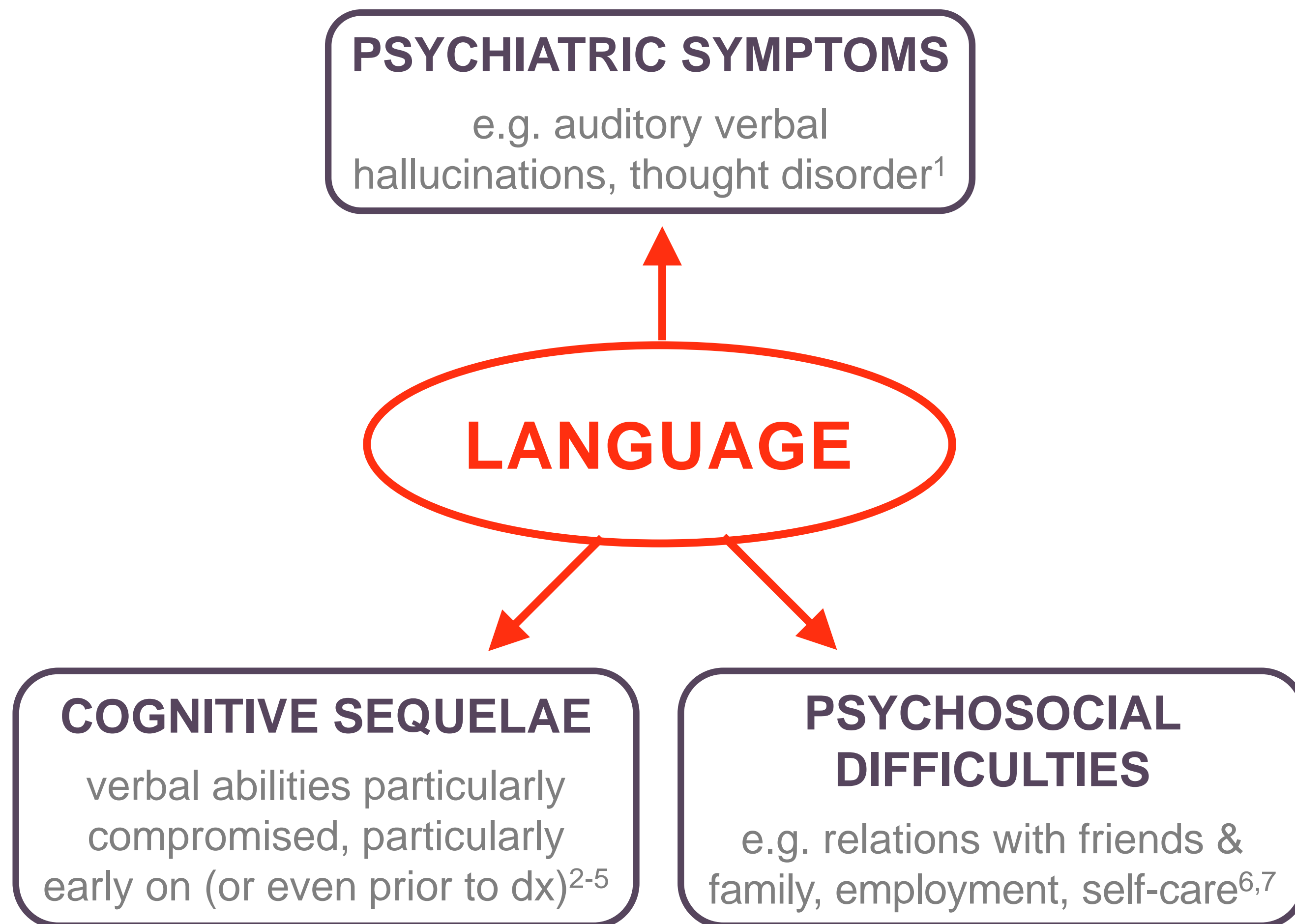


# From speech to meaning: Abnormal predictive processing in schizophrenia

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## Why study language in schizophrenia?



