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IMPLICATIONS OF AMPLITUDE COMPRESSION ON RASTI PERFORMANCE

Peter Barnett

AMS Acoustics, 43 Chase Side, Southgate, London, N14 5BP.

INTRODUCTION

This Paper examines the potential benefit on speech intelligibility provided by the application of amplitude compression in terms of RASTI.

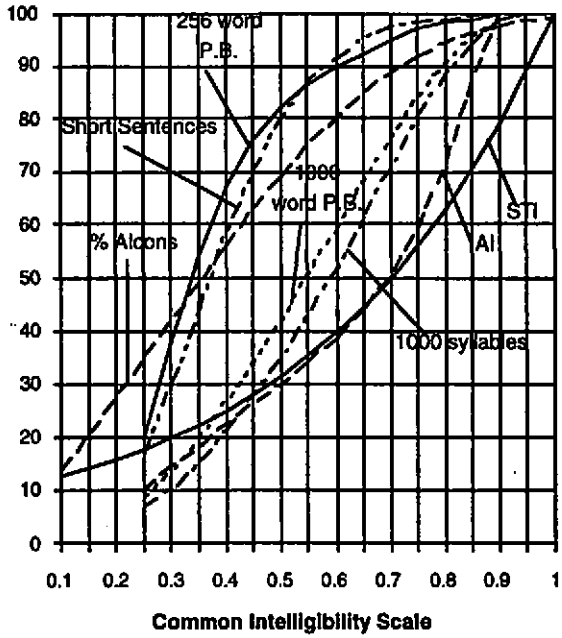
It has been shown and reported [i] that amplitude compression, when correctly applied provides a modest improvement in speech intelligibility.

Our compression work and experimentation was carried out using Word Scores as the intelligibility descriptors. The word lists were taken from the standard population of 1000. It was found that the improvement between compressed and uncompressed speech was subject to signal-to-noise ratio, direct-to-reverberant ratio and reverberation time.

The Common Intelligibility Scale (CIS) [ii], [iii] which is to form part of the new BS 7443: Sound Systems for Emergency Purposes allows for various methods of intelligibility measurement including word score and RASTI.

The relationships proposed are shown in the fig. overleaf:

Relationship Between Intelligibility Scales



The implied relationship used in the CIS between RASTI and word scores (1000 PB set) was taken directly from the work of Houtgast and Steeneken. Hence we are able to translate word scores to equivalent RASTI performance.

THE APPLICATION OF COMPRESSION

The results presented in this Paper are taken from a series of experiments where compressed and uncompressed speech was presented to a listening panel or listening jury (from recorded material). The difference was found to be an improvement.

The premise is therefore that if we are able to show an improvement in Word Scores with the application of amplitude compression, then it should be possible to infer an improvement in RASTI. Furthermore, if this is considered robust then it may be possible to invoke such an improvement within a contractual situation which might allow compliance when other circumstances precluded it, or it might provide an improvement hitherto only achievable through architectural means.

PRESENT DATA

Over the past 3 years (1995-present) considerable work has been expended which has been reported elsewhere [i], [ii]. These studies have measured the improvement as measured by Word Score techniques with the application of amplitude compression. To summarise the very early work centred on optimising the degree of compression and its implications with regards to the word structures. Both noise and reverberation were considered. With the ratio and application optimised compressed and uncompressed words were presented to a binaural recording system (for subsequent jury analysis) in various environments, with different reverberation times. The recordings were also noise-contaminated in various signal-to-noise ratios. In most places each data point resulted from an average of two word lists scored by ten persons. With one exception, the measurement method was in accordance with ISO TR480: The Construction and Calibration of Speech Intelligibility Tests. The variation in scores was consistent with expectations.

The experiments and studies to day are:

1. Effect of noise only.
2. Mass Transit Railway, Hong Kong
3. St. Albans Old Court House
4. Hazelwood School.

Other measurements have been made but these are subject to client confidentiality.

RESULTS

General

For the sake of brevity a full description of the experimental methods has been omitted from this Paper. However it should be understood that the word tests were calibrated and correctly monitored for anomalous results and should not be confused with ad hoc type procedures often encountered. Good experimental practice and procedure was observed at all times.

