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Adapting John Cage's Radio Music for a digital score player

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Adapting John Cage's *Radio Music* for digital performance

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ABSTRACT

This paper discusses the creation of a digital score reader and installation version of John Cage's Radio Music. *The context surrounding the work's composition is explored as well as the changing context of the work in light of the evolution of radio broadcasting since the 1950s. The score for the work is explored in detail particularly in regard to the issues its determinate and indeterminate aspects, and their implications upon the performance of the work. The concept of "available indeterminacy" is introduced to describe the real-world limitations that exist as a result of Cage's specifications for the work. The presence of form-bearing structural features and consequently the potential for the emergence of an indeterminate and nonlinear formal structure from the performance of* Radio Music *is investigated.*

1. INTRODUCTION

Cage's works including radio as a sound source[1] emerged during a period when radio was exercising an increasingly important cultural role in American society. Although radio broadcasting had existed since the 1920s [4 pp. x-xi], it wasn't until the 1930s that "radio's aesthetic possibilities, it's potential to reach vast audiences, and its wealth of institutional resources attracted composer's from a broad stylistic spectrum" [19 p. 106]. The Second World War propaganda successes the consequent consolidation of radio services the also brought greater focus to the ideological influence that this medium was bringing to bear.

In 1945 Adorno directed his attention to radio, declaring:

> Music under present radio auspices serves to keep listeners from criticizing social realities; in short, it has a soporific effect upon social consciousness. (…) While radio marks a tremendous technical advance, it has proved an impetus to progress neither in music itself nor in musical listening. [3 p. 232]

By the end of the 1960s Marshall McLuhan was proclaiming a very different point of view.

> But while radio contracts the world to village dimensions, it hasn't the effect of homogenizing the village quarters." [17 p. 408]

While Cage was ideologically much closer to McLuhan's vision [16 p. 145][13 p. 564] than Adorno's, his recasting of the radio as a autonomous musical instrument does respond to one important question that Adorno posed in his article: "Does a symphony played on the air remain a symphony? Are the changes it undergoes by wireless transmission merely slight and negligible modifications or do those changes effect the very essence of the music?" [3 p. 230]. In Cage's radio works, the decontextualisation of the sonic contents of the radio broadcast is laid bare. Cage discussed his view of the radio as an abstraction in an interview with Kostelanetz:

> I didn't myself turn on a radio to listen to it; but when I was going through the streets or when a neighbor was playing the radio, and so forth, I listened as though I were listening to a musical instrument. (…) It made it possible for me to listen to radio with great interest, no matter what it was doing. [15 p. 220]

Cage's stance, listening to the sonic emanations from a radio in the same manner that he would listen to a piano or a thunderstorm, remained contentious: for example in more than 10 years later musicologist Nicholas Ruwet used *Radio Music* as an example of "non-music" [18]. Radio broadcasts (amongst other media) have, today, long been accepted as a simulacrum of the "real thing". What might be called "Cagean Listening" in which "sounds are just sounds" [10 134], and consequently his *Radio Music* is still a challenge for the audience.

Interestingly Cage wrote this work in semi-seclusion, living with only four others at the Stony Point artist's colony of Paul Williams at the edge of Harrimann state forest in upstate New York. Nicholls has noted that Cage's move to the countryside in 1954 paradoxically brought "increasing interaction with electronic media" [18 p. 105].

2. THE SCORE

Cage's score for *Radio Music* is deceptively simple. Each of the eight parts bears a similar set of instructions:

> Part A of Radio Music to be played alone or in a combination with parts B-H. In 4 sections (I-IV) to be programmed by the player with or without silences between the sections, the 4 to take place

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[1] The most prominent of these works include *Credo in US* (1942) for radio or phonograph, muted gongs, tin cans, electric buzzer and tom-toms and prepared piano [9]; *Imaginary Landscape No. 4* (1951) for 12 radios [5]; *Speech 1955* (1955) for 5 radios and newsreader [6]; *Radio Music* (1956) 1-8 radios [7]; and *Music Walk* (1958) [8] for 1 or more pianists who also play radios and produce auxiliary sounds by singing or other means.

within a total time-length of 6 minutes. Duration of the individual tunings free. Each tuning to be expressed by maximum amplitude. A _____ indicates 'silence' obtained by reducing amplitude approximately to zero. Before beginning to play, turn radio on with amplitude near zero.[8 Part A].

