



# Can we use ACT-R to move towards precision medicine? The case of depression

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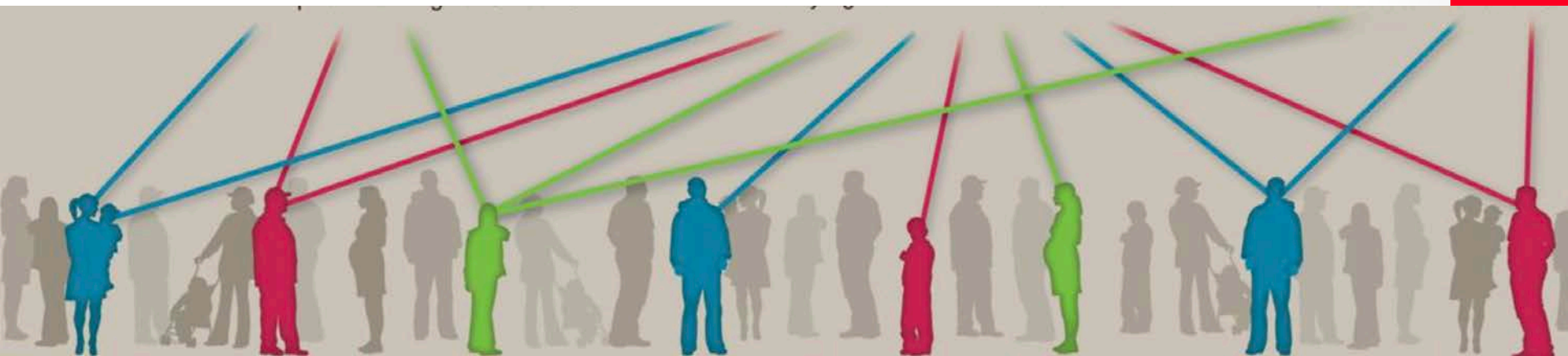
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# Depression



- Disorder characterized by persistent feeling of sadness and loss of interest, difficulty doing normal day-to-day activities
- Associated with tremendous cost to society (Kessler et al., 2015)
- Considerable heterogeneity makes finding treatment challenging (Marquand et al., 2016)



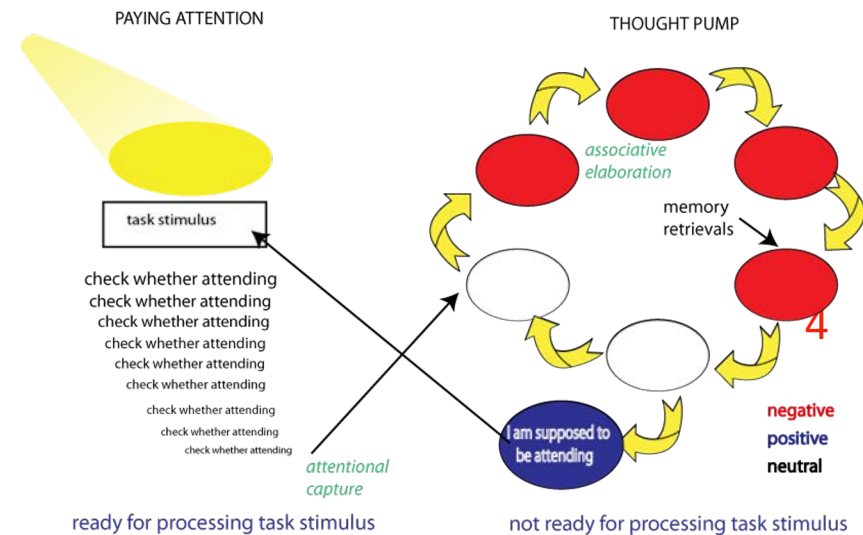
# Variety in proposed depression mechanisms

- Ruminative thinking
- Deficiencies in reward learning
- Attentional bias towards negative information
- Overly general autobiographical memory



