Suitability of New Zealand Halls for Chamber Music

Janne Sanders

Marshall Day Acoustics, Auckland

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Abstract

Chamber Music originated from groups of friends playing together in small rooms for their own enjoyment. The essence of Chamber Music is intimacy and communication between players. In the design of halls for Chamber Music, therefore, the ability for the musicians on stage to effectively communicate with each other is vital, as is the sense of intimacy between the players and the audience.

A survey of New Zealand Halls was sent to New Zealand's leading chamber music musicians, in order to gauge subjective response to halls used for Chamber Music throughout the country, from the point of view of a performer in a small ensemble. Questions were answered regarding Clarity, Reverberance, Ensemble, Balance, Warmth, Support, Visual Impression and Overall Acoustic Impression. This paper presents the preliminary findings of this survey, relating responses to various known measured acoustical parameters of the halls, as well as shape, size and construction.

Introduction

The definition of 'Chamber Music', according to the Concise Oxford dictionary of Music (1) begins: "A term originally intended to cover such music as was not intended for the church, the theatre, or a public concert room" The Cambridge Music Guide (2) defines chamber music as "Music for a chamber (or small room) rather that a hall; hence music played by small groups". Chamber music was therefore originally composed not for an audience, but simply for the pleasure of those who played it, and was certainly not designed to be played in large public halls. (2) Nowadays, chamber music is an important part of the concert repertoire, and is widely played in halls of every size.

Chamber music may well be the form of musical performance where the musician's ears do the most 'work'. Every player is responsible for their own part, and cannot rely on others around them playing the same melody, as is the case with choral and orchestral works (at least for the strings). Additionally, there is no conductor to follow, and a musician must be able to hear minute details of every other players part in order to match timbre, bow strokes, vibrato, intonation, dynamics and timing absolutely accurately with every other player. Good chamber music ensembles have the ability to subtly change tempo, style, and timbre at will, knowing every other player in the ensemble will adjust instantly. The terms conversation, question, answer, surprise, joke, pause, and expression, are often part of the chamber musicians 'lingo' and indicate the closeness of the genre to a form of language or communication.

To enable successful musical expression to take place in a concert or recital hall, a subtle balance must be arrived at between the volume of the players' own instrument and the feedback from the other players. Following experiments involving small groups of chamber music musicians playing in anechoic conditions, Marshall et all (3) identified a 'temporal window' 17 to 35ms after the direct sound where early reflections between musicians were useful for ensemble. Reflections outside this 'window' were judged adversely. Halls without suitable on-stage acoustic conditions for the chamber music musician have the potential to seriously compromise the quality of musical expression able to be conveyed to an audience, even if the acoustic conditions in the audience area are ideal. Without the ability to easily play in ensemble, musicians can not act spontaneously and creatively in the interpretation of the music, and the sense of communication and intimacy at the core of the chamber music genre is lost.

"...listeners with a musical background often seem to demand above all to be able to hear musical detail..."

Baron (4) stated that listeners with a musical background often seem to demand above all to be able to hear musical detail. However, Nakamura *et al* found for orchestral musicians, judgements of 'general impression of the acoustics' correlated most highly with quality and quantity of reverberation, and hearing one's own performance rather than with 'hearing the performance of other players on stage'. (5)

One of the purposes of this study was to test the hypothesis that, for musicians in small ensembles rather than large orchestras, the ability to hear each other and effectively play in ensemble is of higher importance in their assessment of a hall than other factors such as 'reverberance'.

The second major purpose of the study was to gauge the responses of chamber music musicians to halls throughout New Zealand, and find whether there was a consensus among musicians as to which halls were most suitable for chamber music, from a performers perspective. This information can then be used in conjunction with investigations of the objective parameters of these halls, to find aspects that can be improved upon in halls which are at present more suited to other forms of performance.

Survey

Through discussion with chamber music musicians, 24 halls where chamber music is frequently performed were selected from throughout the country. Surveys were sent to expert musicians who regularly travel the country with chamber music ensembles, and who were likely to have had frequent experience playing in a large number of the halls.