The remainder of the score consists of columns of frequencies separated by roman numerals, signifying the work's four sections. The score is a form of tablature, signifying physical actions but not sonic outcomes [14 p. 386].

Figure 1. Radio frequencies arranged in columns in the score of Part A of *Radio Music*.

Although the "authentic instruments" for performing *Radio Music* (RCA Victor "Golden Throat" Radios) similar to the one shown in Figure 2) are still available, "the contemporary radio landscape is completely different from the one in 1956" [12]. In effect the indeterminacy of the score has brought "authentic performance" of the piece to the brink of silence: by the "looming switch-off of the analogue radio signal in favour of the DAB type digital signal" [21] throughout the world.

The "frequencies" listed by that Cage fall between 55 and 155. This has been something of a puzzle as the AM band is general labeled in kHz, and there is very little activity in this range. The most likely solution is that Cage was referring to frequencies in hectohertz (hHz), it was common use the range 55 to 160 to represent the typical AM band of 550 to 1600 kHz, on radios of that era to save space on the dial (as shown in Figure 2) [12].

Figure 2. A 1950s RCA "Golden Throat" radio similar to the type John Cage conceived Radio Music for. Note the AM kHz dial shows frequencies abreviated to two numbers.

Although many have commented on the indeterminate nature of this work many elements of *Radio Music* are quite precisely prescribed. The impact of these determinate elements upon what might be called the "available indeterminacy" - that is the range of choices[2] that may be made without resulting with outcomes that fall outside of the determinate elements of the instructions – will be discussed in the next section.

In Cage's instructions he states that the four sections of *Radio Music* should "take place within a total time-length of 6 minutes" [8], but that the "duration of the individual tunings (is) free". Each of the eight parts has a different number of frequencies to be performed (see Table 1.). The part with the largest number of frequencies is C with 86. In order to perform all 86 in the space of 360 seconds (within a total time of 6 minutes) the performer must retune 86 times at an average rate of just over one every four seconds, not leaving a great deal of leeway for freedom of duration.

Indeed, if the work is to be performed in four sections as specified by Cage, the calculation of the average time allowed for each retuning is dictated not by the part with the greatest number of frequencies, but by whichever part has the largest number of frequencies in any given section. In section I the largest number of frequencies is in part G with 44 changes; II - C with 30; III - H with 38; and IV - F 40 changes. This means that for each section, the average length of each frequency change, in the part with the largest number of frequencies, is calculated by dividing the maximum duration (6 minutes) by the sum of these numbers (44+30+38+40) ie 360/152.

Therefore, the parts with the largest number of frequencies in each section must change tuning at an average every 2.37 seconds. This extremely rapid rate of change means that, although indeterminate, the

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[2] The consequence of an indeterminate element in a score is always a performative choice.

Determinate

Total no. of Frequencies per part	A	B	C	D	E	F	G	H
	68	51	86	42	36	70	71	46

Number of frequencies per part per section		A	B	C	D	E	F	G	H
	I	28	15	37	8	8	7	**44**	*3*
	II	11	14	**30**	2	10	16	6	*1*
	III	3	2	11	23	2	7	2	**38**
	IV	26	20	8	9	16	**40**	19	4

Largest number of frequencies per section	I	II	III	IV
	44	30	38	40

Indeterminate

Duration   152-360s

Number of parts   1-8 parts

Maximum and Minimum length of sections (s)	I	II	III	IV
	min-max	min-max	min-max	min-max
	44-196	30-182	38-190	40-192

Maximum and Minimum length of frequencies (s)		A	B	C	D	E	F	G	H
		min-max	min-max	min-max	min-max	min-max	min-max	min-max	min-max
	I	2-7	3-13	1-5	6-25	6-25	6-28	1-4	15-65
	II	3-17	2-13	1-6	15-91	3-18	2-11	5-30	30-182
	III	13-63	19-95	3-17	2-8	19-95	5-27	19-95	1-5
	IV	2-7	2-10	5-24	4-21	3-12	1-5	2-10	10-48

Table 1. Determinate and Indeterminate characteristics of *Radio Music*.

"available indeterminacy" in duration of the individual tunings is always in fact quite limited for some of the performers.

