Visual feedback learning in singing performance: who benefits from seeing a spectrogram?

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Introduction

Since more than 20 years, real-time visual feedback of the singer's voice found its way into music education and the conservatories. Welch and colleagues published a first pilot study in 1989, showing that pitch accuracy improved in students under real time visual feedback (*Welch, G.F., Howard, D.M., & Rush, C. (1989) 'Real-time visual feedback in the development of vocal pitch accuracy in singing', Psychology of Music 17:146-157*). In the following years, data processing technology improved and allowed the previously time-consuming computing of spectrograms in less than seconds. Visualizations of voice spectra were color-coded and facilitated reading of the spectrograms. Nowadays, voice formants, brilliance, sharpness, hoarseness, vibrato, and more psychoacoustic parameters can be recognized, given the singer-student has acquired a sound knowledge of the underlying acoustic basis of the signal. This of course is not automatically included in the commercially available soft- and hardware packages aiming at providing visual feedback of the voice. The question remains, why these devices are not more frequently applied and why these "modern" methods are still under debate. A second question is, why some students benefit from such a tool, and others do not.

Problems of Feedback Learning

Clearly, singing in a professional way is a highly complex task. Already without visual feedback it is multi-sensory in its very nature. Voice production relies on the voluntary control of more than hundred muscles comprising control of breathing, voice production, articulation, resonance, etc. These complex executive functions take place under the unyielding control of the auditory system, providing a time-resolution of milliseconds and a pitch-resolution of less than a quarter tone – at least in trained singers. Such a time-critical auditory-somatosensory integration is acquired under somatosensory feedback from muscles spindles, mucosal and tendon sensors, vibration-sensors and so on.

Already these basic multisensory activities require a huge amount of information processing in the central nervous system. Its workload will be augmented enormously when it comes to questions of interpretation, emotions, and ensemble singing. Even a trained singer will not be able to pay attention to all these functions simultaneously and will require a guided "spot-light of attention" to switch from one of these many functions

to the others whilst singing. A student will need more time to “digest” all these inputs and to store them in auditory, somatosensory, motor short- and long-term memory. In this way, additional visual feedback could be seen as an overload in information processing.

Indeed, in sport sciences there is a longstanding line of research dealing with visual, or in other words “augmented feedback” in complex motor tasks (*for a review: see R. A Schmidt ad T. Lee (2011) Motor Control and Learning: A behavioral emphasis, 5th. edition. Champaign, Illinois,: Human Kinetics*). The bottom line of this research is that augmented, visual feedback can be useful if applied in the right way: visual feedback should not be immediate, but delayed, it should be infrequent and it should be not too detailed, rather summarizing the results of a certain motor behavior.

Should we encourage our singers to learn along with spectrograms?

With respects to the results of research in sport sciences, real time feedback of spectrograms has opposite characteristics: it is immediate, frequent, over-detailed, and almost abundant in information content. This explains, why some students can take advantage from it and others do not, since it depends on the student’s ability 1.) to extract meaningful information from complex, rapidly changing colorful visual patterns, 2.) to quickly integrate the visual information into the self generated auditory and somatosensory information flow and 3.) to store the three-fold parallel input streams in multisensory long-term memory!

Prerequisites to master such complex processing tasks are 1.) The ability to simplify visual information content and reduce it to important cues (which is by the way one of the hallmarks of general intelligence) 2.) to guide the “spotlight” of attention to the different input streams, and 3) to compare the perceptions with already preexistent memory traces in order to actualize the new experiences and store them in long-term memory. Thus, taking profit from real-time feedback depends heavily on learning and general cognitive capacities, such as set shifting and adaptability of behaviors.

How can the singer teacher and the software designer help students to master these challenges in order to take advantage from computer devices in singing lessons? Already in 2005, David Howard summarized in his article “Technology For Real-Time Visual Feedback In Singing Lessons” *(Research Studies in Music Education 2005, 24: 40-57)* that real-time displays are useful in singing lessons. Displays should be clear and unambiguous and users must be aware of what is expected of them. User-controlled parameters should be altered with caution with an informed expectation of what the output might look like and the impact of any errors that are likely to occur. In other words, an experienced singing teacher is required to guide the student through the system and to share and weight the sensory experiences, be it visual, auditory or somatosensory! Here we come to a final word of caution: Real-time feedback of spectrograms will for sure provide important information of the quality of voice production if read in a correct manner, but it will not always guide the students to use the correct means to obtain a specific result in the spectrogram. Therefore, a supportive teacher and a trustful student-teacher relationship will be always the most important way to bring a singer student to an emotionally touching, artistic performance!