## Hierarchical generative framework

Central role for **predictions** in normal language processing<sup>8-11</sup>

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:

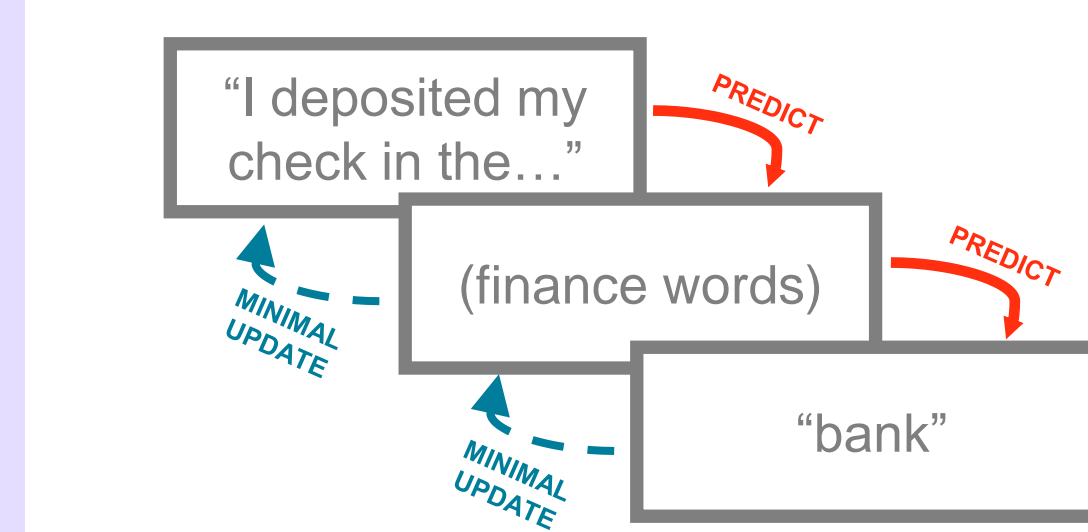
- Patients have difficulty interpreting sentence and word meaning in context, compared to healthy controls<sup>12-17</sup>