However, since Cage allows for *Radio* Music to be performed with between one and eight parts, these speculations about average durations vary depending on the number and combination of parts[3].

Another variable is the length both of the sections themselves, which is only determined by all of the performers completing the prescribed set of frequencies and of the total duration, which is the sum of the durations of each section. Although Cage specifies that the total duration of the work should not exceed six minutes, the performer is not prohibited from attempting shorter durations.

These factors mean that although it is not possible to get an exact indication of the rate at which each player must realize the frequencies in their set, limits can be proposed on the range of durations that a player will need to stay within in order to avoid a situation in which there is not enough remaining time to complete the prescribed frequencies in their set. Table 1 proposes these ranges for each part and section in the work (on the basis that all eight parts are being performed).

Cage's directions for "each tuning to be expressed by maximum amplitude" (Cage), implies that the spaces between the tunings should be lower in amplitude, perhaps even silent. To achieve this, the performer must operate the tuning and volume dials on the radio simultaneously and somewhat independently[4]. Figure 3 illustrates these actions on a graph: showing the volume dial always moving between silence and the maximum volume and the tuning dial moving smoothly between each frequency.

There is a both a limit upon the speed at which the performer can accomplish this task and presumably a limit upon how much time is needed for the audience to perceive of the particular frequency that has been reached. It is suggested here that one second is the lower boundary of this limit.

In performance, the physical difficulties of shifting between the score and the dial of the radio in order to reach the correct frequency are very real. Although it might be argued that a professional musician should not need to look at their instrument, the number of professional radio players is of course rather limited.

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[3] For this reason the performance of the work by the Western Australian new music group Decibel (of which the author is a member) on 20 June 2011 used only parts A, B, D, E and H: the five shortest parts.

[4] Unlike *Imaginary Landscapes No. 4* in which two performers are used for each of the 12 radios.

Figure 3. Manipulation of volume and Frequency controls necessary for the performance of *Radio Music*.
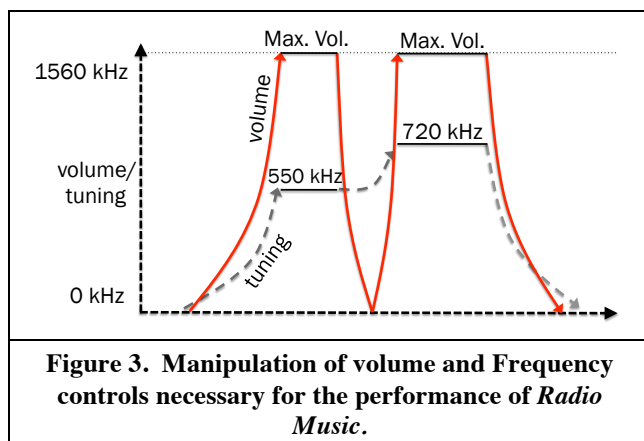
The issue of communication between performers is also a factor in *Radio Music*. Since the sonic output of the radios is indeterminate, it is difficult to take auditory cues from the other performers. As each performer is freely choosing the duration of each frequency it is not possible to take temporal cues from the other performers. These factors combined make a precise reading of *Radio Music* a serious challenge.

3. DIGITAL PERFORMANCE VERSION

The digital version of *Radio* Music alleviates some of some of the issues discussed in the previous section. The score is projected or networked on multiple computer screens. It consists of graphical representations of the radio dial for each of the parts being performed as shown in Figure 4. A red vertical line indicates the destination frequency to be reached and a black vertical line moves continuously to indicate the suggested current position of the tuning indicator. The destination frequency is displayed numerically on the left hand side of the screen and suggested current frequency is displayed on the right side of the moving black line. This allows the performer to follow the changes in frequency in a move intuitive way.


