SUBJECTIVE EVALUATION OF THE ACOUSTICS OF JAZZ AUDITORIA; MULTI-DIMENSIONAL DESCRIPTION OF EVALUATIONS

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1. INTRODUCTION

Jazz is a music genre which originated around the beginning of 20th century in Afro- American communities in the Southern United States from a confluence of African and European music traditions.

Jazz auditoria initially have been conversions of existing enclosures, adapted to the new music genre solely on the basis of intuition. Since then, Jazz, the sound of which was formed in this kind of venues, became popular in the U.S. and beyond, while an increasing number of Jazz auditoria have been making their appearance all over the world. In order that such auditoria be acoustically effective, relevant design principles need be established. Much research has been reported in scientific literature regarding the design of classical music halls, whereas research efforts concerning the design of Jazz clubs have been scanty, to the present authors' knowledge

Jazz is a music genre distinct from classical music, therefore the acoustics of Jazz auditoria should be approached separately. While many musical instruments which are used in Jazz bands, such as piano, double bass, trumpet, etc. are also encountered in classical music orchestras, the role of such instruments, and by extension the acoustic demands upon these, are entirely different in each genre of music. Double bass, for instance, in a Jazz ensemble almost always plays pizzicato, and its role is exclusively rhythmic, whereas this is hardly the case in a classical symphony orchestra. Furthermore, while Jazz initially consisted of natural sound, since the second half of 20th century Jazz clubs usually have been employing a mixture of "acoustic" and electronically assisted sound, unlike classical music auditoria which have, in principle, been designed ever since for the enjoyment of natural sound.

With the above in mind, the present work aims at identifying a number of independent subjective qualities which are used by ordinary Jazz club goers to describe their acoustic experience of listening to Jazz. Although results from this research area do not tell the designer how to build a good Jazz auditorium, they can be used in further research in order to identify physical room acoustic criteria which are subjectively significant. The latter can subsequently be used in order to explore relationships with the design features of Jazz enclosures. This can be done, for instance, through the application of scale models or geometrical computer analysis of reflections on architectural plans and sections.

This work is an experimental study, and consists of a series of subjective acoustic evaluations of recorded Jazz performances in well known distinguished Jazz clubs.

2. REVIEW OF PAST WORK

The most important research effort concerning the design of Jazz clubs is the work of the “Sound of Jazz” (SOJ)[1,2] .In view of the design of “Jazz at Lincoln Center” (JALC) in New York city, specialists from Artec Consultants Inc. and the Walters-Storyk Design Group formed a unique joint-venture consulting team that was soon dubbed as the "Sound of Jazz" (SOJ). This team was the first to deal with the specification of Jazz sound and the acoustic demands of a Jazz auditorium, but this work was targeted to the construction of this specific auditorium (JALC).

A more recent attempt is the work by Daniela Prem and Richard Parncutt[3] who have compiled a long list of attributes describing the timbre of female jazz vocalists. Their list of attributes is a valuable resource which was employed in the present work, although those authors do not attempt to extract the best summary of their initial word bank in terms of a small number of acoustic qualities of Jazz auditoria.

Unlike acoustic research for Jazz enclosures, the subjective effects of the acoustics of classical concert halls have been extensively studied[4,5,6].

Nevertheless, there are studies[7,8] which concern the perception of musical sounds regardless of music genre, such as the work by Jan Stepanek[7]. In that study music professionals were employed to identify experimentally, verbal attributes describing single musical sounds, then the identification of subjective dimensions was explored.

3. EXPERIMENTAL DESIGN AND METHODS OF ANALYSIS

The subjective experiments employed the semantic differential method[9] in which subjective responses are measured by semantic rating scales, in this case bipolar and continuous. The scale judgments were analysed by factor analysis[10]. Factor analysis suits the basic hypothesis of this study, namely, that the labels employed in the rating scales refer to a much smaller number of independent concepts. Comments on the identity of factors, their interpretation and their relative importance, are found in references[4,5].