The survey used the semantic differential method, employed by Baron (4) and others (6) in the study of audience subjective response, whereby subjects respond by indicating a point on a continuous linear scale where a particular hall fits into the given range. Six subjective categories

Table 1: Ranking of Halls

Hall	*Average Overall Acoustic Impression*
Auckland Town Hall	**9.1**
Nelson School of Music	**8.8**
Concert Chamber, Auckland	**8.6**
Dunedin Town Hall	**8.5**
Wellington Town Hall	**8.1**
Great Hall, Arts Centre, Christchurch	**8.1**
St Andrews on the Terrace, Wellington	7.5
CenturyTheatre, Napier	7.5
Hopetoun Alpha, Auckland	7.3
Christchurch School of Music	7.3
Glenroy Auditorium, Dunedin	7.3
Old St Pauls, Wellington	7.1
Wellington Basilica	6.9
Christchurch Town Hall	6.6
Michael Fowler Centre, Wellington	6.4
Wanganui Opera House	6.4
Bruce Mason Theatre, Nth Shore, Akl	**6.3**
Wellington Conservatorium	**6.0**
Wellington State Opera	**5.9**
Regent Theatre, Palmerston North	**5.7**
Illott Concert Chamber, Wellington	**5.5**
Marlborough Centre, Blenheim	**5.2**
Maidment Theatre, Auckland	**3.9**
Founders Theatre, Hamilton	**3.5**

were chosen: Clarity, Reverberance, Ensemble, Balance, Warmth, Support and Visual Impression, with an additional scale for Overall Acoustic Impression. A brief explanation of each 'end' of each scale was included on the survey sheet (Figure 1, omitted). It was chosen to place the question relating to 'Overall Acoustic Impression' at the top, to encourage the musicians to answer this question from a 'gut feel' perspective, before consideration of each individual component of the hall's sound had the potential to change their opinion. A question was included relating to the 'style of music best suited to hall', and space was provided below for additional comments.

Participation

A total of 22 musicians returned surveys, with 324 separate survey sheets completed. The participants included many of New Zealand's leading musicians. There is a predominance of string players and pianists among those who completed the survey, chiefly due to a more extensive repertoire resulting in more common use of these instruments in ensemble performance. A very impressive survey response rate of greater than 88% indicated that this group were actively interested in the acoustics of the halls.

Subjective Responses

Ranking of Halls

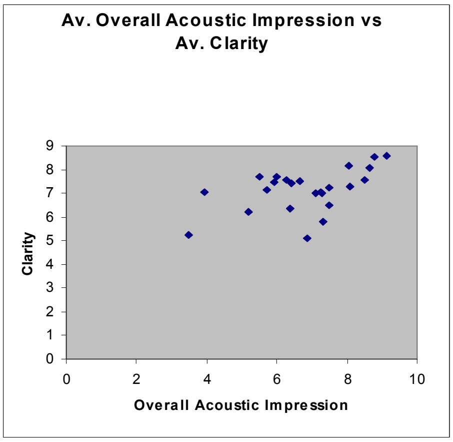
Using the average "Overall Acoustic Impression"(OAI) for each hall, the halls were ranked from most preferred to least preferred. (See Table 1) It should be emphasised that a hall not well suited for chamber music may be very well suited for other functions! Average OAI ranged from 9.1 to 3.5, with a statistical significance of <0.01% separating the two halls at the extremities. Analysis of variance on pairs of halls using a 5% level of significance, resulted in a separation into groups of highly rated and poorly rated halls, with halls ranked 1 to 6 on the scale highly rated, and ranking 17 to 24 poorly rated. These groupings are shown in 'bold' in Table 1.

Correlation of subjective parameters with Overall Acoustic Impression

Correlation of the average Overall Acoustic Impression with the average of the seven subjective

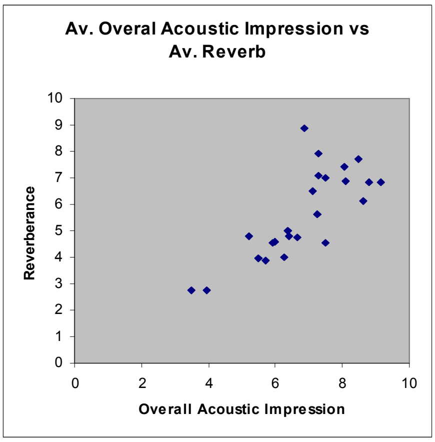
Table 2: Correlation Matrix between questionnaire scales for hall averages