Figure 4. The Real-time Score for the digital version of *Radio Music*.
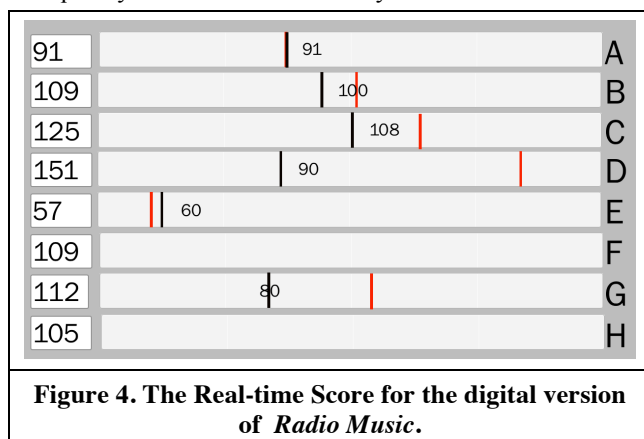
The issue of the duration of each frequency is calculated through a "hierarchy of indeterminacy", taking into account that the available choices diminish hierarchically from formal levels with longer durations (such as the total duration of the work) to shorter formal levels (such as the duration of sections and individual frequencies). Once the total duration of the work is set, duration of the sections cannot exceed that length and similarly once the length of the sections has been chosen, the total duration of the frequencies cannot exceed that length.

The control panel for the digital version of *Radio* Music, provides the option to:

- choose which parts will be included in the performance;
- set the total duration of the work
- set the average duration of pauses between the four movements;
- choose the degree of allowable deviation from the notional average duration of the four movements
- choose the minimum duration assignable to each frequency.

Figure 5. The control panel for the digital verson of *Radio Music*.
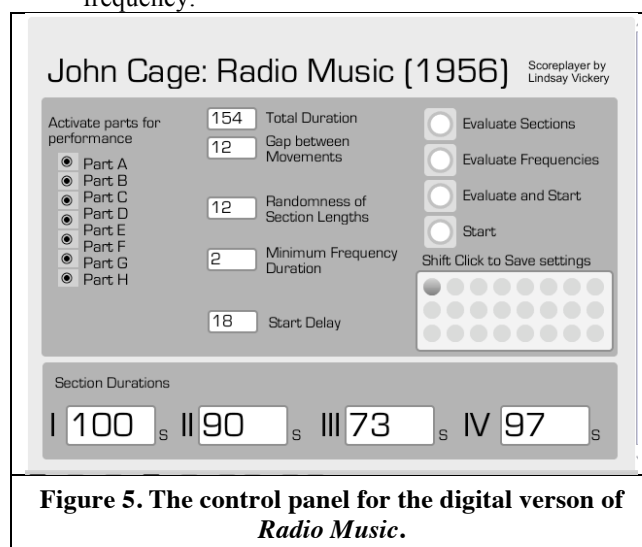
The performer(s) may choose to evaluate the section durations before the performance, allowing proportions that are deemed unsuitable to be discarded, or to evaluate the durations and start the performance immediately.

Performers are given a range of options for selecting both the determinate factors in Radio Music (such as the number of parts performing and total duration) and the "available indeterminacy" of indeterminate factors (such as the amount of variability in section and frequency duration) on the control panel shown in Figure 5. They may also choose the average duration of the gaps between movements and the delay prior to the score activating.

The duration of the work must fall between 360 seconds (the longest duration specified by Cage) and the sum of the largest number of frequencies that are needed to be performed in each section. It should be noted that because the choices diminish with shorter total and sectional durations the work is necessarily less diverse, in terms of durations, as its total duration decreases. For example when the duration is set at its minimum, the performer with the largest number of frequencies in each section will need to maintain an average of one second per frequency change.

total duration (D)	calculation	360 s			
largest no. of frequencies (f) performed by any part in sections I+II+III+IV		$f^{i}=44$	$f^{ii}=30$	$f^{iii}=38$	$f^{iv}=40$
sum of the largest frequencies (F)	$f^{i} + f^{ii} + f^{ii} + f^{iv}$	152			
relative proportions (p) of each section	$f^{(i\text{-}iv)}/F$	$p^{i}=0.29$	$p^{ii}=0.20$	$p^{iii}=0.25$	$p^{iv}=0.26$
average duration in seconds of each section (S) $(D*p^{i\text{-}iv})$	$S^{i}, S^{ii}, S^{iii}, S^{iv}$	104	71	90	95
randomness of section lengths	$S^{(i\text{-}iv)}(+/\text{-} r)$	104(+/-8) 100 (-4)	71(+/-8) 63(+1)	90(+/-8) 83 (-7)	95(+/-8) 91(-4)
Scaled	$(S^{(i\text{-})}(+/\text{-} r))$ $/ S^{(i\text{-}iv)}(+/\text{-} r)* S^{i}$	107	67	89	97

Table 2. Calculation of the indeterminate section lengths of *Radio Music*.

