

# Introduction to DDM

## (Drift Diffusion Modeling)

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Computational Psychiatry Course @ Zurich

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**What can you study  
using DDM?**

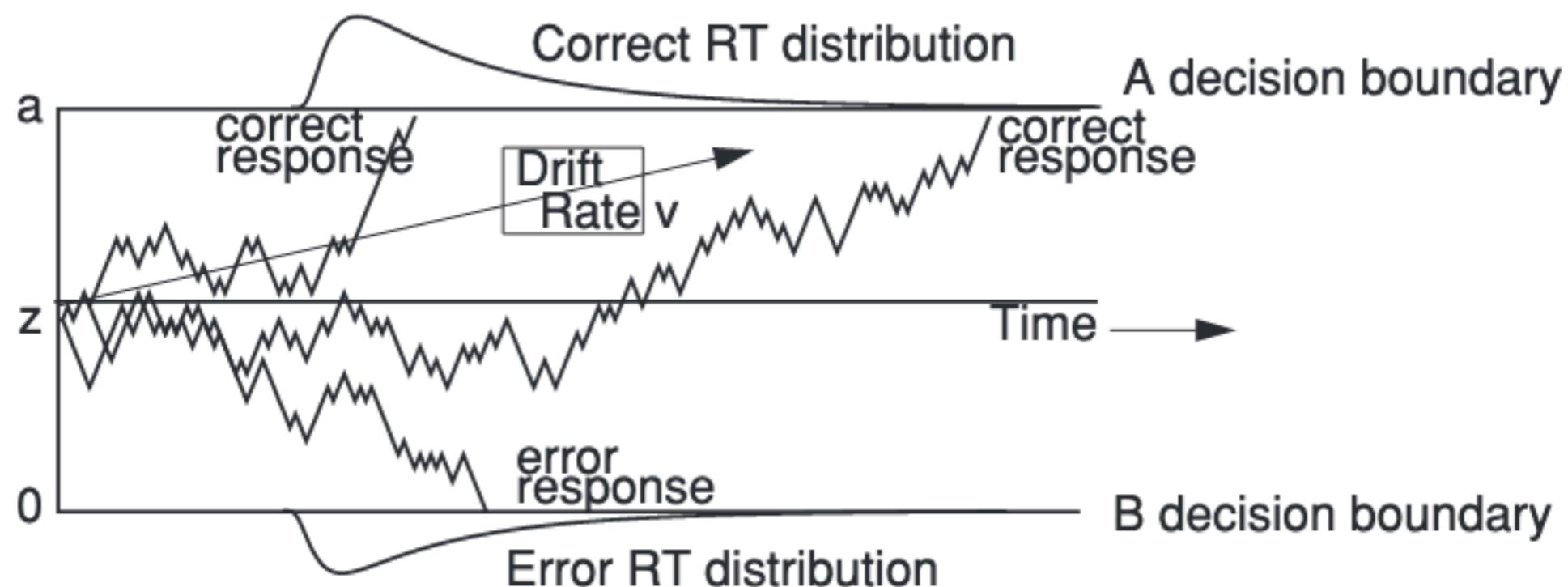
# C.R.E.A.M.

- Cash
- Rules
- Everything
- Around
- Me



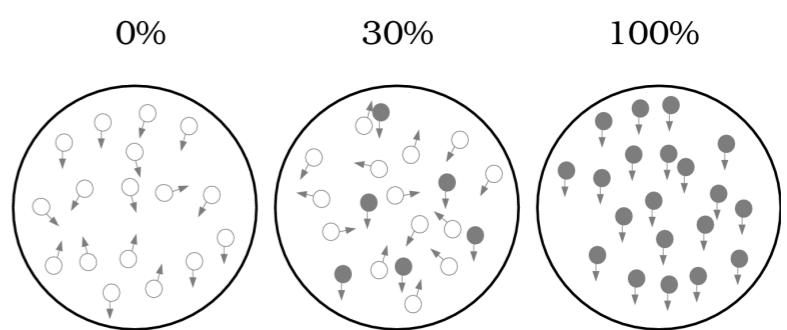
# C.R.E.A.M.

- Choices +
- Reaction times
- Enable
- Accuracy-speed tradeoff
- Modeling

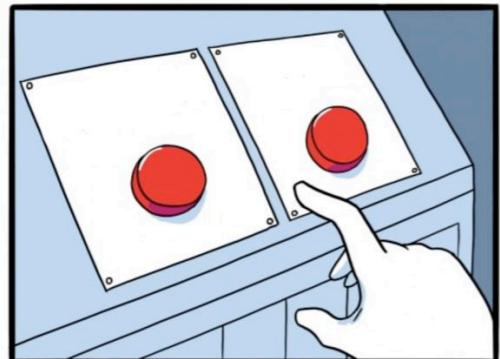


# Choices

- Traditionally: “low-level” cognition
  - Perceptual: random dot motion (Ratcliff & McKoon 2008, Neural Comput)
  - Inhibition: stop-signal (White et al. 2014, J Cogn Neurosci)
  - Response conflict: stroop, flanker, etc (Cavanagh et al. 2011, Nat Neurosci)
- Extensions: value-based decision-making
  - Interplay between reward and attention (Shenhav et al. 2018, Nat Comm)
  - Personal preferences (Krajbich & Rangel 2011, Proc Nat Acad Sci)
- More recently: social and moral preferences
  - Altruistic choice (Hutcherson et al. 2015, Neuron)
  - Food preferences for self vs other person (Harris et al. 2018, J Cogn Neurosci)
  - **Conformity to others' moral values** (Son, Bhandari, & FeldmanHall, 2019)



# Choices



JAKE-CLARK.TUMBLR



Binary  
left/right, yes/no,  
correct/wrong

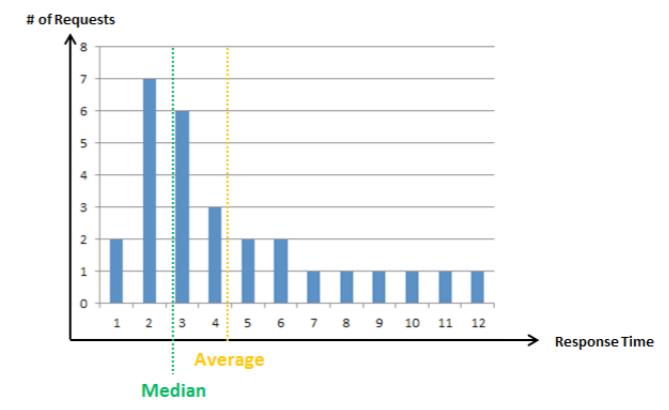
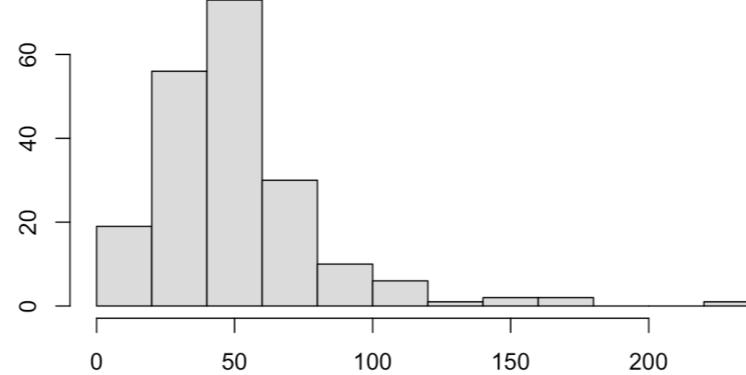
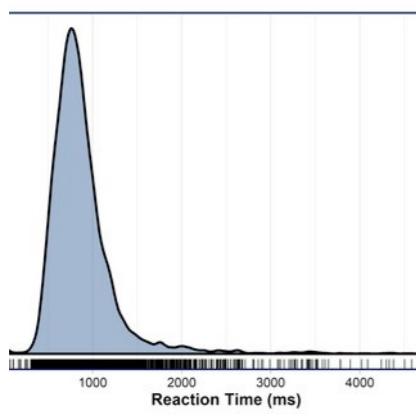
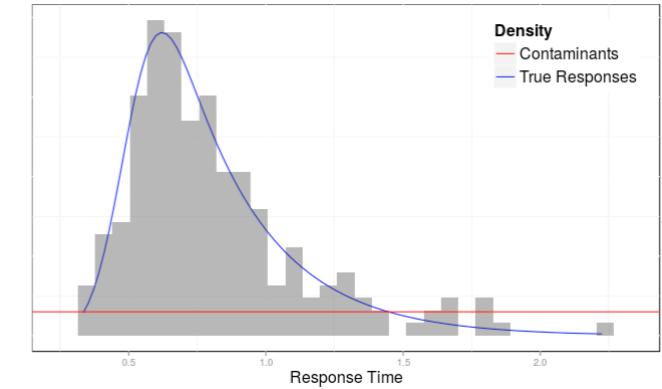
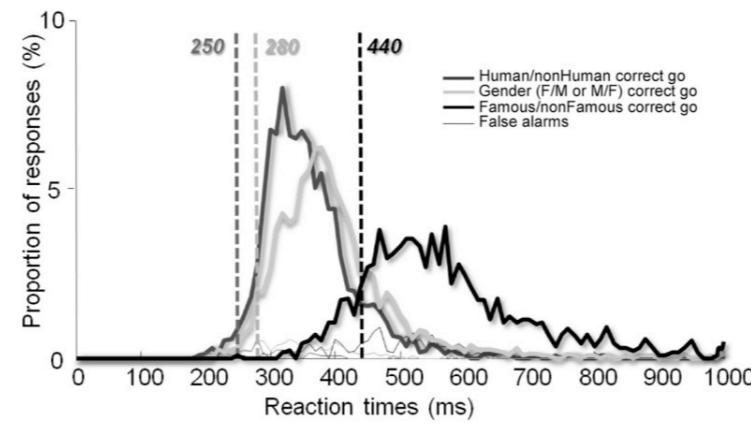
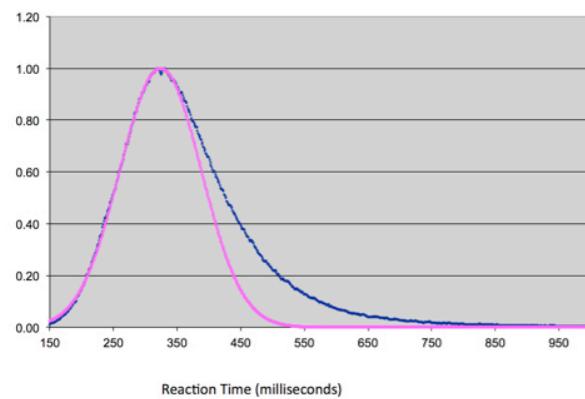
Fast  
mean RTs less than  
1000-1500ms\*



Uncertain  
noisy perception,  
preferences, etc.

