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Analyzing Dynamics of Probability Learning

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Introduction

Probability learning is the process in which we change our predictions about an uncertain environment on the basis of new experiences. This process is dynamic, since it is an evolving product of changing factors along the course of time. Recently, it has become apparent that probabilistic categorization learning tasks (PCL) are solvable by a range of different strategies (Gluck, Shohamy, & Myers, 2002). These strategies may shift, or interact during the course of the process, but standard static analyzing methods cannot explore this dynamism of cognitive functioning.

The purpose of this study was to investigate empirically the effect of different decisional strategies to the performance in probability learning situations. We applied two newly developed statistical methods to analyze the dynamical aspects of decisional policies along a PCL task. The rolling regression technique (Kelley & Friedman, 2002) computes series of regressions by a moving window, generating trial-by-trial estimates of the individual's responsiveness to the observed cues. The State-space model (SSM) (Smith, Frank, Wirth, Yanike, Hu et al., 2004) computes the probability of correct responses for each trial of the learning process by maximum likelihood applying expectation maximization algorithms, where learning is recorded, if the probability of the correct response is higher than chance level with 95% confidence. These two analyzing methods can reveal several aspects of probability learning that remain hidden in data aggregating techniques.

Experiment

Twenty-eight psychology students were presented with a PCL task (Shohamy, Myers, Grossman et al., 2004). In this version participants are told that they are selling ice cream in an ice cream shop and that customers will come in to buy ice creams. Each time a customer visits, they have to try to guess for an extra tip whether he wants vanilla or chocolate. Fourteen pattern combination of the MrPotatoHead toy figure stimulus were presented on screen. The task included 214 trials constructed from the fourteen patterns. The two outcomes were equally probable, but each feature was independently associated with each outcome with a given probability. When the stimulus appeared on the computer screen, the task was to press the corresponding key to guess flavor. After each trial, participants got feedback about the correctness of their guess.

The individual data were contrasted with profiles of ideal learners of three strategies (according as to whether the decisions were based on one or all of the presented cues) and their combinations with recency. Recency profiles were constructed on the assumption that the learner's memory is constrained to the last few trials. A hit rate analysis, a rank correlation of the rolling regression and an analysis of the SSM fit estimates, (the numbers of trials where learning occurred according to the SSM learning definition) were conducted in four blocks of trials (53, 53, 54, 54).

Results

A repeated measures ANOVA of hit rates revealed main effect of block $F(3, 81) = 0.568$, $p < 0.01$, and a linear trend showing significant improvement across blocks $F(1, 27) = 15.818$, $p < 0.01$. A repeated measures ANOVA on rank correlations of rolling regression demonstrated that memory $F(1, 27) = 15.332$, $p < 0.01$ and strategy $F(2, 54) = 19.566$, $p < 0.01$ both had significant main effects where strategies with recency brought higher scores $F(1, 44) = 22.970$, $p < 0.001$ and the multi-cue learning had the highest fit estimate $F(1, 44) = 73.695$, $p < 0.001$. A repeated measures ANOVA on the fit numbers of the SSM, revealed significant block and strategy interaction $F(5.941, 160.413) = 8.370$, $p < 0.01$ showing shift between the applied strategies and demonstrating that even in the case of cue learning strategy, participants considered the patterns. This all indicates that people may follow multiple strategies simultaneously.

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