Proceedings of the 12th International Conference on Music Perception and Cognition and the 8th Triennial Conference of the European Society for the Cognitive Sciences of Music, July 23-28, 2012, Thessaloniki, Greece
Cambouropoulos E., Tsougras C., Mavromatis P., Pastiadis K. (Editors)

Inaccurate singing as a dynamic phenomenon: Interval matching a live vocal model improves accuracy levels of inaccurate singers

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ABSTRACT

One of the most powerful and enjoyable gifts given to man is the ability to communicate with others in song. But for some the gift remains unwrapped. One aspect of such "Non-singing" which has received much attention in the last years is "out of tune" (OOT) singing. Previous studies have found that accuracy of singing or level of OOT is not a static factor. Recent research suggests that the degree of acoustical\physical match of the stimuli source (in terms of vocal range and timbre), to those of a participant, has a significant influence on accuracy levels. This in turn suggests some involvement of a mirror system which could be enhanced when the target tones are produced by a live visible human source. In the current experiment we asked a group of participants, who varied in their ability to sing accurately, to vocally match target intervals produced in five different manners: A live voice of a professional soprano, two versions of her recorded voice, one defined as optimal vocal production and the other defined as poor, "forced" vocal production, a piano played "live" in front of the participants, and a recorded piano. Preliminary findings suggest a significant improvement in accuracy when participants matched intervals produced vocally in comparison to intervals produced by a piano. Furthermore, the improvement was significantly heightened in the live voice condition.

Background

One of the most powerful and enjoyable gifts given to man is the ability to communicate with others in song. But for some the gift remains unwrapped. One aspect of such "Non-singing" which has received much attention in the last years is "out of tune" (OOT) singing. OOT singing has been estimated to affect 10-15% of Western population (Dalla Bella et al., 2007, Pfordresher & Brown, 2007). The estimation rises to about 55%, when the factor of consistency, that is the accuracy rate after repeated attempts to produce a pitch (i.e., precision) is taken into account (Pfordresher et al., 2010). Previous studies have found that accuracy of singing or level of OOT is not a static factor. It depends on a large number of variables such as familiarity with the melody, the tempo of singing, presence or absence of accompanying words, the supporting context (sung following, or accompanied by the target melody. One of the most significant variables found to influence accuracy of singing is the degree of acoustical\physical match of the target stimuli to the vocal range and timbre of the participant (Moore et al., 2008; But: Ogawa & Murao, 2004; Price, 2000; Watts and Hall, 2008). In a recent research Hutchins and Peretz, (2011) have shown that pitch matching in response to pitches recorded by one's own voice is better than matching of a synthesized voice. Similarly, Leveque, Giovanni and Schön (2011) found that the model of a human voice matched by gender and range (female and male recorded voices) to that of each participant, elicited more accurate pitch matching, as compared to synthesized complex tones ("choir" timbre). In the current study we further examine the influence of the human voice model on singing abilities of OOTs. We hypothesize that the advantage of the human voice for improving accuracy in pitch matching has to do with activation of the sensorimotor loop possibly enhanced by the mirror neurons system. We therefore hypothesize that the improvement in singing accuracy should be even bigger if the sound source is a live singer modelling optimal vocal production. In order to test this hypothesis we asked 20 participants to vocally match intervals presented in five conditions interplaying the variables of timbre (vocal vs. instrumental), manner of presentation (live vs. recorded) and vocal production (poor forced vs. optimal vocal technique). We hypothesized that vocally originating target intervals would be more beneficial to accuracy levels than those instrumental. We further hypothesized that the recorded piano variant would be the least beneficial while the live voice optimally produced would be the most beneficial variant.

Method

Twelve women and 8 men with little or no years of musical training, who varied in their ability to sing accurately, took part in the experiment. They were asked to vocally match five target intervals which were presented in ascending and in descending pitch direction. The intervals were chosen to cover a wide range of factors that could potentially influence the participant's performance. The intervals were presented in six blocks in randomized order: live piano (LP), recorded piano (RP), live voice using optimal voice production (L-OV), live voice using forced artificial voice production (L-FV), recorded voice using optimal voice production (R-OV), and recorded voice using poor- forced voice production (R-FV). The live conditions were presented to participants with full view of either the singer or the piano. A pitch-discrimination test, a "tonal memory" subtest from Seashore's (1960) test of musical abilities, was administered in order to examine if the accuracy levels achieved by the participants were compatible with their pitch-discrimination skills. After the pitch-discrimination and pitch-matching tasks, self-assessment and background information questionnaires were administered.

We are reporting the results of five conditions. We decided in the process of obtaining the data to drop the forced vocal condition from the "live" presentations and only retain it in the recorded voice conditions. Accuracy levels were determined by measuring via the PRAAT software the (absolute) deviation between target intervals and participants' production of the intervals. We averaged the deviations of each participant across all nine intervals.

Results

Results reported are based upon repeated measures ANOVA in which the condition of presentation was the independent variable (LV, R-OV, R-FV, RP, LP) and the dependent variable was accuracy of reproducing the entire interval. This ANOVA yielded a significant effect [$F(4,68) = 6.04$, $p < 0.001$, $\eta 2 = 0.26$]. Contrast analyses revealed that the voice conditions were more accurate than piano conditions ($M = 93.9$, $SD = 91.2$ and $M = 172.9$, $SD = 155.9$ for the voice versus the piano conditions, $p < 0.001$) with no differences within the piano conditions ($M = 173.3$, $SD = 199.3$ and $M = 172.5$, $SD = 138.1$ respectively). LV ($M = 46.0$, $SD = 39.2$) elicited higher pitch matching accuracy than R-FV ($M = 116.4$, $SD = 96.6$; $p < 0.01$; $\eta 2 = 0.44$). Differences between R-OV ($M = 119.5$, $SD = 171.5$) and

LV, and R-OV and R-FV failed to reach significance ($p = 0.077$, $\eta 2 = 0.17$ and $p = 0.903$, $\eta 2 = 0.001$, respectively). In all measures (first tone, second tone and interval) low SDs in the live voice condition implies that this advantage was true for most intervals and most participants.

Conclusions

Preliminary findings suggest a significant improvement in accuracy when participants match intervals produced vocally in comparison to intervals produced by a piano. The advantage of the voice conditions over the piano conditions was robust and clear whether we examined the first tone of the interval, the second tone or the entire interval. This finding supports those studies that have found an advantage in accuracy in singing tasks when the presented stimuli were in a human voice versus a musical instrument (Moore et al., 2008; Watts and Hall, 2008). However, while all previous studies have presented recorded voice and most often electronically manipulated vocal sounds, we presented live singing which as hypothesized led to the best singing accuracy. In fact, the mean deviation of sung intervals in this condition was less than 50 cents ($M = 46.0$, $SD = 39.2$ cents), keeping the mean accuracy below the deviation considered as out of tune (100 cents). In a world in which most music consumption is through electronic devices, we should remember that sung music communicates best when it emanates from a live human body, especially when vocal imitation is concerned.

Acknowledgments

The authors are indebted to Dr. Avi Gilboa from Bar- Ilan University, Israel and Dr. Tsafrir Kolatt from the *Iyar* institute, Israel, for their invaluable contribution to the current research and report.

Keywords

Singing, pitch production, intonation, sensorimotor integration, pitch discrimination.

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