Ratcliff & McKoon 2007

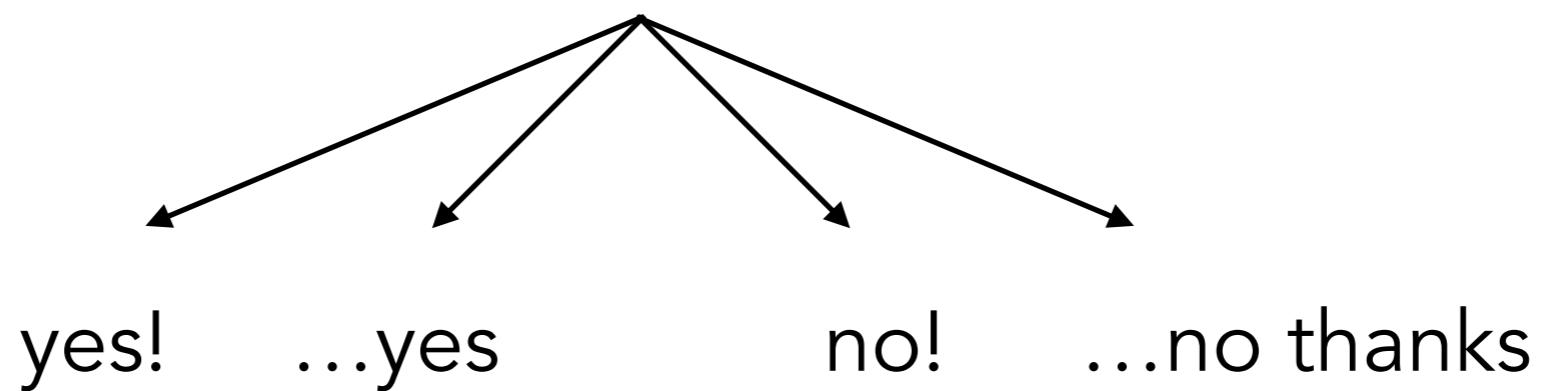
# Reaction Times



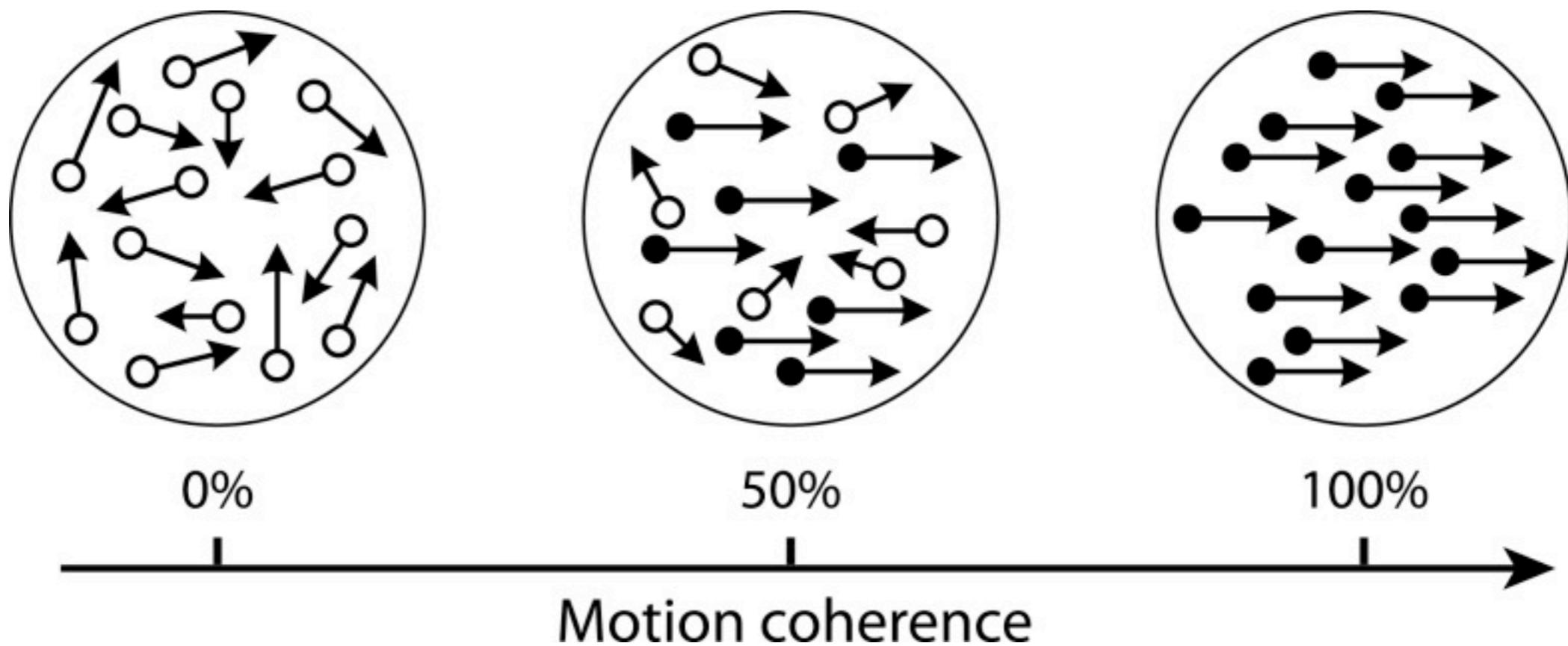
# Why do we need a model?

- Choices matter – economics, decision sciences...
- Reaction times matter – cognitive science, neuroscience...
- Can't we just look at the raw data? What do we gain from modeling these things jointly?

