Learning and Prediction:

Effects of prime entropy and target probability

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Adaptation to a changing environment relies on the ability of the brain/cognitive system to predict future stimuli such as images during visual exploration or words during reading. In human and non-human primates, prediction is related to priming effects that make processing of a target stimulus (e.g. *rain*) faster and more accurate when predicted by a preceding prime stimulus (e.g. *cloud*; Lavigne et al. 2011 for a review).

Priming has a related neurophysiological mechanism of activation of neurons coding for a target by neurons coding for a prime before the actual presentation of the target (prospective activity; e.g. Erickson et al., 1996). Given that a prime (e.g. *cloud*) can predict several potential targets with different probability (e.g. *rain*, *storm*, *lightning*, *sun*, etc.), a cognitive strategy to predict any target that will actually appear would be to activate all possible targets whatever their probability.

However, the working memory system in which targets are activated has a limited capacity. This implies either that only part of the targets can be activated simultaneously, or that the more targets are activated, the less they are activated. This was modeled by the mechanism of retroactive inhibition in the cerebral cortex (Mongillo et al., 2003; Brunel & Lavigne, 2009) where the magnitude of the activation of a target increases with its probability given the prime. In these models, probability is learned in terms of synaptic efficacy between neurons coding for the prime and target stimuli. These models suggest that the strategy is to favor the more probable targets by sharing activation between predicted targets as a function of their probability.

A consequence of competition would be that a target of given probability would be more or less activated depending on the relative probability of the other targets also activated. The distribution of the probability of the targets given the prime defines the entropy of this prime, which measures the uncertainty of the prediction (of targets) by this prime. A recent fMRI study reports that different brain areas are sensitive to the probability and entropy of words (Willems et al., 2015).

We therefore investigated the respective involvement of probability and entropy in prediction, in behavioral and EEG learning/prediction experiments in which participants had to learn prime-target pairs in order to predict the targets when presented with the primes.

Preliminary results indicate that the level of prediction of targets actually depends on their probability, but also on entropy, that is on other targets probability. A candidate mechanism would be that, in a limited capacity system, targets activated would ‘capture’ some activation and influence the amount of activation left for the others. A consequence would be that prediction would not depend on the exact probability of each target, but would be biased by the probability of others targets.

References

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