Indeterminacy in the durations of the sections is obtained in a number of stages. Initially, a notional average length for each section is calculated. This is equal to the largest number of frequencies in a section[5], divided by the sum of the largest numbers of frequencies for *all* four sections, multiplied by the total duration of the work. On the control panel, the performers may choose the degree of "available indeterminacy" to be used when choosing how much deviation each section can have from the notional average length. This process is outlined in Table 2.

The final duration of the frequencies is calculated in a slightly different manner. Again the performers may choose the degree of indeterminacy available when calculating the lengths of frequencies, however the final duration is chosen by randomly distributing the number of frequencies in each section over the total duration of each section. For example, when calculating the durations of frequencies of Part G in Section I using the greatest degree of indeterminacy, the 44 frequencies are randomly distributed over the 107 possible seconds of Section I (giving a range of between 1 and 63 seconds for each frequency). When the degree of indeterminacy is set at the minimum level, the 44 frequencies are equally distributed every 2.43 seconds of the total 107 second duration.

The digital performance version of *Radio Music* has three possible modes, score only, automated volume and installation mode. In the score only mode, a realtime screen score is generated for the performers to follow, changing frequencies as indicated by the score and adjusting the volume to match the changes in frequency. Automated Volume mode transfers control of the volume to the computer, allowing the performers to focus only upon changing frequencies.

In the Installation version the computer operates both the volume and frequency changes via Arduino. The

radios used in the Installation version were modified to allow direct electrical control of volume and the control of the frequency via a stepper motor. Each radio must be calibrated to its zero point (the lowest frequency it can reach) and the range of frequencies employed in *Radio Music* (55hHz to 156 hHz).

4. FORMAL IMPLICATIONS

The problems associated with achieving a precise performance of *Radio Music* have already been discussed. The question remains, however, why it would be necessary to "precisely" perform an indeterminate work. The answer lies in the determinate aspects of the work, which arguably infer a consistent if variable formal structure.

First it is necessary to consider the sonic material of which *Radio Music* is comprised. Unlike the score for a conventional musical instrument the frequencies listed do not specify pitch. Radio broadcasts are strongest at a specific frequency, but are spread, increasingly weakly over a band of frequencies about 10 kHz on either side.

The broadcast frequencies are precise and predictable and contents of radio broadcasts are usually roughly predictable - Classical Music, Rock, Jazz, talkback and so on – and in cases with detailed program listings quite precise. Radio Stations often exhibit strong consistency over a short period of time (such as found in *Radio Music)*, generating what we might consider a linear "narrative", that emerges as a consequence of the timbre of a presenter's voice the continuity of a piece of music, the subject matter under discussion and so on.

In terms of the density of the AM band, it might be expected for a radio to pick up local stations quite strongly, but also to more or less weakly detect regional (or at least non-local) stations.

Although *Radio Music* can not rely on the elements typically found in musical discourse, it does potentially draw on recognizable elements that could be expected to give rise to some of the experiences typical of musical

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[5] Which in turn is dependent upon the Parts that have been chosen by the performers.

listening, such as expectation, surprise a sense of departure and return and so on.

Fourty four different frequencies are used in the 150 frequency changes specified amongst the eight part of *Radio Music*. These are graphed in ascending order in Figure 6.
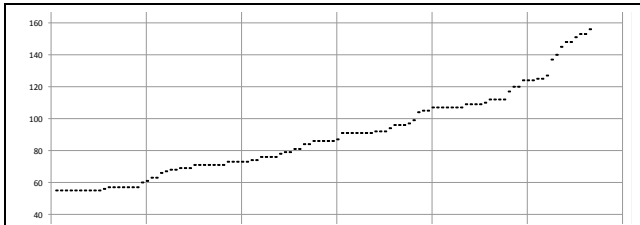

Figure 6. The frequencies in *Radio Music* graphed in ascending order.

The number of repetitions of each frequency is shown in Figure 7, illustrating that although 19 frequencies are only specified once, many others are repeated (between two and ten times) as shown in Figure 7.

incidence	no.	frequencies
1	19	56, 60, 61, 66, 67, 78, 87, 94, 97, 99, 104, 110, 117, 127, 137, 140, 145, 151, 156
2	11	63, 68, 74, 79, 81, 84, 105, 120, 125, 148, 153
3	4	69, 92, 96, 124
4	3	76, 109, 112
5	2	73, 86
7	4	57, 71, 91, 107
10	1	55
blank	37	

Table 3. The incidence of repetition of frequencies in *Radio Music*.