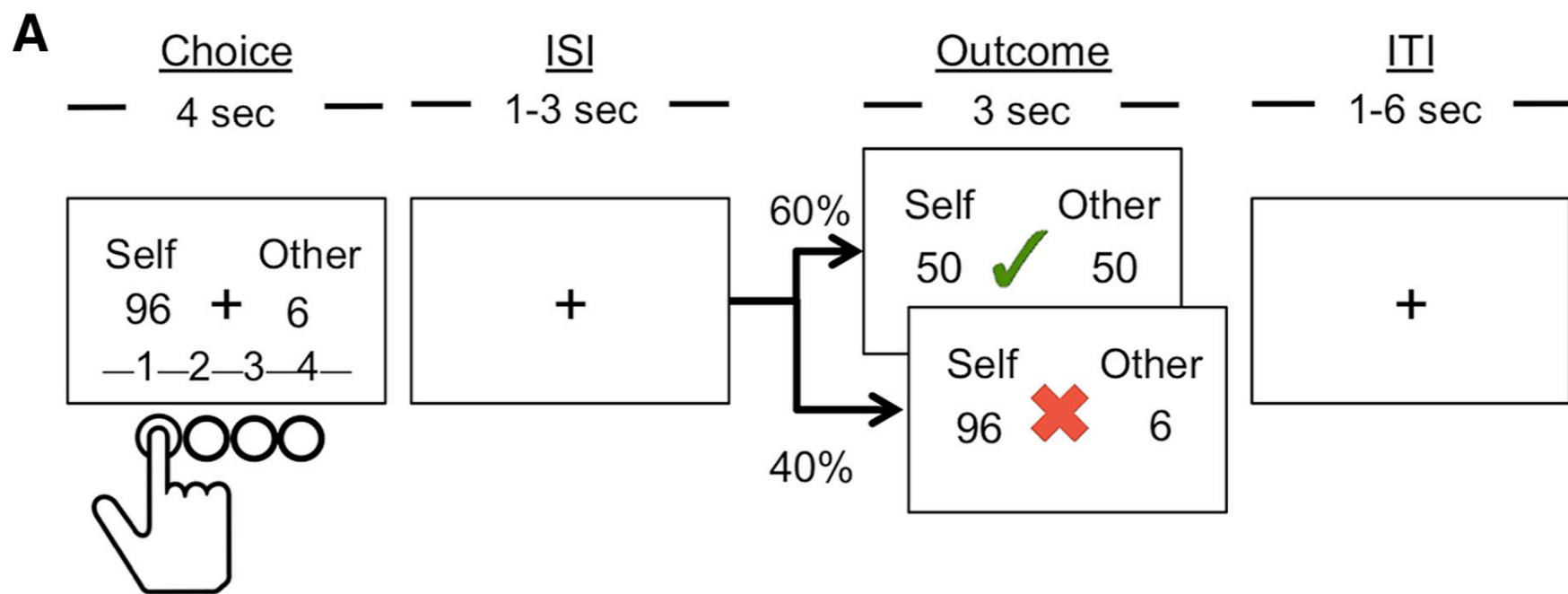
# Speed-accuracy tradeoff



# Speed-accuracy tradeoff



# Speed-accuracy tradeoff for value

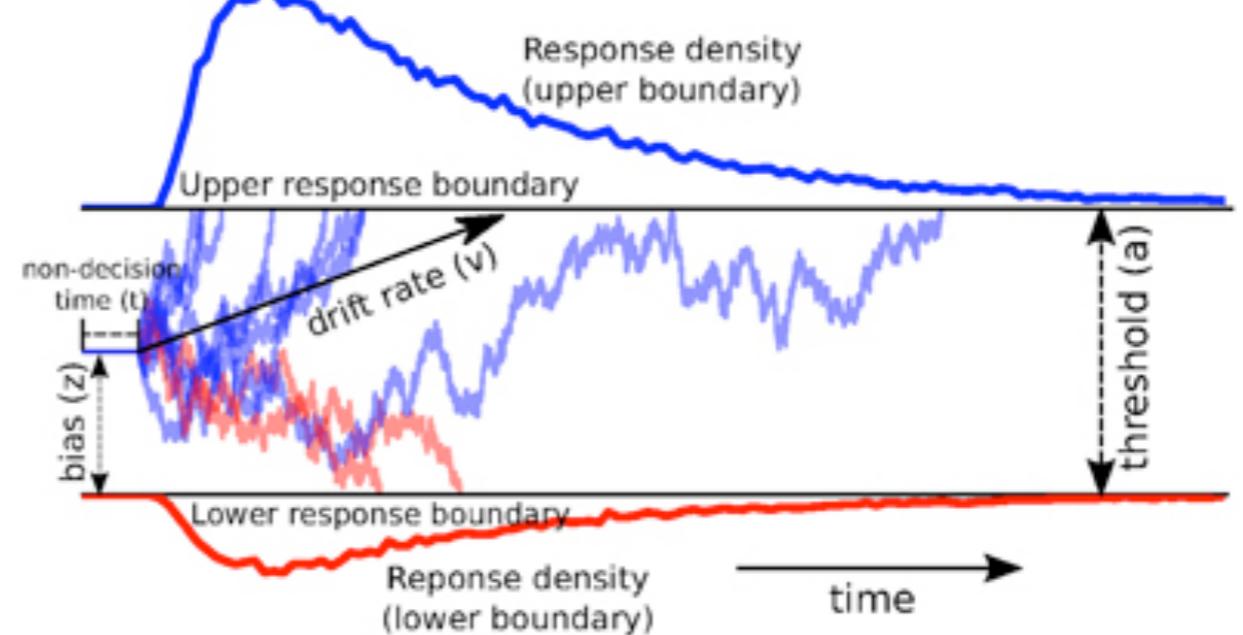


Hutcherson, Bushong, & Rangel 2015

# How does DDM work?

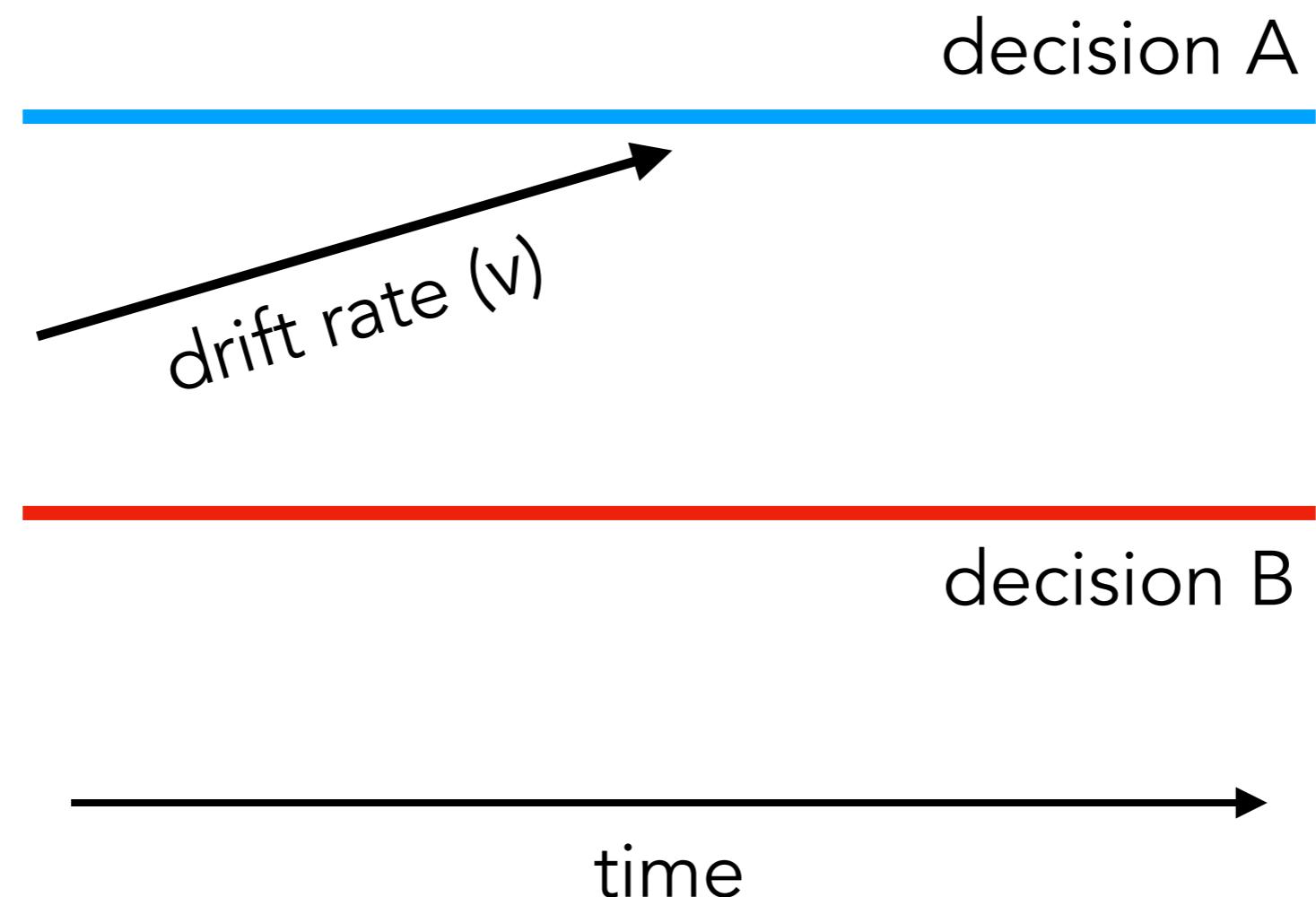
# Model description

- Four main parameters
  - Drift rate ( $v$ )
  - Threshold ( $a$ )
  - Bias ( $z$ )
  - Non-decision time ( $t$ )
- Extensions
  - Variability
  - Collapsing bounds
  - Attentional