Recorded music from Jazz clubs was used in the evaluations, since the impracticalities associated with experiments at live concerts would make the present study almost impossible. Nevertheless, the experimental design can be criticised in that recorded music evaluations may eliminate scales for the reasons analysed in Sotiropoulou et al’ s study[5], some of which could emerge on significant factors under live concert conditions. In planning the present experiments, the assumption was made that there are common acoustic qualities between recorded music sound fields and live concert sound fields, and that the labels employed in the rating scales are used to describe some of these. This assumption has been validated as far as the acoustics of classical concert auditoria is concerned[5].

One difficulty with the semantic rating scale technique is that the factors produced are strongly dependent on the rating scales which are initially supplied to the analysis. To cope with this limitation a preliminary experiment was designed, which formed the first stage of the present experimental work.

4. EXPERIMENTAL PROCEDURE AND RESULTS

The subjective evaluation experiments were carried out in two stages. The first stage was concerned with the development of a number of opposite verbal labels in English, describing the acoustics of Jazz auditoria. Although the experimental subjects were Greeks, english attributes were used in the evaluations since English is recognized to be the original and international language of Jazz. One hundred and twenty three labels were compiled from relevant acoustic and music literature, language thesaurus, and relevant internet sites and "fori"[3,5,11,12]. The labels were experimentally sorted out into pairs of antonyms by thirty four individuals who were relatively familiar with listening to Jazz. The thirty three resulting pairs of labels are shown in Table 1 and were used at the poles of bipolar rating scales in the next stage.

Table 1. Opposite labels experimentally developed

No.	Opposite labels	
1	Close	-Distant
2	Dark	-Bright
3	Woody	-Metallic
4	Light	-Heavy
5	Poor	-Rich
6	Broad	-Narrow
7	In tune	-Out of tune
8	Live	-Dead
9	Cool	-Warm
10	Clear	-Hazy
11	Full bodied	-Thin
12	Faint	-Strong
13	Clear	-Dull
14	Dark	-Transparent
15	Near	-Distant
16	Smooth	-Harsh
17	Balanced	-Unbalanced
18	Crystal	-Muddy
19	Gentle	-Harsh
20	Loud	-Silent
21	Dark	-Brilliant
22	Edgy	-Smooth
23	Harsh	-Velvety
24	Colored	-Dark
25	Brilliant	-Dim
26	Clear	-Noisy
27	Near	-Remote
28	Smooth	-Rough
29	Smooth	-Sharp
30	Dead	-Resonant
31	Even	-Uneven
32	Clear	-Blurred
33	Preferred	-Non preferred

The second and final stage consisted of a series of subjective evaluation experiments of recorded Jazz. This was intended to identify the best summary of the rating scales developed in stage one above, in terms of a small number of independent subjective factors. In order to encourage the production of these factors a number of different recordings were used; this helps with increasing the variation between subjective judgments, therefore encourages interscale correlations which are necessary for the production of factors.

The music was compiled from three distinct commercial records respectively for the three experiments, namely: i) "Clotilde", performed by Steve Kuhn Trio at Village Vanguard, ii) "You 'd Be So Nice To Come Home To", performed by Keith Jarrett Trio at Blue Note and iii) "Stella By Starlight", performed by Steve Kuhn Trio at Birdland[13,14,15]. The above New York city venues are among the "classic" Jazz auditoria, their capacity ranging from 123 to 220 seats, which is typical of standard Jazz club. Piano trios were deliberately selected for the evaluations since first, this small ensemble constitutes the most common Jazz band, secondly this ensemble is a basic constituent part of larger Jazz bands and thirdly, and most important, the way Jazz piano trios are recorded conveys to sound reproduction, to a large extent, the original sound of the concert venue. The duration of the music pieces ranged from about five to eight minutes.

Table 2. Results of factor analysis of data obtained from the three recorded music evaluations

