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Complementary relationship between 1D and 3D acoustic analyses of the vocal tract

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To examine speech production processes, acoustic properties of the vocal tract have been calculated from its geometry by 1D and 3D analysis methods. Chronologically, 1D methods such as a transmission line model[1] were developed first, then 3D methods such as a finite-difference time-domain method[2] were introduced. It is true that 3D methods have much higher simulation accuracy than 1D methods, but at the same time 3D methods are not preferable in every respect. For instance, 1D methods are much faster in calculation of speech sounds. In short, 1D methods are much more practical than 3D methods. 3D methods, however, can evaluate limitations of 1D methods, because 3D methods can exactly reproduce acoustic phenomena in the vocal tract up to 10 kHz[2]. For example, although in 1D methods the piriform fossae are modeled as two independent parallel impedances, 3D methods revealed that this type of modeling is not precise because there are acoustic interactions between the fossae[3]. On the other hand, 3D methods also revealed that 1D methods can reasonably calculate the transfer function up to 8 kHz, even if the modeling of the piriform fossae is rough[4]. In short, 3D methods are slow in calculation but can validate the effectiveness of the fast and practical 1D methods. Thus, 1D and 3D methods can be regarded as complementing each other. Regarding the nasal and paranasal cavities, such validations have not yet been performed, because we have just begun to apply 3D methods to these structures. In this presentation, we discuss what needs to be validated regarding these cavities and how to carry out such validation, in addition to a summary of the complementary relationship between 1D and 3D methods.

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