

Introduction to DDM

(Drift Diffusion Modeling)

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Computational Psychiatry Course @ Zurich

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**What can you study
using DDM?**

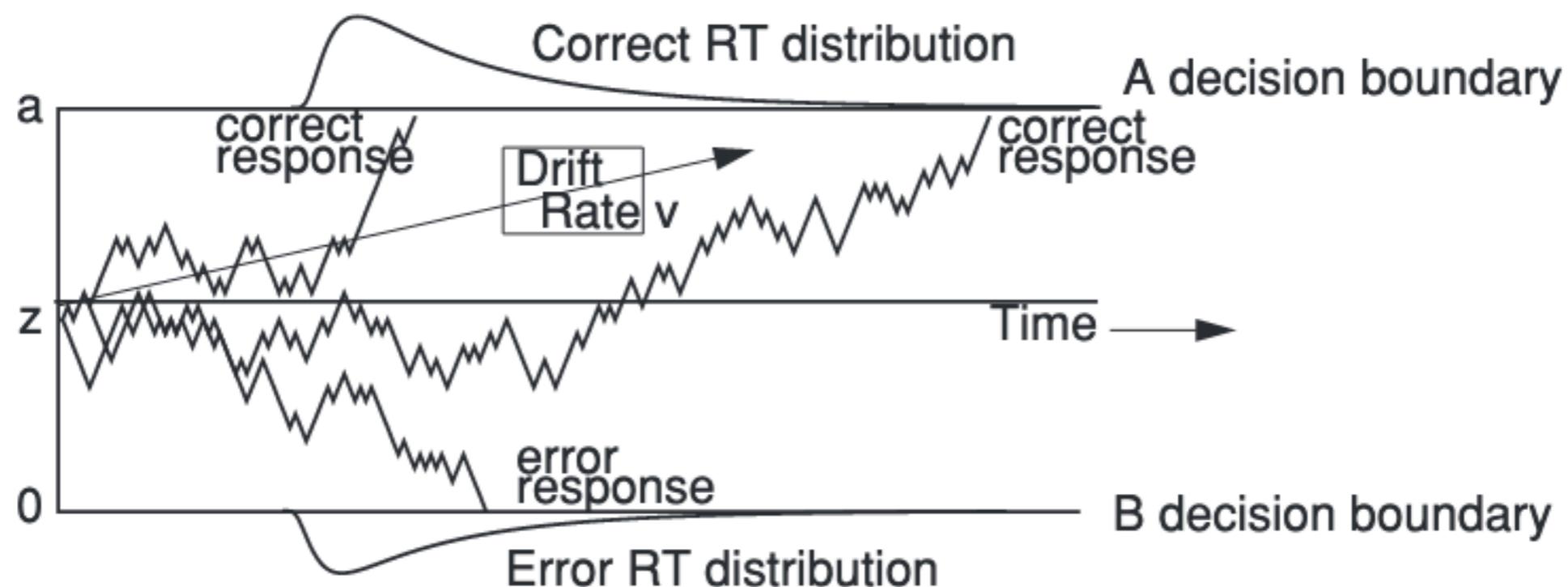
C.R.E.A.M.

- Cash
- Rules
- Everything
- Around
- Me



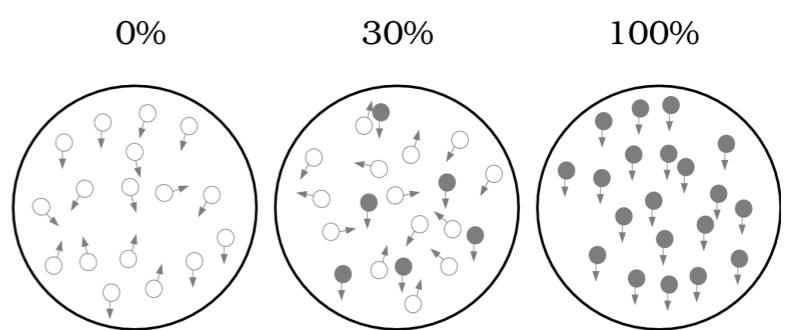
C.R.E.A.M.

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

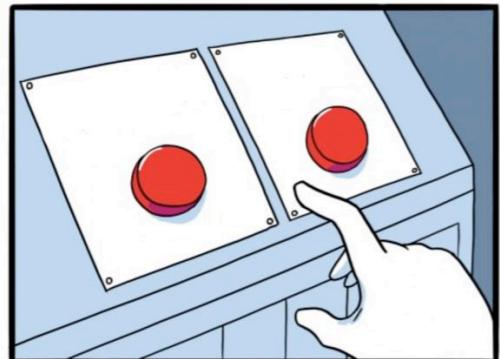


Choices

- 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



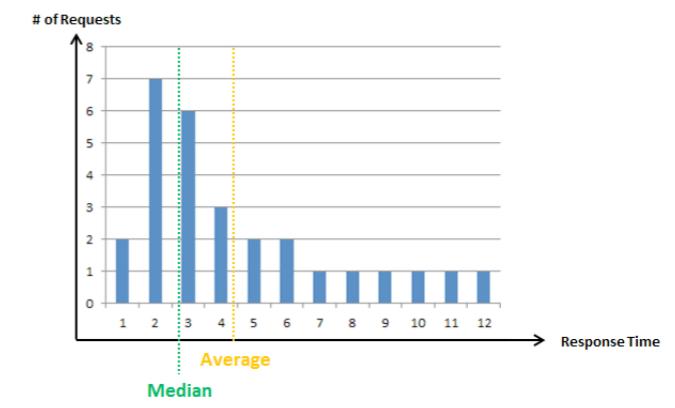
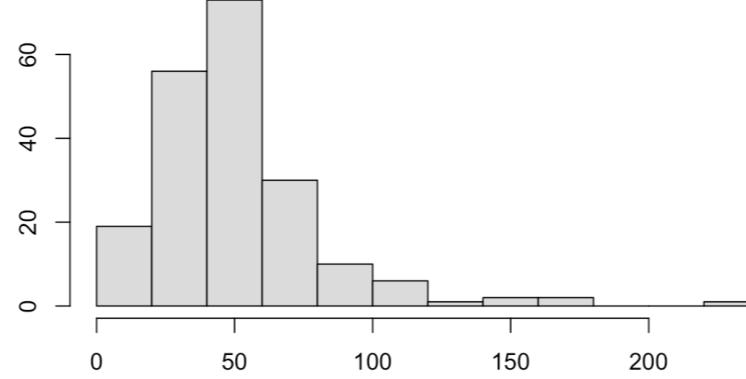
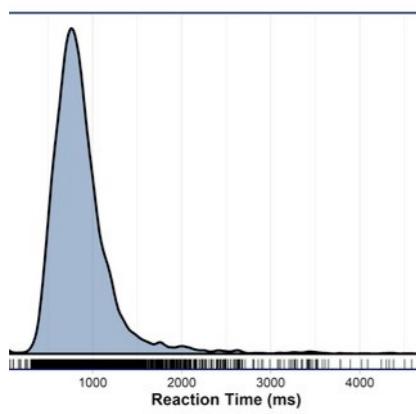
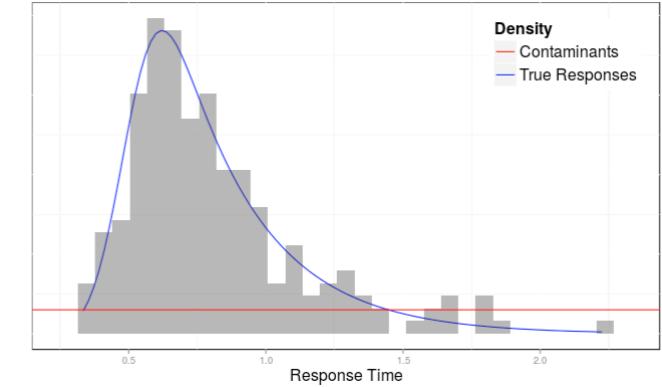
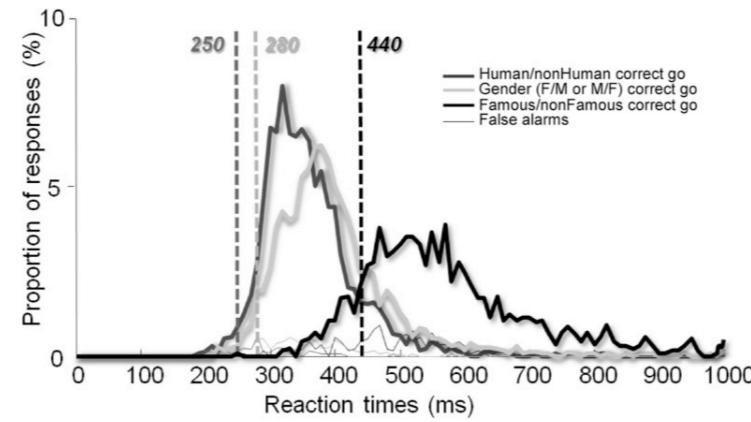
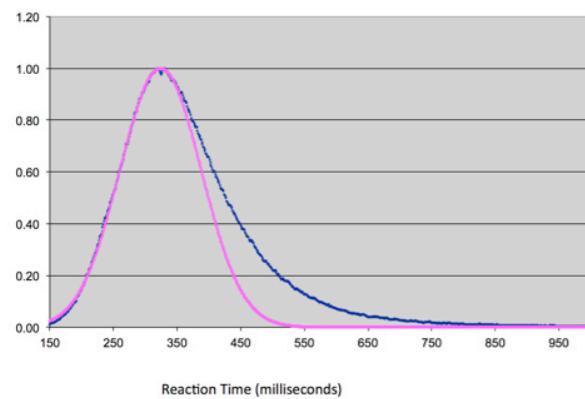
Fast
mean RTs less than
1000-1500ms*



