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EXAMINATION OF THE VALIDITY OF A SINGLE FIGURE MEASURE OF PRIVACY AND INTELLIGIBILITY

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INTRODUCTION

In the early stage of the design of a building, when the spectrum background noise level of air conditioning or other noise is not known, it is necessary to be able to specify sound insulation values or, in the case of open plan offices, screening and sound absorption requirements. A similar requirement exists at the other end of the signal/noise ratio scale - when examining the requirements for communicating in noisy areas, such as factory premises. For this reason it would be useful to have available a single figure measurement of privacy, that would give reasonably accurate results, and be derived from other single figure data, such as NR, dBA or Rw.The validity of a simple method for the single figure description of privacy and communication potential has therefore been examined.

METHOD

The method adopted was to generate spectra using a pseudo-random number generator and then move this spectrum up and down, calculating Articulation Index for voice levels of 65dB long term RMS, dBA, Noise Rating curve and Preferred Speech Interference level. The 1/3rd octave spectra were generated by choosing two peaks - the first between 250Hz and 2000Hz, the second between 250Hz and 20,000Hz. The level of the first peak was at 0dB and the level of the second peak between -30dB and 0dB. The slopes up to each of these peaks were selected to be between 0 and 3dB per third-octave, and those down to between 0 and 4dB per third-octave.

The effect was to generate spectra which tended to have a higher peak at the low frequency end and a lesser peak near the mid to high frequency end. Though a high peak at the top end and a lower one further down was not ruled out. A visual examination of graphs of the spectra showed that in general they were typical of the spectra that might be obtained in measurements of a wide range of environmental noise from office air conditioning to various kinds of factory noise.

At each run one hundred different spectra were generated, and six runs were carried out in total using 3 pairs of random number seeds. The first 3 runs used the speech spectrum as measured in free field. The second 3 runs used a speech spectrum that might be expected immediately outside a room with a partition having sound reduction indices increasing by 6dB per octave.

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VALIDITY OF RESULTS

In order to examine the validity of the single figure measure, we have first looked at the situation where the background noise level is such that the Articulation Index is 0.28. This level has been chosen because it is approximately equal to the point defined as "Just reliable communication" under the Preferred Speech Interference Level - that is 70% word score. The test results give values for PSIL at this point of 58.5, 58.9 and 58.5 with a standard deviation of less than 1.5dB. This agrees closely with the figure of 58dB for Just reliable communication for normal voice, and therefore shows that the correlation between Articulation Index and Preferred Speech Interference level is good.

In passing it is of interest to note that the numerical difference between the dBA values of the spectra and the NR level is a little under two, with a standard deviation of about 2. However, only one of the 42 groups of measurements examined had a mean value for this difference of less than Zero (and then only -.02). There is therefore probably substantial skew in the distribution curve.

Before commenting on the closeness of fit of the single figure measurement it is worth examining the difference in the standard deviations of the A-weighting and NR level figures for the various values of AI. All the runs showed a substantially smaller standard deviation when the background level was measured in dBA, than when it was measured by the NR curves. Generally, the standard deviation was about 1.75 times larger when measured as an NR level. For these sets of curves then the best fit is obtained by using a background noise level measured in dBA.

To examine the importance of the variance of the results a table of subjective privacy or communication levels has been compiled, based on values of Articulation Index.

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AI	Privacy	Communication
		Excellent
0.59		
		Very Good
0.43		
		Good
0.31		
	Poor	Fair
0.21		
	Fair	Poor
0.10		
	Good	
0.035		
	Very Good	
0		
	Excellent	

As a result of preliminary investigation of the results, it was decided to define CPI - communication & privacy index - as follows:

1. For open area:

$$CPI = A - (V - 67) + D$$

Where A is the A-weighted background level
VdB is the long term rms of the voice at 1.0m in free field.
D dBA is the difference in level between the voice at 1.0m and at the measurement point.

2. Through a partition:

$$CPI = Rw + A - (V - 65)$$

Where Rw is the weighted sound reduction index of the partition

If we relate these to a "normal" voice level of 65dB long term RMS, the formulae become:

for open area:

$$CPI = A + D + 2$$

and through a partition:

$$CPI = Rw + A$$

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The constant in the formula was chosen so that the simple addition of Rw and A-weighted background noise would give the CPI. It is also of interest to note that for the open area the CPI is equal to the NR level plus D.

