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Nonlinear neural network dynamics accounts for human confidence in a sequence of perceptual decisions

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Electrophysiological recordings during perceptual decision tasks in monkeys suggest that the degree of confidence in a decision is based on a simple neural signal produced by the neural decision process. Attractor neural networks provide an appropriate biophysical modeling framework (Wong and Wang 2006), and account for a variety of experimental results. Here we report on our work providing the first quantitative confrontation of an attractor neural network behavior with human behavior during full sequences of perceptual decisions, modelling reaction times, success rate and confidence. For this we experimentally investigate confidence formation and its impact on sequential effects in human experiments. Participants perform an orientation discrimination task on Gabor patches that deviates clockwise or counter-clockwise with respect to the vertical. In some blocks, after reporting their decisions, participants perform a confidence judgment on a visual scale. For the modelling, following Wei and Wang (2015), we assume that confidence is an increasing function of the difference, measured at the time the decision is made, between the mean spike rates of the two neural pools specific to one or the other of the two possible choices. We show that behavioral effects of confidence can be accurately estimated for each participant. Moreover, we find that the attractor neural network accurately reproduces an effect of confidence on serial dependence which is observed in the experiment: participants are faster (respectively slower) on trials following high (resp. low) confidence trials. Standard models of decision making are based on the biased diffusion of variables (neural activity levels) representing the accumulation of evidence in favor of one or the other choice. These models cannot account for sequential effects without ad-hoc changes of parameters from trial to trial. In contrast, our results show that a biophysical neural network accounts for these effects without any change of parameters in the course of the experiment. We conclude that the sequential effects result from the intrinsically non-linear nature of the underlying neural network dynamics.

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Auteurs principaux: BERLEMONT, Kevin (NYU); Dr NADAL, Jean-Pierre; Dr SACKUR, Jerome; Dr MARTIN, Jean-Remy

Orateur: BERLEMONT, Kevin (NYU)

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