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Research Article

Extending the Perception of Speech Intelligibility in Respiratory Protection

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Abstract

In the field of respiratory protection, speech intelligibility is perceived to be the quality of sound transmission through a respiratory interface. This paper aims to explore how speech intelligibility is a complex issue in part comprising of sound transmission, as well as other more subtle but no less important aspects, such as the visual cues gained from lip movement. The link has long been established as explained by P. Erber in the *Journal of Speech and Hearing Disorders*, where he states "Hearing-impaired persons usually perceive speech by watching the face of the talker". The data and results gathered from this investigation of respiratory interfaces aims to demonstrate how the interaction between hearing and vision is perceived in speech intelligibility and how this phenomenon may be used to advantage by manufacturers of Respiratory Protective Device systems. With an understanding of this phenomenon, a manufacturer may create a respiratory interface that helps persons with impaired hearing who need to wear respiratory protection in their chosen occupation, be useful members of the workforce. It may also help completely able bodied people to communicate if their hearing is temporarily rendered obsolete by an unforeseen event. The methodology employed consists of using an adapted modified rhyme test (MRT). The test involves "listeners" being able to see the speakers' lips through the respiratory interface as well as hearing them. The results of 'seeing and listening' are compared with 'listening only'. A third scenario, where the listeners wear ear plugs but can see the speakers' lips, is also examined. The results are analysed to show a marked improvement when able to see the speakers' lips.

Keywords: *Speech Intelligibility; Respirator; Modified Rhyme Test*

Introduction

Charles Darwin [1] once wrote that "I cannot doubt that language owes its origin to the imitation and modification, aided by signs and gestures, of various natural sounds, the voices of other animals, and man's own instinctive cries". What is of importance to us in this study is the idea that "signs and gestures" are at the roots of modern language. The link has long been established and many different accounts of this exist, as also stated by Walden., *et al*. [2], Munhall., *et al*. [3] and P Erber [4] when he states in the *Journal of Speech and Hearing Disorders*, "Hearing-impaired persons usually perceive speech by watching the face of the talker".

We find that in respiratory interfaces, more often than not, the face of the user is hidden from view. As suggested by the literature, an abundance of visual cues can be drawn from the face and in particular the lips of the speaker. Thus, this paper looks to examine the effects of covering the face and lips of the speaker and seeing what if any effect this has on the intelligibility of speech.

The reason why such a study is important is that it may help persons with impaired hearing that need to wear respiratory protection in their chosen occupation be useful members of the workforce. It may also help able-bodied people to communicate if their hearing is temporarily rendered obsolete by some unforeseen event. An example of this may be a deafening explosion that causes one to be deafened either permanently or temporarily and it is critical that one understands what a colleague is saying. Essentially, any situation that involves wearing respiratory protection is usually combined with heightened sound levels, thus making any gain in speech intelligibility levels very useful.

Methods

To determine how a certain respiratory interface performs, most Standard Issuing Bodies use a Modified Rhyme Test (MRT) [5]. The MRT in its essence is a test where a speaker talks while wearing a respirator and the clarity of his/her speech is judged by a group of listeners. The speaker reads out words from a list (as supplied by the standard issuing body) and the listeners circle the word they believe they heard from a multiple-choice list. The MRT test used as a basis for this experiment was that as defined by NIOSH (42 CFR Part 84, Subpart G, Section 84.63 (a)(c)(d)) and set forth in procedure TEB-CBRN-APR-STP-0313. All deviations from this standard test protocol are detailed in this section.

This test is adapted to determine how a respiratory interface performs when "listeners" are able to see the speakers' lips through the respiratory interface as well as hearing them. The results of 'seeing and listening' are compared with 'listening only'. A third scenario, where the listeners wear ear plugs but can see the speakers' lips, is also examined.

The first stage in understanding whether or not being able to see the speakers lips makes any difference to their intelligibility is choosing a suitable respiratory interface. The interface chosen was the 3M Versaflow Respirator (3M, Model - M306). It was chosen for its ease of modifying in the adapted MRT to be performed, which was the addition of a piece of card to block out the line of sight to the speakers lips. An illustrated image of the interface in both, its modified and unmodified state is shown in figure 1. The interface is connected to a C420 blower (Avon Protection) that was fully functional when tested (not shown).