Uncertain
noisy perception,
preferences, etc.

Ratcliff & McKoon 2007

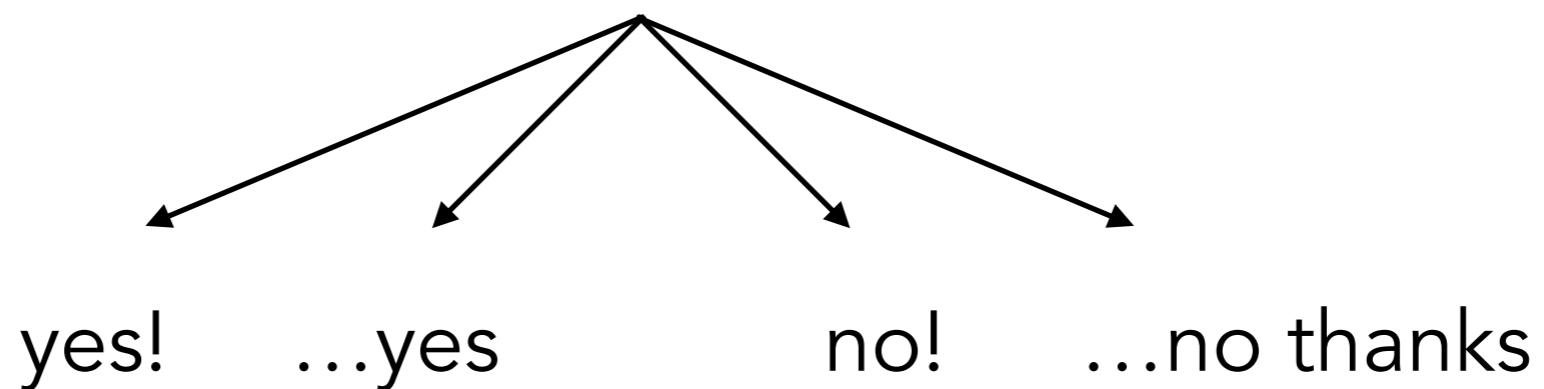
Reaction Times



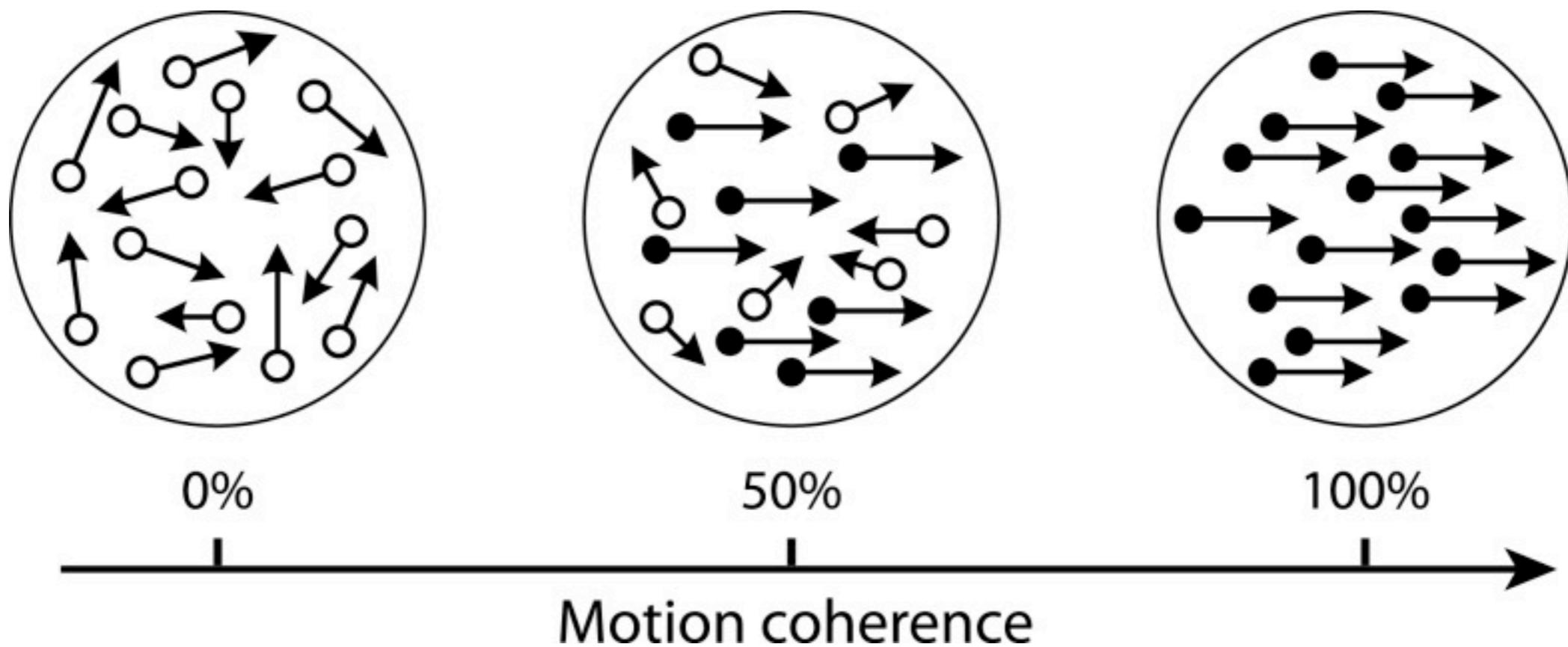
Why do we need a model?

- 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?

