Proceedings of the Ninth Triennial Conference of the European Society for the Cognitive Sciences of Music, 17-22 August 2015, Manchester, UK
Ginsborg, J., Lamont, A., Phillips, M., Bramley, S. (Editors)

Formal measures of complexity predict the accuracy in guessing the end of rhythmic patterns

Remi de Fleurian[*1], Tim Blackwell[#2], Oded Ben-Tal[+3], Daniel Müllensiefen[*4]

[*]*Department of Psychology, Goldsmiths, University of London, United Kingdom*
[#]*Department of Computing, Goldsmiths, University of London, United Kingdom*
[+]*Department of Music, Kingston University London, United Kingdom*
[1]r.defleurian@gmail.com, [2]tim.blackwell@gold.ac.uk, [3]o.ben-tal@kingston.ac.uk,
[4]d.mullensiefen@gold.ac.uk

ABSTRACT

Background

There is a long history of using notions of complexity to understand how people perceive art. Empirical research initially explored the influence of stimulus complexity, often arbitrarily assigned by the experimenter, on its aesthetic perception (Berlyne, 1970; Heyduk, 1975; North & Hargreaves, 1995; Vitz, 1966). While some studies have been conducted with measures derived from music theory (Fitch & Rosenfeld, 2007; Gomez, Thul, & Toussaint, 2007) or human performance (Essens, 1995; Povel & Essens, 1985), more recent work has been using formal measures in order to quantify the complexity of art – including music and rhythm – and its relationship with human perception and the effects of repeated exposure, familiarity, and musical training, among others (Hansen & Pearce, 2012; Madsen & Widmer, 2006; Shmulevich and Povel, 2000).

Aims

This study aims to identify if theoretically derived measures of complexity can predict the difficulty of correctly guessing the next note in rhythmic sequences. We used five measures from information theory and algorithmic complexity: Shannon entropy, entropy rate, excess entropy, transient information, and Kolmogorov complexity. These measures differ from classical indicators (e.g. Povel & Essens, 1985) insofar as there are no background assumptions, such as the existence of an internal clock; the measures relate purely to abstract structural properties. The influence of musical expertise and general pattern identification ability on the success in this task is also investigated.

Method

We artificially generated 48 rhythmic sequences of 50 symbols (1's and 0's), and measured their complexity according to the five selected formal measures. We replaced the 1's by drum hits and the 0's by rests, with a notional pulse of 150bpm, resulting in sequences that were approximately 20 seconds long. These, while not giving rise to metric sensation, are rhythmic in the musical sense of durational patterns. We designed a rhythm perception experiment, in which 32 participants guessed the last beat of each sequence, by selecting 'drum hit' or 'rest', and indicated the difficulty of doing so, aided by a visual representation of the length of each sequence. The participants also completed a short version of the Raven's Matrices and the Gold-MSI questionnaire in order to quantify their general pattern identification ability and several aspects of their musical expertise.

Results

Predication accuracy and judgements of the task difficulty were moderately correlated (r = .407, p = .004), which suggests that the sequences perceived as easier to solve were solved more successfully. The average prediction accuracy for each sequence was correlated with their entropy rate (r = -.407, p = .004) and Kolmogorov complexity (r = -.402, p = .005), and the average judgement of the task difficulty for each sequence was highly correlated with their entropy rate (r = -.834, p < .001) and Kolmogorov complexity (r = -.866, p < .001), suggesting that entropy rate and Kolmogorov complexity can accurately predict the perceived complexity of rhythmic patterns. The participants' overall score on the rhythm perception task was correlated with their self-assessed musical perceptual abilities (r = .449, p = .011). Finally, a logistic regression showed main effects of entropy rate, Kolmogorov complexity, and musical training, and interactions between these two measures of complexity and musical training.

Conclusions

Our results show that formal measures of complexity capture some aspects of human rhythm perception, and more specifically that the perception of rhythm complexity scales with departure from periodicity. Moreover, we add to the body of evidence showing the effect of musical expertise on music perception. Tentative interpretations are provided, as well as suggestions for further research.

Keywords

Rhythm perception; Rhythm complexity; Information theory measures; Musical expertise

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