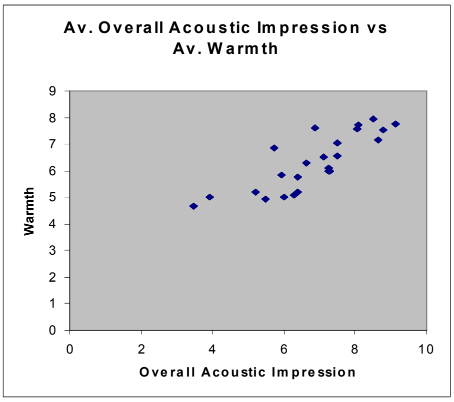
	Avg	Avg	Avg	Avg	Avg	Avg	Avg	Avg
Avg Overall								
Avg Clarity	**0.509**							
Avg Reverb	**0.776**	-0.0097						
Avg Ensemble	**0.832**	**0.672**	**0.54**					
Avg Balance	**0.885**	**0.678**	**0.612**	**0.884**				
Avg Warmth	**0.825**	0.2845	**0.764**	0.4859	**0.644**			
Avg Support	**0.922**	0.3167	**0.878**	**0.769**	**0.837**	**0.783**		
Avg Visual	**0.767**	0.3217	**0.68**	**0.508**	**0.522**	**0.803**	**0.635**	



Correlation Coefficient:
0.5092, $p<0.05$

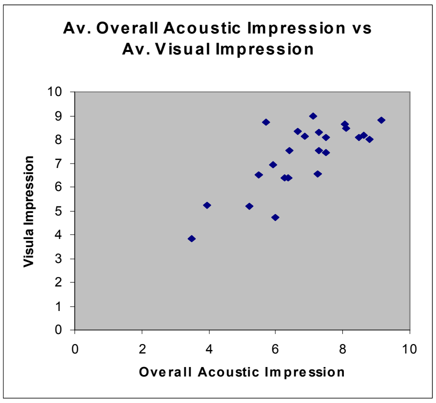
Correlation Coefficient:
0.7763, $p<0.001$

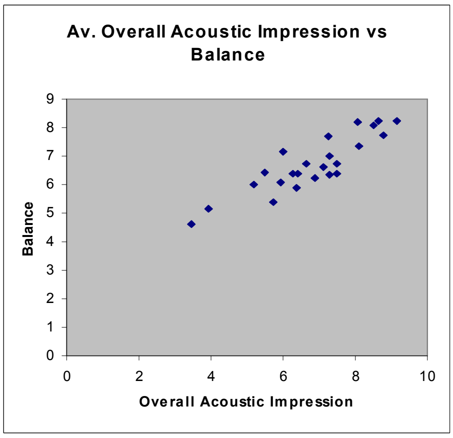




Correlation Coefficient:
0.8246, $p<0.001$

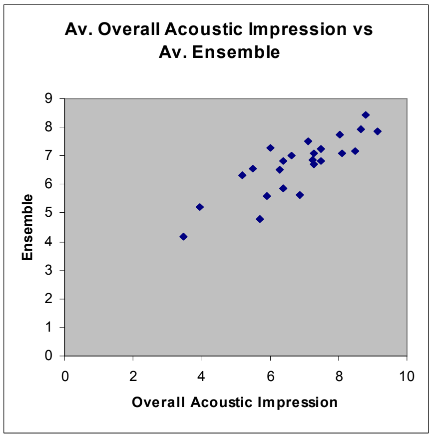
Correlation Coefficient:
0.7665, $p<0.01$





Correlation Coefficient:
0.8846, $p<0.001$

Correlation Coefficient:
0.8323, $p<0.001$



Correlation Coefficient:
0.9215, $p<0.001$

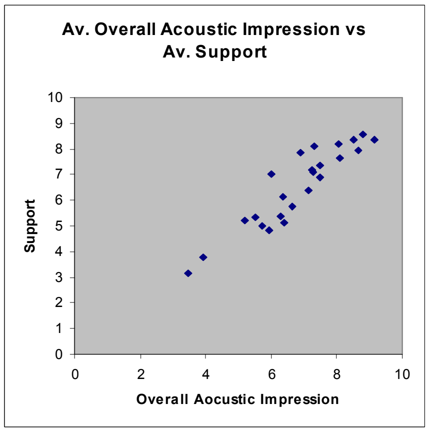


Figure 2: Correlations

variables for each hall, resulted in the correlation matrix shown in Table 2. (5% statistically significant correlations are shown in bold type)