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<sup>18-22</sup>

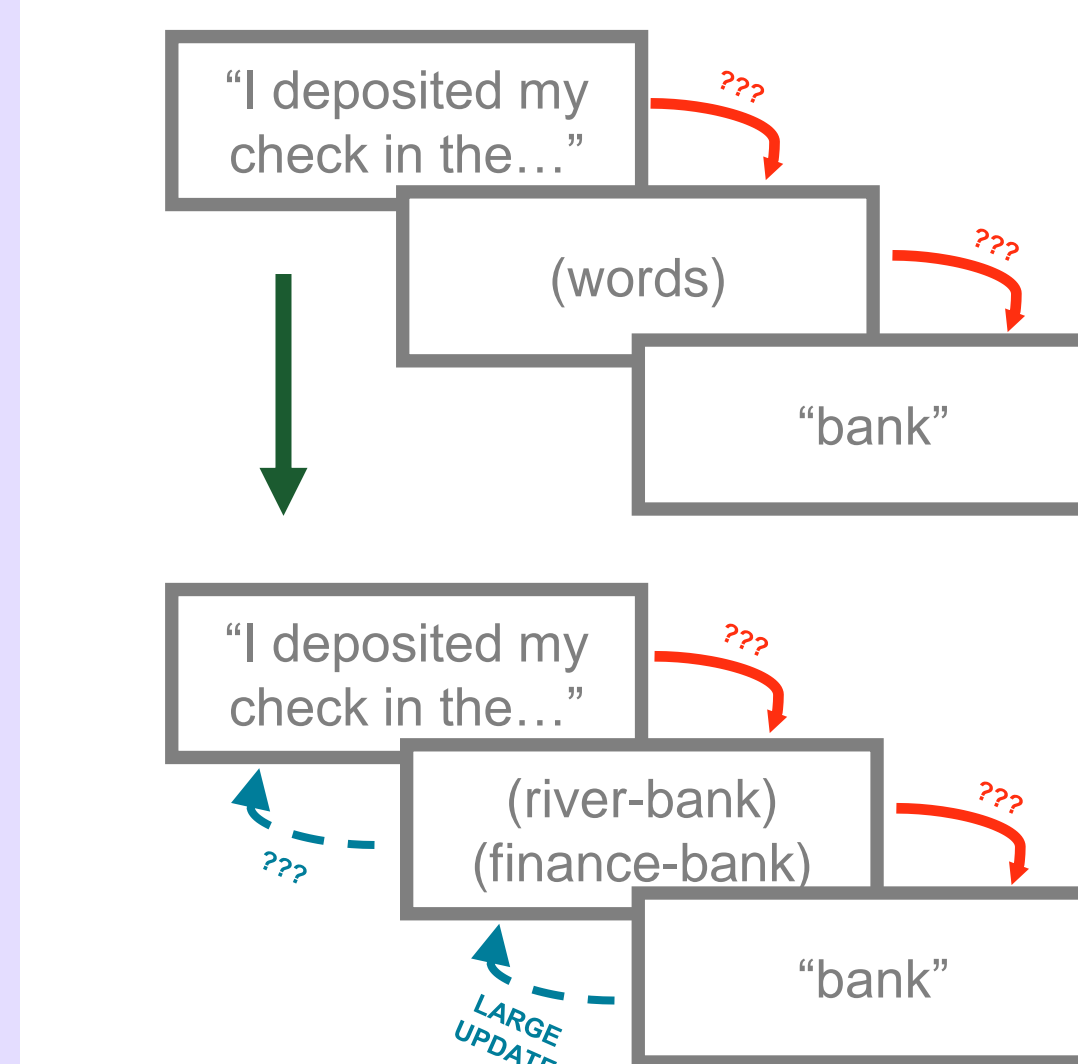
#### Explanation within generative model framework:

##### 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)<sup>23</sup>

### Perceiving speech sounds

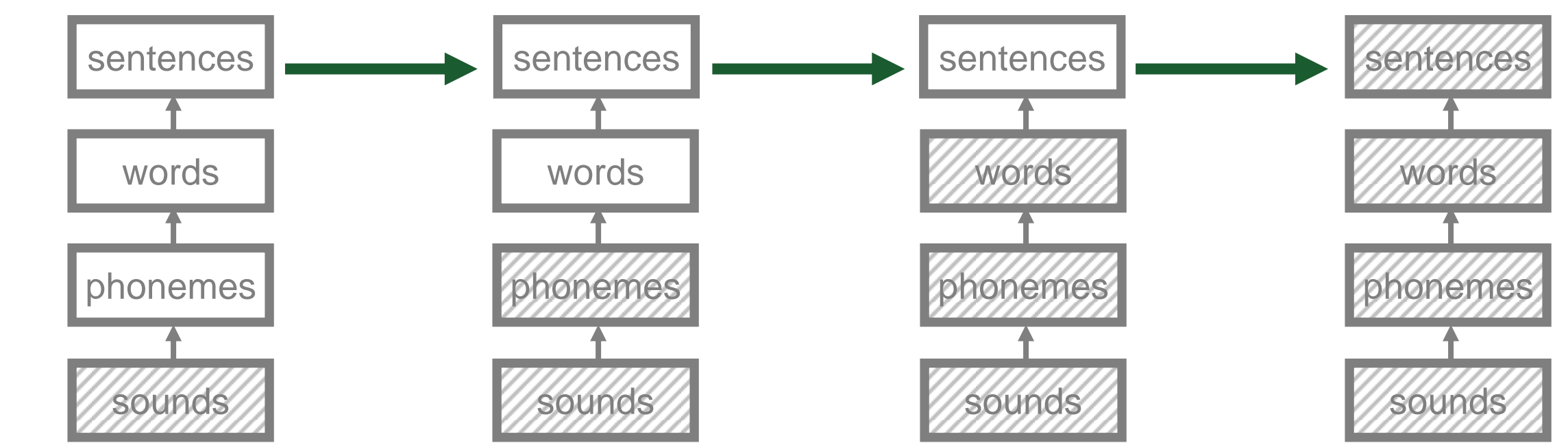
Low-level **sensory & perceptual changes** in schizophrenia, for both speech & non-speech stimuli<sup>24-30</sup>

