VOCAL IMITATION OF PITCH, SPECTRAL SHAPE AND LOUDNESS ENVELOPES

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ABSTRACT

We conducted a vocal imitation study to investigate the degree to which people can exercise vocal control over multiple feature envelopes simultaneously. Participants were asked to imitate synthesised stimuli that varied in pitch (P), loudness (L) and spectral centroid (C). The envelope shapes applied to these features were ramps (up and down), and modulation (with a rate of 5Hz and 2Hz). The imitations of stimuli with a single feature envelope (e.g. 'P ramp up') were then compared to imitations of stimuli with two feature envelopes combined (e.g. 'P ramp up' with 'L ramp down'). Initial analysis of the results indicates that the accuracy of ramp slopes for P is significantly lower when the envelope is combined with modulation envelopes for L or C. A similar trend is also seen for the range of the ramp. Accuracy of modulation rate and extent is significantly lower when a P envelope is combined with modulation envelopes for L or C that have different modulation rates (e.g. 5Hz P combined with 2Hz L). Interestingly, the accuracy of C envelope imitations is generally not effected when the envelopes are combined with those for other features.

1. INTRODUCTION

Vocal imitations have been studied for applications in: sound design [3]; sound classification [4]; describing sounds [5]; audio sample retrieval [1] and automatically setting synthesiser parameters [2]. Previous studies address applications of the voice when used to imitate sounds, however there appears to be very little low-level feature based analysis of how accurately people can imitate multiple time varying features. We have conducted this study to develop our own dataset of stimuli and imitations, as a step towards understanding some of the uses and limitations of using the voice for imitating sounds used in music production.

2. METHOD

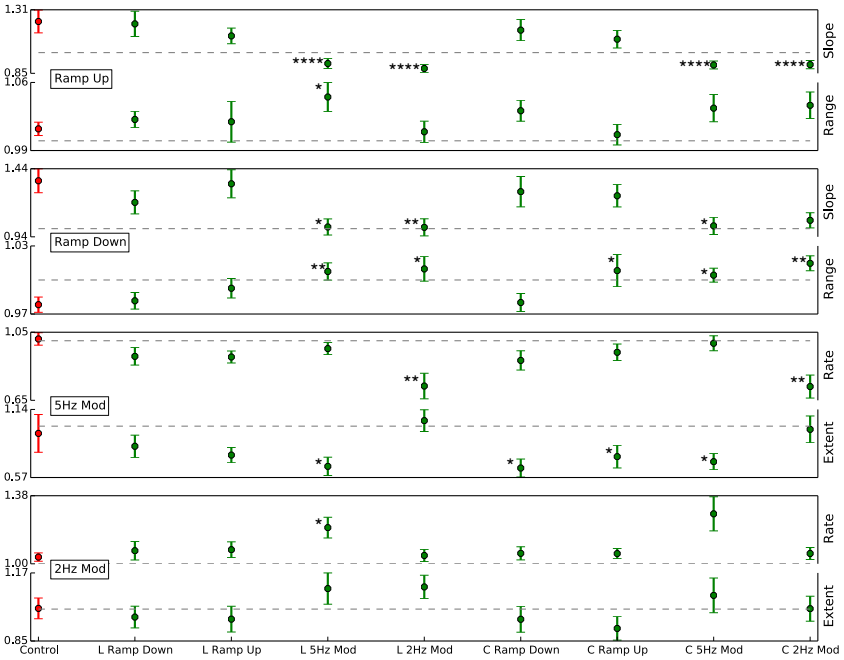
The 4 feature envelopes shown in Figure 1 were applied to create the stimuli. A combinatorial design was used, resulting in pairwise combinations of inter-feature envelopes, excluding L and C combinations. This resulted in 12 'control' stimuli for individual feature envelopes (4 each for P, L and C), plus 16 P-L and 16 P-C combinations. All the envelopes consist of 3 pieces with durations of 500ms, 1000ms and 500ms respectively. This was to give the participants a clear origin and destination value for each of the shapes.

Figure 1: Feature-envelope shapes used for the stimuli.