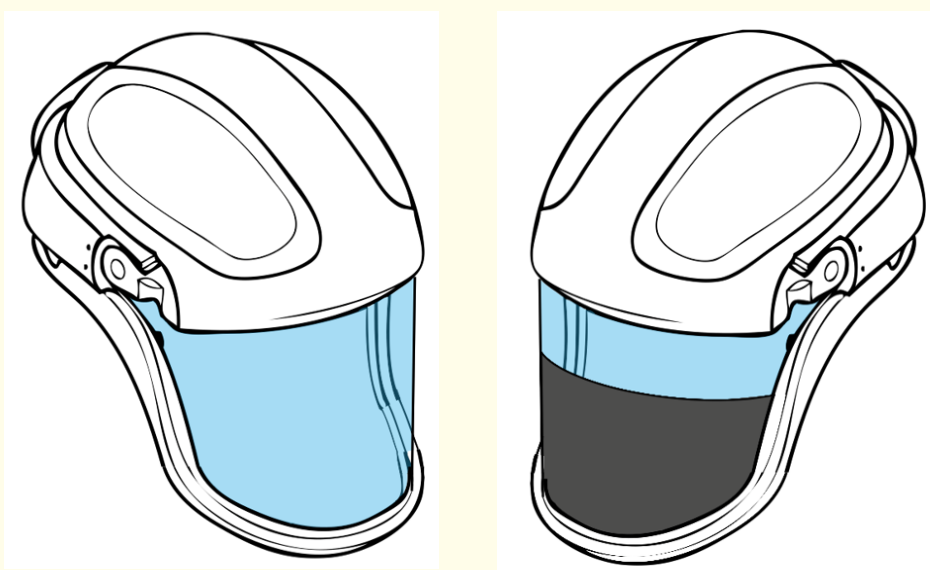

Figure 1: *The 3M Versaflow Respirator in its unmodified (left) and modified (right) state.*

Before commencing the test, it was imperative that the modified mask was examined to understand how the addition of a sheet card effect sound transmission through the respirator. This was done by placing the interfaces on a test head with a speaker mounted in it as shown in figure 2. A sample of pink noise at 80dB was played through the speakers and the sound that was transmitted through the masks was analysed using a live Fast Fourier Transformation (FFT) function. The resultant waveforms are shown in figure 3.

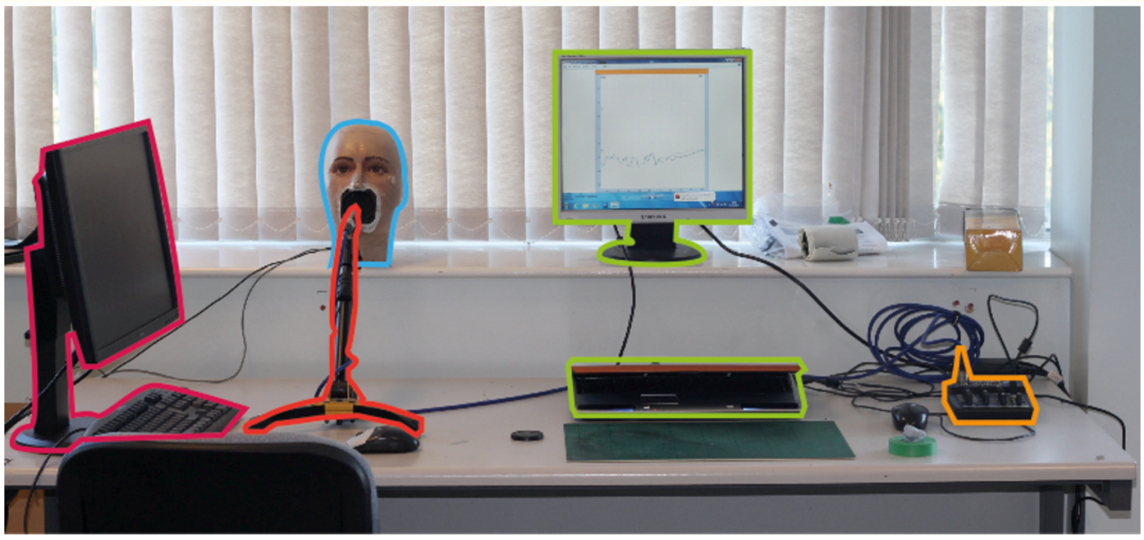

Figure 2: *Test apparatus used to determine the effect of the addition of card on frequency transmission through the respirator.*

One can see from the data in figure 3 that the addition of the black card has some effect on the frequencies coming through. There is a notable loss around the areas of 200 Hz, 2.3 KHz, and 6 KHz. There are also slight gains at around 50 Hz and 1 KHz, and a notable gain around 500 Hz. Figure 4 shows the attenuation levels with the unaltered respirator as a baseline. The difference in the results is negligible and one has for all practical purposes two identical respiratory interfaces to test out the hypothesis that being able to see the speaker's lips whilst wearing respiratory protection does improve speech intelligibility. If anything, the setup is favourable to the scenario where the mask is unaltered, as expected.