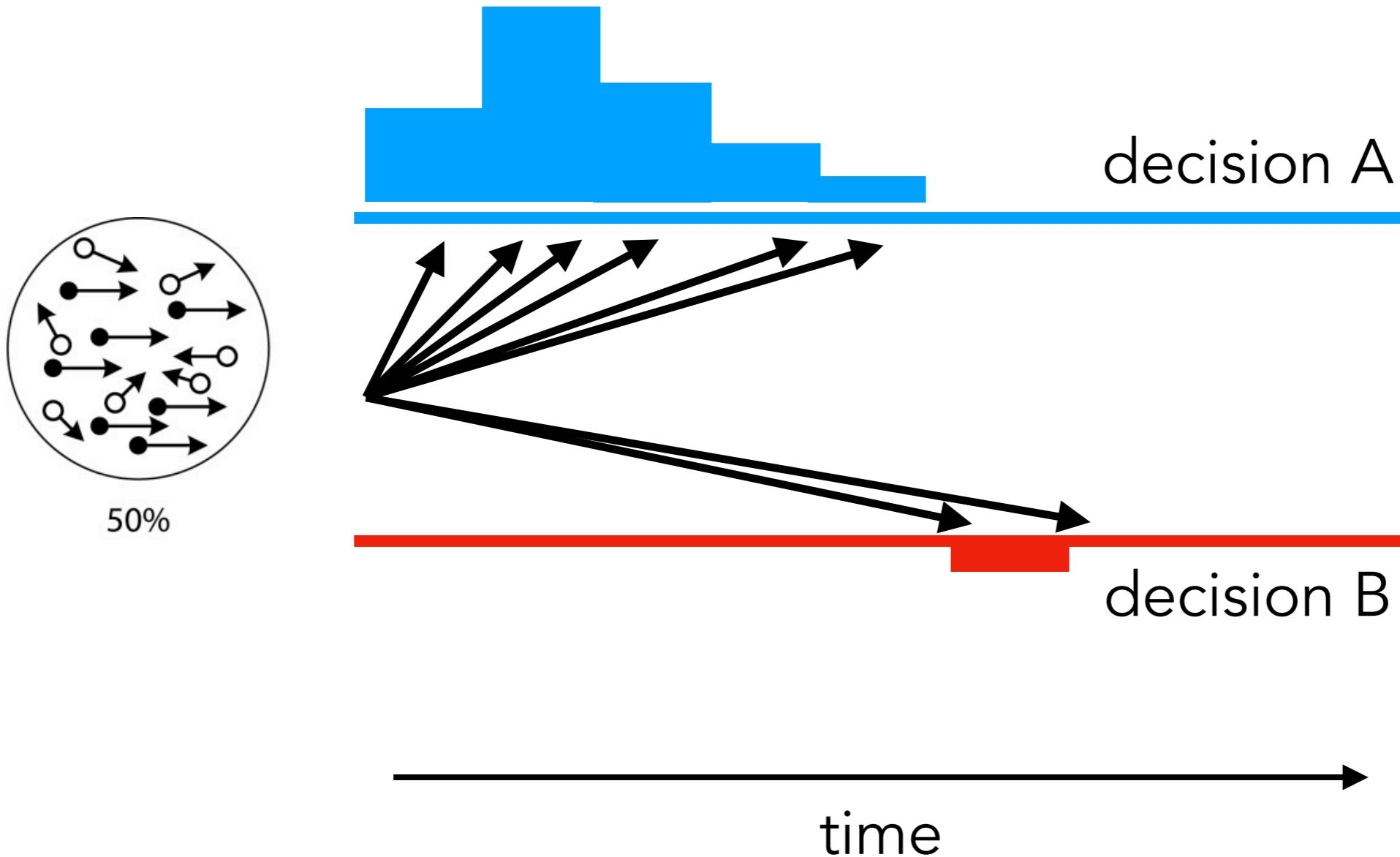


Wiecki, Sofer, & Frank, 2013

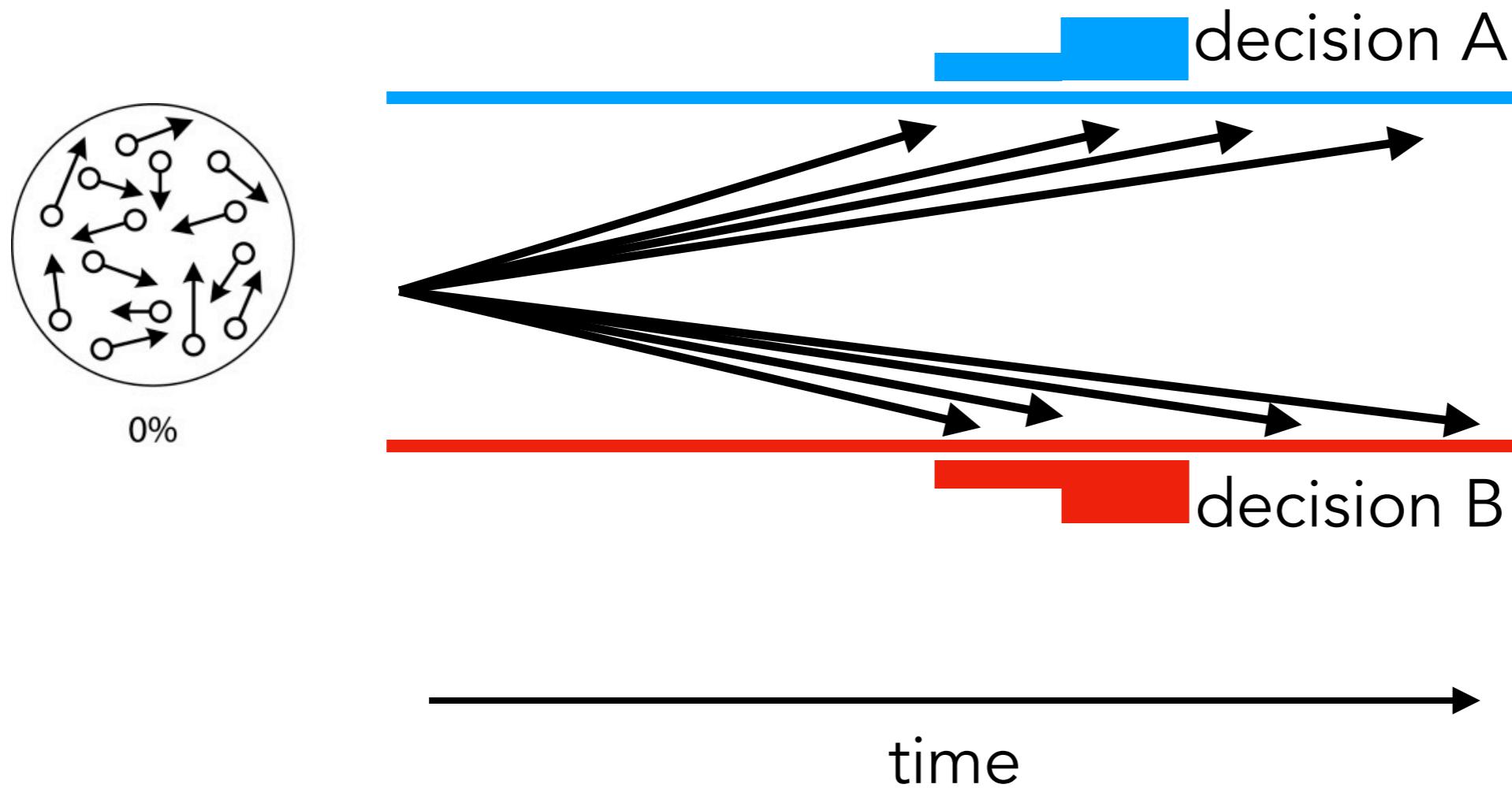
# Drift ( $v$ )



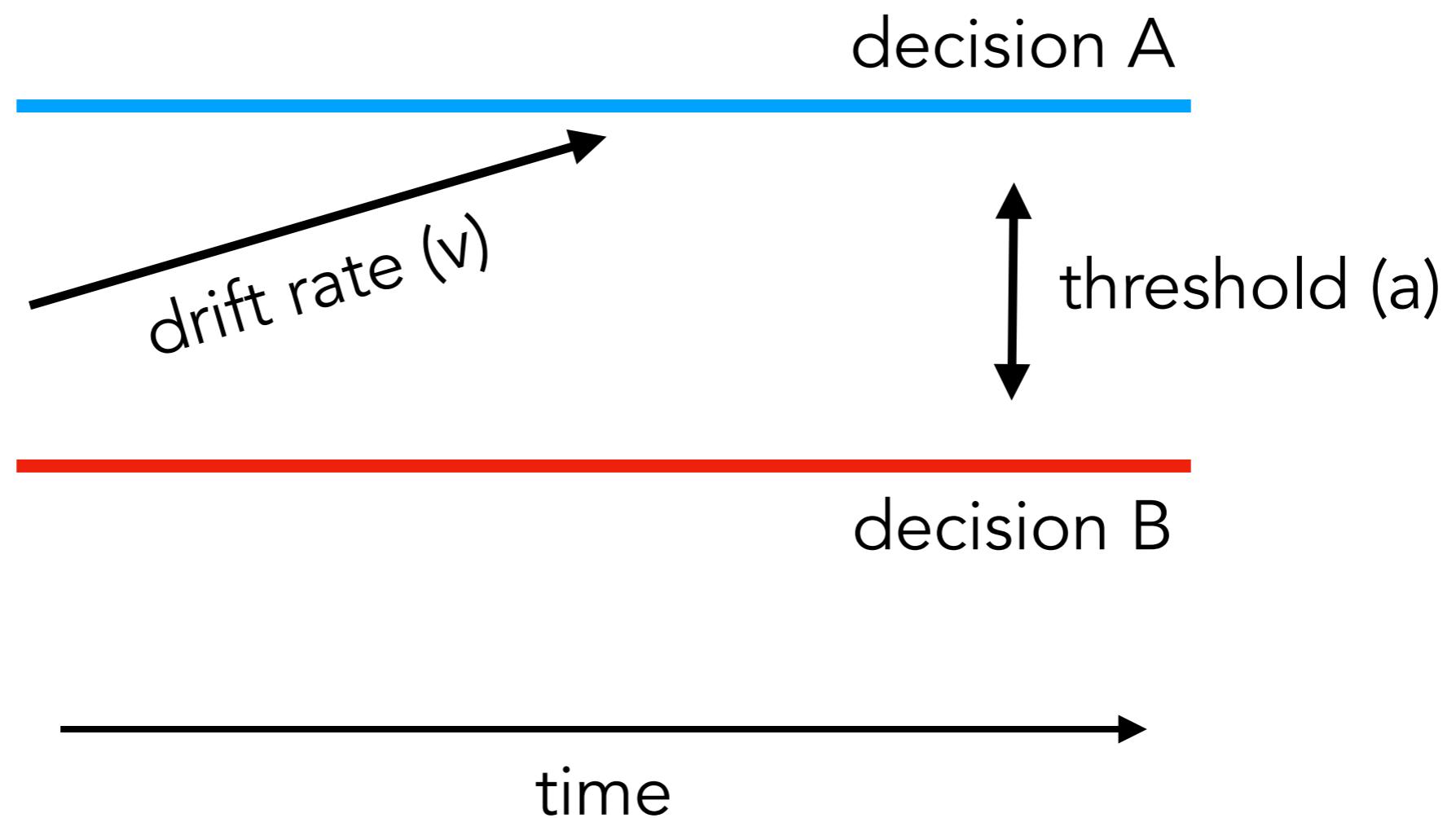