Although it is not possible to predict exactly when each frequency will be performed, they are performed in a strict order, and due to the limitations on available indeterminacy due to the narrow time constraints required by Cage, as discussed previously, it is possible to create a probabilistic picture of when particular frequencies will occur in relation to one another. It should be noted that broadcasts from radio stations, along with static, are also struck as performers tune from frequency to frequency.

Figure 8 is graphs the frequency changes in Section I of *Radio Music*, spacing them equally over the same duration. It gives an approximation of how active the eight parts are in relation to one another.
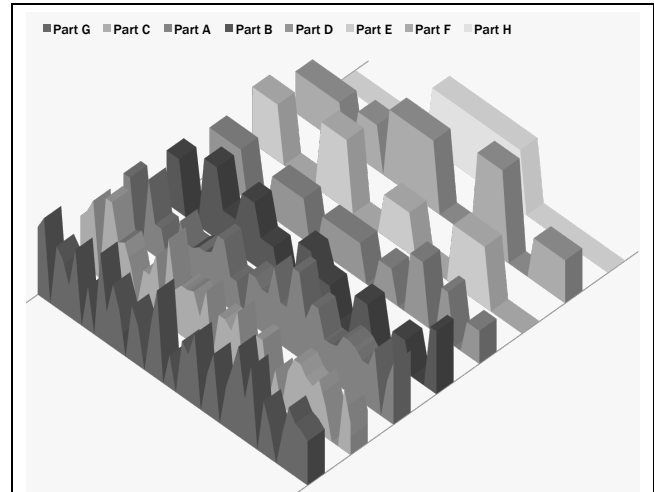

Figure 8: A representation of the frequency changes in Section I of *Radio Music*, spacing the changes equally over the same duration.

If this data is viewed in cross-section, with each part outlined as a "wire-frame", as shown in Figure 9 it is possible to see certain structures emerging from this "indeterminate" work: repetitions of the same frequency reoccurring at different points during the section and gradually rising frequencies that may more toward or away from a radio station (as shown in Figure 6 some frequencies are "clustered" together, while others are more isolated form one another). These inherent structures suggest at least the possibility of structures being detected.
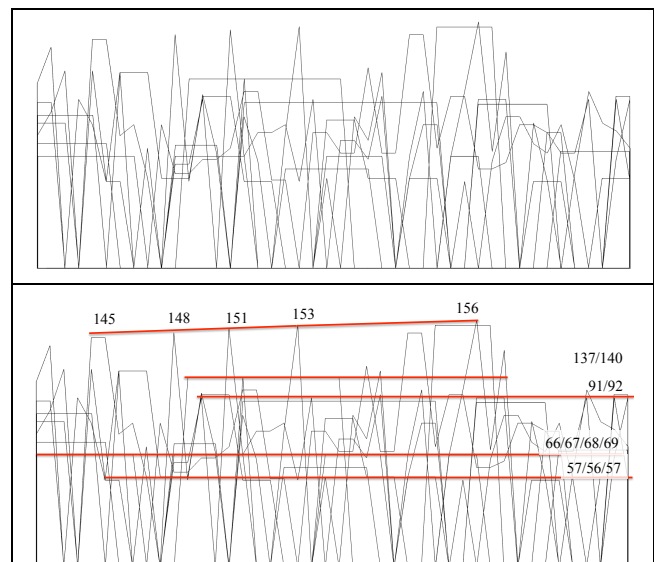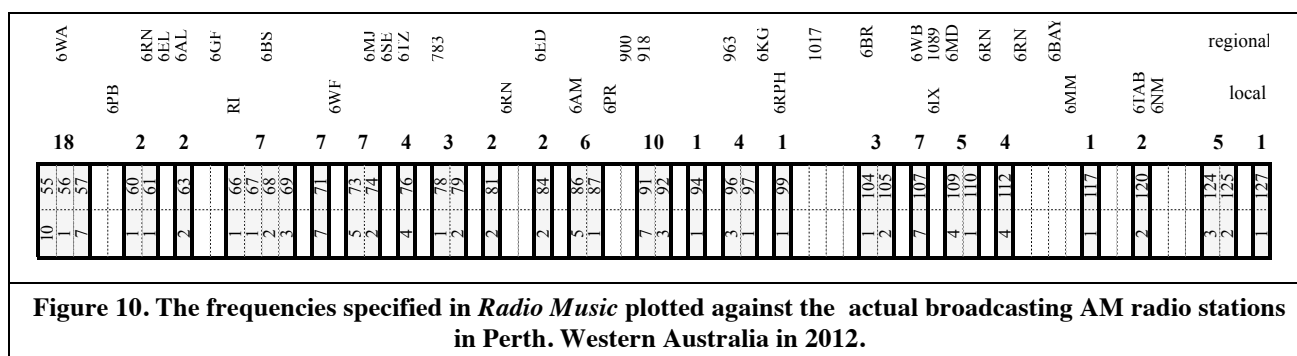

