

## **Dynamic Systems Tutorial**

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Dynamical systems analysis will be argued in this tutorial to be fundamental to our understanding of acoustic and articulatory phonetics, phonological representation, and phonological computation. Even though dynamical systems are routinely used for simulation in areas as different as articulatory synthesis and phonological learning, it will be argued that dynamics should be properly treated as a theoretical first principle, rather than just a useful implementational tool. Linear, nonlinear, coupled, and Laplacian dynamical systems will be explicated intuitively through arithmetic simulation, showing that the meaning of differential equations (once discretized) is quite graspable. These ideas will then be illustrated through the basic equations of task dynamics and articulatory phonology (Saltzman and Munhall, 1989; Browman and Goldstein, 1989; Sorenson and Gafos, 2016) and Lindblom's theory of formant undershoot (Lindblom, 1963). Gafos and Benus's (2006) dynamical theory of markedness and faithfulness constraints will then be exposed to show the degree to which many modern developments in the theory of phonological computation are based on dynamical first principles. Goldsmith (1994)'s dynamical theory of metrical structure will then be illustrated and extended to show how theories of phonological representation and computation can be interlaced. There are many open questions in the dynamical approach, some of which will be discussed.