# An ACT-R model of depression

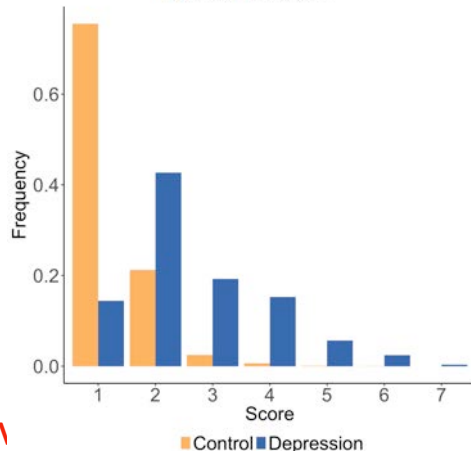
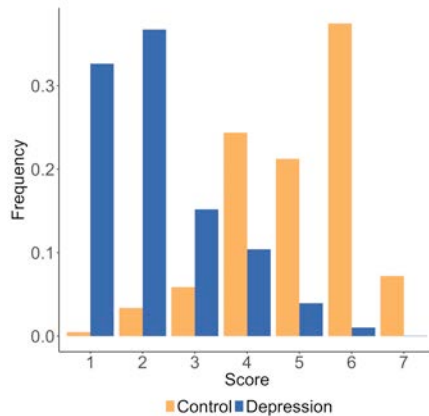
- Formalizes ruminative thinking: competition between on-task and mind-wandering
- Difference between healthy and depressed:
  - Memory structure: more negative memories, tightly bound together for depressed
  - Makes returning to task challenging



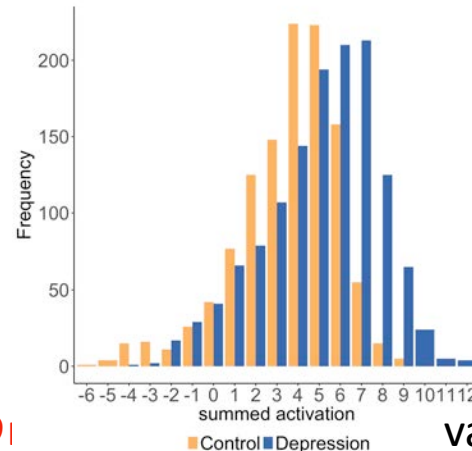
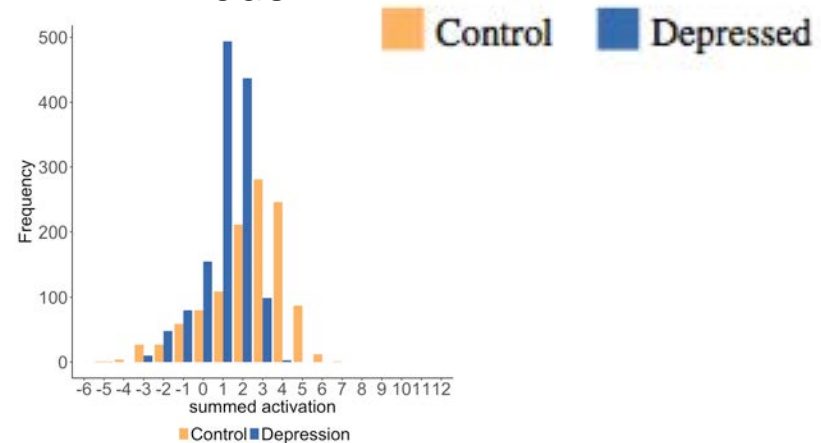
# An ACT-R model of depression

