders are an acceptable and efficacious means of hearing protection in noisy environments and may be superior in workplaces where both noise reduction and effective communication to preserve normal operations is required. This study is however limited by the small number of participants. As no significant difference could be found between the Howard-Leight Thunder\(^{TM}\) and the COM-55 hearing defenders, follow-up studies should be undertaken to compare the efficacy of different active hearing defenders and in addition, to further define the use of these active hearing defenders in the area of industrial operations.

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REFERENCES