UC San Diego

Lecture 9.2 Predictive Processing

MUS 20 Exploring the Musical Mind

Summer Session II 2025

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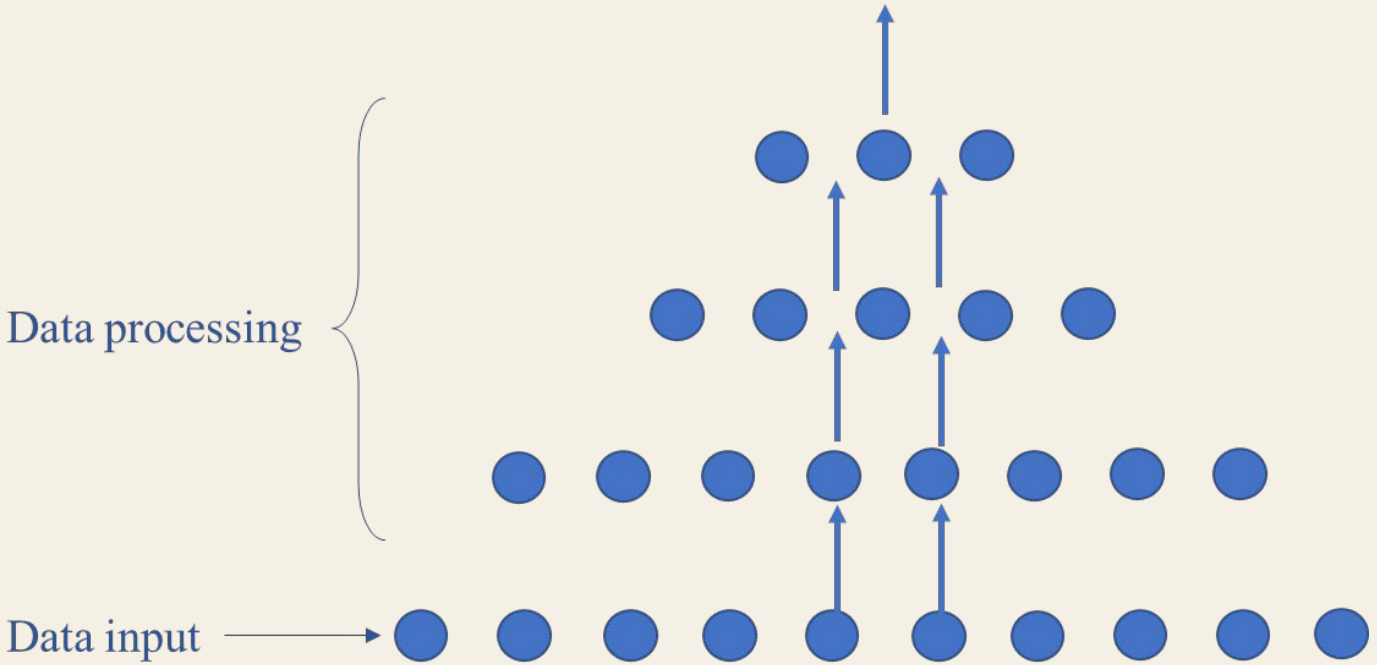
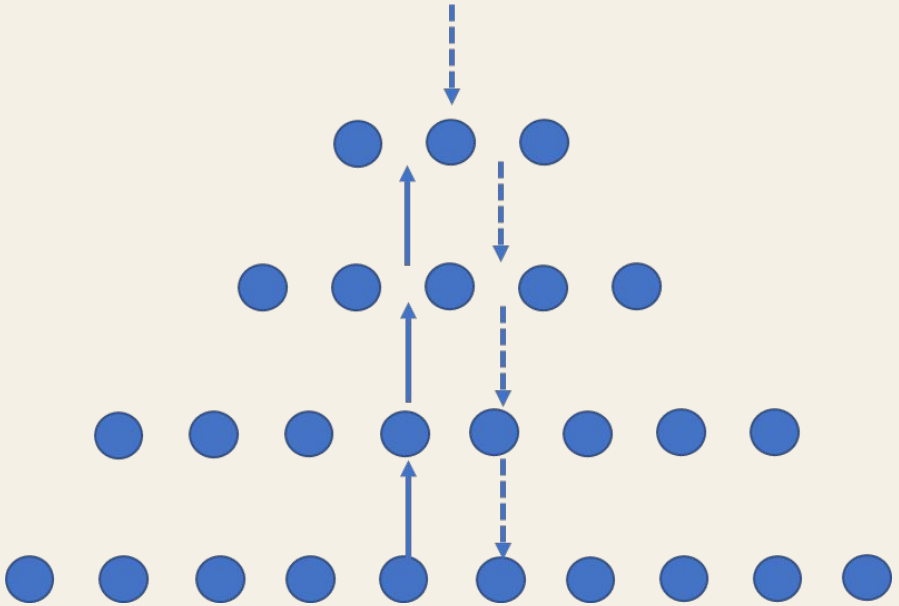
Bottom-up Processing



