

THE RELATIONSHIP BETWEEN SOUND PRESSURE LEVEL AND SPONTANEOUS BODY BEHAVIOUR IN WESTERN CONTEMPORARY POPULAR SINGING

Gemma Turner and Dianna T. Kenny

Australian Centre for Applied Research in Music Performance, Sydney Conservatorium of Music,
University of Sydney

ABSTRACT

Singers of Western contemporary popular (WCP) music are known for their dynamic stage behaviour, both physically and vocally. This paper tests the hypothesis that body movement in WCP singing may be associated, not only with idiosyncratic expression but with the generation of the high sound amplitudes achieved by singers in this vocal style. Six professional and semi-professional singers performed a section of an R&B/soul song, first with their usual stage behaviour and then while standing still. This was recorded using a headset-mounted microphone to avoid the singers changing their mouth distance from the microphone during performance. The recordings were analysed for sound pressure level and the results of the two conditions were compared. There was a significant reduction in the sound pressure level recorded by the singers both statistically and acoustically in the 'no movement' condition. Movement during WCP singing may therefore facilitate SPL control, though by what means is yet to be determined.

1. BACKGROUND

The Western contemporary popular (WCP) music world values the excitement generated in an audience by a singer who can produce a powerful sound. High sound pressure levels (SPL) are an important part of the perception of the acoustic expression of emotion in speech and singing, particularly for strong emotions such as anger and happiness [1, 2]. However, high sound levels are physically taxing for the voice especially when delivered at high pitch [3,4]. This combination of vocal stressors may lead to functional problems with the voice in the long-term if not executed with the appropriate technique [5]. As a result, singers want to know how to master control of high vocal sound levels. In

this paper, we observed the interaction of body movement and SPL in professional contemporary popular singing in order to discover whether some aspects of body movement during singing serve a functional as well as expressive role in vocal production in WCP styles.

WCP singing has a different acoustic profile to that of a western classical singer [6,7] which means that techniques suitable for Western classical singing may not be appropriate for a singer in the WCP style: WCP vocal production is more "speech-like" in timbre, although a large range of techniques are employed and considered acceptable [8]. WCP singers also differ markedly from Western classical singers in body behaviour. Classical training leads to the minimisation of body movement [9] in contrast to WCP singing. WCP singers use a variety of body behaviours when singing, some idiosyncratic, some observable across a wide range of singers. These movements often appear to parallel dynamic variations in the vocal line.

The aim of this study was to determine whether the body behaviour of WCP singers is associated with SPL levels. Given that some postural and movement characteristics have been associated with dysfunctional voice [10, 11] it is possible that there are similarly characteristic patterns of optimal voice use. Singers learn by various means to optimize their posture and respiratory drive [12]. The dependent variable in this study is acoustic output and SPL represents the physical correlate of that output as well as providing a good measure of subjective loudness [13].

This study compared singers' spontaneous singing performance behaviour against a performance condition that required them to sing while standing still. It was hypothesised that if movement is being used to optimize SPL production then the removal of movement should lead to a reduction in SPL, especially at moments of high vocal

loading such as at high pitch. We hypothesized that it would be less likely to have an effect at points where loading is lower such as at low pitch or at quieter parts of the songs.

2. METHOD

Participants were 6 singers, 1 male and 5 female, ranging in age from 21 to 46 years. They were all professional or semi-professional singers of WCP music. with strong voices with an ability to produce a powerful sound.

The study design permitted observation of singers in a manner consistent with their performance style while maintaining sufficient rigor such that valid data could be collected in as authentic a performance setting as possible, thereby making the results more meaningful to practitioners. The common song (CS) spanned a 2-octave range, originally F3 (175 Hz) - F5 (698Hz), without a transition to loft register. This large range ensured that even if the singers lowered the key they would not be able to avoid the transition point. To avoid problems which could be created by singers using microphone technique, the microphone was mounted on a headset to keep the singers' distance from the microphone constant.

