The balloon in the box model; exponential factors in voice control

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Introduction

An essential element in the mapping of spectral voice metrics over the VRP [1], is the exclusive use of logarithmic scales. This means that when a linearized dependency is observed as a function of the (logarithmic) fundamental frequency or the SPL (the logarithm of the acoustic pressure), then it will actually represent a constant *exponential factor* in the relationship. For instance, the color maps that show the distribution of the spectrum balance (SB) metric over the interior of the VRP (Figure 2), display sections with constant gradients, e.g., constant exponential factors. It is possible to zoom into these maps and to study the linearization of the SB-SPL relationship in detail, at selected vertical bands of constant fundamental frequency. Remarkably, the exponents that are associated with the SB-SPL linearization vary largely between individuals, but are very reproducible within individuals. Moreover, seen over the total SPL range, the observed SB-SPL dependency, in some cases, exhibits several regimes, with different exponential factors depending on the SPL interval. The SPL where such regime changes might occur, varies again between individuals, but appears to be very reproducible within individuals [2]. If we assume that the voice production mechanism is largely comparable between individuals, how can there be such diversity in (1) the sloping, (2) the offset for the SB-SPL slope, and (3) in the appearance and alignment of different regimes? What is the origin of these regimes?

Thesis

The exponential relationships that are observed with this mapping paradigm would not be so systematic if they were not an expression of an underlying generating principle that follows the same paradigm. In this paper, the idea is explored that constant proportional dependencies (constant exponents) are the shared factors in the parametric control of the voice.

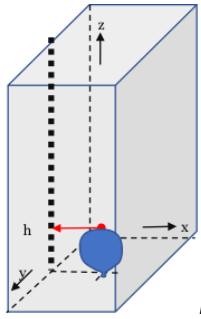

Figure 1, balloon in the box model.

To illustrate how a single physical system can exhibit regime changes, the model of a balloon in a box is used as an analogy (Figure 1). I will discuss the embedding of this model in statistical mechanics, the transformation that model parameters go through when going from the micro-scale to the macroscale, and the implications that such a model has for the dependency between subglottal pressure and acoustical pressure. VRP maps that show the different regimes of the SB metric for different voices will be reviewed to motivate the idea.

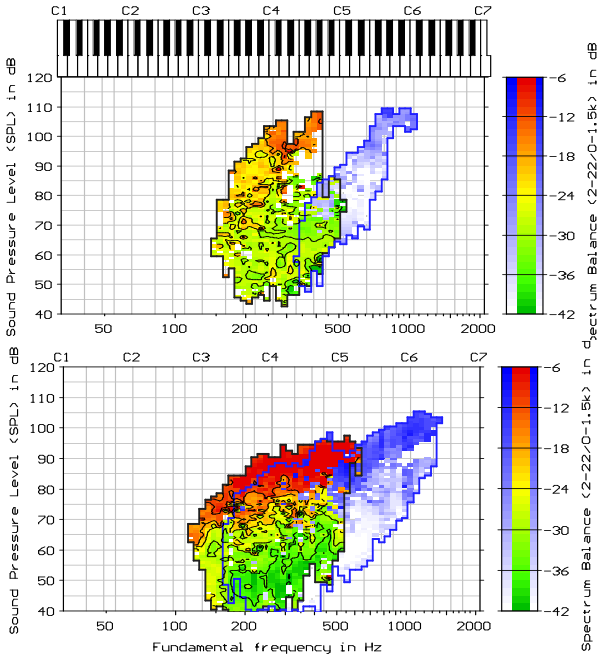

Figure 2: Maps of the Spectrum Balance metric over the VRP for the modal voice range (M1) for two different untrained female voices. Taken from [1] to demonstrate how different these distributions can be in offset, range and incline for different individuals.

References

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