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The Influence of Constriction Geometry on Sound Generation in Fricative Consonants

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Sound generation in fricative consonants is traditionally supposed to depend only on the Reynolds Number, usually defined in terms of the constriction area and the volume velocity at the constriction. The potential influence of the detailed three-dimensional geometry of the constriction is often ignored, even though previous empirical studies have shown this to have an important effect on the spectral shape of the source and the overall sound strength. At present, the physical processes governing turbulent jet formation and aeroacoustic source generation in fricative consonants are not fully understood. In this paper, we use large-eddy simulations of three-dimensional viscous incompressible flow to visualize the development of the turbulent flow field and aeroacoustic source distribution in an elliptical duct representing the vocal tract, for elliptical, laminar, and grooved constriction shapes that share the same cross-sectional area function. By contrasting results for these geometries, we test the hypothesis that turbulent jet formation is determined largely by the shape of the boundary layer where flow separates at the exit of the constriction, and that the perimeter of the constriction, rather than the cross-sectional area, may therefore be a more appropriate parameter for characterizing properties of the aeroacoustic source.