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

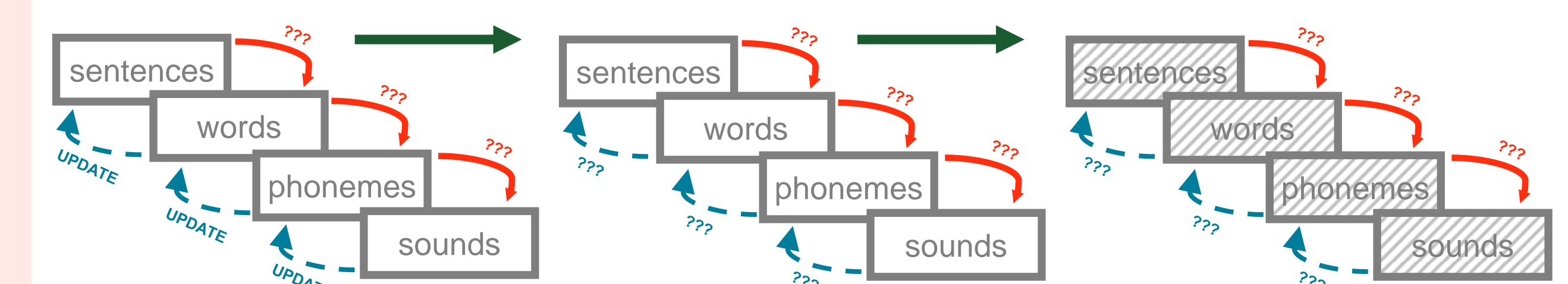
#### How do perceptual abnormalities relate to higher-order processing? <sup>\*</sup>

