SPEECH INTELLIGIBILITY MEASUREMENTS WITH LOW LEVEL OUTPUT – EFFICIENCY LIMITATIONS
(This work is in progress)

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1 INTRODUCTION

Excessive background noise levels or simply annoyance caused by a high test signal level commonly comprise the main reasons for having low signal to noise ratios (S/N) or using low level output during a measurement session. A significant error, in this sense, can be introduced in the resulting data since the measurement technique would require, among others, a minimum S/N ratio for an accurate outcome. Threshold efficient values of the latter are highly affected by additional factors, including the general acoustical characteristics of the space in consideration, the test signal in use and measurement duration. Speech intelligibility measurements in particular require a higher degree of accuracy since small variations can result in larger errors in the space assessment procedure. In the attempt to establish a point of reference for verification of data accuracy this paper considers these relations. An indication of their function could be obtained through practical experimentation. Results are reported here.

2 EXPERIMENTAL PROCEDURE

2.1 S/N ratio measurements

Measurements were performed in a reverberation chamber, employing the WinMLS platform and omni-directional equipment. Two RT conditions were considered (high, low), adjustable through the additional use of absorbent material in a single room surface.

Using sine and MLS test signals, multiple 10 second measurements (T_{30}) were performed in descending 1dB steps in the attempt to determine threshold efficient S/N ratio values for a particular setup. The reference to establish an accurate performance included a high S/N ratio measurement, obtained prior to commencing on the process; the RT curve being used to monitor the results. The latter were analyzed in terms of T_{30} to reflect the effect on intelligibility measures, resultant of the room impulse responses.

2.2 Measurement duration alteration

The effect of altering the measurement duration was tested using the levels that marginally produced errors in the initial approach. Fluctuating background noise was present at the time of measurement, therefore increasing the measurement duration was expected to allow for increased tolerance to noise. Measurements were performed for increasing measurement duration in steps of 5 seconds, combined with sequential level decreases to establish threshold values, in terms of time and level, for the particular setup.

3 INITIAL RESULTS

3.1 Sine wave vs. MLS test signal

Sine wave and MLS test signals are often used for speech intelligibility related investigations, the former normally preferred for general purpose measurements. An efficiency comparison in terms of low S/N ratios was carried out here (Figure 1) to establish the magnitude of the generally acknowledged difference in performance. Referencing the high RT case, MLS performed on average about 6 dB better. For the low RT case, the equivalent difference approached 4 dB.

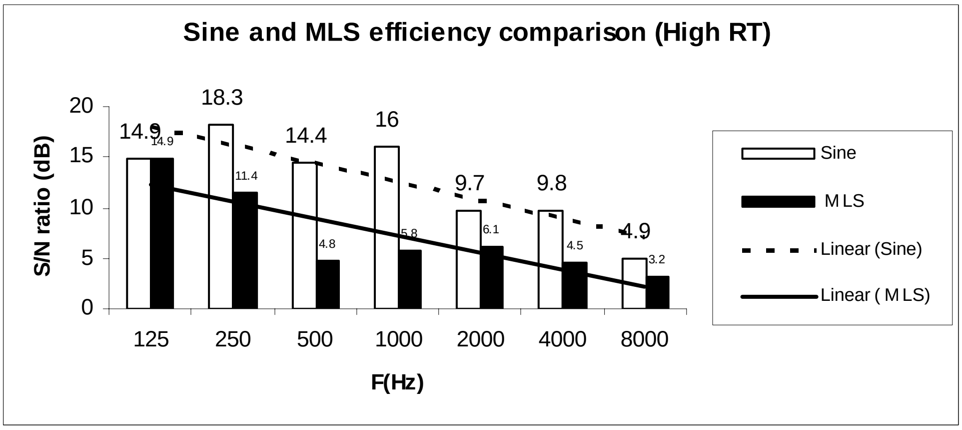

Figure 1. Example of Sine and MLS efficiency comparison in terms of S/N ratio (high RT)

3.2 Threshold efficient S/N ratios

Measurements that were performed in the attempt to establish reference threshold efficient S/N ratios, resulted in four datasets for the associated conditions examined (Table 1). It was pointed out that the particular value is not static, and is highly affected by several parameters, including RT (Figure 2). For the latter case, correlation coefficients of up to 0.7 were obtained. Source / receiver positioning, background noise character and absorption uniformity were identified as some of the additional parameters that have an effect, mainly by means of preventing measurement accuracy, rather than correlating with the outcome. For the current setup, a smaller difference in performance, between Sine and MLS, was obtained for the low RT case. Combined with the initial efficiency assessment's output, possible errors were suggested in the MLS dataset for the particular condition.

