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Self-Organization in Vocal Mechanics and Physiology

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Self-organization is now an accepted concept in biological systems. Complex systems with many interactive components do not need microcontrol of each component to produce a well coordinated output of the system. If given enough individual freedom, the components will interact in such a way as to produce an organization for optimum efficiency. Contrary to classical thinking, regularity can be produced with much variability in the system, or even irregularity in the input. Heartbeat is a good example. The neural inputs to the heart muscles are not as regular as the heartbeat itself. The muscles self-organize for their collective output. In the old way of thinking, noise-in always meant noise-out. In the new way of thinking, some added noise can actually help in self-organization. It gives the system more choices for possible coordinated activity.

Feedback and ample exchange of energy between components is a requirement. Feedback can be positive or negative. Positive feedback reinforces the output of a component by taking a portion of the output and adding it to the input in phase. Negative feedback subtracts some of the output from the input. With the two forms of feedback, many forms of interaction are possible between subsystems.

Consider some examples in vocalization. The subsystems can be the left vocal fold, the right vocal fold, the subglottal resonator, and the supraglottal resonator. Each has its own natural resonance properties. They all can be thought of as oscillators. Energy transfer is facilitated by glottal aerodynamics and acoustic wave propagation in the airways. Without energy transfer and feedback between the subsystems, the components all would likely have their own frequency, amplitude, and phase in their oscillatory patterns. The output would not be periodic (harmonic) unless each is controlled with precision. With interaction, however, they can synchronize their motions and the forces that keep them in motion. No separate control is needed. However, synchronization is more likely if the subsystems have great flexibility, a wide range of operation.

So, what is the take-home message for singers? To obtain regularity and predictability in our vocal output, we need to resist the tendency to restrict the range of operation of some of the components. The theory suggests that we not limit the range of tongue or lip movements, or the range of lung pressure, or the choice of vowels, or the choice of larynx position. Allowing for maximal self-organization would speak against such restrictions. Focusing on the desired output and its repeatability pays the higher dividends. If the system

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knows what to produce, it will use its internal variability to produce it. We should not constrain the interaction between the system components. This is especially the case if there is a deficiency or abnormality in one or more of the components. The rest of the system has to compensate, which means that the range of operation and mobility of some components has to increase.

In summary, the message is: Let the vocal system organize itself. Give it the right output targets and it will find a way to get there with lots of alternative solutions.

[Dr. Titze's bio is republished here because his updated version regrettably was omitted in the last issue.]

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