- Memory structures based on experience sampling data

experience sampling

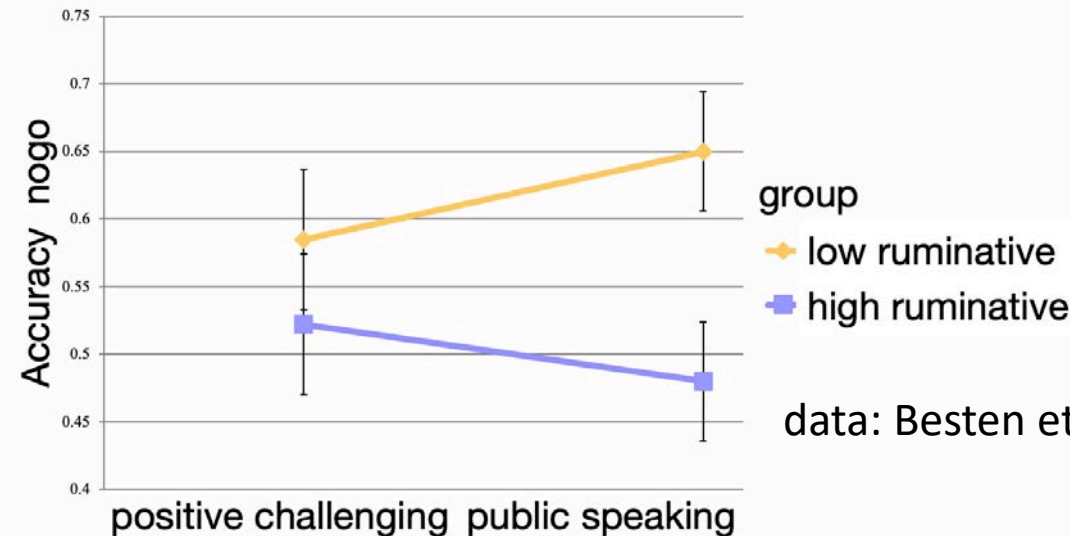
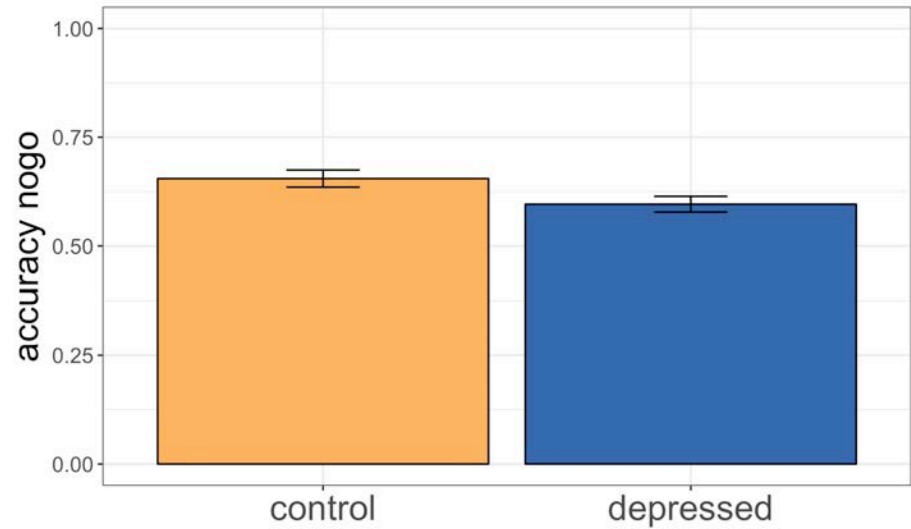


