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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[1]

LANGUAGE

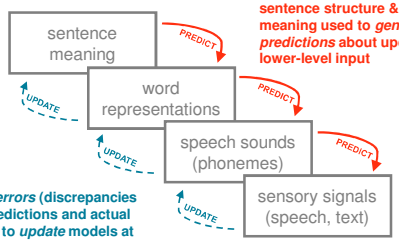
COGNITIVE SEQUELAE
verbal abilities particularly compromised, particularly early on (or even prior to dx)[2-5]

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



Inferences **about higher-level sentence structure & meaning used to *generate predictions* about upcoming lower-level input**

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?**

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Understanding language processing abnormalities across domains

Interpreting sentence & word meanings

An apparent paradox:

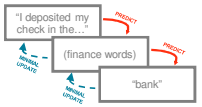
- Patients have difficulty interpreting sentence and word meaning in context, compared to healthy controls[12-17]

  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]

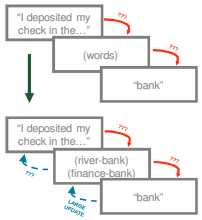
Explanation within generative model framework:

Healthy adults



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

Patients with schizophrenia



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

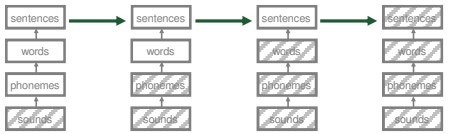
Low-level **sensory & perceptual changes** in schizophrenia, for both speech & non-speech stimuli[24-30]

- behavioral: decreased contrast sensitivity, increased stimulus detection thresholds
- neural: reduced amplitude of evoked responses to speech & non-speech stimuli

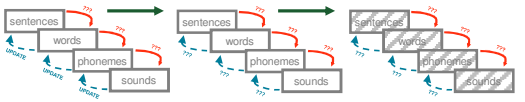
How do perceptual abnormalities relate to higher-order processing*?

* not much work has looked at this

Possibility #1: core problem = **perception**[31-35]



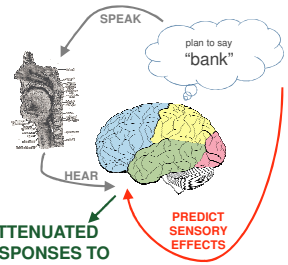
Possibility #2: core problem = **generative models**



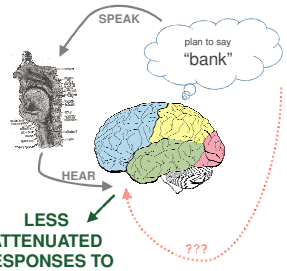
- abnormalities in schizophrenia are much more pronounced when perceiving stimuli in context than when perceiving isolated stimuli[36-39]
- and speech sounds, in particular, are extremely context-dependent[40-42]

Relating action to perception

Healthy adults



Patients with hallucinations



Hypothesis: 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"[46-47]
- 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

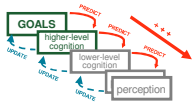
Implications & directions

Emphasis on **interfaces** between domains

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

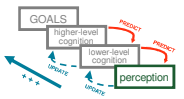
Implications for **cognitive remediation**

- cognitive remediation programs **consistently somewhat effective** despite vastly different approaches[48-50]

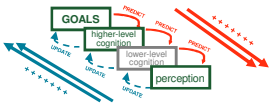


approaches focusing on high-level cognition[50] rebuild generative models via **predictive pathways**

(particularly when linked to **higher-order goals** via combination with psychosocial therapy or skills training)[49,51]



approaches focusing on perceptual abilities[52-53] rebuild generative models via **model updating pathways**



possible that an **integrated approach** would have **synergistic benefits**