Factor	Associated scales		Factor loadings	Percentage variance	Cummulative percentage variance
1. TONAL QUALITY	• Smooth	-Rough	0.86	21.0	21.0
	• Smooth	-Harsh	0.86		
	• Gentle	-Harsh	0.85		
	• Harsh	-Velvety	- 0.82		
	• Smooth	-Sharp	0.80		
	• Even	-Uneven	0.77		
	• Edgy	-Smooth	- 0.68		
	• Clear	-Noisy	0.67		
	• Balanced	-Unbalanced	0.67		
	• Preferred	-Non preferred	0.56		
	• Loud	-Silent	- 0.52		
	• Light	-Heavy	0.46		
	• Faint	-Strong	0.43		
	• In tune	-Out of tune	0.35		
2. CLARITY	• Clear	-Dull	0.78	15.6	36.6
	• Brilliant	-Dim	0.76		
	• Crystal	-Muddy	0.75		
	• Clear	-Blurred	0.74		
	• Colored	-Dark	0.70		
	• Dark	-Brilliant	- 0.62		
	• Clear	-Hazy	0.61		
	• Broad	-Narrow	0.57		
	• Dark	-Transparent	- 0.42		
	• Cool	-Warm	0.40		
	• Dark	-Bright	- 0.39		
3. BODY	• Poor	-Rich	- 0.80	11.1	47.7
	• Live	-Dead	0.72		
	• Fullbodied	-Thin	0.66		
	• Faint	-Strong	- 0.57		
	• Woody	-Metallic	0.57		
	• Loud	-Silent	0.56		
	• Dark	-Bright	- 0.54		
	• Broad	-Narrow	0.40		
4. PROXIMITY	• Near	-Remote	0.85	9.6	57.3
	• Near	-Distant	0.81		
	• Close	-Distant	0.79		

Subjects were instructed to make their evaluations while listening to the music, so as to keep the assessment time under control as well as to encourage subjects refer to the music played. The questionnaire pads and the music pieces were circulated to the experimental subjects through the internet; the music pieces were in ".wav" format. Subjects were explicitly instructed to evaluate qualities of the sound, not those associated either with the audio system or with the music itself. According to answers to preliminary questions, a sifting was applied to the assessors, so as to ensure first, that the evaluations were made in a relatively quiet room, for instance in a living room, which is considered to be acoustically neutral, and for which type of enclosure commercial records are intended; so the listening enclosure would influence as least as possible the quality of the reproduced sound. Secondly, it was also ensured that, subjects employed a pair of loudspeakers of relatively good quality, so any likely distortion of sound could have been minimised. Thirty three subjects from amongst ordinary Jazz club goers, took part in the evaluations.

The raw scale judgments from the three subjective evaluation experiments were pooled together and were analysed according to factor analysis[10]. The "principal factoring with iterations" method was used for the extraction of initial factors, and the "varimax" method was used for the orthogonal rotation of factors. Four independent subjective factors were produced from the analysis. Results are shown in Table 2. Owing to the large sample size, the standard error of loadings for each factor was relatively low even at the 1% level of significance, i.e. .loadings around that limit were too low to be amenable to meaningful interpretation. Therefore, an arbitrary limit of 0,35 was adopted and only loadings above that limit are tabulated.

Table 3. Comparison of subjective factor scores between the three recorded music evaluations

Factor	F-ratio	Significance
1 TONAL QUALITY	26,85	0,00
2 CLARITY	3,61	0,03
3 BODY	5,96	0,00
4 PROXIMITY	0,32	0,73

5. DISCUSSION

The results from the subjective evaluation experiments confirmed the hypothesis of the present study, namely that the labels employed in the rating scales refer to a much smaller number of independent qualities of the acoustics of Jazz auditoria. The results also show that there is more than one such quality (factor), which demonstrates that the acoustics of Jazz auditoria, as perceived through commercial records by a wide cross section of Jazz club goers, does not correspond to a single experience. These findings are in agreement with results from earlier studies using either recorded music or live music in the case of classical concert auditoria[4,5,6].

The present factors are found, broadly speaking, to be in agreement with the factors of Sotiropoulou et al's study[5] who used evaluations of classical music repertoire played either through commercial records or in live concerts; three of these factors, namely TONAL QUALITY, CLARITY, and BODY, were also found, by and large, to be in agreement with the subjective factors of the Berlin study[6], who worked through dummy head concert hall recordings of classical music. These three factors, broadly speaking, are also in agreement with Stepanek's[7] subjective acoustic dimensions which are derived from evaluations of single sounds of music. All the above support the view, that these factors are independent sets of subjective acoustic qualities, which are common i) to distinct music genres, ii) to single sounds of music, and iii) to a wide range of music listening conditions.