Perception is traditionally depicted as a process of *passive*, *stimulus-driven*, *"bottom-up"* feature detection (Schenkerian analysis; GTTM)

Top-down Processing

Radical Predictive Processing by Andy Clark



- Turning the passive, “bottom-up” data processing into active inference by adding “top-down” predictions that reflect expectations.
- The downwards-flowing prediction works as a filter that copes with noisy and ambiguous sensory inputs.

Predictive Processing

Radical Predictive Processing by Andy Clark

- Predictive processing performs a kind of “Bayesian flip” upon the standard (passive, feedforward) image of sensory processing.
- Instead of trying to build a model of what’s out there on the basis of a panoply of low-level sensory cues, these models aim, in effect, to predict the current suite of low-level sensory cues from their best models of what’s likely to be out there.
- In these models, percepts emerge via a recurrent cascade of “top-down” predictions that involve (mostly sub-personal) expectations, spanning multiple spatial and temporal scales.
- These expectations are probabilistic and concern the present nature and state of the world as presented via the driving sensory signal.

Predictive Processing

Radical Predictive Processing by Andy Clark

- It is this key role for downwards-flowing prediction that allows these systems to cope with noisy and ambiguous sensory inputs.
- The downwards predictions reflect what the system expects given what it already ‘knows’ about the world and about the current context.
- These predictions are combined with incoming sensory data to arrive at better guesses about the signal source.
- The driving sensory signal is here compared, at multiple levels, to a cascade of downwards predictions and mismatches send forward ‘prediction error signals’ that nuance or alter the prediction until a match is found and the sensory data is accommodated.

Predictive Processing

Radical Predictive Processing by Andy Clark

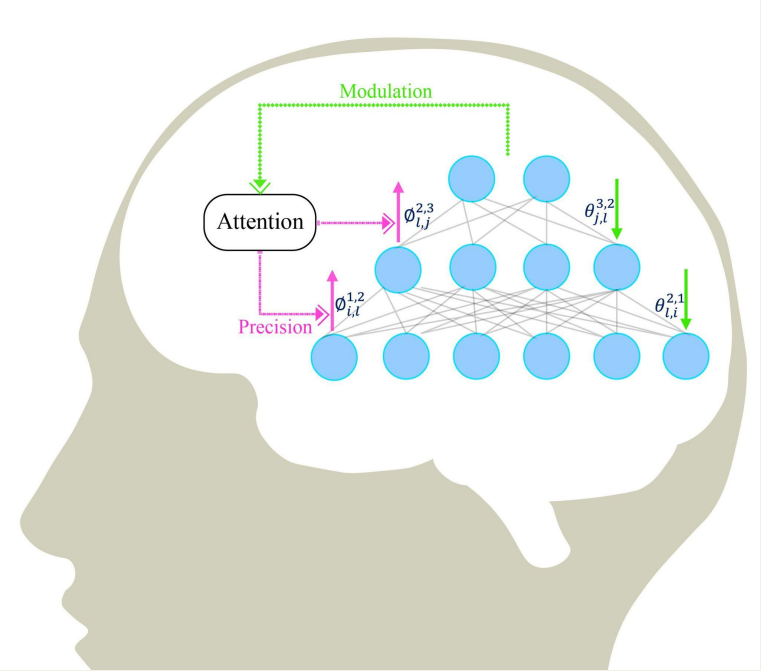
Two core features of predictive processing:

1) **Perception** involves the use of a unified body of acquired knowledge (a multi-level 'generative model') to predict the incoming sensory barrage.
2) The use of that knowledge is subject to a constant kind of second-order assessment (known as "**precision estimation**") that determines the weighting assigned to specific predictions at all levels of processing and to different aspects of the incoming sensory signal.