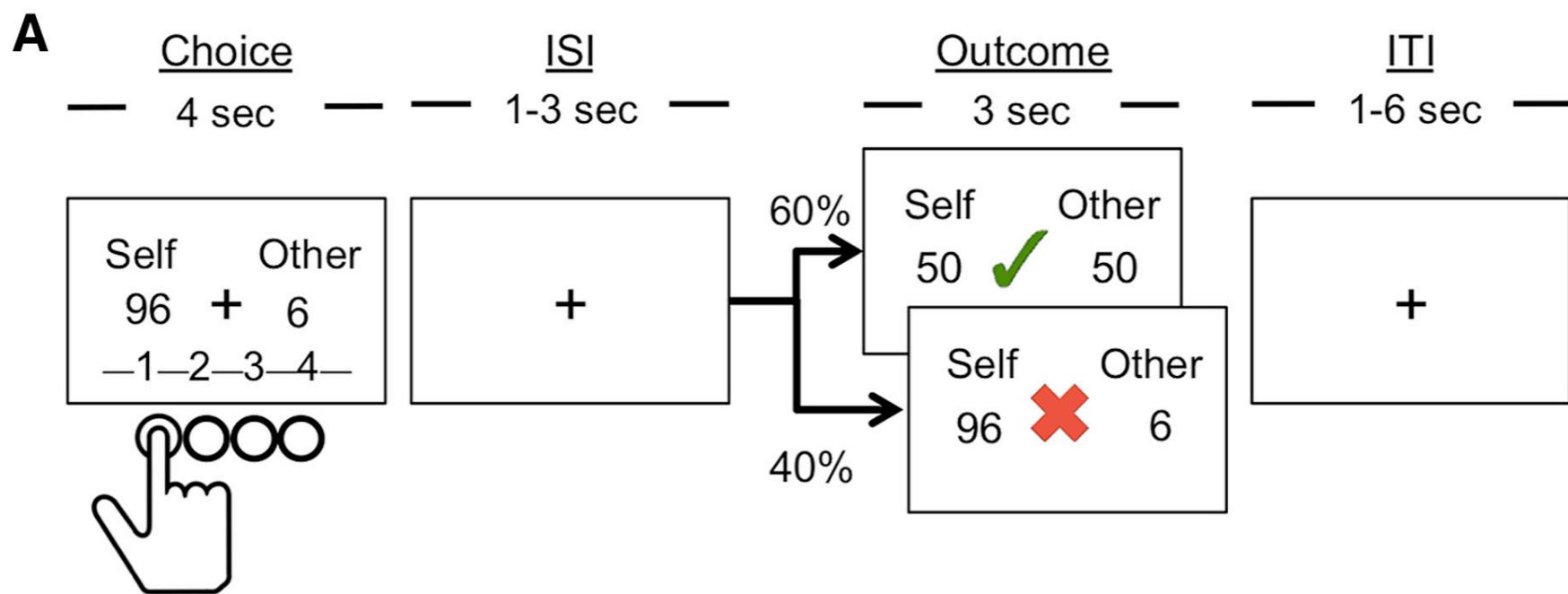
Speed-accuracy tradeoff



Speed-accuracy tradeoff



Speed-accuracy tradeoff for value

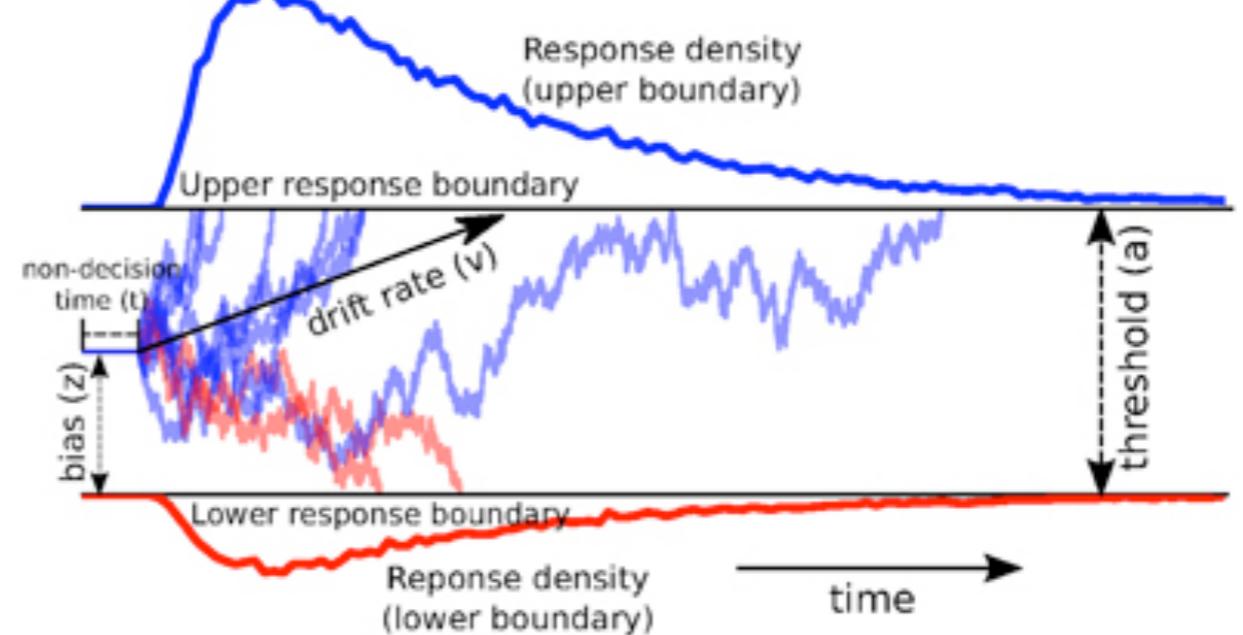


Hutcherson, Bushong, & Rangel 2015

How does DDM work?

