Modelling Novice and Expert Listeners' Ability to Detect Changes in Short Melodies

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Background

Although short-term musical memory and melodic change detection (ChDet) have received significant attention in the literature, the relative influence of different psycho-musical parameters on ChDet performance is not well understood. With the aim of determining which combination of parameters best predicts ChDet performance, we developed a computational model, based on the perceptual salience of notes arising from tonal and rhythmic features, to simulate the results of two previous change detection experiments (Agres, 2018). In these experiments, the listener's task on each trial was to indicate whether a standard and comparison melody were the same or different (different melodies contained one changed tone). Listeners were either professional musicians or non-musicians.

Aims

Our goal is to simulate results from two ChDet experiments using a novel computational approach. By systematically varying the weights (i.e., relative contribution to the model) of several rhythmic and tonal features, we aim to discover which feature combinations best account for ChDet performance in musicians and non-musicians, thereby providing insight into the cognitive mechanisms underlying short-term memory for melodies.

Method

We developed a rule-based model to predict the likelihood of a change being detected in each pair of melodies. The model quantifies the salience of each note as a weighted sum of its duration, the metrical strength of its onset time, tonal stability and tonal instability. Tonal stability is calculated by dividing the value of the pitch class of the changed or to-be-changed tone (according to the tonal hierarchy; see Krumhansl, 1990) by the value of the tonic of the key, tonal instability is calculated as `1-tonal stability`, duration salience has a linear relationship with note length, and metrical salience is based on the metrical strength of a note's onset time. A maximum of one non-diatonic tone could occur in either the standard or deviant melody. We compute which combination of weighted salience features best predicts listeners' ChDet performance. We explore the effect of musical experience by comparing the optimal relative weightings of the various features for musicians with those for non-musicians. Seventy-two melodies were used, including 36 *stylistic* melodies conforming to traditional Western musical norms, 18 *non-stylistic* melodies containing unusual melodic leaps or implied harmonies and 18 *random* melodies in which the tones were randomly selected from a diatonic scale. Stylistic and non-stylistic melodies could contain non-diatonic tones.

Results

We discovered that tonal instability in the comparison melody was the largest, most reliable predictor of ChDet performance for both musicians and non-musicians, perhaps due to the salience of non-diatonic tones in otherwise diatonic contexts (see also temporal asymmetry effects in Krumhansl, 1990). Note duration and tonal stability in the first melody also had an effect, as did tonal instability in the first melody (for musicians only). We were able to model non-musicians' performance with a correlation of 0.51 (Exp 1) and 0.55 (Exp 2), and musicians' performance with a correlation of 0.58 (Exp 1) and 0.65 (Exp 2). All correlations were at a significance level of $p < 0.001$.

Conclusions

By using a linear combination of rhythmic and tonal features, we were able to model listeners' ability to detect tone changes in pairs of brief melodies. Our results indicate that an important factor for both musicians and non-musicians is the tonal instability of the notes in the second melody presented. The other main contributing factors were note duration, tonal stability and tonal instability in the first melody. This approach allowed us to discover which features are most likely to drive listeners' change detection performance in music.

References

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