   These weightings reflect the varying *reliability*, in context, of differing aspects of the generative model and of the sensory inputs currently available.

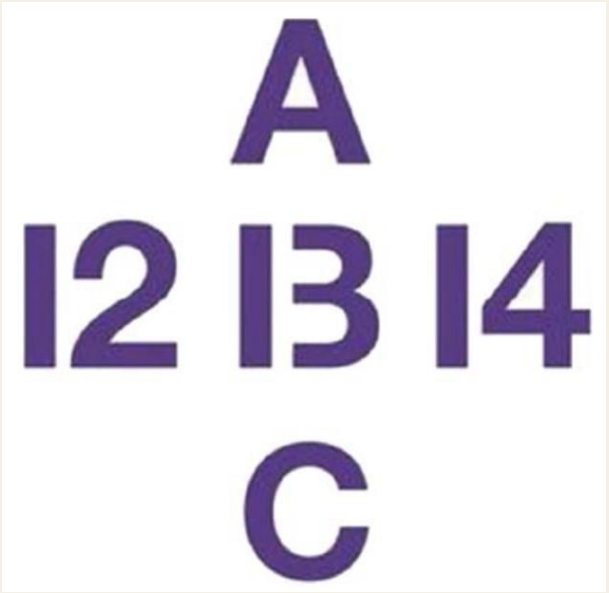
Predictive Processing: Physiology

Cerebral Hierarchies: Predictive Processing, Precision and the Pulvinar



- A simple cortical hierarchy with ascending prediction errors and descending predictions.
- The prediction errors are weighted by their expected precision, which is the neuromodulatory gating or gain control (pink) of superficial pyramidal cells determining their relative influence on deep pyramidal cells encoding expectations.

Predictive Processing: Examples



Visual Contextual Cues

G major	I G	ii Am	iii Bm	IV C	V D	vi Em	vii^{o} F♯^{o}
D major	IV G	V A	vi Bm	vii^{o} C♯^{o}	I D	ii Em	iii F♯m

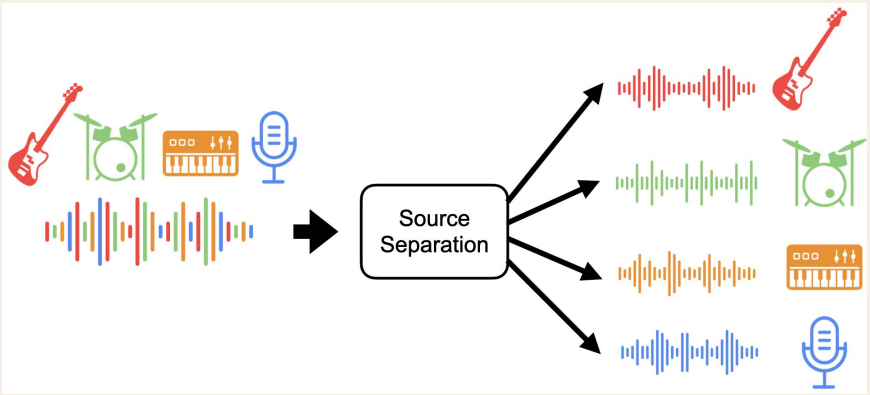
Key Modulation (Common-chord Modulation)

- Bottom-up vs. top-down processing
- Top-Down Processing (Explained in 3 Minutes)

Perception and Attention

Attention, Uncertainty, and Free Energy

- *Perception* is the inference about causes of sensory inputs and *attention* is the inference about the uncertainty (precision) of those causes.
- *Attention* can be construed as inferring the precision of sensory signals and their causes.
- Attention entails estimating uncertainty during hierarchical inference about the causes of sensory input.
- State-dependent precisions modulate the responses of the error-units to their pre-synaptic inputs. This modulation depends on the conditional expectations about the states.
- Put simply, this involves weighting data in proportion to their estimated precision.



Selective Attention in Auditory Scene Analysis

- Theories of Selective Attention
- Divided Attention, Selective Attention, Inattentional Blindness, and Change Blindness

Readings:

- Auditory Scene Analysis: An Attention Perspective
- Attention, Awareness, and the Perception of Auditory Scenes