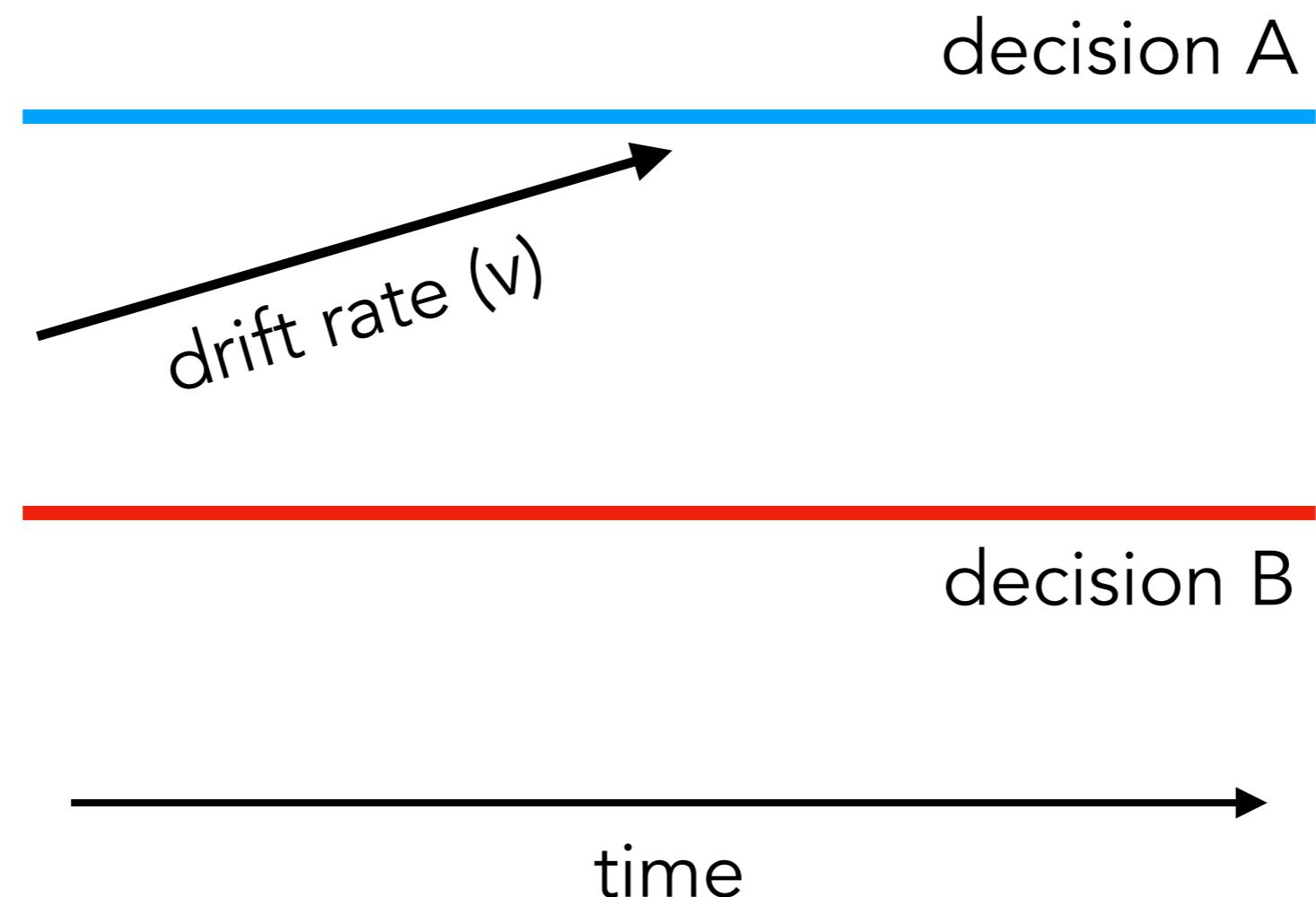
Model description

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

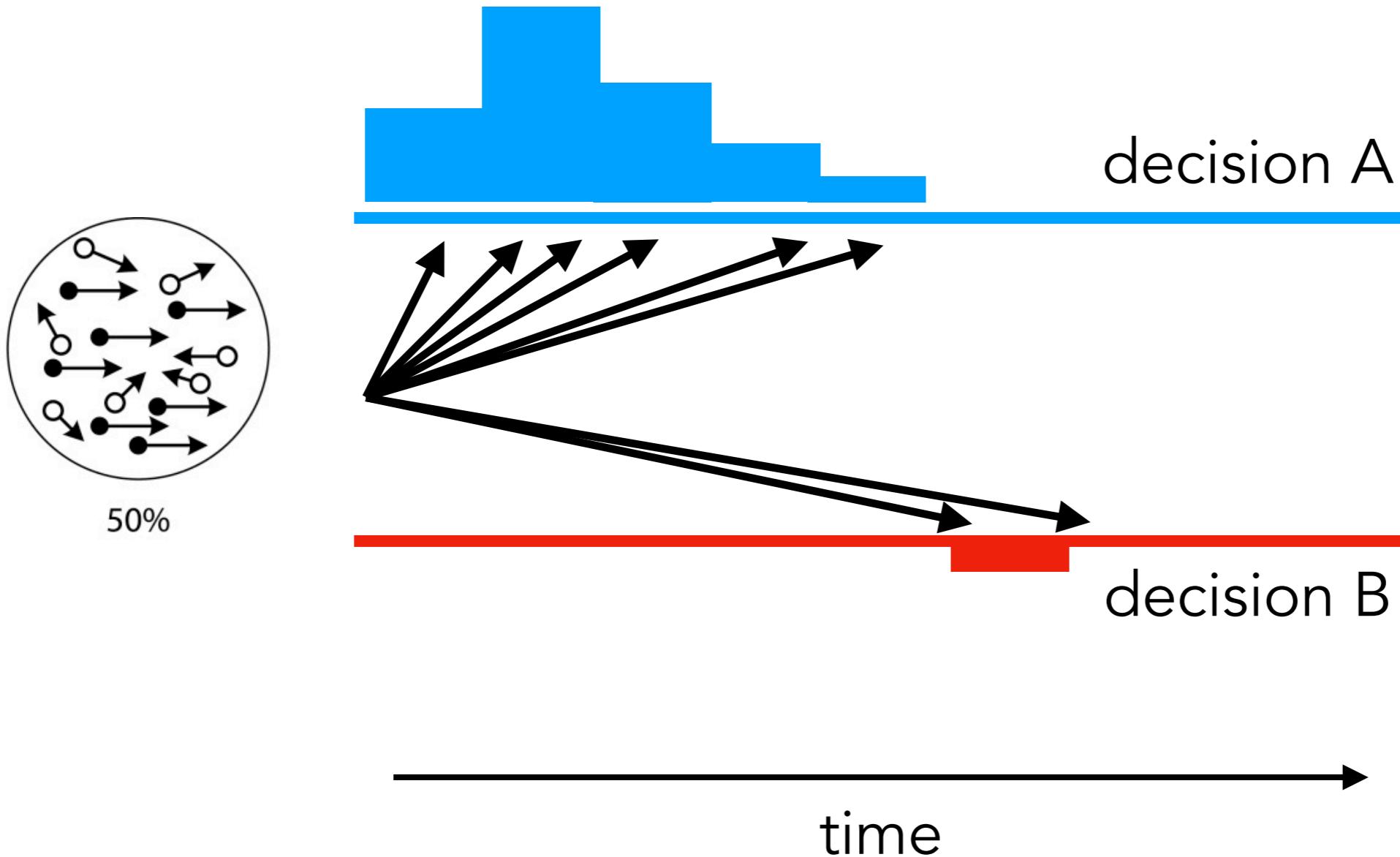


Wiecki, Sofer, & Frank, 2013

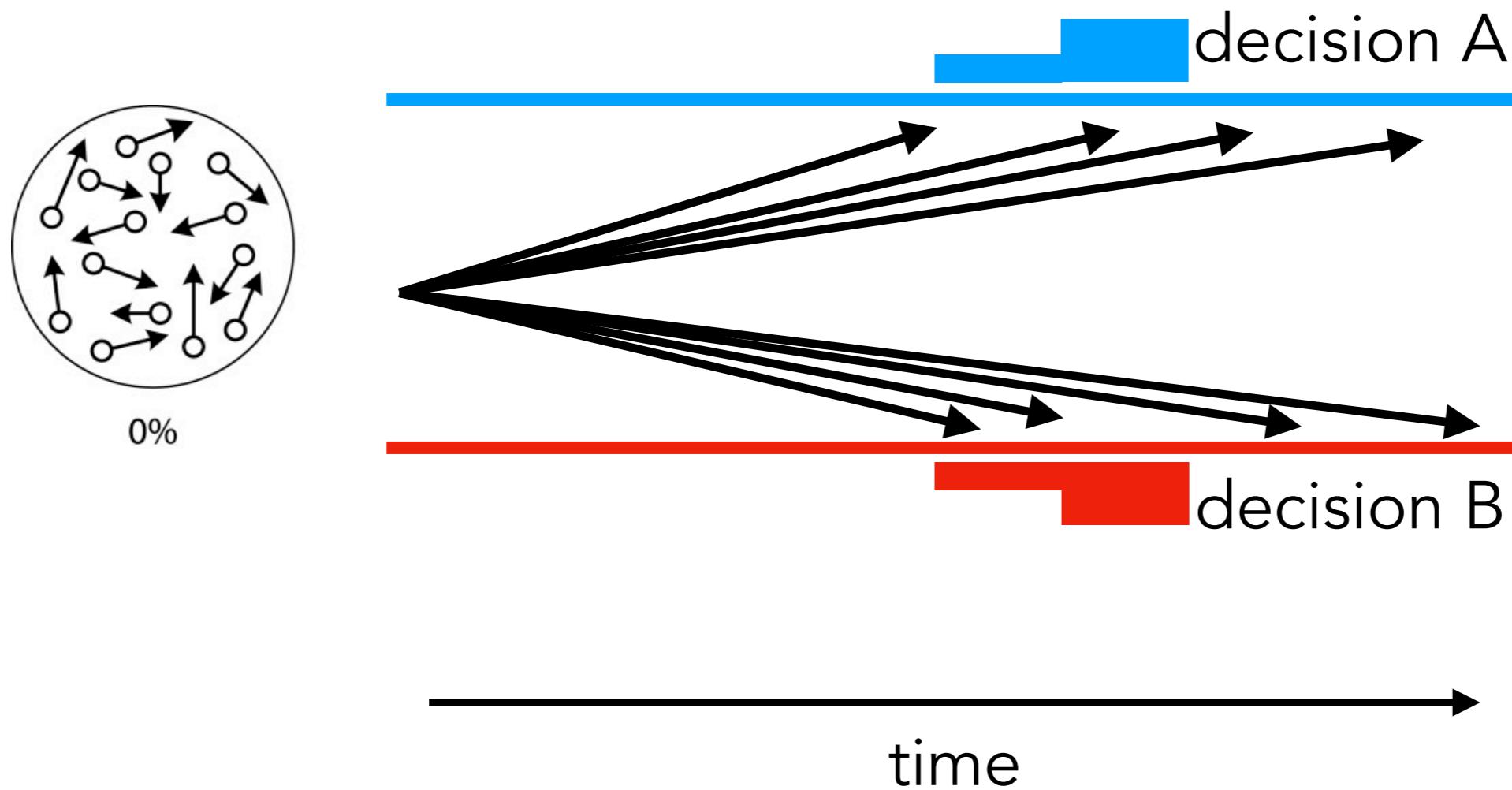
Drift (v)