Figure 9. A "wire-frame" cross section of the representation of frequency changes shown in Figure 8. The lower graph shows the incidence of recurring frequencies with potentially form-bearing characteristics.

Cage stated that his radio works make "available something which you're already in. You are bathed in radio waves (…) radio simply makes audible something that you thought was inaudible" [11 p. 19)].

Figure 10. The frequencies specified in *Radio Music* plotted against the actual broadcasting AM radio stations in Perth. Western Australia in 2012.

6WA	6PB	6RN 6EL 6AL	6GF	RI	6BS	6WF	6MJ 6SE 6IZ	783	6KN	6ED	6AM 6PR	900 918	963	6KG	6RPH	1017	6BR	6WB 1089 6MD	6IX	6RN	6RN	6BAY 6MM	6TAB 6NM	regional local
18	2	2	7		7		7	4	3	2	2	6	10	1	4	1	3	7	5	4		1	2	5 1

Figure 11. A graph of the falling audience share of AM radio in major Australia cities from 1980 to 2006 [1 p. 14]

Had he only intended to make this point, he might have permitted the performers of *Radio Music* to freely explore the AM band or even have provided specific timing[6] and non-specific frequencies. That fact that Cage specifies frequency rather than duration implies that the precise structure – the proportions of different frequencies and the possibilities for their temporal relationships with one another was crucial to the composer.
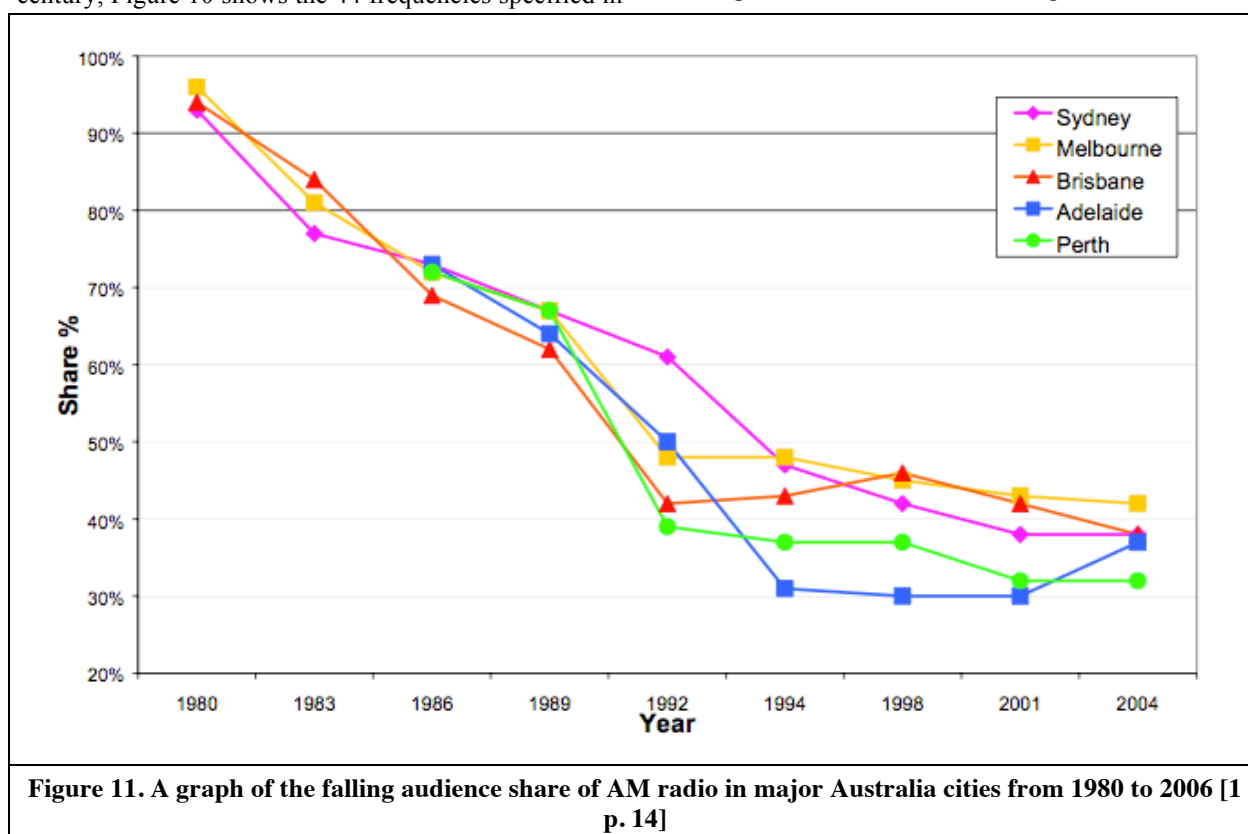
5. PERFORMANCE OF *RADIO MUSIC*