In the open case the change in CPI from one category in Table 1 to the next is 4dBA. That is to say, a rise in background level of 4dBA will, for example, change privacy levels from good to very good. In the second case of noise via a partition, the change of CPI from one category to the next is 5.

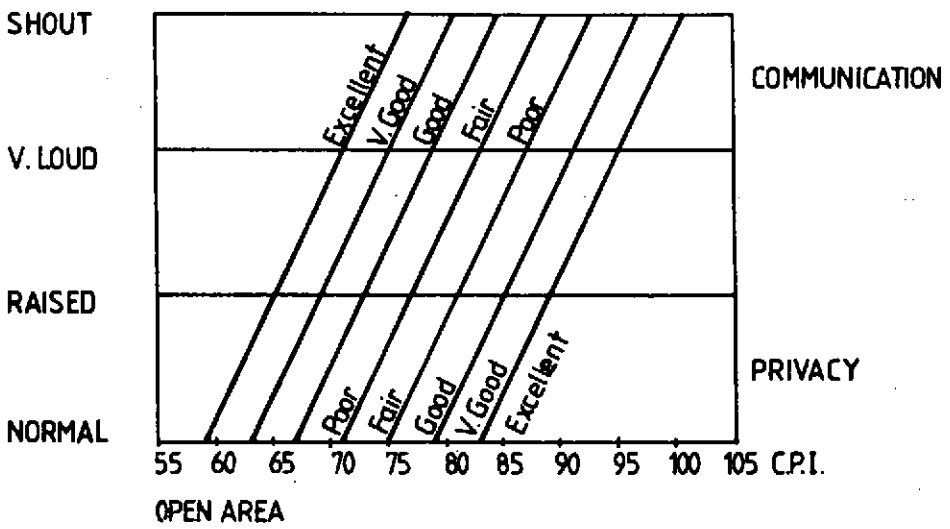
The validity of the single figure measurements can be judged by the standard deviation of the CPI for each of the fixed values of Articulation Index. The mean standard deviation for open areas is 2.75, and for partitions is 2.33.

Taking the standard deviations calculated, the probability of a result being at least one whole category in error is about 15% for the open area case and about 3% in the case of sound through a partition.

It is generally accepted that voice levels are categorised as follows:

Normal	65dB	long	term	RMS
Raised	71dB	"	"	"
Very loud	77dB	"	"	"
Shout	83dB	"	"	"

From these figures and those calculated above, we can prepare the diagrams below to show the CPI necessary to achieve the various subjective categories.



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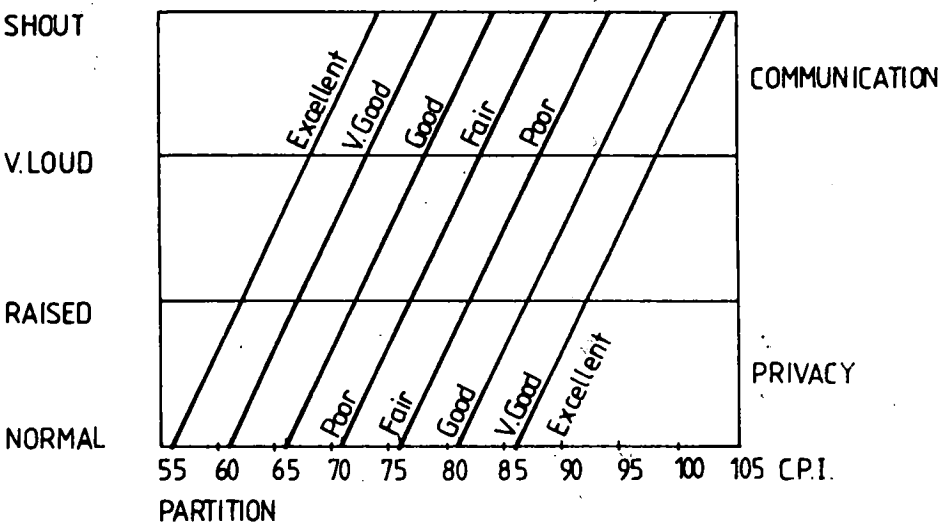

CONCLUSION

For early planning in partition design, or for initial assessment as to privacy levels or efficiency of communication in an open area, the results obtained using the single figure measures proposed are probably close enough, particularly bearing in mind that the results are highly dependent on voice level.