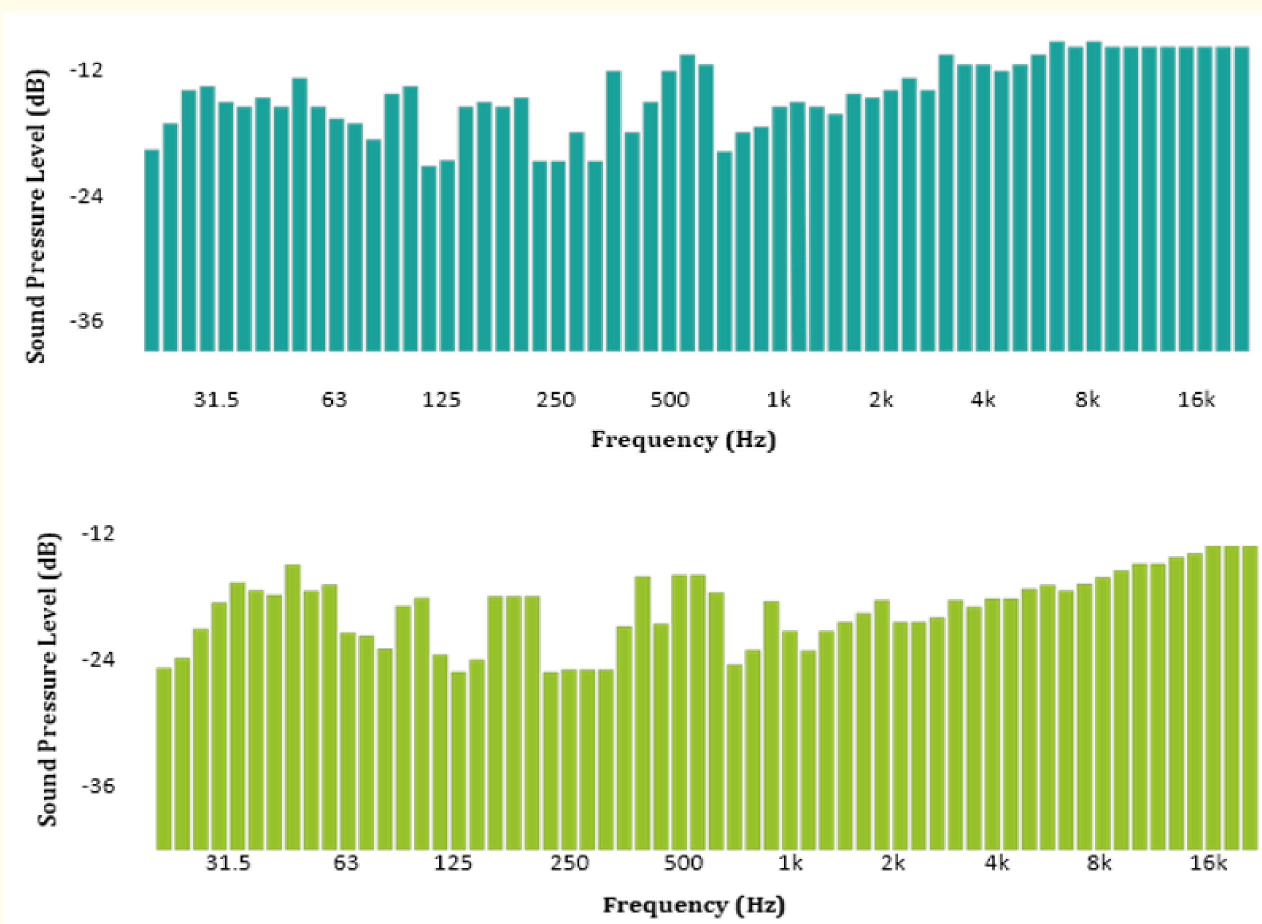

Figure 3: *The frequencies of sound being transmitted though the respirator (above), and the effect of adding the extra piece of card (below).*