TONAL QUALITY was extracted first i.e. this was the strongest factor in the present analysis, unlike results of classical music evaluations in earlier studies[5,6], in which other factors were invariably extracted in the first order. The order of extraction of a factor depends on the situation been judged. Jazz harmony consists of four, five, or more voice chords, unlike classical symphonic music the harmony of which is basically made up of triads even when a fourth voice is involved; the latter is a dominant chord / part of the basic triad. The dominance of tonal character in the case of Jazz, makes the evaluations on the relevant scales, such as 'smooth-rough", "gentle-harsh", "even-uneven" etc., easier to make, i.e. random error is relatively reduced, therefore high interscale correlations are given rise, which lead to the production of a strong factor. Not surprisingly, the present results also suggest that preference about the acoustics of Jazz auditoria was judged against the prevailing factor i.e. TONAL QUALITY (Table 2).

Absence of variation of the source-receiver distance in the present tests, provides evidence that the subjective factor PROXIMITY can be the effect of a solely acoustic sensation,

The cumulative percentage of total variance, accounted for by the present structure of four factors, is 57,3 % (Table 2). This implies that only about half of the variation in the subjective data, corresponds to common views amongst subjects about the acoustics of Jazz clubs.

The present results illuminate some of the ways, ordinary Jazz club goers, interpret the labels employed in the rating scales. For instance, in the case of scale "clear-noisy" subjects agreed that a sound which is "clear (of noise)" is also "smooth", "gentle", "even", etc. This interpretation is in agreement with the way the term "clear (of noise)" is intuitively employed in Jazz jargon; apparently this interpretation is independent of what is commonly understood as clarity of classical music sounds.

Nevertheless, the scale "broad-narrow" was interpreted here in two distinct ways, being associated either with scales such as "clear-dull", "brilliant-dim", "crystal-muddy", etc., of factor CLARITY, or with scales such as "poor-rich", "live-dead", "full bodied - thin", etc., of factor BODY. The first interpretation confirms the intuitive view for Jazz, that the perception of acoustic clarity is directly related to the sound (source) width. This, in particular, is obvious in the case of Jazz piano trios, since each of the three instruments involved, performs in almost distinct frequency domain; this makes the perception of the sound (source) width more pronounced and closely associated with the sound definition of each individual instrument. The second interpretation of the scale "broad-narrow" is in agreement with the established[16] view for classical music, that the perception of envelopment of sound is associated with the (apparent) width of the sound source; envelopment is considered here to be collectively represented by the labels "rich", "full bodied", "strong", "loud' etc. on factor BODY.

Furthermore, the label "dark" which is commonly used in Jazz jargon, was interpreted here in two distinct ways, being associated either with "dull", "dim", "muddy", etc. sound represented by factor CLARITY, or with "poor", "dead", "thin", etc. sound represented by factor BODY.

Last, regarding the scale "woody-metallic", the terms of which are commonly used in Jazz jargon, there was fair consensus between subjects that the term "metallic" referred to "thin", "faint", etc. sound, whereas the term "woody" referred to "rich", "full bodied", etc. sound, described by factor BODY. This finding confirms the intuitive interpretation of the above labels, in Jazz jargon.

6. CONCLUSIONS

The results from the subjective acoustic evaluations confirm the hypothesis of the present study that, the acoustics of Jazz auditoria, as perceived through commercial records by a wide cross section of Jazz club goers, is described in terms of a small number of independent subjective qualities (factors). There is more than one such quality, which demonstrates that the acoustics of Jazz auditoria, does not correspond to a single experience. These findings are in agreement with earlier studies[4,5,6], concerning the acoustics of classical concert auditoria.

The present factors TONAL QUALITY, CLARITY, AND BODY, by and large, are in agreement, first with subjective factors concerning the acoustics of classical music, identified either through commercial recordings[5], or at live concerts[5], or through dummy head concert hall recordings[6], and secondly with subjective acoustic dimensions of single sounds of music[7]. The above support the view that these factors are independent subjective acoustic qualities common i) to distinct music genres, ii) to single sounds of music, and iii) to a wide range of music listening conditions.

An analysis of variance test applied to the factor scores for each subjective factor (Table 3) showed that, for the factors TONAL QUALITY and BODY the subjective judgments were the effect of some systematic objective influence. The identification of these influences in terms of physical room acoustic criteria can be the object of a further study.

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