IS THERE A 'RISE-FALL TEMPORAL ARCHETYPE' OF INTENSITY IN ELECTROACOUSTIC MUSIC?

Roger T. Dean[1] and Freya Bailes,
MARCS Auditory Laboratories, University of Western Sydney, Australia, NSW 1797. roger.dean@uws.edu.au

1. INTRODUCTION

We seek to identify recurrent temporal structures in a range of musics, which may relate to affect. Huron proposed a 'ramp archetype' in intensity patterns, based on his study of Western classical score notations[2, 3]. He observed more notations for 'crescendo' (increases in loudness) than 'diminuendo' (decreases), and estimated that crescendi occupied greater lengths of notational time than diminuendi. Since the word ramp can refer to both rises and falls, we will discuss a possible 'rise-fall temporal archetype'. Huron proposed that rises occupy greater time than falls, and that this may optimise attention, since rises may share features of environmental sonic looming.

We made specific predictions from this theory: first, that within most successive rise-fall pairs, rises last longer than falls. Since there are limits to the maximum and minimum intensities, commonly the intensity range covers the whole possible range, and so rises and falls on average involve similar magnitude intensity changes. Thus we predict, second, the rate of intensity change during a (longer) ramp is smaller than that in the succeeding (shorter) damp. The critical feature for a listener is probably perceptual loudness, but here we investigate the only possible surrogate for it in the case of the complex sonic textures of computer music, physical sound intensity. Huron did not make acoustic measurements. We are undertaking computational analysis of recordings within various music genres, to asess whether these predictions are upheld, and to extend them to other possible analogues of such archetypes beyond dynamics. Here we present such analysis of an anthology of Canadian computer music.

2. METHOD

We studied the 25 short pieces presented in the 1st CD of the 'DISContact! II' anthology of the Canadian Electroacoustic (ea) Community(1995). The pieces (from 80 to 188 seconds in length) are not primarily notated, rather their embodiment is sonic; they depend little on enculturated Western devices such as tonality.

Praat [1]scripts analysed durations and intensity rate changes of successive rises and falls in the pieces. First, the mean intensity (SPL) over time frames of 40msec, 0.5, 5 and 10 seconds was measured and each peak and trough identified. By definition, every intensity peak is followed by a trough (the 'all peaks' measure). There were between 235 and 792 rise-fall pairs in the 40msec analyses of these pieces, but in some cases there were 0 in the 5 and 10 second window analyses. Second, 'significant peaks' and troughs were measured for the 40msec data. Here only peaks/troughs which differ from the immediately preceding peak/trough by >=1/7 (the 'dynamic step') of the range between the 10 and 90% quantiles of intensity means are recorded as significant. The 1/7 criterion parallels the dynamic ranges used in contemporary notated music (ppp-pp-p-mp-mf-f-ff-fff). Rise times and corresponding intensity increase rates are measured by cumulating the parameters of each immediate succession of peaks, and fall parameters for each succession of troughs. There were between 5 and 266 rise-fall pairs in the analyses. Only analyses 1 and 2 with 5 or more pairs were considered in the statistical analysis.

In a third analysis, we tested whether acoustic 'crescendi' are more common than 'diminuendi'. We used the 'significant' peaks and the 0.5s window, since musically significant crescendi and diminuendi operate over at least this time frame, and it permits the detection of any longer patterns. A 'crescendo' is an increase in intensity of > (¼*dynamic step) from the reference value current at any particular time (the most recent peak or trough); and a diminuendo is a comparable decrease. Successive values which oscillate within ±(¼*dynamic step) of the current reference are 'plateaux'. Here, as in musical notation and in contrast to the earlier determinations, if crescendi precede and succeed a plateaux, this is counted as two crescendi.

The main parameters determined were the duration of each pair of rises and falls in the 'all peaks' and 'significant peaks' approaches, using the indicated time windows; and the log-ratio of the times within each such pair. The overall times occupied by ramps and damps were also computed for each piece. Using the 'crescendo' approach, we determined the number of crescendi and of diminuendi (not necessarily paired). The statistical significance of the hypotheses that the ramp-damp time log-ratio and the log(crescendo-rate/diminuendo-rate) differ from 0, was tested for each sound file in each data set, using a two-tailed t-test. The hypothesis that numbers of crescendi and decrescendi differ significantly was tested for each sound file in each data set with the chi-square test. The hypothesis that overall ramps are on average longer than damps (i.e. not considering them as pairs) was tested using a two-tailed paired t-test. The alpha level was set at 0.05.