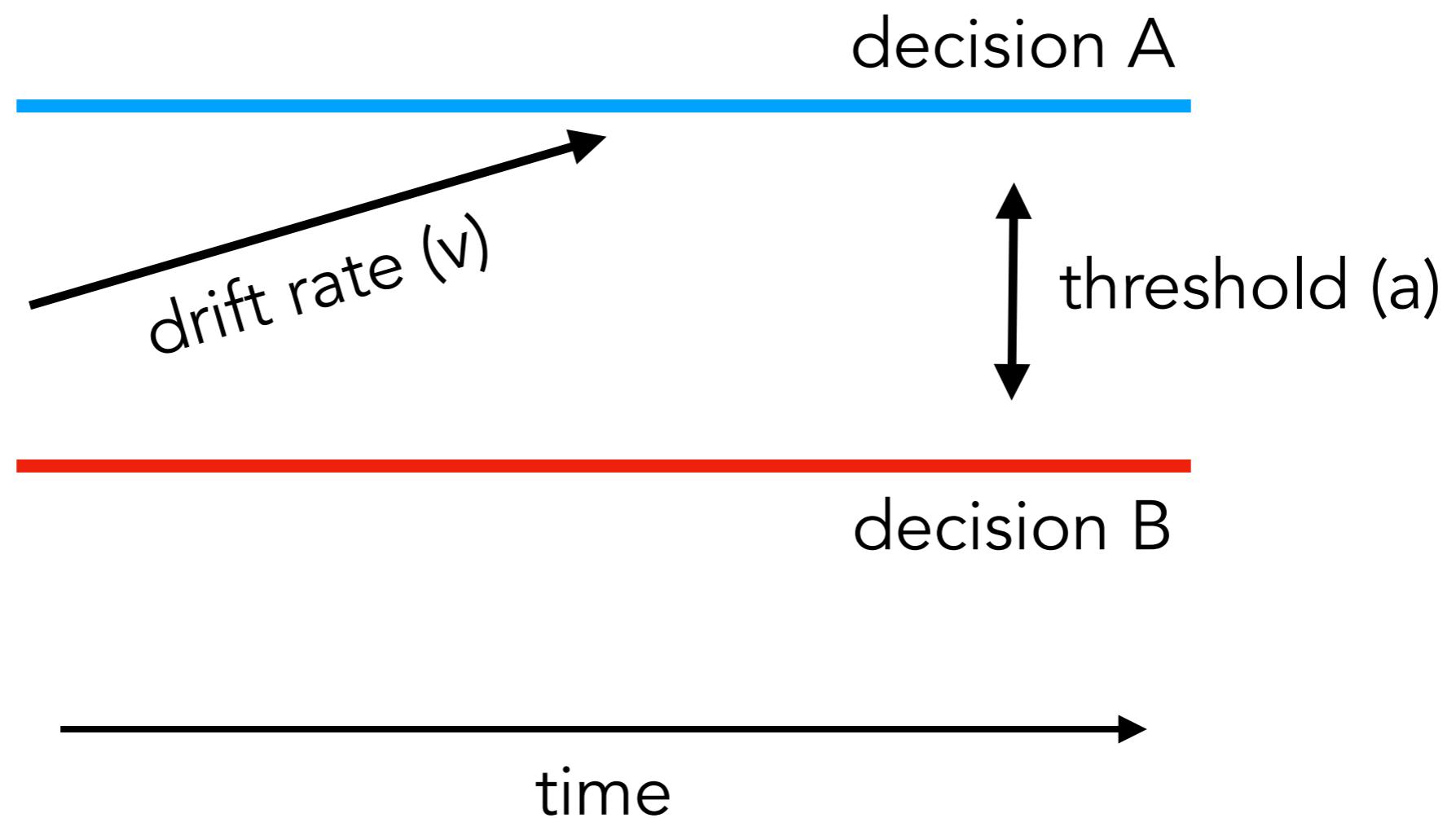
Drift (v)



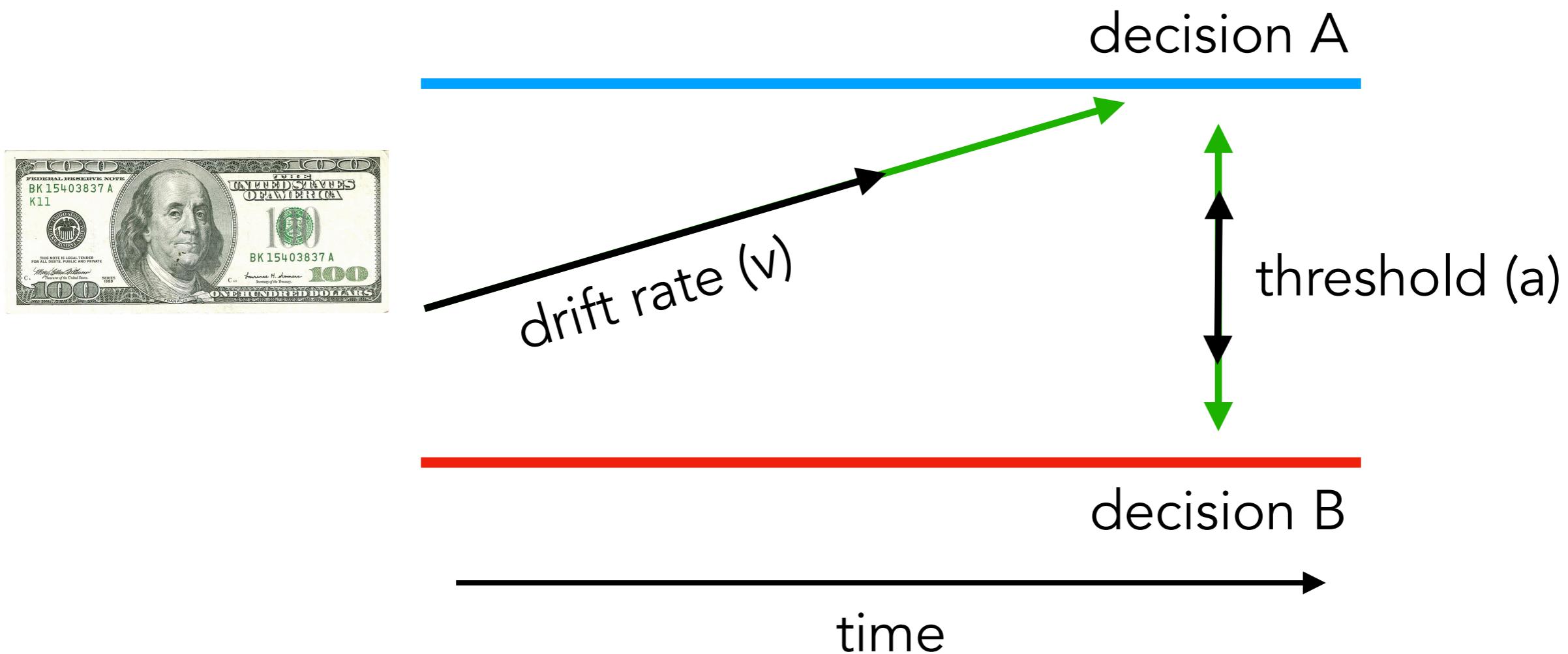
Drift (v)