	Sine				**MLS**			
	High RT		**Low RT**		**High RT**		**Low RT**	
F(Hz)	RT(s)	S/N (dB)	RT(s)	S/N (dB)	RT(s)	S/N (dB)	RT(s)	S/N (dB)
125	2.42	**15**	1.31	**12.1**	2.48	**10.8**	0.94	**3.7**
250	2.35	**18**	1.32	**11**	2.42	**11.4**	1.33	**8.4**
500	2.35	**14**	1.27	**12.3**	2.33	**4.8**	1.24	**8.7**
1k	2.59	**16**	1.41	**16.3**	2.54	**5.8**	1.39	**11.2**
2k	2.51	**9.7**	1.37	**14**	2.52	**6.1**	1.38	**9.3**
4k	2.21	**9.8**	1.3	**4.1**	2.22	**4.5**	1.31	**3**
8k	1.54	**4.9**	1	**5.5**	1.58	**3.2**	1.02	**3.5**
	Correl. 0.7		Correl. 0.7		Correl. 0.6		Correl. 0.7	

Table 1. Threshold efficient S/N ratios for Sine and MLS (for current conditions)

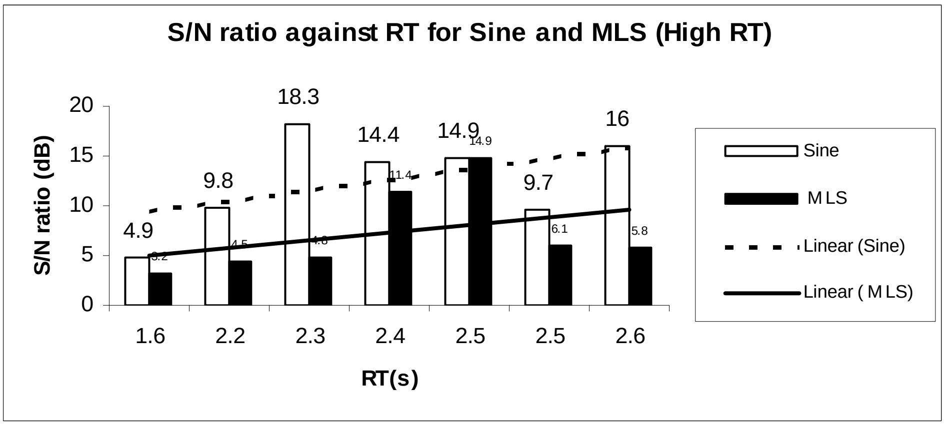

Figure 2. Relation of RT and threshold S/N ratios (for high RT, ascending order)

3.3 Measurements incorporating a noise source

Due to the low signal levels involved in the procedure and the capacity for better correlation between RT and S/N ratios, a need was presented to verify the risk of the test signal level not being high enough to excite the room. The fluctuating character of the background noise level could also be responsible for any effects. For this reason a noise source was later added in the system in order to allow for low S/N ratios with higher signal levels; also creating a steady state background noise. From the initial approach, a more stable system was demonstrated.

3.4 STI results for reference and low level measurements

The STI derived from the low S/N ratio measurements was compared to the reference values, in order to verify the level of accuracy (Table 2) in terms of the specific measure. The octave specific STI (i.e. Modulation Transfer Index) was referenced in this case, for the additional reason that the values among individual octave bands did not necessarily relate to a single measurement. Good agreement was found for all conditions.

STI								**Average**
F(Hz)	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**	
Reference	0.46	0.43	0.4	0.43	0.39	0.42	0.52	*0.44*
Sine (High RT)	0.46	0.43	0.4	0.42	0.39	0.43	0.55	*0.44*
Reference	0.58	0.61	0.56	0.56	0.52	0.55	0.62	*0.57*
Sine (Low RT)	0.57	0.62	0.57	0.57	0.52	0.57	0.64	*0.58*
Reference	0.47	0.43	0.4	0.42	0.4	0.43	0.52	*0.44*
MLS (High RT)	0.47	0.43	0.42	0.43	0.41	0.44	0.55	*0.45*
Reference	0.58	0.61	0.56	0.56	0.52	0.55	0.63	*0.57*
MLS (Low RT)	0.66	0.62	0.59	0.57	0.53	0.56	0.65	*0.60*

Table 2. Comparison of STI for reference and experimental conditions

3.5 Measurements with altering duration

For the current setup, the initial approach demonstrated that increasing the measurement duration from 10 to 20 seconds was adequate to allow for measurements to be performed with a test signal level a few dB lower. Given the fluctuating character of background noise however, these results can be treated as indicative only, at this point. It should be noted that a lower test signal level does not necessarily denote a lower S/N ratio in this case.

4 FUTURE WORK

Through practical experimentation, it was demonstrated that several factors have an effect with respect to the threshold S/N ratio values needed for an accurate measurement. As a single dataset cannot relate to the multitude of possible conditions, there is a need to further assess the functions taking place, for different conditions and measurement setups, so as to better define their relations. For MLS test signals in particular, added attention with respect to the conditions examined is needed, due to the special character of the latter.

This work is in progress