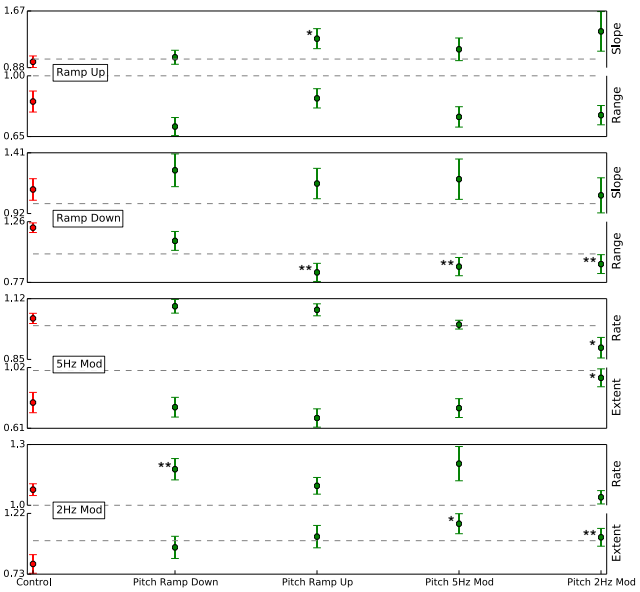
The study was conducted in an acoustically treated listening room. Participants were allowed to listen to each stimulus as many times as they wished before recording their imitation. 19 participants with musical training ($>$ 5 years) took the study, resulting in 836 imitations. Rate and extent parameters were extracted from the modulation imitations using a threshold based peak picking algorithm. Range and slope parameters were extracted from the ramp imitations using a continuous linear piecewise regression model with the following constraints: number of pieces = 3 ($p1, p2, p3$), slope of $p1$ and $p3 = 0$.

3. RESULTS

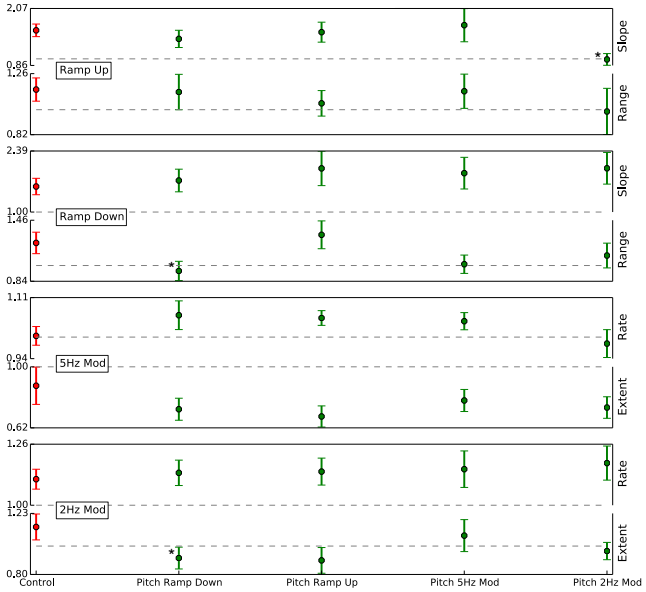
The resulting parameters are expressed at ratios, where a value of 1 is a perfect imitation. Significance testing was performed using a Wilcoxon signed rank test. The results are show in Figure 2, where significance is indicated by ****, ***, ** and * for $p < 0.000$, $p < 0.001$, $p < 0.01$ and $p < 0.05$ respectively. For the P ramp envelopes (Figure 2a), the scores for range were reasonably accurate (0.97-1.06), indicating that all participants were able to sing in tune. The slopes were less accurate, which is due to duration errors in the ramp section of the envelope. This timing improves when the ramp is combined with modulation envelopes for other features, which may be due to the modulation rate acting as a time-keeping aid. For L and C envelopes, the range generally also more accurate than the slope, but considerably less accurate than the ranges for P. This may be due to the lack of a familiar interval based scale for these features. In general the combination of P with other feature envelopes appears to have more of a significant impact on the accuracy of the imitations for P than it does on the accuracy of the imitations for L and C.



(a) Pitch envelopes.



(b) Loudness envelopes.



(c) Spectral centroid envelopes

Figure 2: Each of the 12 controls (stimuli with 1 feature envelope) against the feature-envelope combinations containing the control. All parameters are expressed as mean and standard errors of the $imitation : stimulus$ ratio for all participants.

4. REFERENCES

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