Graphs of each subjective parameter vs Overall Acoustic Impression (averages for each hall) are presented as Figure 2. It can be seen that there is a significant correlation between the averages of every subjective scale with Overall Acoustic Impression. This is consistent with findings by Gade (7), where Factor Analysis of seven subjective scales designed to explain on-stage room acoustics conditions showed that the scales were not independent, with one factor, comprising 6 of the 7 scales, accounting for 82% of the variance.

The order of significance for correlation with each of the parameters surveyed in this study is as follows, with the parameter 'support' being the most highly correlated with 'Overall Acoustic Impression'.

Groups of Musicians

Increasing Correlation with Overall Impression ↑

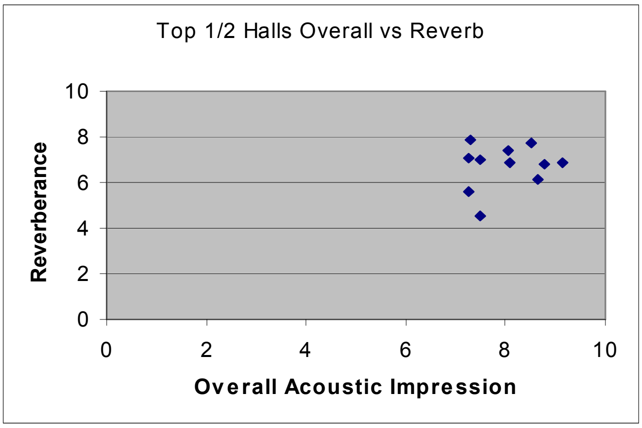
Support
Balance
Ensemble
Reverberance
Visual Impression
Clarity

Analysis of Variance between the ranking of venues by Average Overall Acoustic Impression for strings vs pianists showed six halls where the response from the two groups was significantly different (<5% significance). It may be interesting to note that these halls included the three largest in the survey, which pianists rated significantly higher than string players.

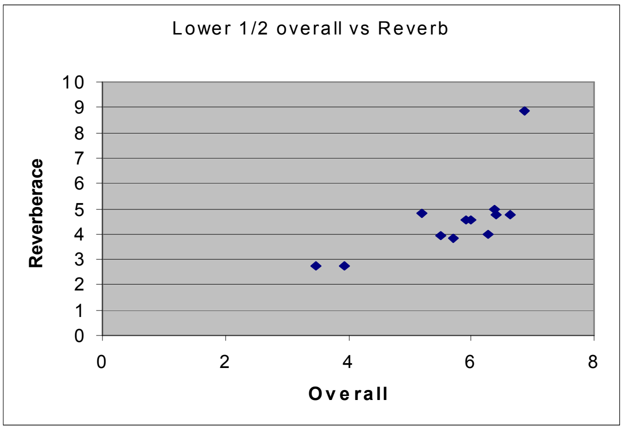
Analysis of Variance for the subjective parameters within these 6 halls showed that pianists rated 'Ensemble' and 'Balance' significantly higher than strings. No other parameters were significantly different between the two groups. When every hall with 3 or more returned surveys in each group was included, despite no significant difference in any other parameter, strings gave a significantly lower rating for ensemble than pianists (1.1% significance) The parameters of Balance (6.5%) and Support (9.4%) were under the 10% level of significance. In every other parameter, the difference between the two groups was not significant.

Strings are therefore consistently rating the ensemble quality of the hall lower than pianists. It may be that the level of detail required to be heard by string players for effective ensemble is higher that that for pianists.

Figure 3



Correlation Coefficient 0.178, p>>>0.05



Correlation Coefficient 0.704, p, 0.01

One example where this may be the case, is in the field of intonation. Pianists are forced by the nature of the tuning of their instrument to play in a tuning close to 'equal temperament', where the octave is divided into twelve equal semitones. In this tuning, 'perfect' intervals are not possible. (although 4ths and 5ths come close.) Small ensembles comprised only of string players, however, frequently deviate from this equal temperament, and are able to play perfect intervals, where the frequencies in a chord are exact ratios of each other. This results in a 'bloom and clarity' to the sound that string players strive for. Perfect intonation is far easier to achieve, however, if overtones of a chord can be heard, as the pitch of the same note varies depending on its relationship to the rest of the chord.