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All of the results are for optimised compression and application.

In the presence of noise: In this series of experiments compressed and uncompressed word lists were mixed with binaurally-recorded noise in various signal-to-noise ratios and then subjected to jury testing.

Mass Transit Railway (Hong Kong): In these tests a single position was taken in a ticket hall with an RT of 1.7/1.5 secs. at 500Hz/2kHz.

St. Albans Old Court House: These measurements were not subject to calibration but represented a simple ad hoc test using reliable source material. The exercise was carried out live by students on an IOA teaching course. The students were cognisant of word score methods, though not practised. They were unaware of the compression issue. It is worth showing the results obtained.

Table of Word Score Results

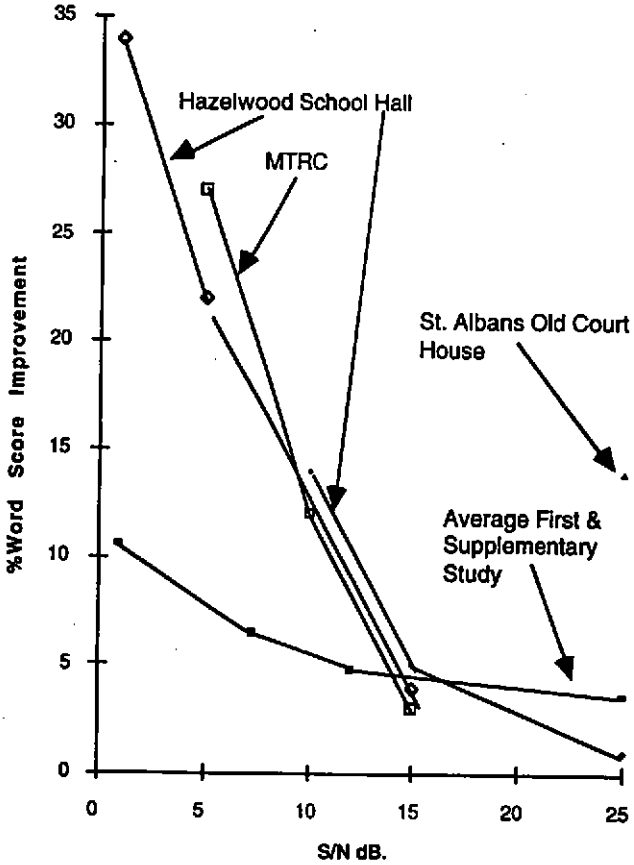
Student	Uncompressed	Compressed
1	84	96
4	78	90
2	76	92
3	76	92
8	72	84
7	71	88
9	70	82
5	68	84
6	68	88
AV	73.7	88.4

The variations between individuals results partly from the lack of proper calibration and also from the fact that some were closer to the source than others. The RT in this space is 3.5/2.8 sec. (500Hz/2kHz).

Hazelwood School: This formed part of a much larger experiment to validate the use of binaural recordings. Hazelwood School has an RT of 2.4/2.2 secs. Two positions, one close to the source and the other distant were used.

The results in terms of Word Score improvement are displayed in the graph below:

Graph of Word Score Improvement from Various Studies

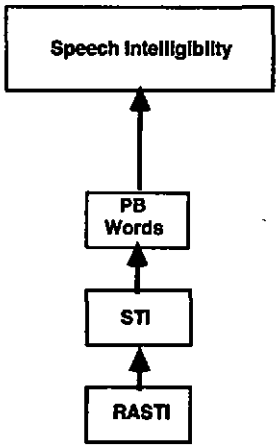


The individual test results are given in Reference 1.

TRANSLATION TO RASTI

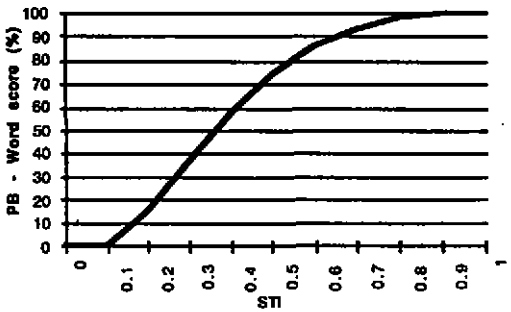
Since RASTI correlates to speech intelligibility through Word Scores as shown below.