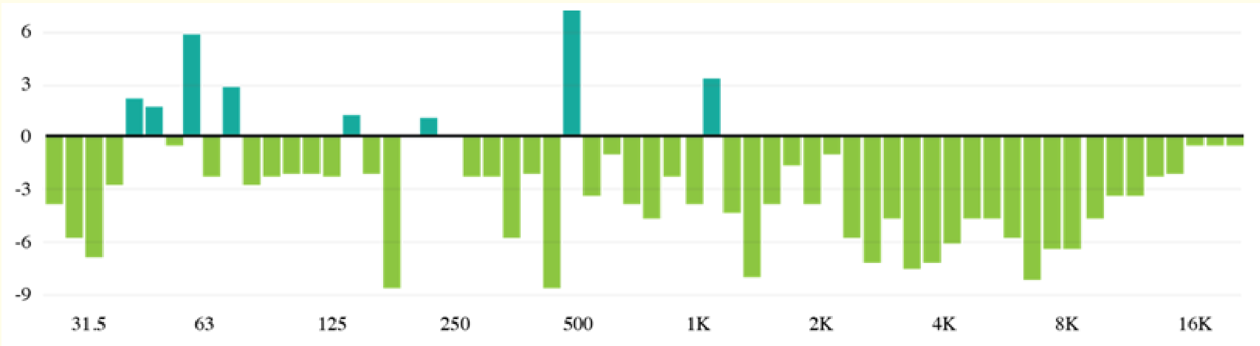

Figure 4: *The difference in sound pressure levels with the unaltered respirator's performance taken as a baseline.*

The second stage of the process is conducting an adapted MRT test. The following step by step methodology was employed:

- An MRT test was conducted with the modified respiratory interface.
- An MRT test was conducted with the modified respiratory interface. The listeners all wore ear plugs (Howard Leight, Model - QUIET) that had a Single Numerical Rating (SNR) number of 28. This equates to them causing an equivalent of a 28 dB attenuation.
- An adapted MRT test was conducted with the unmodified respiratory interface. The listeners were asked to look at the speaker whilst the words were being spoken and then circle the word they thought they heard. The interval between sentences was increased from 6 seconds to 10 seconds, to compensate for the time "lost" in listeners having to move their line of sight between words. The level of light intensity at the speakers face was noted using a Testo 545 Digital Light Meter (CE compliant).
- An adapted MRT test was conducted with the unmodified respiratory interface and a spotlight fixed upon the speakers face. The listeners were asked to look at the speaker whilst the words were being spoken and then circle the word they thought they heard. The interval between sentences was increased from 6 seconds to 10 seconds, to compensate for the time "lost" in listeners having to move their line of sight between words. The level of light intensity at the speakers face was noted.
- An MRT test was conducted with the unmodified respiratory interface and a spotlight fixed upon the speakers face. The listeners all wore ear plugs and were asked to look at the speaker whilst the words were being spoken and then circle the word they thought they heard. The interval between sentences was increased from 6 seconds to 10 seconds, to compensate for the time "lost" in listeners having to move their line of sight between words. The level of light intensity at the speakers face was noted.

It may be important to note, that at each stage a masked and unmasked tests were performed to arrive at the MRT scores as detailed in section 5.7.6 of procedure TEB-CBRN-APR-STP-0313.

The MRT test varied from the original in that:

- No female listeners or speakers were present.
- Only 1 test administrator was present.
- Loudspeakers were 7.5ft from the centreline not 9ft.
- Speakers consecutively performed their test, speaking first without and then with a mask.
- All participants (excluding the Administrator) were native speakers of British English, having been born and brought up in England. Some regional variation exists but all test subjects were from one geographical area - Southern England. All listeners would agree that they had no trouble understanding the speakers in normal conditions.

Additional information regarding the nature of the test is as follows:

- A total of 6 speakers and 4 listeners were used to obtain 6 sets of MRT data for each scenario. The age of the listeners ranged from 20 - 23 at the time of testing. The age of the speakers was in the range of 20 - 64 at the time of testing. All the participants of the test were at the time employees of Avon Protection, consent forms had been taken prior to the testing, and are archived on location.
- Pink noise used in the test was computer generated using NCH Tone generator software.
- Sound decibel level measurement were made using Sper Scientific Type 2, model 840029 sound meter.
- The sound of the active C420 blower was found to be below ambient background noise - i.e. the sound that it product did not go over 60dB as per the standard for background pink noise (Section 5.4.5 of TEB-CBRN-APR-STP-0313)
- Standard deviation and a normal distribution were the statistical methods used to analyze the data gathered.