Subjective difference between highly rated and poorly rated halls

Others(8) have raised the probability that, for listeners, reverberation time is an important parameter up to a particular level of reverberance. Above 'optimum' reverberance, it is suggested that other parameters take on more importance in the rating of a hall. In the correlation of the overall averages for the halls in this study, reverberation time was less highly correlated that other 'ensemble' parameters. This seems to support the original hypothesis that 'reverberance' is secondary to 'ease of ensemble'. Figure 3 however shows interesting results when the halls are split into two 'groups' (ie lower half and upper half according to Overall Acoustic Impression).

It can be seen from figure 3 that for the highly rated halls, Reverberance and Overall Acoustic Impression are not correlated, however the lower rated halls have a strong correlation between the two parameters (<1% significance). The anomaly in the second graph is due to the Basilica, which was rated as over reverberant.

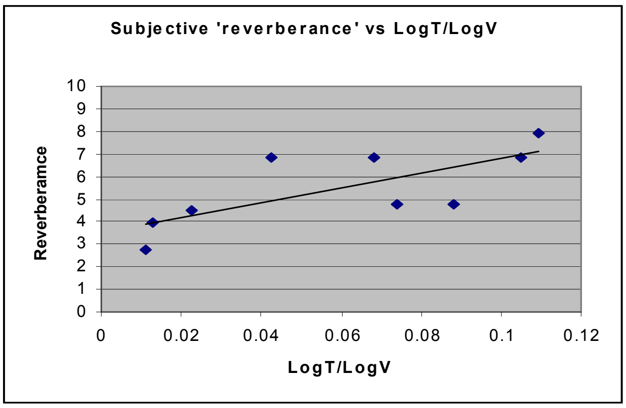
These findings illustrate that, even for musicians in ensemble on stage, if the 'reverberance' is subjectively too low, the hall is rated poorly. However once a minimum level of reverberance is achieved then the other parameters determine quality.

Relationship between subjective findings and objective parameters

Stage measurements of the halls have not been carried out as yet, and detailed findings with relation to objective parameters will be the subject of a subsequent paper.

It may be worthwhile, however, in the light of the preceding section to relate subjective impression of reverberation with known Reverberation Time measurements made in the body of the halls. In this study, halls have been included with a wide range of volumes. In graphing the two parameters, therefore, I have used the widely held view documented by Cremer and Muller (9) that the perception of reverberation time has a linear relationship on the graph of Log (RT) vs Log(Volume). Figure 4

Figure 4



Correlation Coefficient 0.7269, p<0.05

shows subjective reverberance scores from the survey vs Log(RT)/Log(V), where T is the measured unoccupied reverberation time of the halls and V is the room volume.

The significant correlation shows that the measured reverberation time of the halls does correlate with the subjective parameter of reverberance. Hence the findings in the section above may be extended to include the statement; even for musicians in ensemble on stage, if the Reverberation Time relative to the hall's volume is too low, the hall is rated poorly.

Table 3

	RT(500,1k)	ST1(250:4k)	ST2 (250:4k)
Gade's Recommended Ideal Range	2s (larger halls)	-12dB ±1	-8 to –12dB
Auckland Town Hall measured results	1.9s	-15.1dB	-13.5dB

Objective Measurements of the Highest Rated Hall

We are fortunate to have access to on stage measurements of the highest rated hall in this survey (Auckland Town Hall). The conclusions from the subjective data suggest that the most important parameters for chamber music (given adequate reverberation is provided) are 'support', 'balance' and 'ensemble'. These parameters have been found to be highly correlated with each other. Gade (10) suggested the following descriptors for measuring on-stage acoustics:

ST1: suggested measure indicating the ability to 'hear each other' on stage (ie 'ensemble')

ST2: suggested measure for the degree to which reflections from the room assist the sound created by the musicians own instrument (ie 'support')

These descriptors involve the ratio of the early reflection energy sent back to the stage, and the direct sound, and are described extensively in Gade's papers (7,10,11). A technical summary is provided as Appendix A. In Table 3, Gade's recommended optimal range (7) of these descriptors and Reverberation Time are presented alongside measurements taken in the Auckland Town Hall.