model



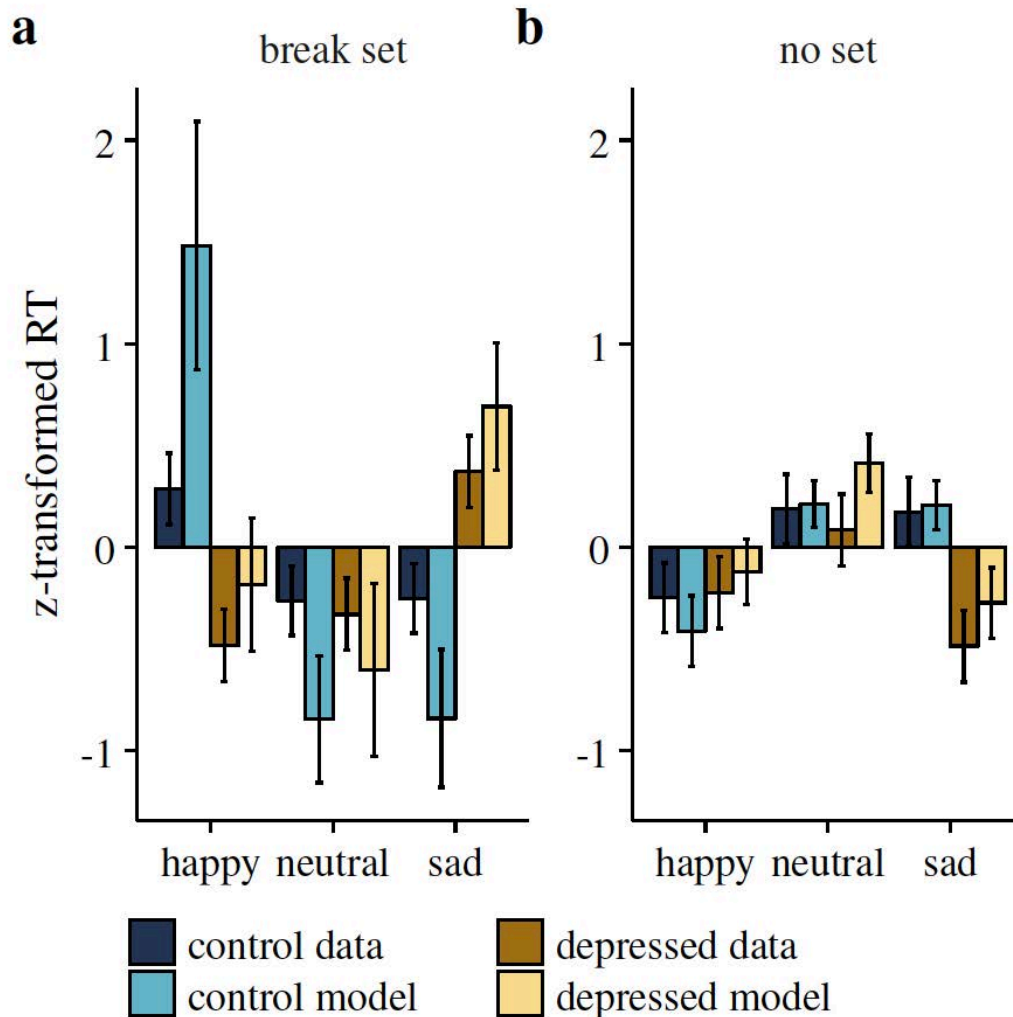
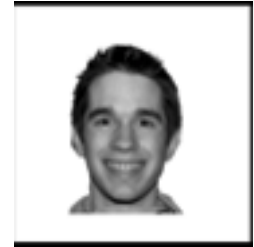
# Model predicted impairment in attention performance

van Vugt & van der Velde (2018)



data: Besten et al (in prep)

# Similar model attempted to predict working memory performance



*For successful prediction, attentional bias to negative information was needed as well!*

van der Velde & van Vugt (2018)

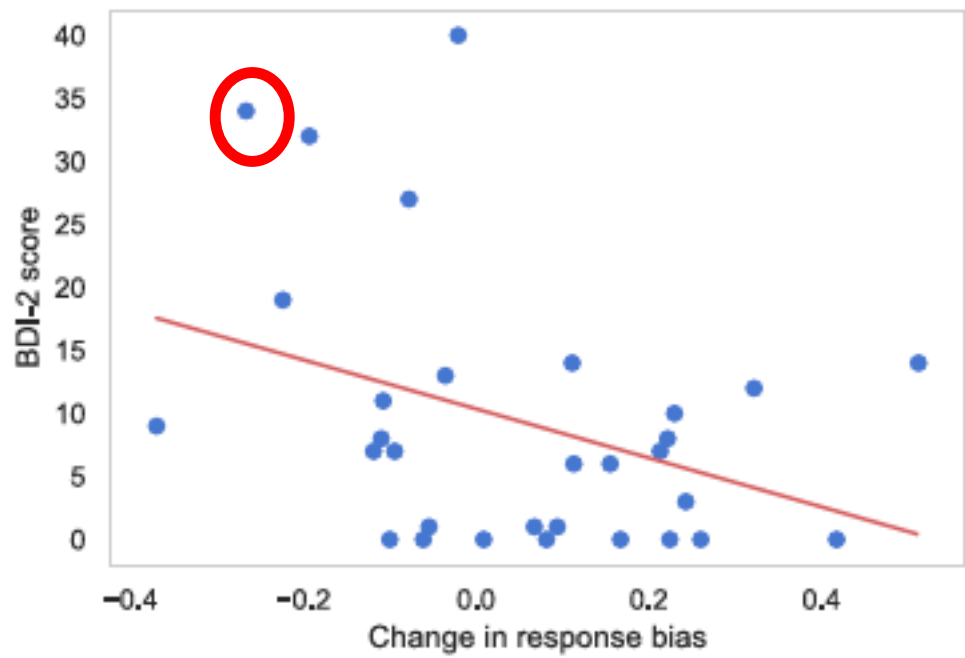
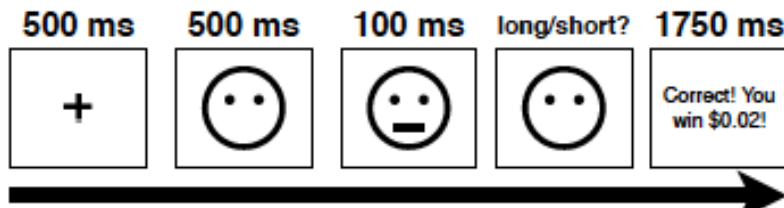