Results and Discussions

The results of the MRT test are shown in figures 5 and 6. Figure 5 shows the results of the test where listeners are wearing ear plugs and figure 6 is where they are not.

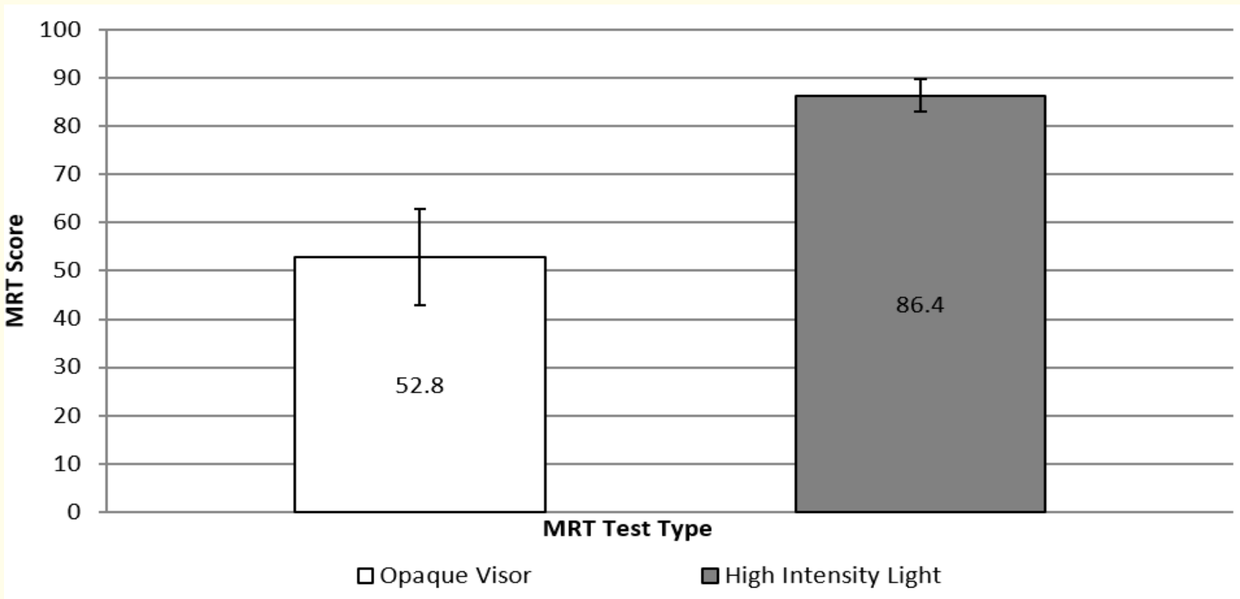

Figure 5: *Results of MRT test with 3 sigma standard deviation when ear plugs are worn.*