It is difficult to draw any conclusions about the significance or otherwise of the variations from the 'ideal' support parameters without looking at the data for the other halls, hence these values will need to be more fully explored at a later date.

Size/Shape of Halls in relation to subjective impressions

The 6 most highly rated halls, although all rectangular, vary widely in size. (from 2, 800m^3 to 13, 000m^3). The perception among performers seems to be that the larger halls are able to be used successfully for chamber music, given the right acoustic set-up, and are very rewarding to play in. It should be noted that the large hall with the highest rating has been provided with a recently designed over-stage reflector, which ensures a higher level of on stage support is achieved. It would be interesting now to find an audience perception of the use of these larger halls for chamber music, as conditions for performers and audience are different, and I am aware of an attitude among certain listeners that chamber music listened to in 'Town Halls' is quiet, rather muddy and lacking the energy, vitality, and intimacy of the performance conveyed in a smaller hall.

The countries two largest concert halls (Christchurch Town Hall, 22,713m^3 and Michael Fowler Centre, 20,700m^3) however, are situated in the middle of the preference ranking. Comments received along with surveys of these halls include 'Too large for chamber music' and 'Feeling of remoteness and lack of projection', and this may have influenced the acoustic assessment.

The two halls rated lowest are both fan-shaped in plan, one with a large fly tower. A fan shaped hall by design lacks useful early reflections for musicians, as sound is either directed out to the back, or up into the fly tower. However we will need to investigate the use of reflectors in these spaces to see if there are any in existence, and if so whether they are proving effective in providing reflections to the musicians.

Conclusions

Subjective data has been collected by way of a survey from chamber musicians specifically in relation to the suitability of New Zealand halls for chamber music from the point of view of a performer on stage.

Halls have been ranked according to the average Overall Acoustic Impression, and differences between halls have been found to be statistically significant.

A number of separate subjective parameters have been found to be highly correlated with Overall

Acoustic Impression, and they have been ranked according to degree of correlation. The 'support' parameter is the most highly correlated to Overall Acoustic Impression.

Pianists and strings have been found to respond differently to the parameter 'ensemble', with strings having more stringent requirements for this parameter.

Overall Acoustic Impression has been found to be highly correlated with the 'reverberance' parameter in poorly rated halls. There is no such significant correlation for the highly rated halls. A hypothesis of this study was 'for musicians in small ensembles, the ability to hear each other and effectively play in ensemble is of higher importance in their assessment of a hall than other factors such as reverberance'. This has been shown to be the case only when a certain level of reverberance has been exceeded.

Subjective reverberance has been found to correlate with the objective measure of Reverberation Time in the halls where this measurement was available.

The highest rated halls vary widely in size. From the point of view of a musician on stage, halls of 13,000 m^3 are able to be used effectively and well for chamber music.

The highest rated halls were rectangular, while the lowest rated halls were fan shaped.

Further studies may include the following;

- thorough objective measurements of the hall's on-stage acoustic characteristics,
- investigation into ways of improving halls where the performance of chamber music has been found to be difficult, and
- a survey to find the audience perspective of the halls

"...The highest rated halls vary widely in size, [and are] rectangular, while the lowest rated halls [are] fan shaped..."

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Appendix A:Technical Terms

Reverberation Time

Reverberation time is defined as the time taken for an interrupted sound to decay to one millionth of its original intensity (or by 60 decibels). In practice, this is approximated by measuring the time it takes for sound to decay from −5 to −35 dB, multiplied by a factor of 2 (T_{30}), or from −5 to −25 dB, multiplied by a factor of 3 (T_{20}).

Support Parameters (ST1 and ST2)

$$ST1 = 10 \log\left(\frac{E(20-100ms)}{E(0-10ms)}\right) dB$$

$$ST2 = 10 \log\left(\frac{E(20-200ms)}{E(0-10ms)}\right) dB$$

E=Total energy in the time period indicated.

The support parameters describe the ratio in dB between the early reflection energy sent back to the platform from the stage enclosures and beyond, and the energy of the direct sound. They are measured on stage, with a microphone placed one metre from the sound source. Values at four octave bands between 250 and 2000 Hz are averaged to give a single value. ❑