The Need for a Global Familiarity Measure

Population Coding using Familiarity-Contingent Noise

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Main Ideas
- The principal neurons in a competitive cluster should compete on the basis of their specific inputs (via synapses carrying contextual information, reflecting prior learning).
- How does a sparse set of cells in a patch of cortex (e.g., macroneuron) become organized as a population code representing a particular concept? One way is to compute a measure of the familiarity (inverse novelty) that depends on the patterns of inputs to all cells in the patch, i.e., a global familiarity measure. We propose a specific algorithm for this.
- The algorithm implies that the process of choosing which cells become active in a region in any small Δt, e.g., a gamma cycle, has two stages:
- Stage 1: principal cells integrate their specific inputs and compete with neighbors. This emerges as winner-take-all (WTA) selectivity and transynaptic facilitation of the input.
- Stage 2: but still cells have low maximal activity level (V = 0), summations of the principal cells taken across all minicolumns are chosen randomly (GU ≈ 0). This results in a choice of winners having only chance intersection with any previous population codes previously assigned in the macrocolumn.
- Rather than picking (all the cells comprising a sparse) code in one decision event, and acquiring the code with Q independent decision events (one per cluster), this does not deterministically guarantee that the code as a whole is selected or not (as in other, localist decision theories), but depending on the parameters of the distribution in each cluster. It can make the threshold of the code as a whole being instantiated unambiguously close to one.

Processing to the final code for the cycle. 

What to do with G?

1. If G ≥ 1: Highly familiar input
   - Should recruit the same code that was learned in a study.
   - Global information does not need to be feed back to the local minicolumns.
   - Simply allow new cells to win in their respective minicolumns.

2. If G < 0: Highly novel
   - Should choose winners pretty much at random.
   - Global information does need to be fed back.
   - Add a lot of noise into process of cells computing their individual pathways.

Important Computational Implication
- Principal cells undergo two rounds of integration and competition within the basic computational cycle.
- The 1st round results in the activation of a preliminary code which drives the computation of G.
- The 2nd round includes a variable amount of noise (dependent inversely on G), resulting in the final code for the cycle.

Ach Data
- Acetylcholine, not NE, is the main regulator of the level of spontaneous activity of cortical neurons. Lidski & McGehee (2007).
- Ehrma, Takeda, & Tsujii (2009). Ach causes:
  - synaptic facilitation,
  - synaptic depression,
  - direct hyperpolarization,
  - direct depolarization
- Ach increases excitability, reducse spike frequency.
- Increased Ach leads to learning of other (i.e., feature, temporal) theories, but depending on the parameters of the distribution in each cluster. It can make the threshold of the code as a whole being instantiated as an unary close to one.

NE Data
- Phasic NE: latency (~100-200 ms), short duration (~100-200 ms).
- LC exhibits “unpredicted uncertainty” - i.e., novelty, sadness & Ys (2006).
- Dopamine, serotonin, GABA (F. Hasselmo et al., 2007).
- The NE burst causes rats to fly up, releasing Ach in hippocampal network (Bann et al., 2005).
- The overall profile of围绕 levels of noradrenaline may facilitate pattern completion or may elicit intrinsic activity higher levels would recruit global mapping and promote long term memory formation.