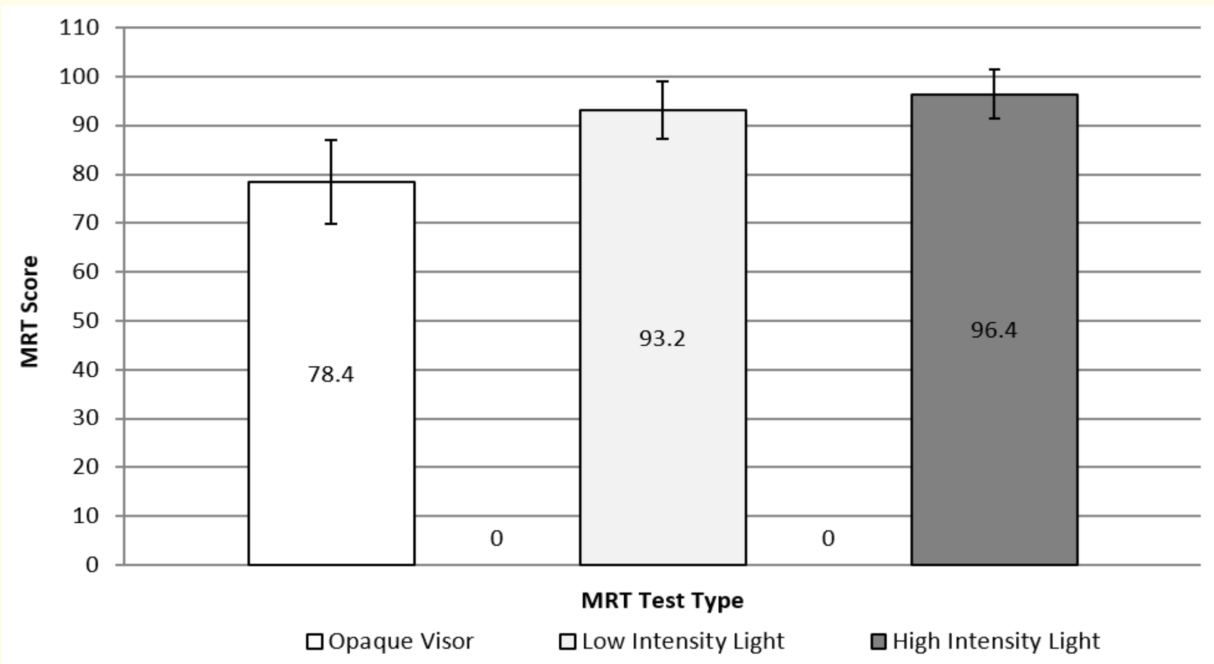

Figure 6: *Results of MRT test with 3 sigma standard deviation when ear plugs are not worn , and with varying light intensities.*

Three sigma's of standard deviation (SD) are expressed in deviation bars. It is important to note that the data used to calculating the SD is limited to a set of 6 tests (each test consisting of 3 data points). Thus, the significance of a three sigma variation is limited.

The level of light recorded was 30 Lux in this situations referred to as "low intensity light" and 270 Lux in that of "high intensity light".

These findings are important in that they show a way in which a member of society who is hearing impaired may be a fully-fledged member of society. It also shows how speech intelligibility may be improved in respiratory protection by a potentially very cheap and simple method. It opens up a new avenue of exploration for manufacturers of respiratory protection.

On the other hand, the results show a potential "flaw" in the current MRT test. It is evident that being able to see the speaker's lips improves MRT results. This begs the question as to whether the test should specify as to whether or not the listeners are allowed to look up at the speaker or not. One proposal is the implementation of an acoustically transparent but visually opaque screen in between the listeners and speakers as to prevent the listeners seeing the speaker's lips. Alternatively, another route may be the deliberate inclusion of the instruction to look up at the speakers face as to encourage respiratory manufacturers to design for the fact that being able to see the speaker's lips does aid in speech intelligibility.

Conclusions

One can conclude that being able to see the speaker's lips whilst a respirator is donned, does increase speech intelligibility. This can be concluded from the fact that when a listener's hearing was artificially impaired; being able to see the speaker's lips in high intensity light gave a 64% increase in results (Figure 5). It is important to note that with the earplugs, listeners were still able to hear the speaker but their hearing was impaired; as is reflected in the difference of MRT scores.

In addition to this, the second test scenario (Figure 6) also indicates a marked improvement in MRT test scores when being able to see the speaker's lips with unimpaired hearing. When the listeners hearing was unimpaired and they were able to see the speakers lips in low intensity light, the MRT score achieved increased by 19%. This figure grew further to a 22% increase in MRT scores obtained when high intensity light was shone on the speakers' lips. Both tests would benefit from further experimentation.

Although the intensity of light does make a difference, this difference is not large. Thus it would appear that being able to see the speaker's lips does improve speech intelligibility dramatically while further increasing the light intensity does improve the results but only incrementally.

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The research was presented at the ISRP conference in 2012, Boston. The author was the recipient of the Bob Bentley Bursary Award.

Bibliography

1. Charles Darwin. "The Descent of Man, and Selection in Relation to Sex". London: John Murray (1871).
2. Walden., *et al*. "Benefit from visual cues in auditory-visual speech recognition by middle-aged and elderly persons". *Journal of Speech, Language, and Hearing Research* 36.2 (1993): 431-436.

3. Munhall., *et al*. "Visual prosody and speech intelligibility: head movement improves auditory speech perception". *Psychological Sciences* 15.2 (2004): 133-137.

4. P Erber. "Audio-Visual Perception of Speech". *Journal of Speech and Hearing Disorders* 40.4 (1975): 481-492.

5. House., *et al*. "Articulation-Testing Methods: Consonantal Differentiation with a Closed-Response Set". *Journal of Acoustical Society of America* 37 (1965): 158-166.

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