Precise Minds in Uncertain Worlds: Predictive Coding in Autism

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The plan

- Predictive coding?
- Autism?
- Predictive coding -> autism?
- Neural mechanisms?
- Is it all even possible?
1. PREDICTIVE CODING

Bayesian approach to brain functioning
What is Bayesian probability?

\[ P(A|B) = \frac{P(B|A) \times P(A)}{P(B)} \]
What is Bayesian probability?

\[ P(A|B) = \frac{P(B|A) \times P(A)}{P(B)} \]

Allergy = 1.5% actually have
Claim = 30% say they have
\[ P(\text{allergy}|\text{claim}) = 1 \times 0.015 / 0.3 = 0.05 \]
What is Predictive coding?

\[ P(A|B) = P(B|A) \times P(A) \]

Perception = Likelihood * Priors
What is Predictive coding?

Goal of the brain: Minimizing prediction errors.
“The theory assumes that the brain continually generates predictions on what input comes next based on current input and learned associations. These predictions are compared to incoming sensory input and the comparison leads to the computation and representation of an error signal.”
Dark room problem
What is Predictive coding?

Can account for:

- Fundamental stages of perceptual processing.
- Complex dynamics between predictions and input.
- Adaptation to predictable stimulus contingencies.
- Separate representations for input and error signals.
One more thing:

Precision

A mechanism to alter the extent to which the prediction errors generated by online estimation affect future learning.
One more thing:

Precision
What is Predictive coding?

Perception = (precision*Likelihood) * (precision*Priors)
2. AUTISM SPECTRUM
A range of neurodevelopmental disorders
What is Autism Spectrum Disorder?

Early onset neuro-developmental conditions. Deficits in:

- executive functioning
- communication
- social-emotional reciprocity
- motor movements
- behavior and interests

Heritability around 70%, prevalence 1%

Diagnosed by behaviour!
3. PREDICTIVE CODING IN AUTISM

High, Inflexible Precision of Prediction Errors in Autism
HIPPEA

High, Inflexible Precision of Prediction errors in autism. The predictions are shaped by noise that is unlikely to repeat in the future (overfitting). New data will generate large errors, meaning little or no generalization.
Superior visual search has been found both for a target defined by a single feature and for conjunctive targets.
ATTENTION

Find the red “L” among the distractors!
Children with autism perform well on general attention and social perception questions containing one cue.
ATTENTION

We often have multiple social cues!

https://www.youtube.com/watch?v=GvG7CHWyol0
PERCEPTION

Biased towards a disinclination for global or a preference for local processing (noise, speech)
PERCEPTION

Can you tell the difference?

PERCEPTION

Can you tell the difference?

https://www.youtube.com/watch?v=PWGeUztTkRA
FACES

Typical differential response to inverted faces not present. A bias for the mouth region and outer face characteristics.
Larger amplitudes / earlier latencies to infrequent pitch changes in tones, suggesting hypersensitivity.
SAVANT SKILL

an exquisite discriminative sensory ability plus
an exceptional (rote) memory capacity
SENSORIMOTOR ABILITIES

Actions entail their consequences.
In ASD traits, rubber hand illusion effects were reduced.
Chronic Unpredictability

Mood problems & anxiety as secondary symptoms, originating from irreducible prediction errors and repeated frustration in learning.
4. NEURAL MECHANISMS
How?
Neural mechanisms

**Acetylcholine (ACh)** - assumed to enhance precision of perceptual prediction errors. Increases the event-related response to deviations of predictions and attenuates the decrease in responses with repeated stimulation.
Neural mechanisms

ACh linked to known unreliability, norepinephrine / noradrenaline (NE/NA) tracking unexpected uncertainty.
Insula and anterior cingulate cortex (ACC)
Neural mechanisms
Insula, ACC and neighboring regions cooperate to estimate where predictive progress can be made, setting precision accordingly. The salience/precision network is closely connected to the motor system, suggesting a role in generating exploratory actions.
5. IS IT ALL EVEN POSSIBLE?

Why should we believe this theory?
VARIABILITY

A developmental account will predict quite some variability in the unfolding of clinical symptoms depending on interactions with the environment.
The theory should be able to give good, constraining explanations for the cognitive and neural specificities.
BRAIN-BASED

Connecting clinical to neurobiological descriptions and providing a firmer foundation for treatment.
Relying more on the senses than on prior beliefs

Sampling the world more and for a longer time

Everything is new!