From speech to meaning: Abnormal predictive processing in schizophrenia

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Why study language in schizophrenia?

PSYCHIATRIC SYMPTOMS
- e.g. auditory verbal hallucinations, thought disorder

COGNITIVE SEQUELAE
- verbal abilities particularly compromised, particularly early on (or even prior to dx)\(^{5,7}\)

PSYCHOSOCIAL DIFFICULTIES
- e.g. relations with friends & family, employment, self-care\(^{6,7}\)

 Hierarchical generative framework

Central role for predictions in normal language processing\(^{8-11}\)

Goal: Optimal inference of intended message, given available information

Prediction errors (discrepancies between predictions and actual input) used to update models at successively higher levels

Explains:
- how we simultaneously take multiple sources of context (such as visual scene, discourse history, who we are talking to) into account during language processing
- how we rapidly and flexibly adapt to (and keep up with) new speakers & situations
- abnormalities in multiple aspects of language processing in schizophrenia?

Understanding language processing abnormalities across domains

Interpreting sentence & word meanings

An apparent paradox:
- Patients have difficulty interpreting sentence and word meaning in context, compared to healthy controls\(^{12-17}\)
  - e.g. interpreting "bank" as a river bank vs. a financial institution
- But patients (particularly those with thought disorder) exhibit faster automatic spreading activation within networks of semantically related words\(^{18-22}\)

Explanation within generative model framework:

Healthy adults

"I deposited my check in the \(\text{bank}\)"

Predications constrain interpretation of words to contextually relevant meanings and "explain away" the lower-level signal (when accurate)

Patients with schizophrenia

T deposited my check in the \(\text{bank}\)

Activation of word meanings is unchecked by expectations from sentence or discourse context

Implications for time-course of sentence processing: Reliance on slower non-predictive mechanisms likely to disrupt processing under time pressure (as in most normal communicative situations)\(^{23}\)

Perceiving speech sounds

Low-level sensory & perceptual changes in schizophrenia, for both speech & non-speech stimuli\(^{24-30}\)
- behavioral: decreased contrast sensitivity, increased stimulus detection thresholds
- neural: reduced amplitude of evoked responses to speech & non-speech stimuli

How do perceptual abnormalities relate to higher-order processing?\(^{\star}\)

Possibility #1: core problem = perception\(^{31-35}\)

Possibility #2: core problem = generative models

Implications & directions

Emphasis on interfaces between domains
- effects of higher-level context on speech perception
- relations between all these abnormalities within the same patients

Implications for cognitive remediation
- cognitive remediation programs consistently somewhat effective despite vastly different approaches\(^{40-50}\)

Possibility #1: core problem = perception\(^{\star}\)

Possibility #2: core problem = generative models

- abnormalities in schizophrenia are much more pronounced when perceiving stimuli in context than when perceiving isolated stimuli\(^{36-39}\)
- and speech sounds, in particular, are extremely context-dependent\(^{40-42}\)

Hypothosis: disruptions in generative models linking self-action to self-perception

auditory verbal hallucinations may arise from failure to recognize self as source of "inner speech"\(^{43-47}\)

disruptions in these generative models might reflect more general disruptions to abilities to attribute speech to its source (whether internal or external, as with different speakers)

might also scale up to disordered monitoring of higher-level language production in thought disorder