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Bayes on the court: Evidence for continuous prior-knowledge integration in virtual-reality tennis returns

Due to noisy signals in the sensorimotor system, our perception is constantly subject to uncertainty. This is particularly evident in highly dynamic situations, such as returning a tennis serve. In fundamental research taking on a Bayesian approach to decision-making and sensorimotor control, it is argued that uncertainty is reduced by the reliability-weighted integration of current sensory information and accumulated prior knowledge (Körding & Wolpert, 2006). Therefore, we investigated this mechanism in a virtual-tennis return situation.

To this end, 32 young adults (22 females and 10 males, M_{age} = 21.0, SD = 2.5) learned two probability distributions of serve's impact locations in a within-subject design over two days that differed regarding the central tendency closer to the left or the right of the service field. The kinematic information in the serving movement remained identical over all trials due to the identical avatar simulation. The perceptual demands in tracking the ball were high because of a speed similar to a serve in professional tennis. As an indicator of participants' expectation of the ball-bounce location in action, we assessed the gaze fixation after the predictive saccade before the ball's bounce.

A shift of the fixation in relation to the ball's actual impact location towards the respective distribution's central tendency was detected that, on top of this, increased over the acquisition period. These results perfectly fit a Bayesian explanatory framework since (1) Körding and Wolpert's (2006) claim that prior knowledge is integrated into tennis returns according to Bayesian principles is empirically confirmed, and (2) prior-knowledge integration must be understood as a dynamic process in which the eye movements in the early phase of the return movement are increasingly affected by accumulated prior knowledge – which, to our knowledge, was empirically confirmed for complex sensorimotor behaviour for the first time by our study.

Körding, K. P. & Wolpert, D. M. (2006). Bayesian decision theory in sensorimotor control. *Trends in Cognitive Sciences*, *10*(7), 319–326. doi: https://doi.org/10.1016/j.tics.2006.05.003