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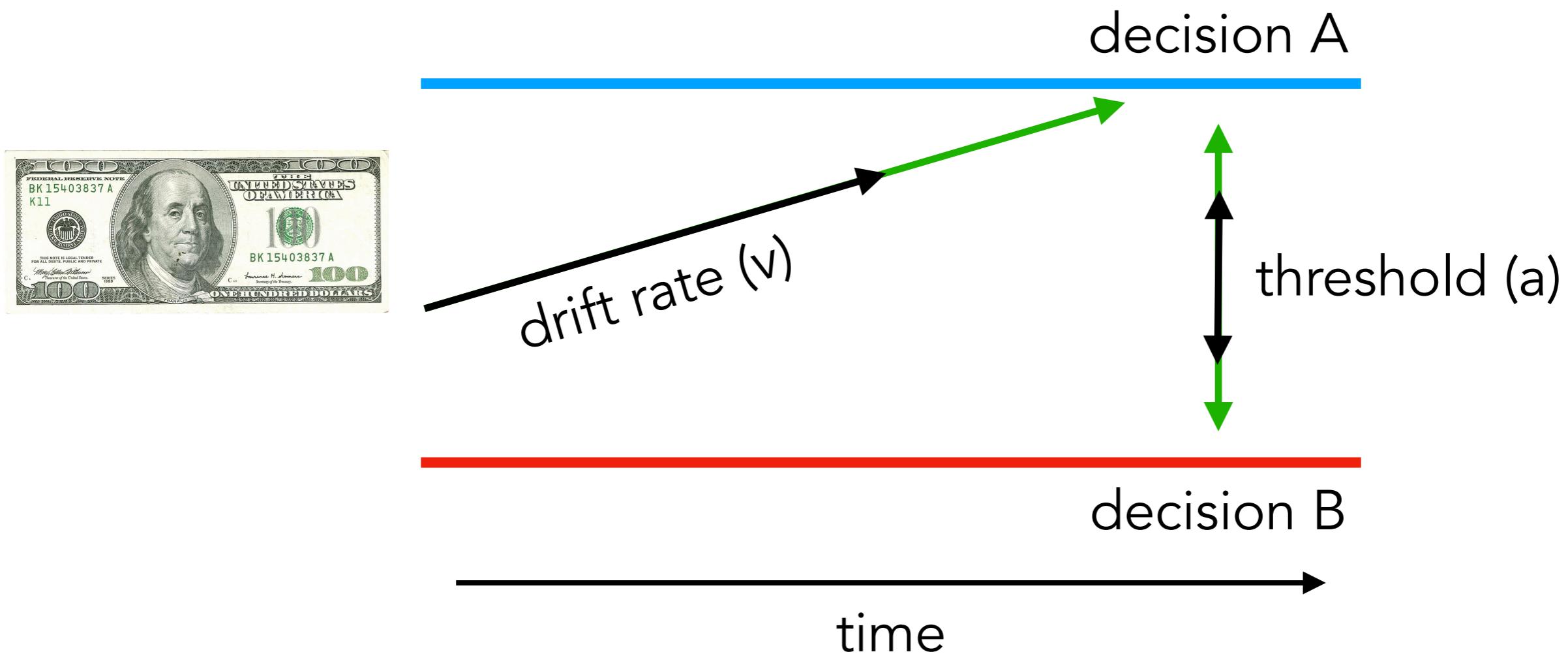
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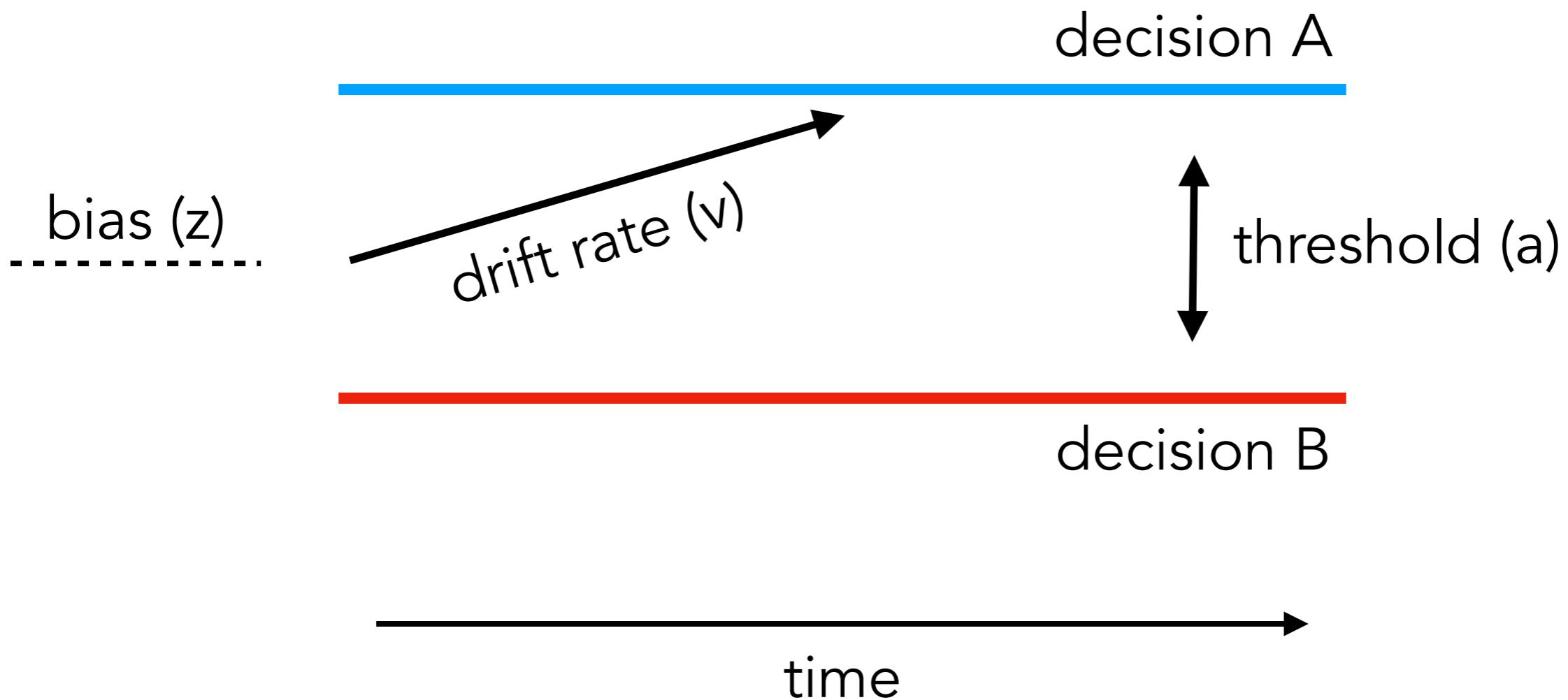
# Threshold