All the singers prepared three short song excerpts, two of their own choice from their own repertoire including a verse plus chorus in addition to the song excerpt provided by the researchers. These self-chosen songs were used as a vocal warm-up and also as a means of helping the singers feel at ease by singing familiar songs.. The own repertoire songs were also used to assess whether the samples taken of the CS represented the singers' usual vocal performance standard.

Singers were advised that they could sing the song in the key of their choice and could personalise the song as they would any other song in their repertoire. However, they were requested to maintain a similar dynamic range to the original recorded version provided to them. It was requested that the other two song excerpts they were to bring to the session have a similarly large dynamic range as the song provided to them. No limitations were placed on pitch range or musical style.

All the singers sang unaccompanied in a large untreated room at the Faculty of Health Sciences, The University of Sydney. The singers sang each of their three song excerpts three times. The starting pitch of each song was nominated by the singer and was played on a pitch-pipe before each recording. Songs were recorded digitally and videoed simultaneously with two video cameras from front and side-on. Singers were encouraged to sing and behave as if in performance. A taped rectangle on the floor represented the range of the cameras and singers were advised that they could move as they wished within this space. The video was intended for later analysis but also had the effect of making the singers more performance aware and more likely to behave as if on stage.

When this first part of the protocol in which the singers performed in their usual manner [i.e. called the Movement (M) condition] was concluded, singers were requested to sing the songs again, but this time behaving as if they had been given the instruction by a stage director to remain still. All three songs were then repeated under this second Non-Movement (NM) condition. The protocol took no more than 40 minutes for all participants.

Line 11 of the song excerpt contained notes of both high pitch and highest SPL, therefore representing the most demanding section of the song in terms of maximal voice production. This was referred to as the Peak Phrase (PP). The notes of highest SPL within the PP were referred to as Peak Notes (PN) in the subsequent analysis. The PP was a note on the first syllable of the word "never," the vowel /ε/, was measured for mean dB in PRAAT from the offset of the sound /n/ to the onset of the /v/.

A one sample t-test was conducted to assess the null hypothesis that there would be no difference between the movement and non-movement conditions; that is, the difference in Peak Note SPL between the two conditions would not be significantly different from zero. A paired t-test assessed the averaged differences over the three takes in each condition for all six singers between the M and NM conditions.

The SPL of the entire song excerpts were calculated at a sampling rate of 100 Hz using PRAAT. SPL percentile values were calculated from the dB listings generated in order to show the entire dynamic range of the whole song samples. The percentile levels indicate which SPL levels had been exceeded between 1 and 99% of measurement time.

3. RESULTS

For all singers, the maximum SPL attained on the PN occurred in the M condition (Figure 1). SPL values and difference scores (N-NM) were consistently lower in the NM condition for each singer. The hypothesis tested by the one-sample test was not confirmed. The mean difference was 2.37dB (SD=1.3); $t=4.46$ (df=5), $p(\text{two-tailed})=.007$. The paired t-test assessing the averaged differences for all six singers between the M and NM conditions, averaged over the three takes in each condition (see Table 1) showed that the mean difference of 2.87dB (SD=1.3) was statistically significant [$t=4.42$ (df=5), p (one-tailed) =.039].

All singers showed an absolute dynamic range of ~30dB in both conditions at the dynamic extremes. Figure 2 shows graphs representing percentile levels 1-99 for all singers in both conditions. It illustrates that highest and lowest SPL occurred in parallel; that is, when peak SPL was reduced, there was a concomitant reduction in lowest SPL, and when highest SPL increased, lowest SPL increased. This allowed singers to maintain a consistent dynamic difference in SPL throughout the song. For mid range SPL, singers showed more variation. The percentile levels across all singers show SPL of greater than ~80dB for 99% of the duration of the song.

The graphs show higher SPL levels in the M condition at the extremes of the dynamic range in most cases. In all singers the maximum L99 attained was in the M condition. Singers 3, 5 and 6 showed larger differences between conditions at all percentiles. Singer 5 showed the phenomenon of parallelism of SPL most clearly, with a ~3dB gap between the lowest M percentile line and the highest NM percentile line up to the 40th percentile area, with some crossing over at ~L80-90.

