



## **Modeling Dynamic Aspects of Mode (*Echos*) in Modern Greek Church Chant: A Mathematical Framework and Its Analytical Applications**

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The concept of mode, as formulated by musicologists, has played a prominent role in the study of many non-Western musical idioms. Often systematizing and extending indigenous theoretical ideas, recent scholarship has explored many different conceptualizations of mode, each of them tailored to the thought and practice of the musical culture under investigation. These conceptualizations employ ingredients that typically fall into two broad categories: (i) static (“outside-time”) features, including scale construction, tuning, and scale-step functions; and (ii) dynamic (“inside-time”) features, including motives, formulas, and models for musical phrases.

Unlike their static counterparts, the dynamic aspects of mode have proven resistant to systematic formulation. Accounts of dynamic modal behavior are typically descriptive rather than explanatory, often consisting of simple inventories of melodic patterns. Such approaches fall short of defining precisely to what extent a dynamic entity, such as a melodic formula, can vary while maintaining its identity; moreover, they do not specify the causes and conditions underlying this variation.

In this paper, we address these questions using the mathematical framework of Hidden Markov Models. The framework’s ability to capture melodic structure relies on statistical corpus analysis, which systematically abstracts recurring patterns or schemata found in concrete instances of melodic behavior.

We illustrate our formalism by applying it to the modes (*Echoi*) of modern Greek church chant. Our analysis identifies (a) the set of prototypical phrase schemata employed by each mode; (b) the rules of syntax that determine how several of these schemata can be stringed together to produce a complete chant; (c) how each phrase schema’s concrete melodic content is realized through the deployment of a well-defined vocabulary of melodic formulas. We also show how our formulation of the *Echoi* can be applied analytically to annotate existing chants, shedding light on the underlying processes of composition or improvisation.