\* not much work has looked at this

##### Possibility #1: core problem = perception<sup>31-35</sup>



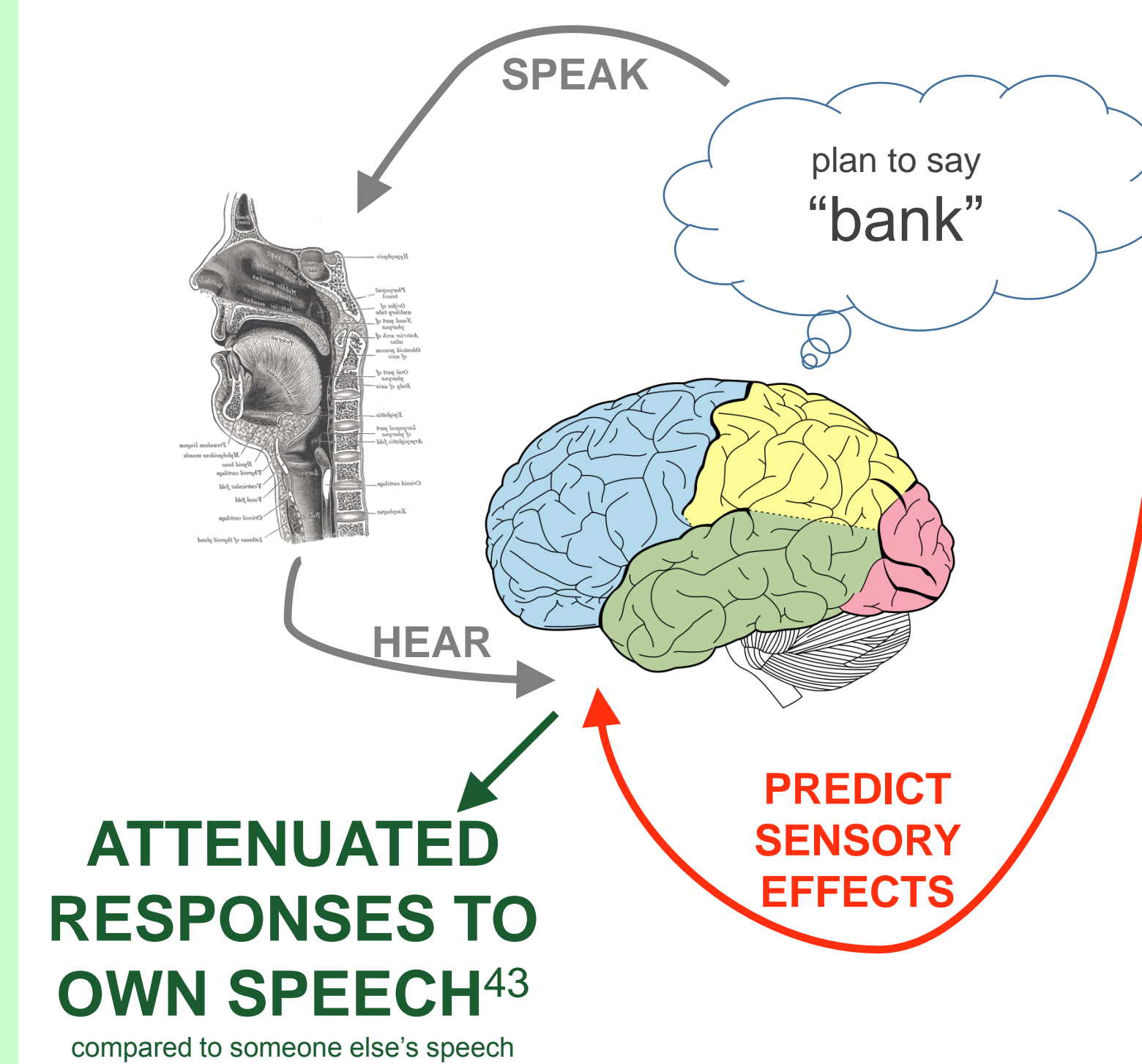
##### Possibility #2: core problem = generative models