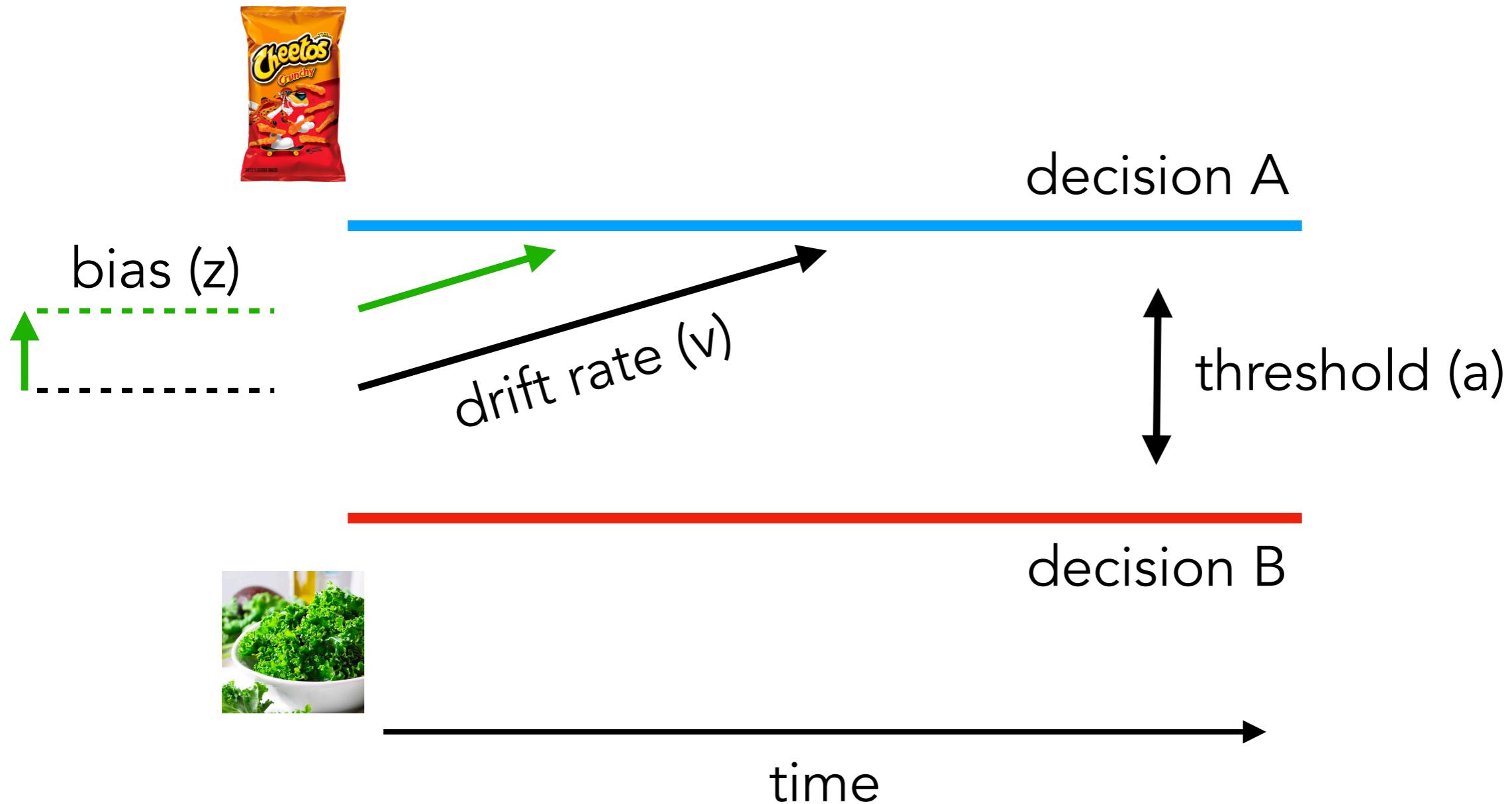
# Threshold



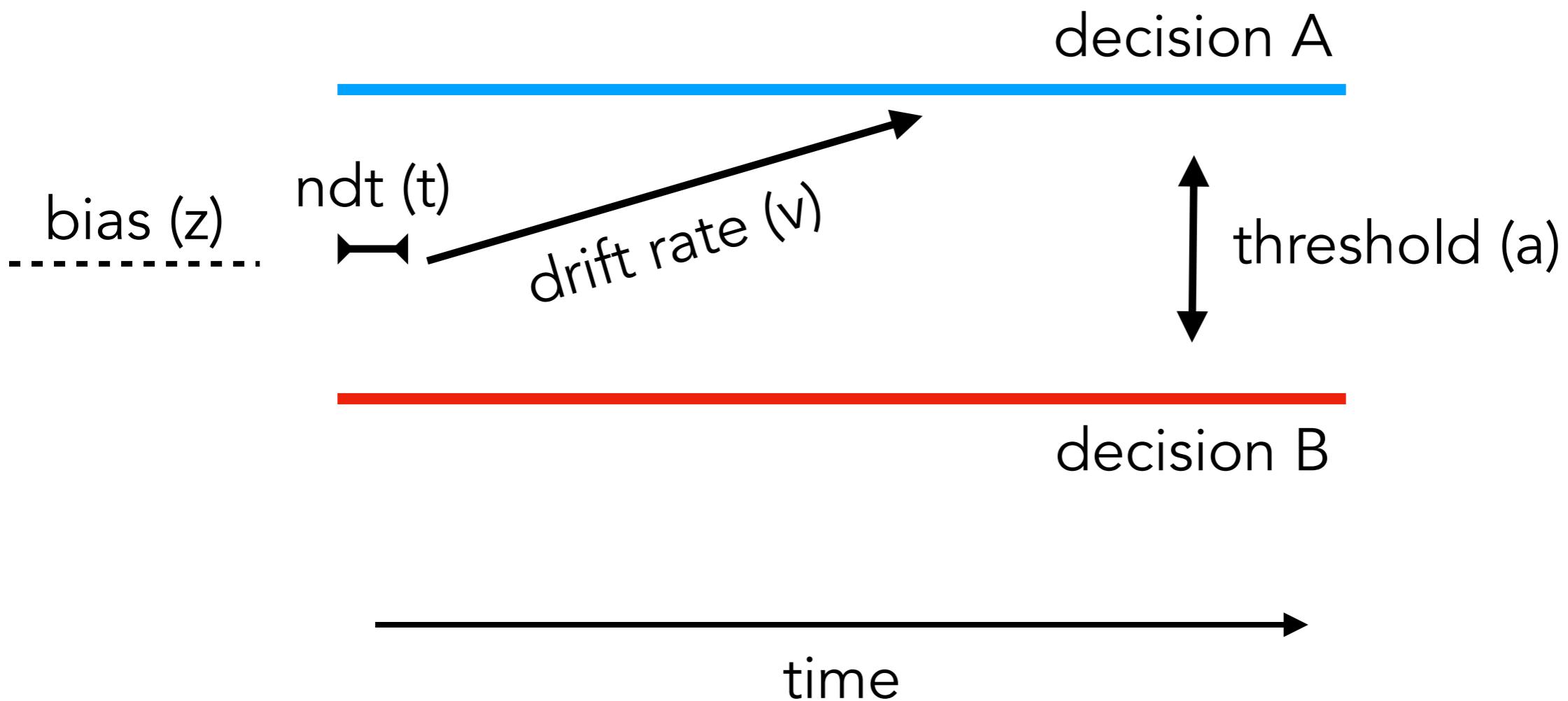
# Bias



# Bias

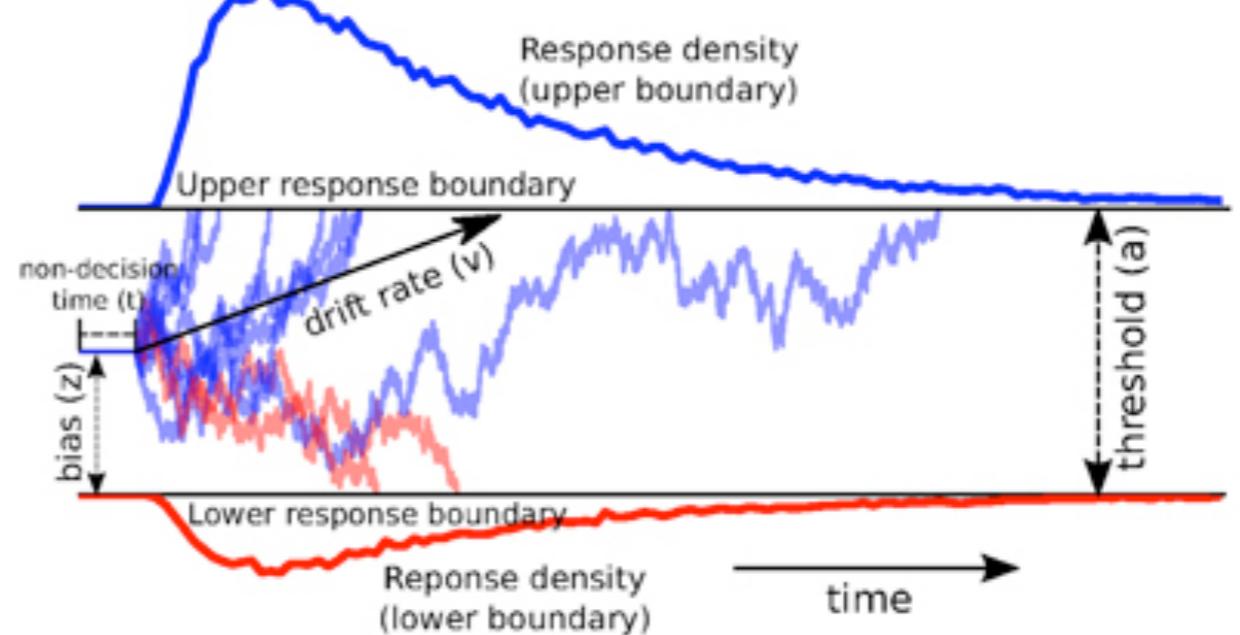


# Non-decision time ( $t$ )



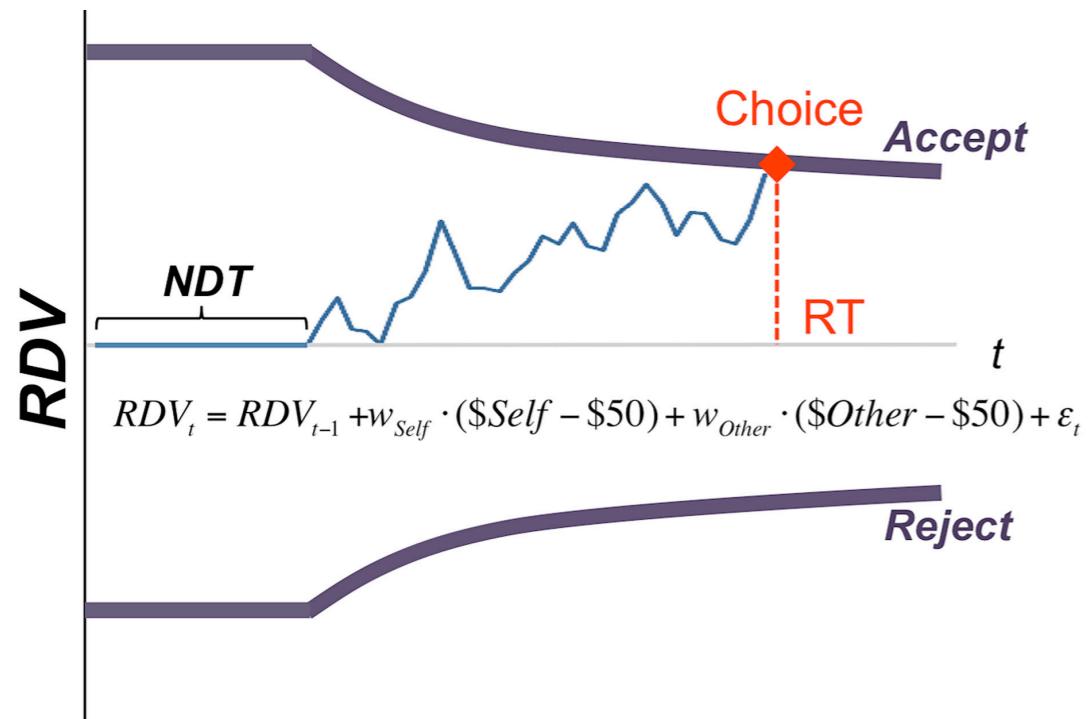
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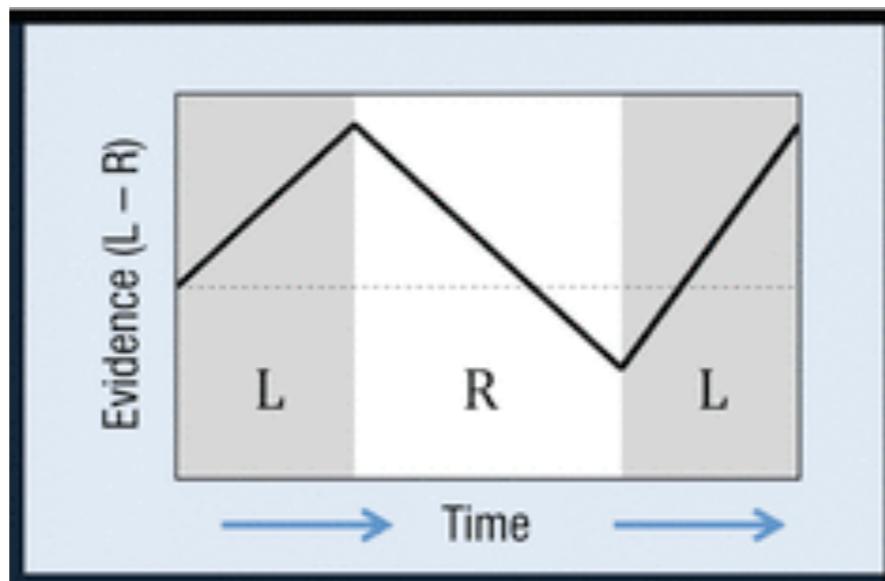
Wiecki, Sofer, & Frank, 2013

# Collapsing bounds for value



Hutcherson, Bushong, & Rangel 2015

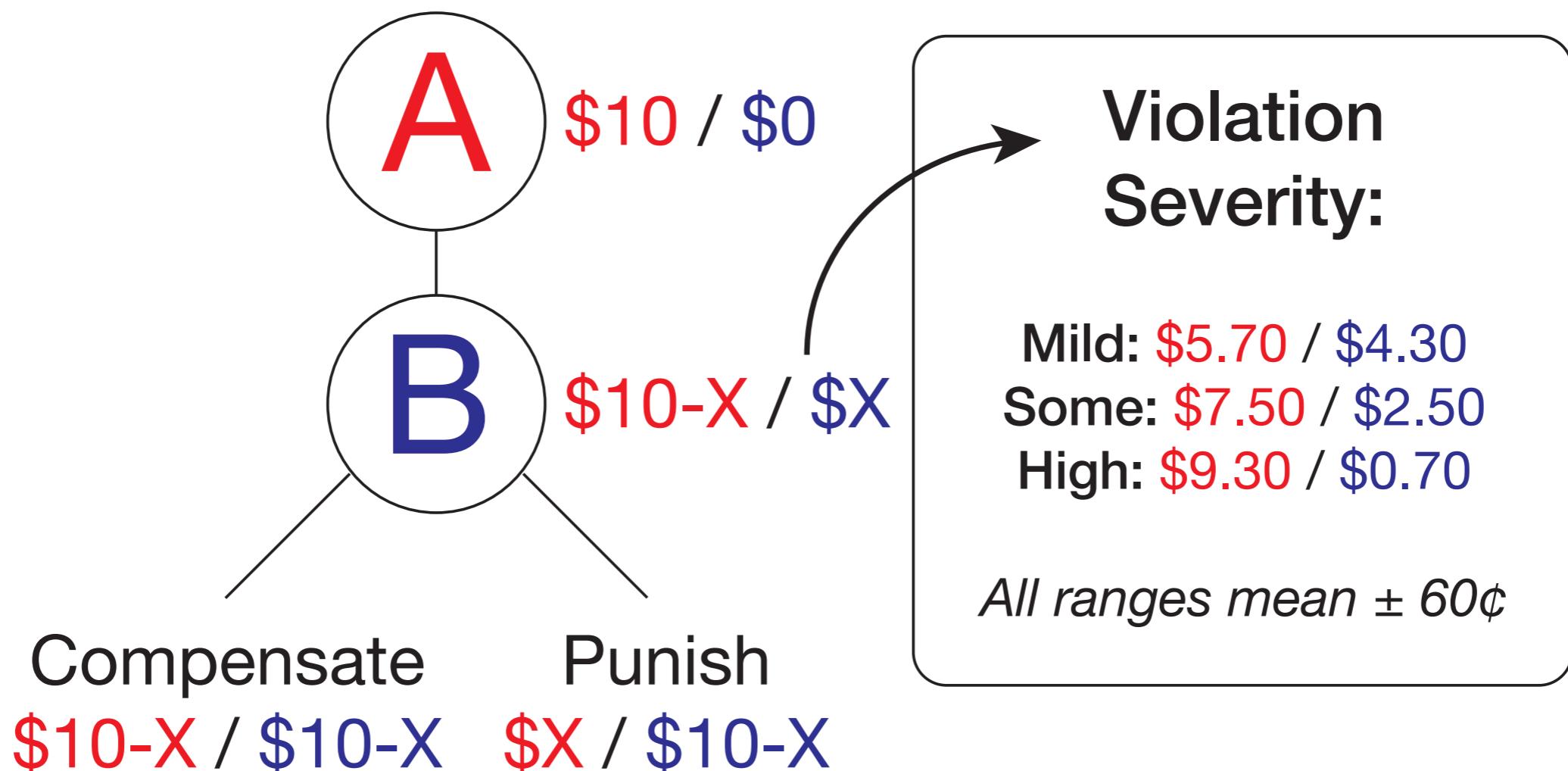
# Attentional DDM (aDDM)