To explore how Cage's specifications for *Radio Music* match up to the realities of AM radio in the early 21st century, Figure 10 shows the 44 frequencies specified in Perth, Western Australia in 2011. As can be seen, only four of the eleven local radio stations coincide with frequencies specified by Cage. In regional stations are included the number goes up to 17 out of 44 stations.

Although the Australian Communications and Media Authority's 2006 report on AM Radio Issues claims that the "AM sector is not in terminal decline" [1], the graph in Figure 11 showing the falling audience share of AM radio stations, suggests that the introduction of commercial FM licences in the 1980s dealt a crippling blow to the AM band.

The result of the ever-diminishing number of AM band radio stations is that *Radio music* will be increasingly comprised of static rather than signal. There are several the work plotted against the actual existing local and regional radio stations that might be detected from possible responses to this issue:

1. to embrace the realties of evolving technology and realize the work principally with the "noise" of static;

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[6] Many of Cage's works from this period (for example *4' 33"* (1952), *59 1/2" for a String Player* (1953), *34' 46.776" for a Pianist* (1954), *31' 57.9864" for a Pianist* (1954) and *26' 1.1499" for a String* (1955)) explore this territory.

2. to "transpose" the work into a frequency band such as FM which is still relatively populated with Radio stations;

3. to "narrowcast[7]" internet radio stations in the vicinity of the performance.

The first approach is certainly defensible, but will undoubtedly result in outcomes in which the recognisable structural features potentially present in the work will be greatly diminished. The second approach might be likened to performing Baroque music on modern instruments. FM is less noisy than AM, but would still provide many of the outcomes found in an AM performance: such as noise between stations and tuning that is off-station.

The final approach is complex, requiring multiple digital receivers and transmitters. Interestingly it could afford the possibility for reconstructing an AM environment similar to the one for which the work was originally envisaged or even an "authentic" using recordings of broadcasts from 1956.

6. CONCLUSION

Douglas Kahn describes Cage's *Radio Music* as a work pitting "disintegration against disintegration, noise against noise" [13 p. 578]. It is certainly true that this is a work that takes a very commonplace medium and rends its sense of continuity and familiarity. However, it can also be said that the continuity and familiarity of radio broadcasting is also the essential material of *Radio Music*, material which provides structural features that are decontextualised and recontextualised in relation to one another in the work.

This paper has shown the potential for the emergence of structure, albeit an indeterminate nonlinear structure in *Radio Music* and the benefit of attempting to realize the work in the most precise manner possible to maximize its inherent characteristics.

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[7] The term "narrowcasting" describes a radio or television service whose reception is limited in some way, such as being targeted to special interest groups, being intended for limited locations (for example, arenas or business premises), being provided during a limited period to cover a special event, to provide programs of limited appeal, or for some other reason. [2].