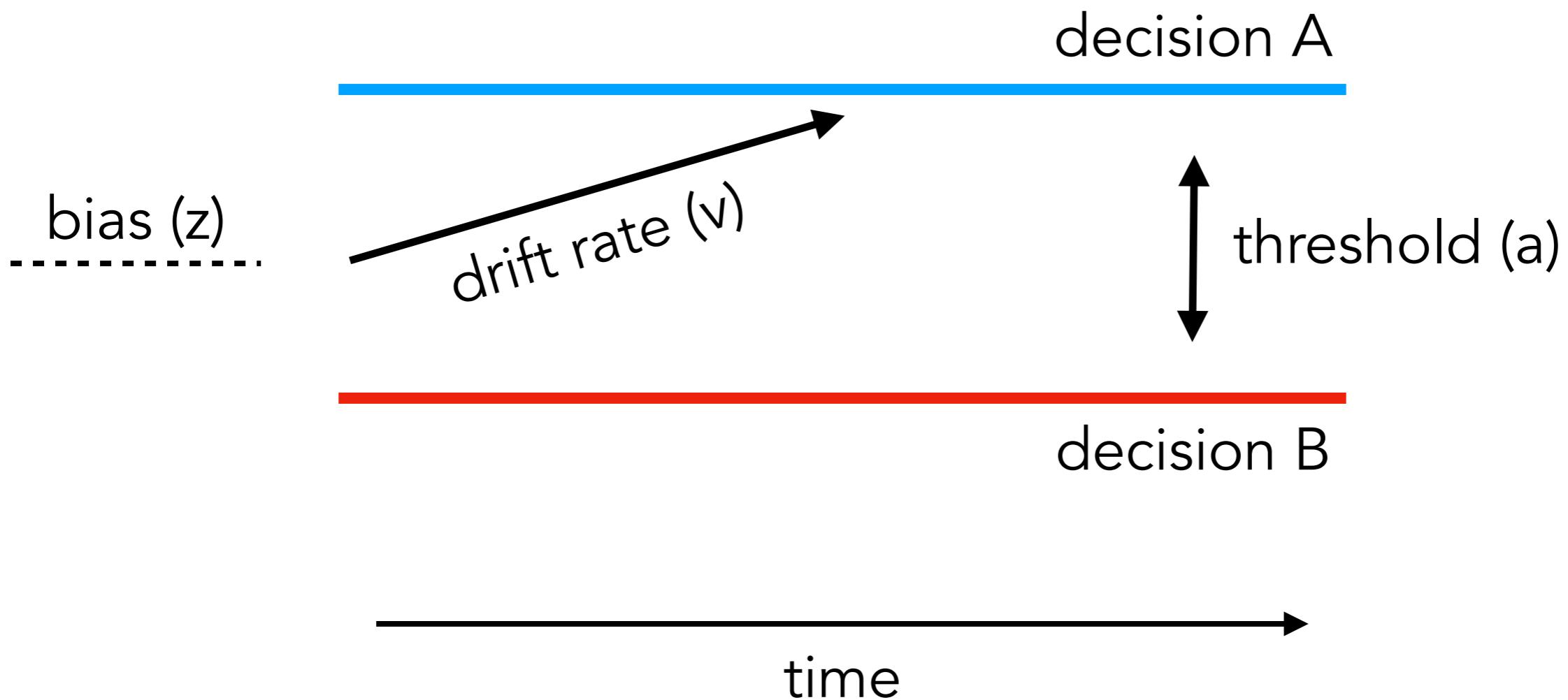
Threshold



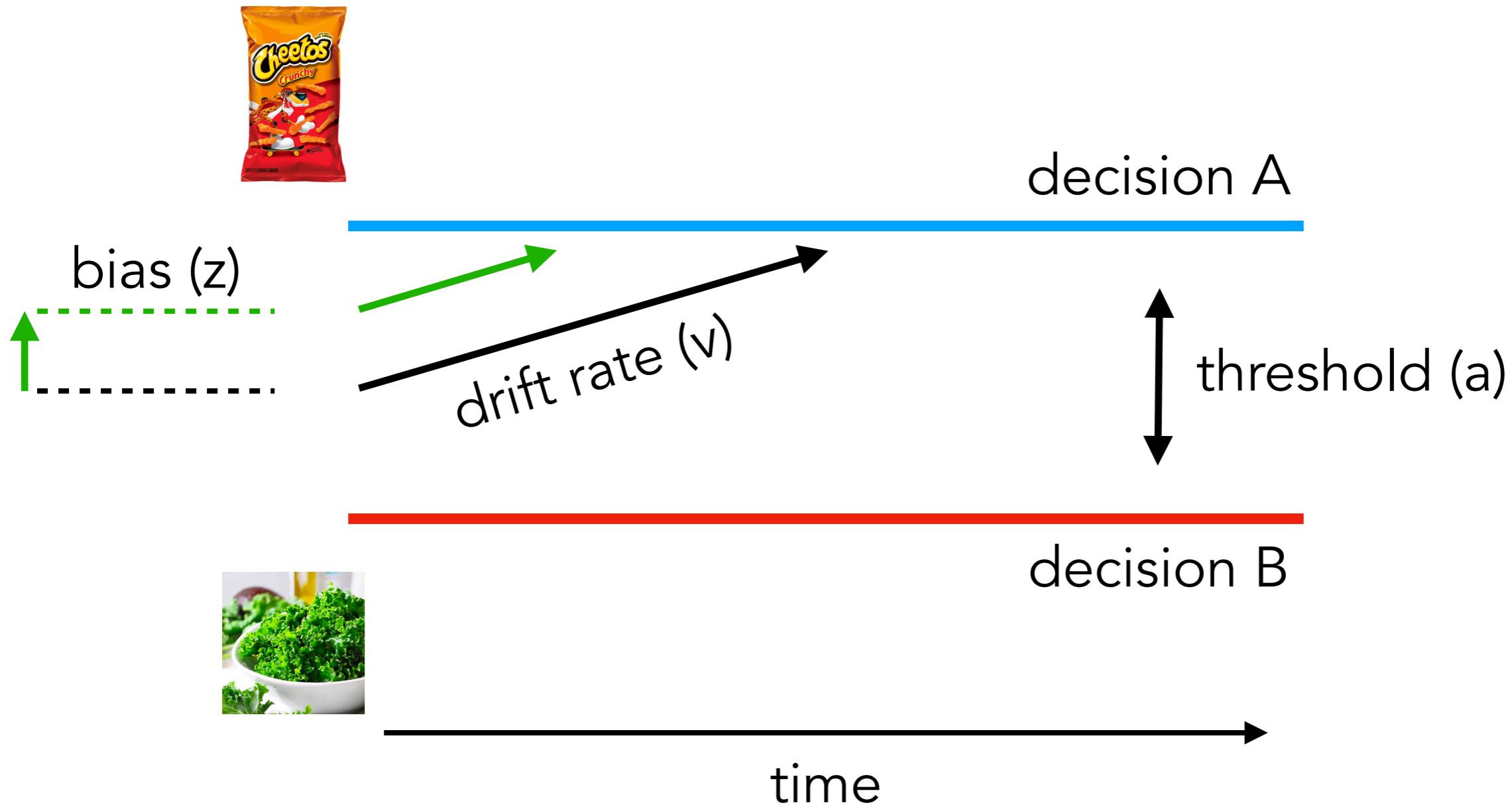
Threshold



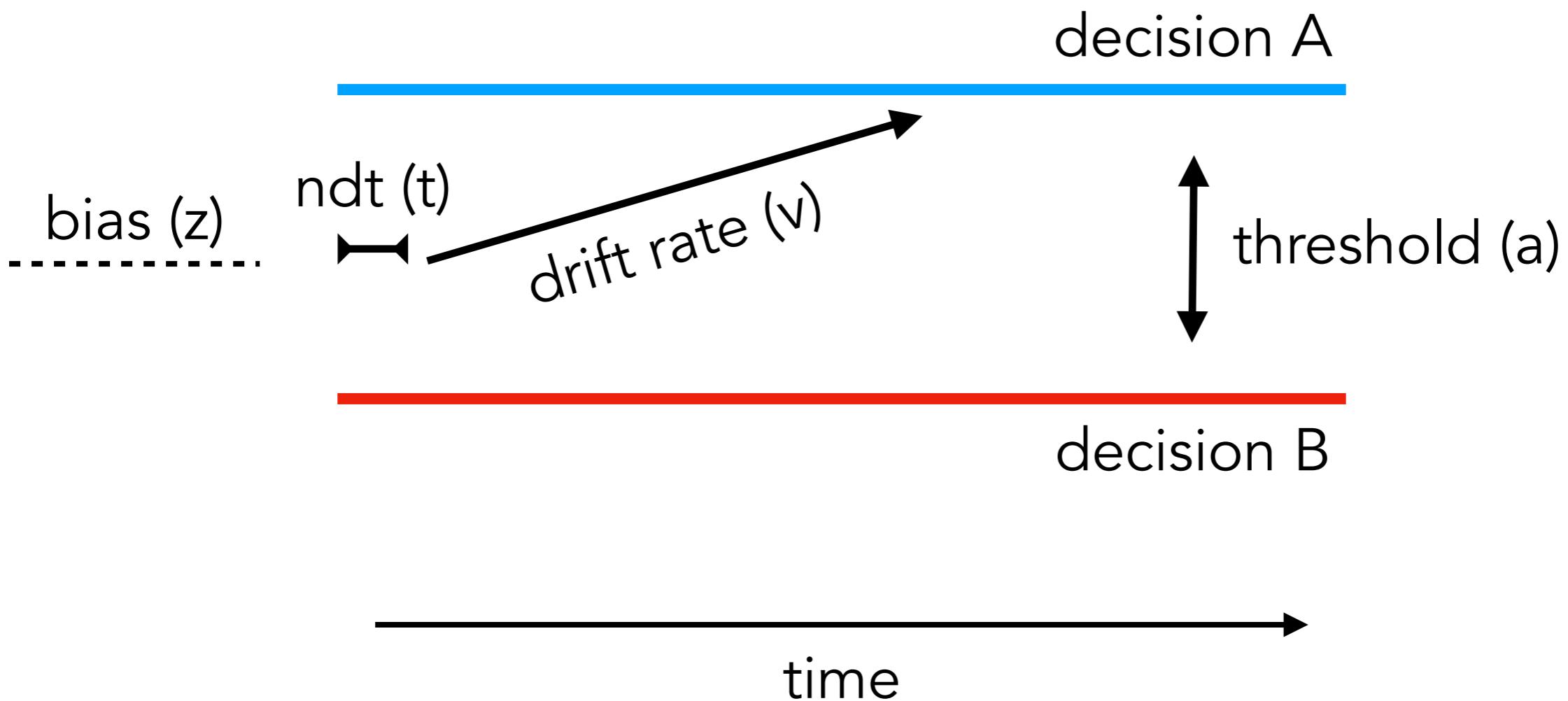
Bias



Bias

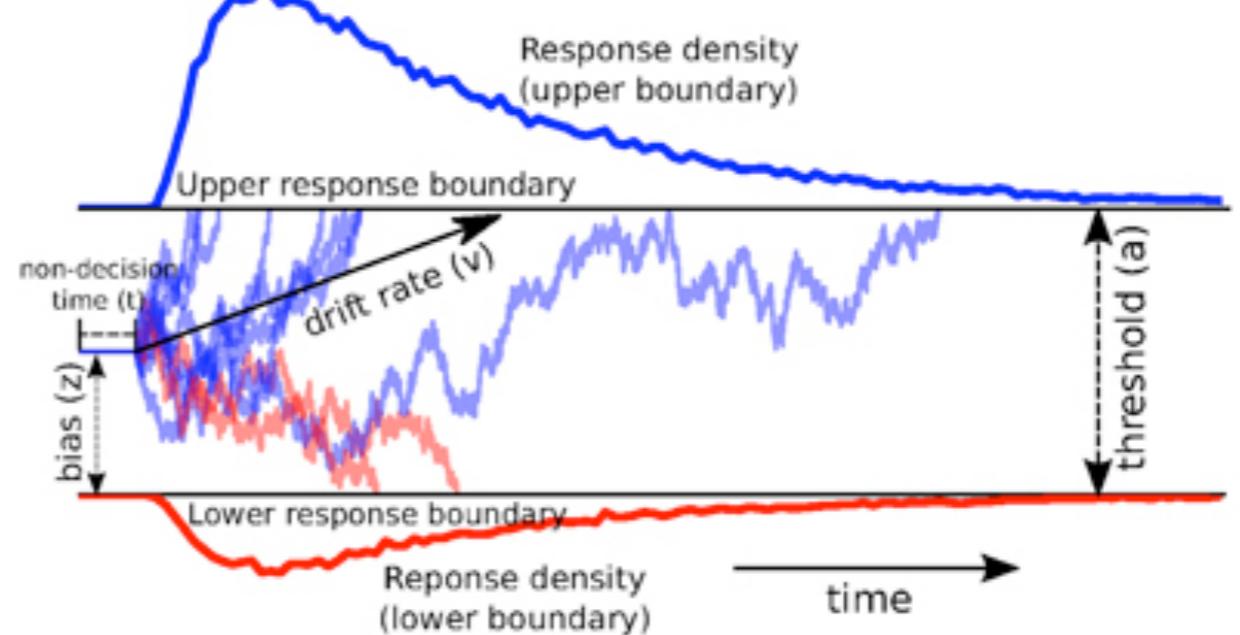


