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Task Difficulty and the Spatial Structure of Movement in Young Adults

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Abstract

Studies using a variety of experimental tasks have established that when humans repeatedly produce an action, the amount of variability in system output is distributed across a range of time scales or frequencies. A finding of particular interest is that fluctuations in the output of cognitive systems are the highest at the lowest frequencies with fluctuation magnitude (power) systematically declining as frequency increases (e.g., for a review see Gilden, 2001). Such time-series structure—captured by spectral analysis—is termed *pink noise.* (In contrast, *white noise* has equal amounts of power at all spectral frequencies.) However, the appearance of pink noise is limited to tasks where action is executed in the absence of external, action-related feedback (e.g., Gilden, Thornton, & Mallon, 1995; Gilden, 2001). A few studies have shown a white-noise structure for action executed in the presence of sensory feedback (e.g., Miyazaki et al., 2004). Here, we sought to determine if movement amplitude (MA) time-series structure would vary with variations of movement difficulty, viz., the index of difficulty (ID) [$\log_2(2A/W)$ (Fitts, 1954)]. The current task required young adults ($n = 16$) to generate long sequences of cyclical hand movements over different movement amplitudes requirements (A) to targets that varied in their width (W). Levels of A and W were combined to produce different levels of ID. Visual feedback of movement was always available. Given that increases in ID are known to induce increased reliance on the available visual feedback (e.g., Flowers, 1976) we predicted an ID-induced shift in time-series structure from pink to white noise. In other words, at low IDs movement should mainly be controlled by internal information processes—with minimized visual feedback processing—and pink noise should result; however, as ID requirements increase there should be increased reliance on visual feedback and time-series structure should shift toward white noise. Indeed, as ID requirements increased there was shift in MA structure from pink to white noise.