Smith & Krajbich 2018  
Krajbich, Lu, Camerer, & Rangel 2012

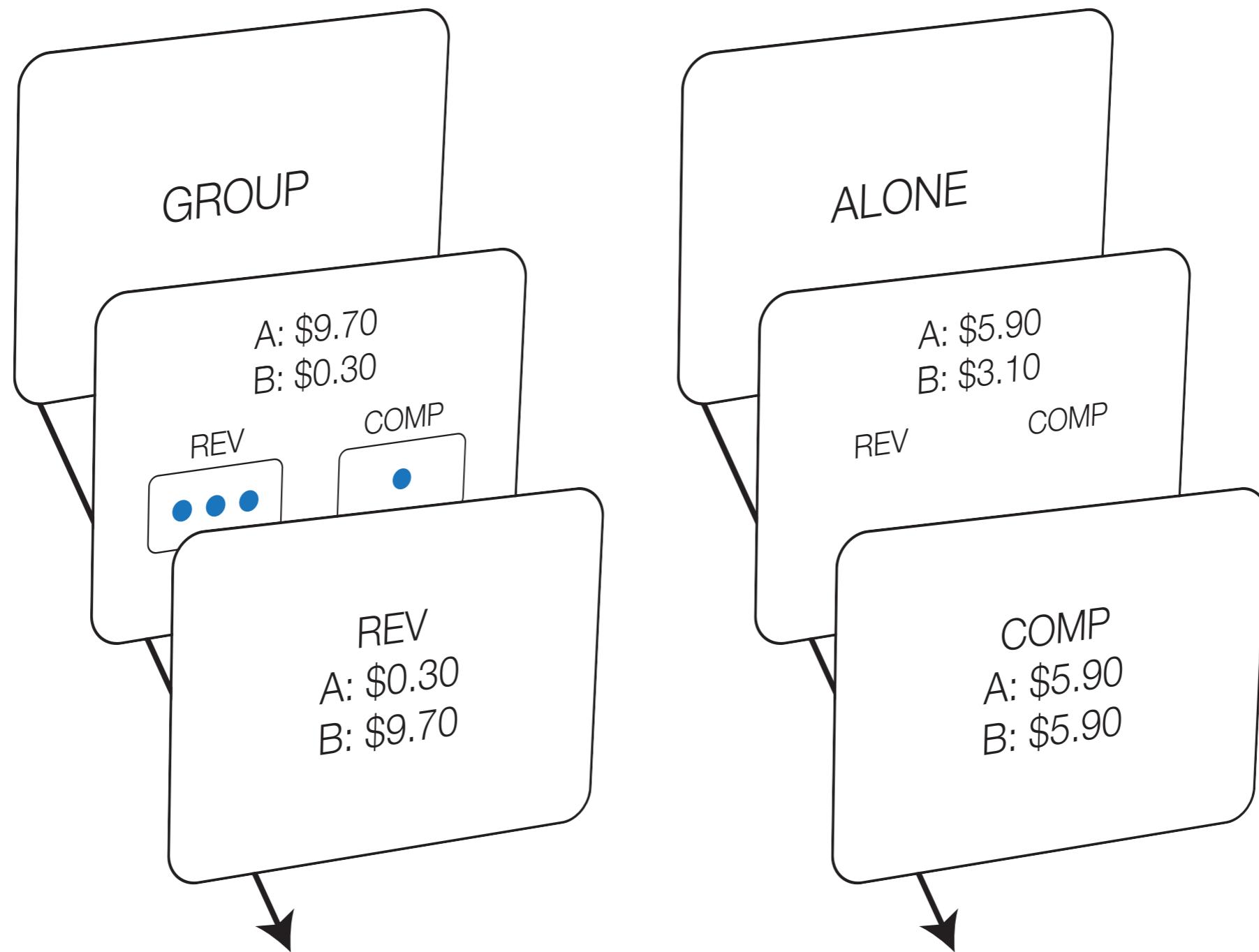
Example: conforming  
to others' moral values

# Measuring punitive preferences





# Conformity paradigm





# Victim vs Juror

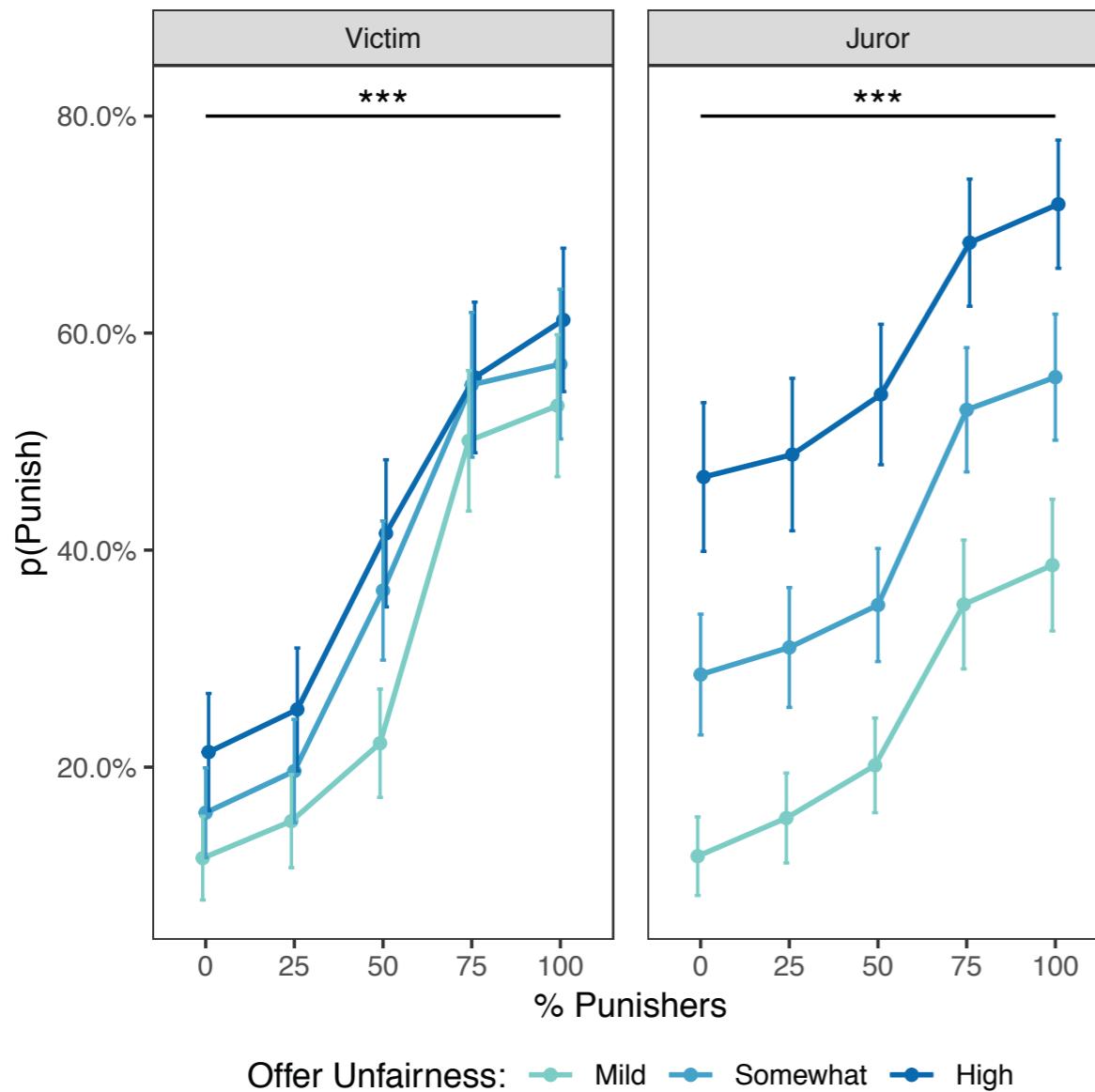


**Victim:** Was harmed by the perpetrator's moral violation, punishment decision affects how much money they earn



**Juror:** Makes punishment decision on behalf of a victim; wasn't harmed, won't earn more money based on their choice

# Behavioral results:



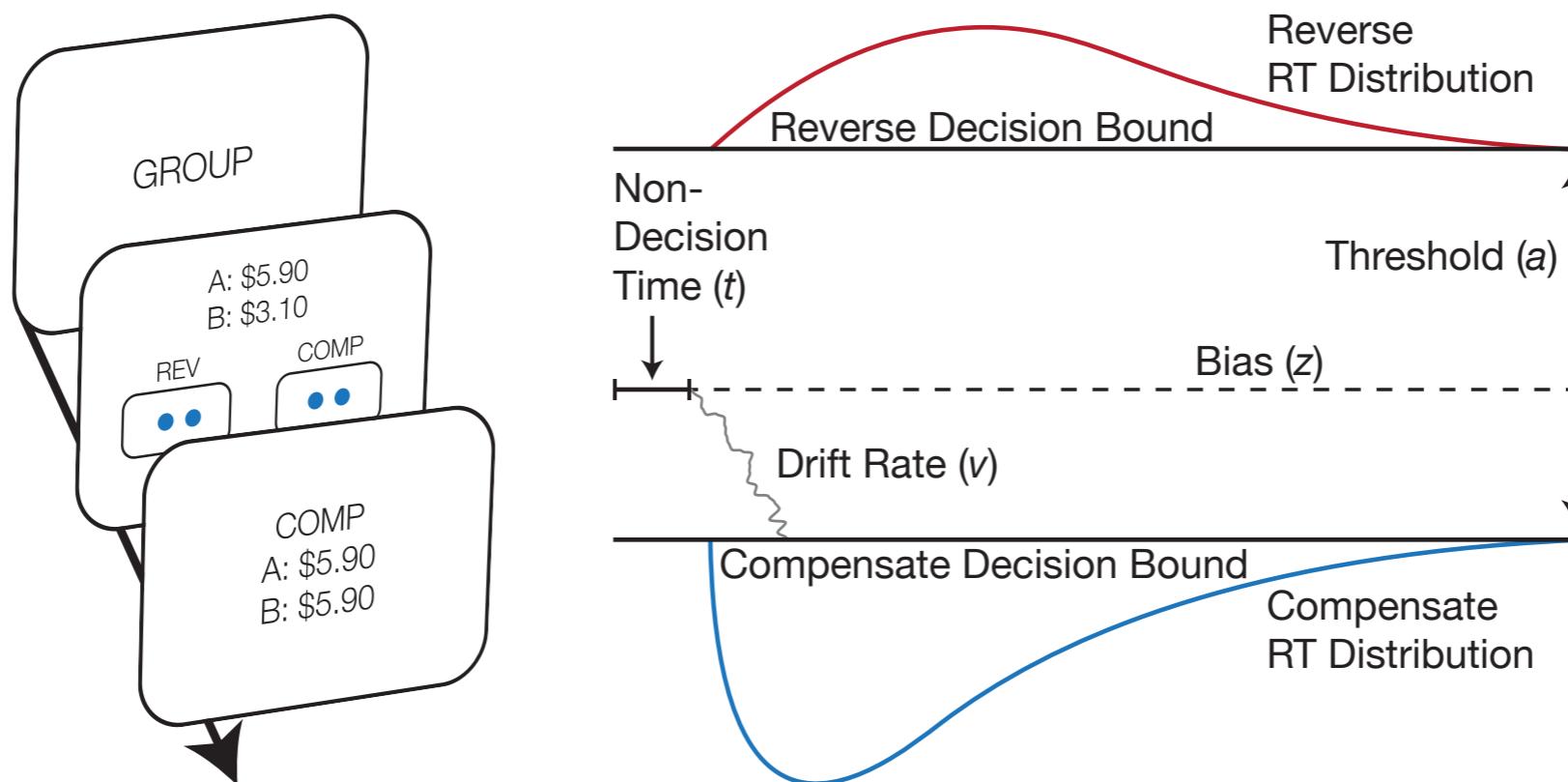
*Two longstanding hypotheses about why people conform:*