3. RESULTS

Table 1 shows a summary of the data. The hypothesis that rises are longer than paired falls is not supported: they are generally shorter. Concordantly, determinations of the average lengths of crescendi and decrescendi in individual pieces are in 34 cases indicative of shorter and only 7 of longer crescendi than decrescendi. Crescendi and diminuendi are not significantly different in number, with one exception, in which there are fewer crescendi. Of the 25 pieces, only 7 show a crescendo count greater than their diminuendo count. This is in contrast to Huron's observations of scored dynamics. Given that rises are shorter than falls, it is perhaps not surprising that rates of intensity change during crescendi are generally greater than those during the succeeding decrescendo. The global means and the mean of all significant determinations were as follows, respectively: log(paired time ratios): -0.04, -0.09; log (paired intensity change rate ratios) : 0.03, 0.15; ratio of total rise: fall time : 0.89, 0.91. Taking all the pieces together, there were 989 crescendi, and 1064 diminuendi.

	No. of paired log(time) ratios < 0	No. of paired log(time) ratios > 0	No. of paired log(change-rate) ratios < 0	No. of paired log(change-rate) ratios > 0	No. of pieces with total rise time < fall	No. of pieces with total rise time > fall
0.5secAllpeaks	4	1	1	0	3	0
5secAllpeaks	1	0	1	0	2	2
10secAllpeaks	1	0	1	0	1	0
Allpeaks	11	0	1	1	13	0
0.5secSigpeaks	3	2	2	0	6	2
5secSigpeaks	1	1	4	0	2	1
10secSigpeaks	0	0	0	0	0	0
Sigpeaks	8	1	9	3	7	2
Totals	29	5	19	4	34	7

Table 1. 'Allpeaks' and 'Sigpeaks' are defined in the text, and the seconds value indicates the window duration for the analyses (40msec when not stated). Only determinations which reach statistical significance ($p<0.05$) are shown. The composers represented are: Bouhalassa; Chuprun; Dhomont; Feist; Frigon; Gobeil; Jean; Kennedy; Koustrup; Leduc; Normandeau; Polen; Radford; Routhier/ Migone/ Coté; Roverselli; Schryer; Trudel; Winiarz; Bebris; Ciamaga; Cross; Cruickshank; Degazio; Buono; and Lekkas. The text gives additional data.

4. DISCUSSION

We observe a temporal archetype of intensity, in which rises take longer than their succeeding falls, and intensity changes faster during rises than falls. It will be interesting to see whether such acoustic features characterise longer pieces and Huron's classical canon, or whether they are particular to short works or ea music.

The features of the archetype, although different from prediction, may still relate to attention and the affective response. Intensity rises are arousing in rate- and length-dependent way [5]. So if a continual long increase gradually becomes less effective (habituation), rises might be shorter than falls, and increase rates might intensify with rise duration, or within a ramp, as does the looming of a sounding object approaching at constant velocity [4].

Our data may reflect the force-energy input to the music, judged by listeners as effort-loudness-affect (our 'FEELA' interpretation). Just as a performer uses force and effort to vary the intensity of their sound, an ea composer creates sonic counterparts to this. A listener may be influenced by the observed force and effort (FE) of a live performer, and perhaps gain similar stimulus range from sculpted ea sound. In each case they may perceive effort and loudness (EL) from the signal.

Loudness (closely related to measures of acoustic intensity) is a known correlate of the real-time affective (A) responses to certain classical music[6], and this relationship is probably more general. Thus we have perceptual evidence to link segmentation and affect in ea music; segments may be constituted by rises and falls. As yet it is not known whether loudness is an important determinant of affect in such music, but we suggest that it is: so a piece aiming for affective expression will use the intensity structures we describe (i.e. the FEELA process).

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