4. DISCUSSION

The results indicated that vocal SPL is reduced when movement is reduced or eliminated in WCP singing. Our first hypothesis was confirmed. Individually, singer mean differences on the PN ranged from at 0.96 dB (Singer 4) which is at JND to 4.6 dB (Singer 6). This occurred even though the singers were not restricted in the way they could sing the song, and were permitted to lower the key in accordance with their habitual pitch range. Even though the singers sometimes reduced the two-octave pitch range of the song thus minimizing the vocal load and making the song easier to sing, the relationship between movement and SPL remained significant.

The SPL percentile graphs in Figure 2 present an overview of the SPL range used within the entire CS excerpt. Figure 2 shows that, as hypothesised, the mid-range SPL was more variable than the higher range. Contrary to expectation, SPL percentiles at the low end of the dynamic range reduced to a similar degree to the reductions shown at maximum SPL. The singers in this study were asked to sing with a large dynamic range but remained consistently within ~30dB. The precision of the maintenance in SPL range in the NM condition is noteworthy and to our knowledge has not been previously reported.

5. CONCLUSION

The results of this study indicate that body movement may facilitate SPL production in WCP singing. The links between voice and body movement are complex: we will aim, in a future study, to provide a detailed description of the kind of movements singers use at different levels of SPL. It is a conventional wisdom that classical vocal training prepares a singing student for any kind of singing. The results of this study indicate that the Western classical singing method, with its emphasis on physical restraint may not be appropriate for singers wanting to sing in popular styles, at least with respect to physical behaviour.

6. REFERENCES

1. Kotlyar, G.M. and V.P. Morozov, "Acoustical correlates of the emotional content of vocalized speech", *Soviet Physics Acoustics*, 1976. 22(January-December):208-11.
2. Scherer, K.R. "Expression of emotion in voice and music", *Journal of Voice*, 1995. 9(3):235-48.
3. Jónsdóttir, V., et al., "Effects of amplified and damped auditory feedback on vocal characteristics", *Logopedics Phoniatrics Vocology*, 2000. 26:76-81.
4. Schutte, H.K. "The efficiency of voice production", 1983, Groningen: Kemper.
5. Hollien, H. "Report on vocal registers", In *Stockholm music Acoustics Conference*, 1985. Stockholm: Royal Swedish Academy of Music.
6. Bestebreurtje, M.E. and H.K. Schutte, "Resonance strategies for the belting style: Results of a single female subject study", *Journal of Voice*, 2000. 14(2):194-204.
7. Schutte, H.K. and D.G. Miller, "Belting and pop, nonclassical approaches to the female middle voice: some preliminary considerations", *Journal of Voice*, 1993. 7(2):142-50.
8. Middleton, R. "Rock Singing". In: J. Potter, editor, "Cambridge Companion to Singing", 2000, Cambridge: Cambridge University Press.
9. Pettersen, V., "Muscular patterns and activation levels of auxiliary breathing muscles and thorax movement in classical singing", *Folia Phoniatr Logop*, 2005. 57(5-6):255-77.
10. Grini, M.N., et al., "Modifications posturales et segmentaires contemporaines du forçage vocal" [Contemporary postural and segmental modification of forced voice], *Revue de Laryngologie Otologie Rhinologie*, 1998. 119(4):253-7.
11. Grini-Grandval, M.N., et al., "Forçage vocal et variance de la vitesse: correlation entre la vitesse de déplacement du centre de gravité et le travail des muscles posturaux" [Forcing the voice: the correlation between the speed of displacement of the centre of gravity and the work of the postural muscles], *Revue de Laryngologie Otologie Rhinologie*, 2000. 121(5):319-23.
12. Pettersen, V. and R.H. Westgaard, "The association between upper trapezius activity and thorax movement in classical singing", *Journal of Voice*, 2004. 18(4):500-12.
13. Rasch, R. and R. Plomp, "The Perception of Musical Tones", In: D. Deutsch, editor "The Psychology of Music", 1999, San Diego: Academic Press: 99-101.