Non-decision time (t)



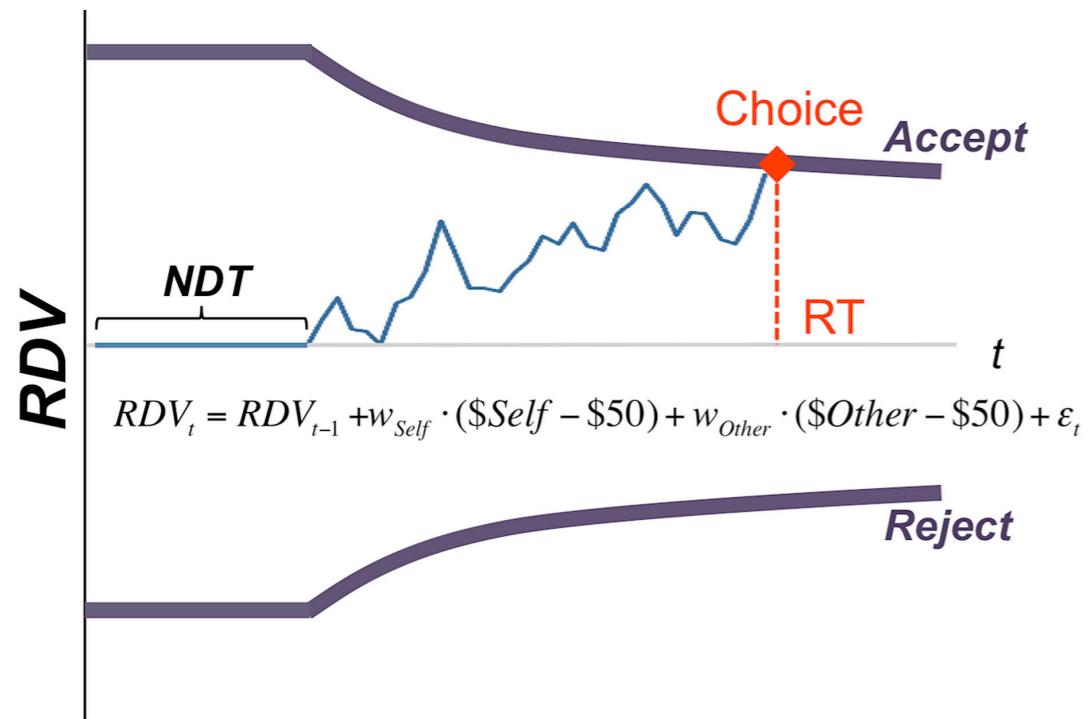
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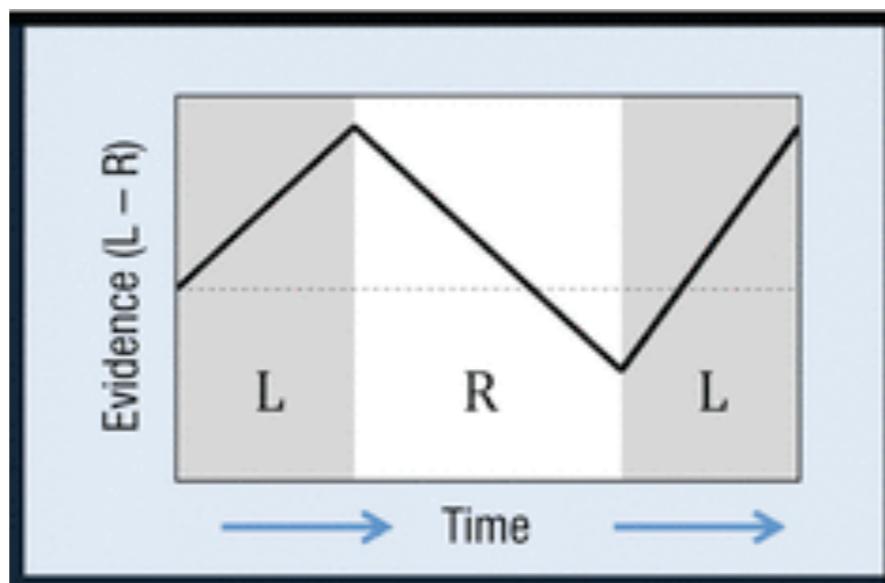
Wiecki, Sofer, & Frank, 2013