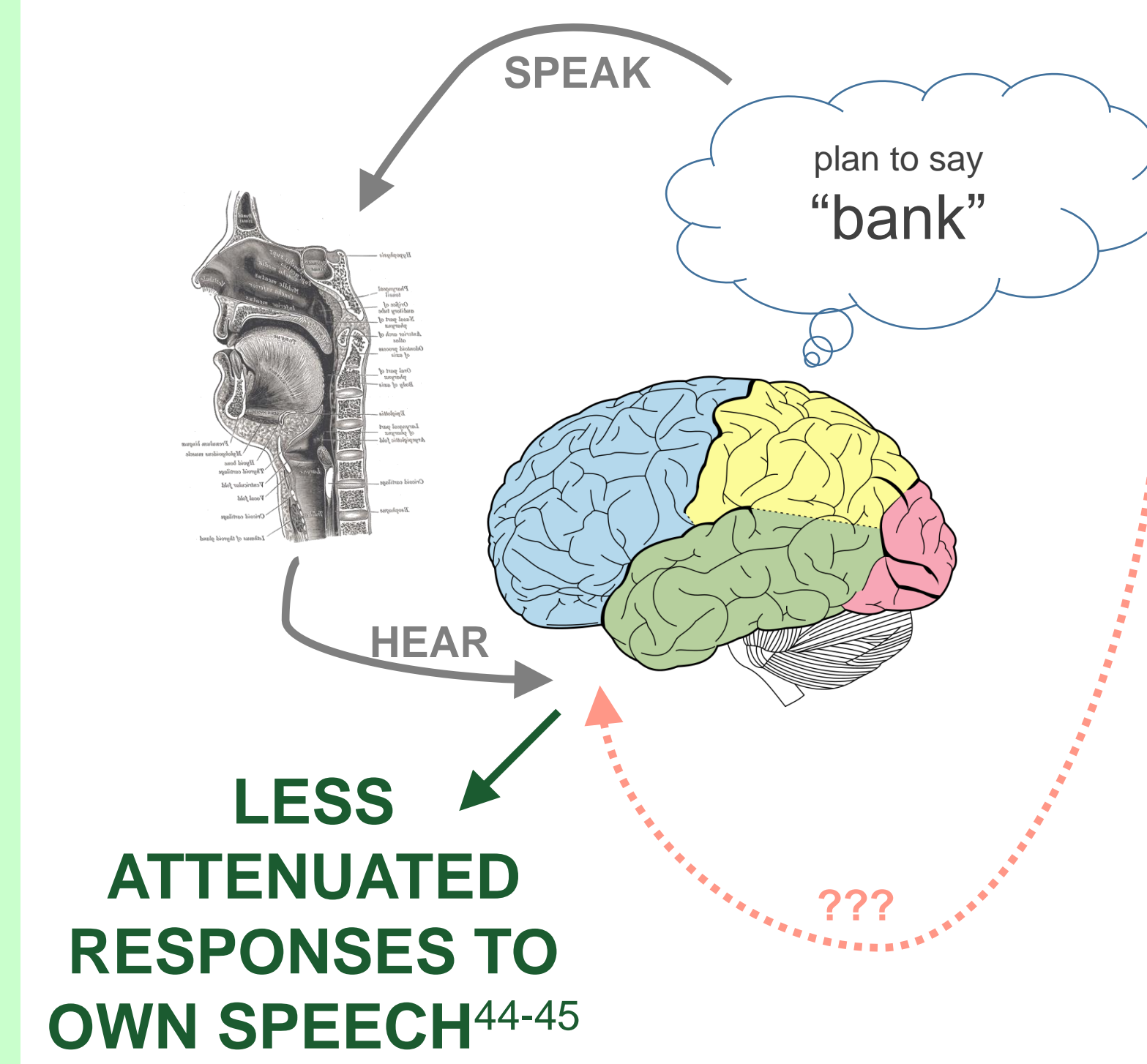
- abnormalities in schizophrenia are much more pronounced when perceiving stimuli in context than when perceiving isolated stimuli<sup>36-39</sup>
- and speech sounds, in particular, are extremely context-dependent<sup>40-42</sup>

## 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"<sup>46-47</sup>
- 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