# Possible explanation: individual differences

- Some individuals may be more impaired in attentional bias, others in reward learning, others in ruminative thinking

Data from Bachelor project of Boris Winter

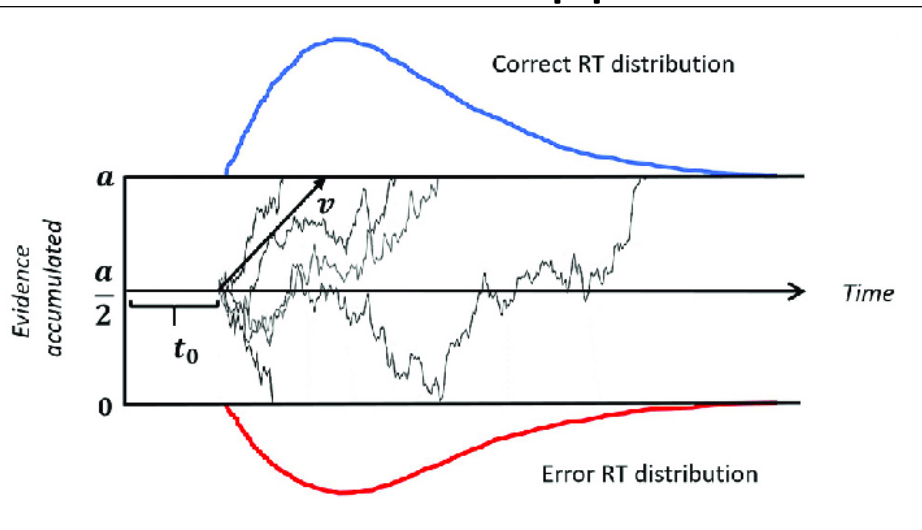
Task: Pizzagalli et al (2005)





# Can we find the dominant mechanism for an individual?

- Inspiration: drift diffusion models (Ratcliff, 1978) can distinguish between individuals' quality of attention, speed-accuracy trade-off
- Requires detailed statistics on response time distribution
- Can this be applied to ACT-R depression models?



# Step 1: make ACT-R models of different depression mechanisms

Mechanism	Possible ACT-R implementation
Rumination	Add mind-wandering process that gets stuck in negative recalls
Reward learning impairment	Reduce reward learning parameter
Negative attentional bias	Make chunks with a negative valence slot more active
Overgeneral autobiographical memory	??? Inability to make subgoals on self-related tasks

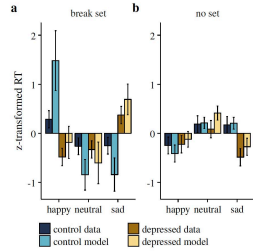
# Step 2: Connecting individuals to mechanisms

- Collect detailed behavioural data across a range of tasks
  - Sustained attention to response task
  - Reward learning
  - Attention task with emotional stimuli
  - Autobiographical memory (maybe)
- Compare an individual's performance to a bank of simulated **detailed** performance patterns turning mechanisms on or off (adjusting strength if possible)
  - Find best fit

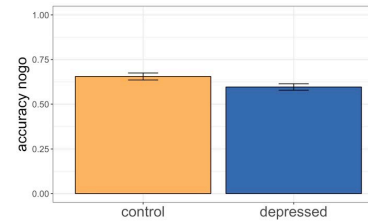
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# Summary



- Depression is a heterogeneous disorder
- Current ACT-R model centered around a single mechanism
- Modeling individual differences in common in simple models such as the diffusion model
- Can we create families of models to simulate patterns of task performance across individuals?
- Can we use these simulated cognitive profiles to predict effects of interventions? (e.g., mindfulness, van Vugt & Moye, 2019)