Family Tree of Intelligibility Indicators



then if we accept the relationship between RASTI and Word Scores deduced by Houtgast and Steeneken.

Reproduced Graph of STI vis Word Score (after Houtgast and Steeneken)



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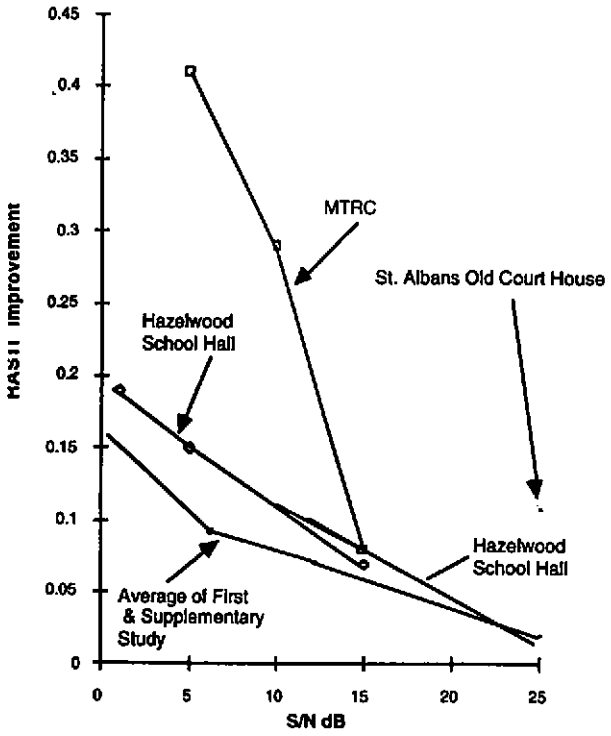
It is possible to convert Word Scores to equivalent RASTI. It is again important to understand that the Word Score method must be calibrated for such a translation to be made.

The figure below gives the translated RASTI improvements.

Summary Results Translated to RASTI Performance



DISCUSSION

It can be seen that a worthwhile improvement in RASTI can be achieved. We largely discount the huge improvements measured on the MTRC experiment since these results centred on a region of the RASTI/Word Score graph were δ(RASTI)/δ(Word Scores) was large to the extent that normal experimental variations could have a profound effect.

Notwithstanding this, the results do indicate that improvements in the region 0.05 to 0.15 are clearly possible. Hence if a reliable and robust method of predicting the improvement can be deduced, then the application of amplitude compression will become a powerful tool in off-setting the deleterious effects of noise and reverberation allowing compliance with specification.

IMPLEMENTATION

Since RASTI is a factor of reverberation time, direct-to-reverberant ratio and signal-to-noise ratio i.e. RASTI = f(RT)(D/R)(S/N) then it seems reasonable that the effects of compression should be implemented in this way
i.e. RASTI = f(RT+ΔRT)(D/R+ ΔD/R)(S/N+ ΔS/N)
where: ΔRT, ΔD/R and ΔS/N is the change in variable that would have caused the improvement brought about by compression.

We have examined the effect of noise and the expression seems to be in the form:

$$\Delta S/N = C - \frac{C}{100} \cdot 10^{\frac{S/N}{10}}$$

where C = constant.

From the data points available the effect of D/R seems to be much the same. Further data points are required to fully formulate the expressions.

CONCLUSIONS

Work reported elsewhere has demonstrated an improvement in Word Score results when the source is subject to amplitude compression. Given the raison detra of RASTI, a simple translation between the two descriptors does seem reasonable. Once the improvement may be reliably quantified for given sets of conditions, the implications of this procedure is considerable.

A programme is in place to complete the data matrix and hence provide the necessary information to determine the necessary relationships.

Note: A Patent on the means and method is pending.

References

[i] Technical Article: P.W. Barnett: IOA Bulletin: October 1997
[ii] The Common Intelligibility Scale: P.W. Barnett, R.D. Knight: IOA Proceedings: Vol. 17: Part 7 (1995).
[iii] A Review of Speech Intelligibility Indicators - Their Relationship and Applications: P.W. Barnett: Noise Con. 97: Penn State, USA.