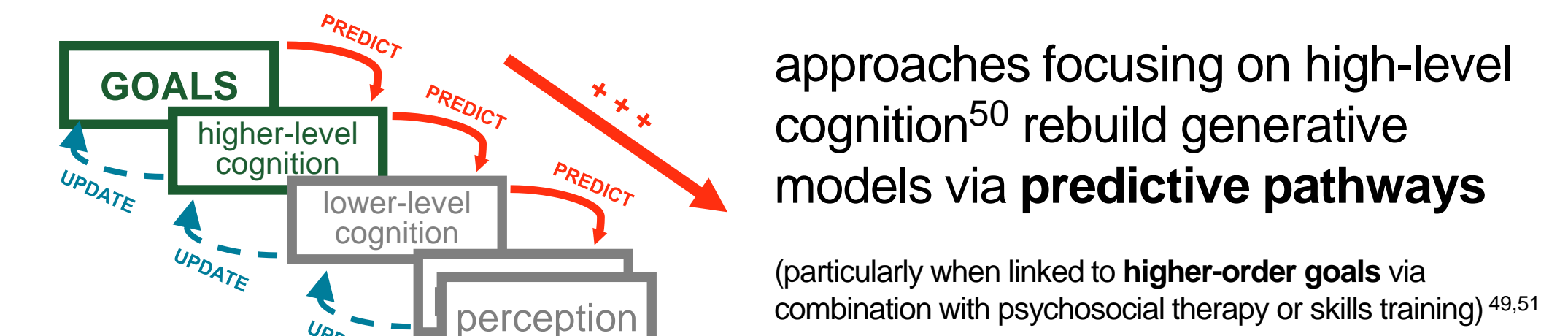
## Implications & directions

Emphasis on **interfaces** between domains

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

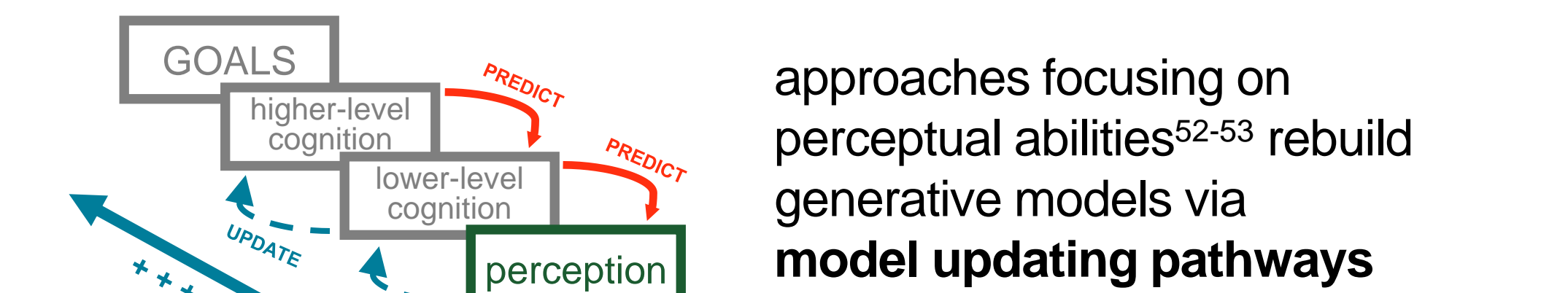
#### Implications for cognitive remediation

- cognitive remediation programs **consistently somewhat effective** despite vastly different approaches<sup>48-50</sup>

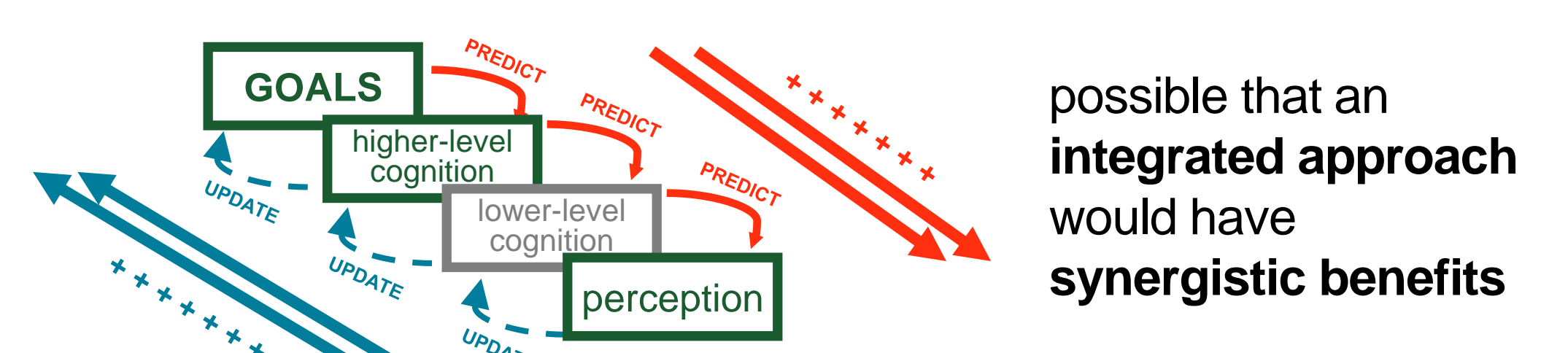


approaches focusing on high-level cognition<sup>50</sup> rebuild generative models via **predictive pathways**

(particularly when linked to higher-order goals via combination with psychosocial therapy or skills training)<sup>49,51</sup>



approaches focusing on perceptual abilities<sup>52-53</sup> rebuild generative models via **model updating pathways**



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