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Stochastic aspects of motor behavior and their dependence on auditory feedback in experienced cellists

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This study aimed to investigate movement accuracy of experienced cellists, the statistical properties of their note sequences during a reciprocal task, and the degree to which these movement characteristics depend on auditory feedback. Nine experienced cellists were asked to shift alternately between two notes using only their index finger to make contact with the string and fingerboard. Shifting sequences continued for two minutes at a rate of one note per second. The task was performed under two conditions: with auditory feedback (provided by the

bow) or without auditory feedback (i.e., without the use of bow). When the bow was used, subjects had no difficulty in shifting between target notes with precision and stability. Some variability was present, but notes in these sequences were generally uncorrelated. The contact data and correlations in most bowed trials resembled those expected of a *renewal process*, a process in which successive values are statistically independent and identically distributed. Without the bow, subjects lost their ability to reach the same target positions accurately; contact locations tended to drift and had a random quality, indicating that without the bow subjects were uncertain of the target location in relation to the spatial location of their fingertips. Within these unbowed sequences, finger positions were highly correlated—within and between note sequences. In some trials without the bow, the statistical correlation patterns of the sequence were consistent with the expectations of a discrete *Wiener process*. Throughout our study, computer simulations of renewal and Wiener processes enabled us to determine the types of correlations to be expected from these theoretical models. The implications of the statistical results in terms of subject behavior are discussed.

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Keywords: motor control, serial correlation, sensory feedback, stochastic, reciprocal movements, musical performance, martingale

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