1. Being part of a group makes you less vigilant about your decisions
2. Groups provide evidence about what is (socially) valued

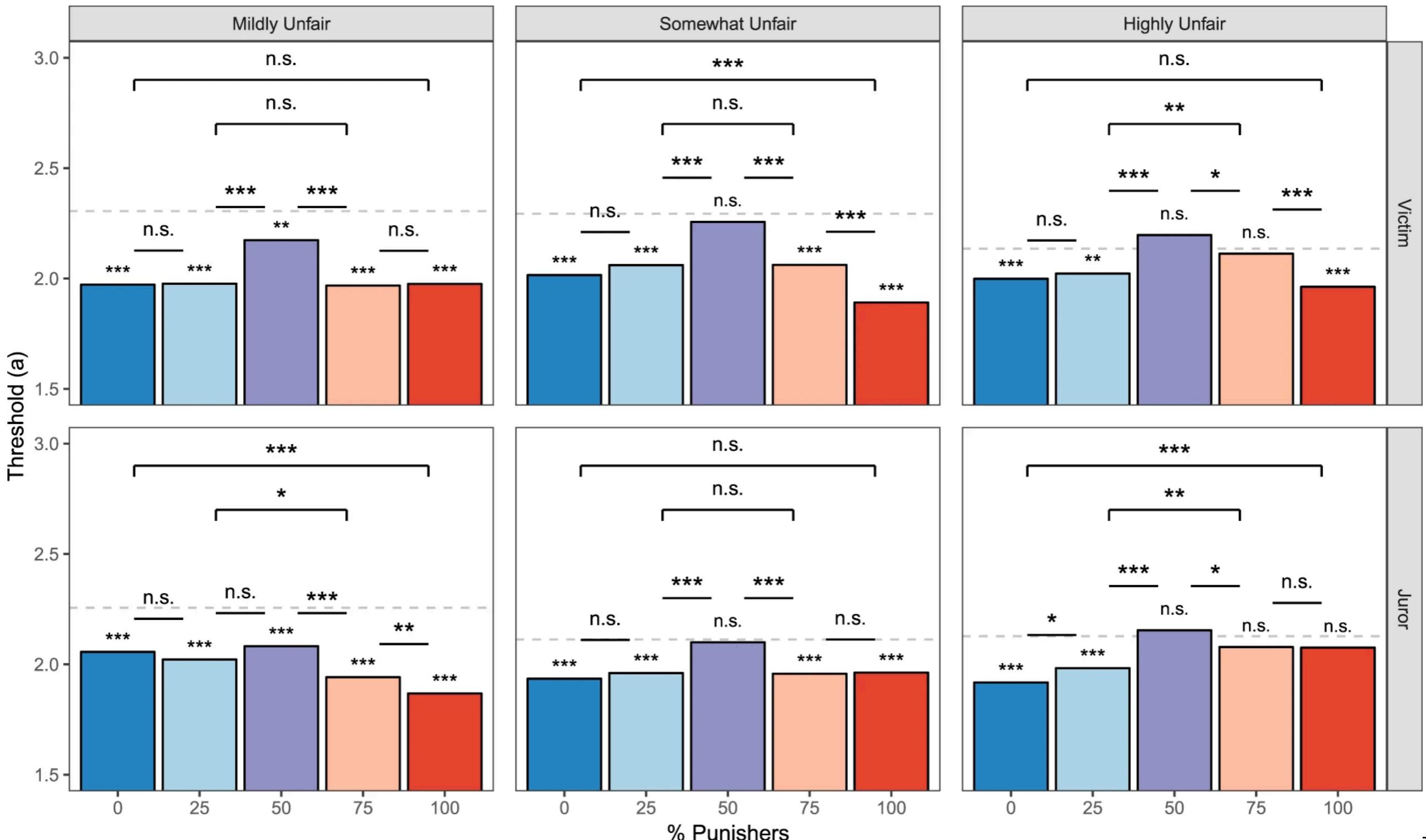
**Problem: our behavioral data can't tell us WHY people are conforming to others' punitive preferences!**

# How does DDM help us?

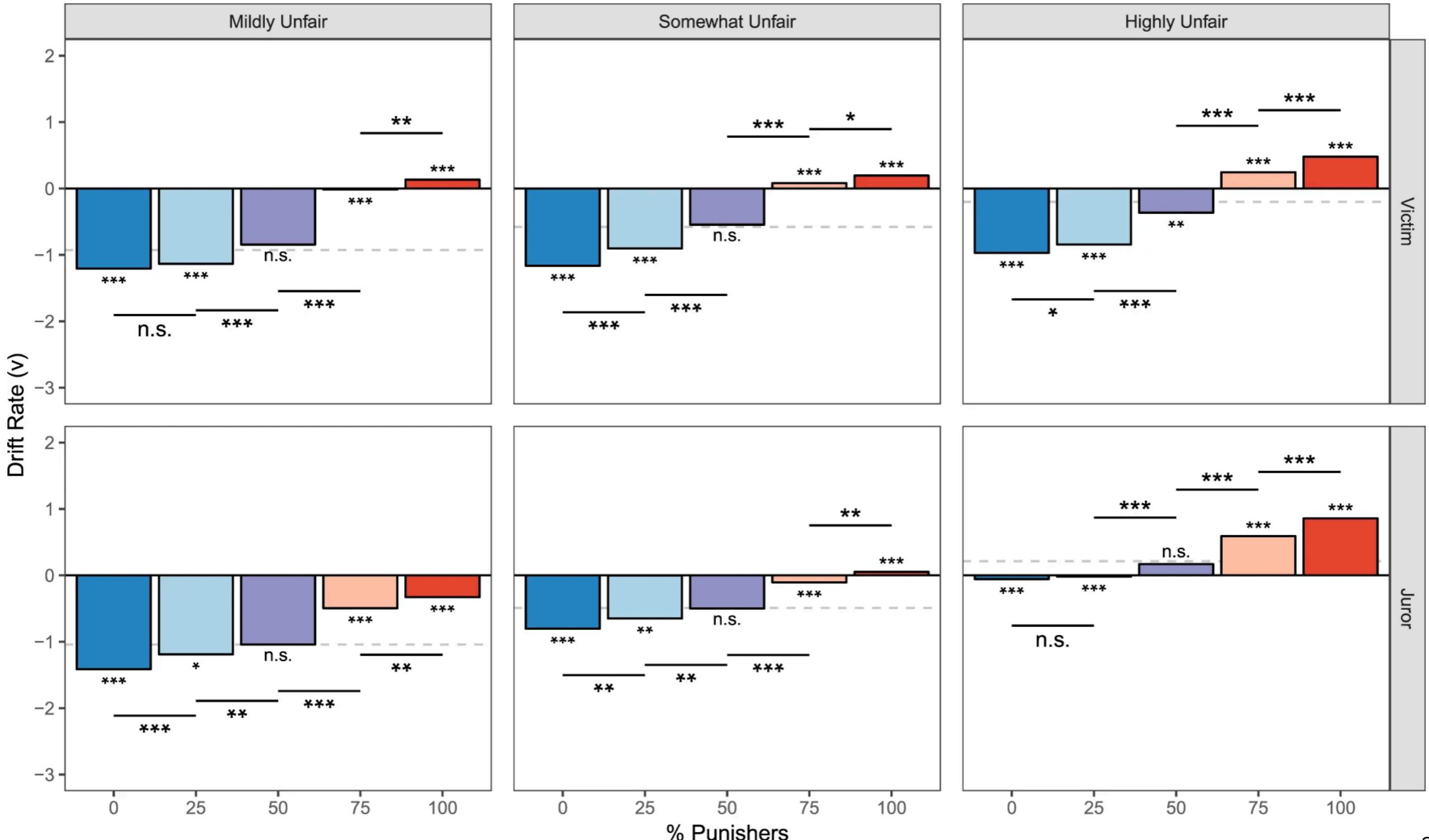
- Parameters are psychologically interpretable:
  - Bias  $z$  = how much individuals prefer punishment in the absence of group influence
  - Threshold  $a$  = the extent to which groups cause individuals to relinquish moral responsibility
  - Drift  $v$  = the extent to which groups provide evidence that punishment is (socially) valued



# Results – threshold



# Results – drift



# Open resources and materials

Watch the video version of this talk:

<https://youtu.be/jzsl69VGseU>

HDDM tutorial here:

[https://github.com/psychNerdJae/hddm\\_tutorial](https://github.com/psychNerdJae/hddm_tutorial)

Visit our Open Science Framework page here:

<https://osf.io/8ka47/>

Read the paper here:

<https://www.nature.com/articles/s41598-019-48050-2>