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Modeling Individual Variability in Developmental Sleep Transitions

Sleep patterns undergo substantial changes during early childhood, as many children transition from a daily nap and nighttime sleep to a single consolidated nocturnal sleep episode. This transition occurs gradually across development, with considerable individual variability in its timing and characteristics. In this talk, we present a neurophysiologically based mathematical model of the sleep-wake network that incorporates interactions between arousal circuitry and circadian and homeostatic processes. Using longitudinal and cross-sectional sleep data from preschool-aged children, we calibrate the model to reproduce representative sleep patterns of habitual nappers and children who have transitioned to consolidated nighttime sleep. We then investigate how changes in key model parameters drive the transition from biphasic to monophasic sleep. Combining bifurcation analysis with numerical simulations, we identify different pathways through which naps may disappear, including abrupt and gradual transitions. Our results provide insight into the dynamical mechanisms underlying individual differences in nap cessation and suggest how external influences, such as light exposure and sleep schedules, may affect the timing and stability of these developmental transitions.