Collapsing bounds for value



Hutcherson, Bushong, & Rangel 2015

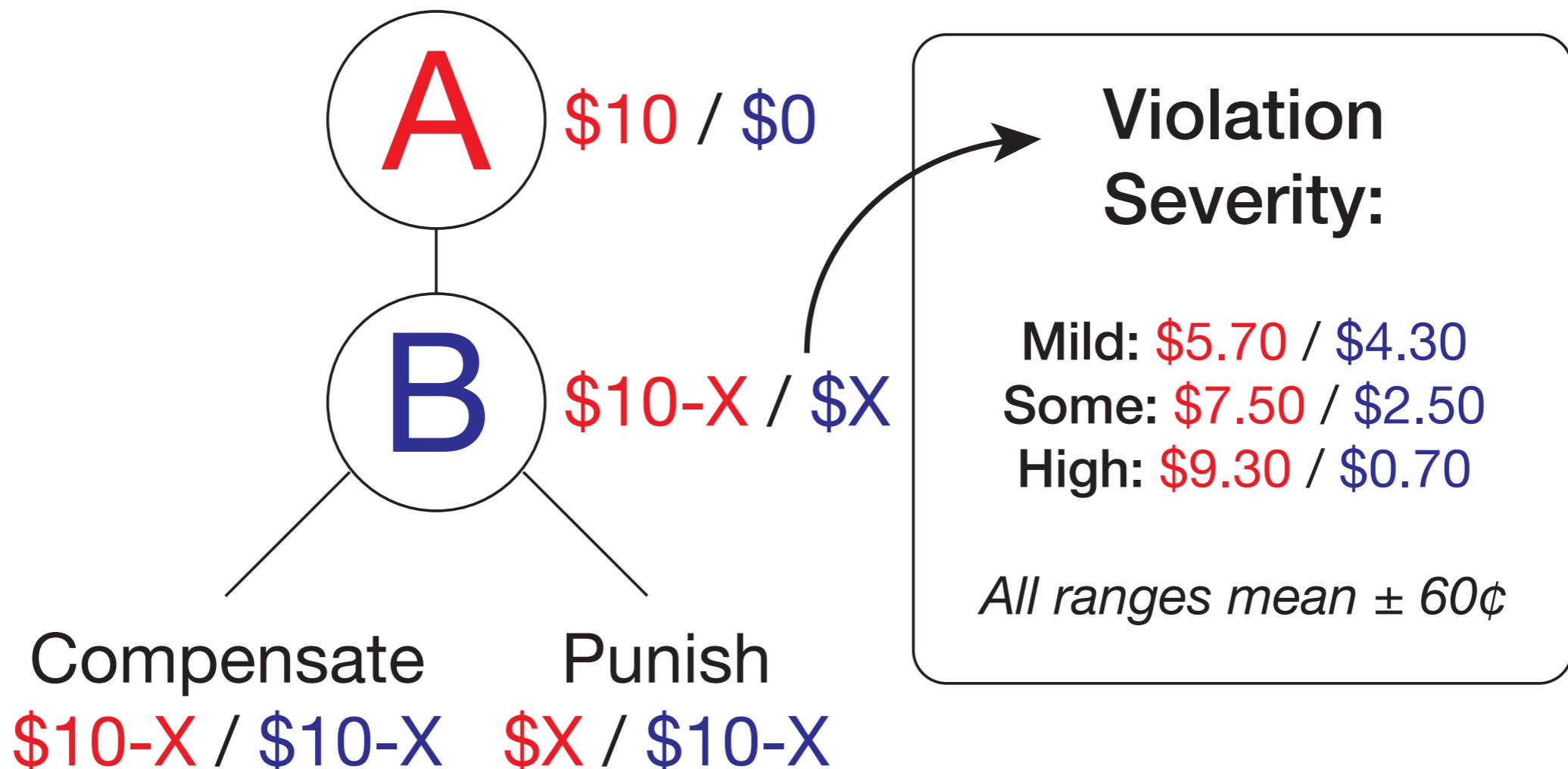
Attentional DDM (aDDM)



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

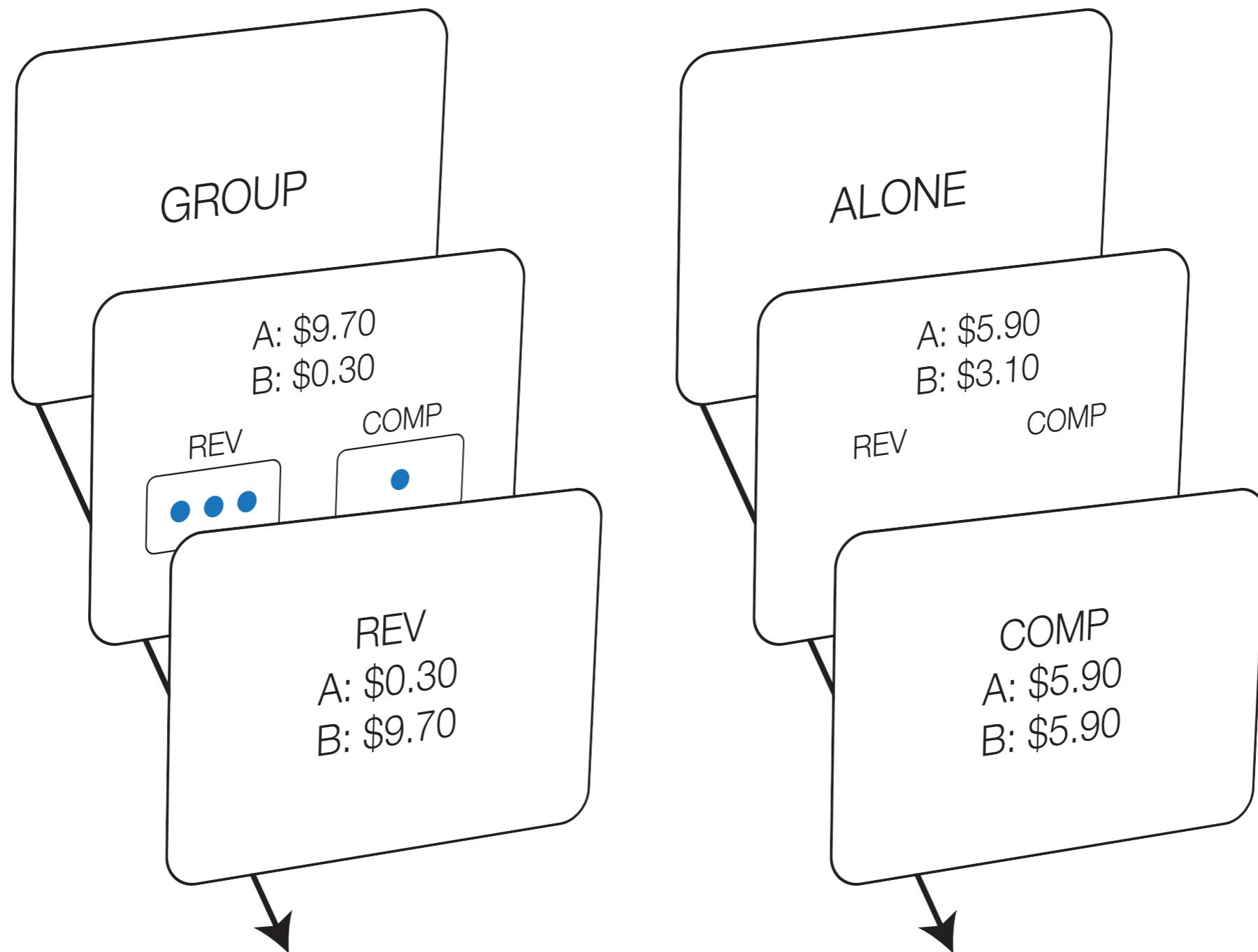
Example: conforming
to others' moral values

Measuring punitive preferences





Conformity paradigm





Victim vs Juror

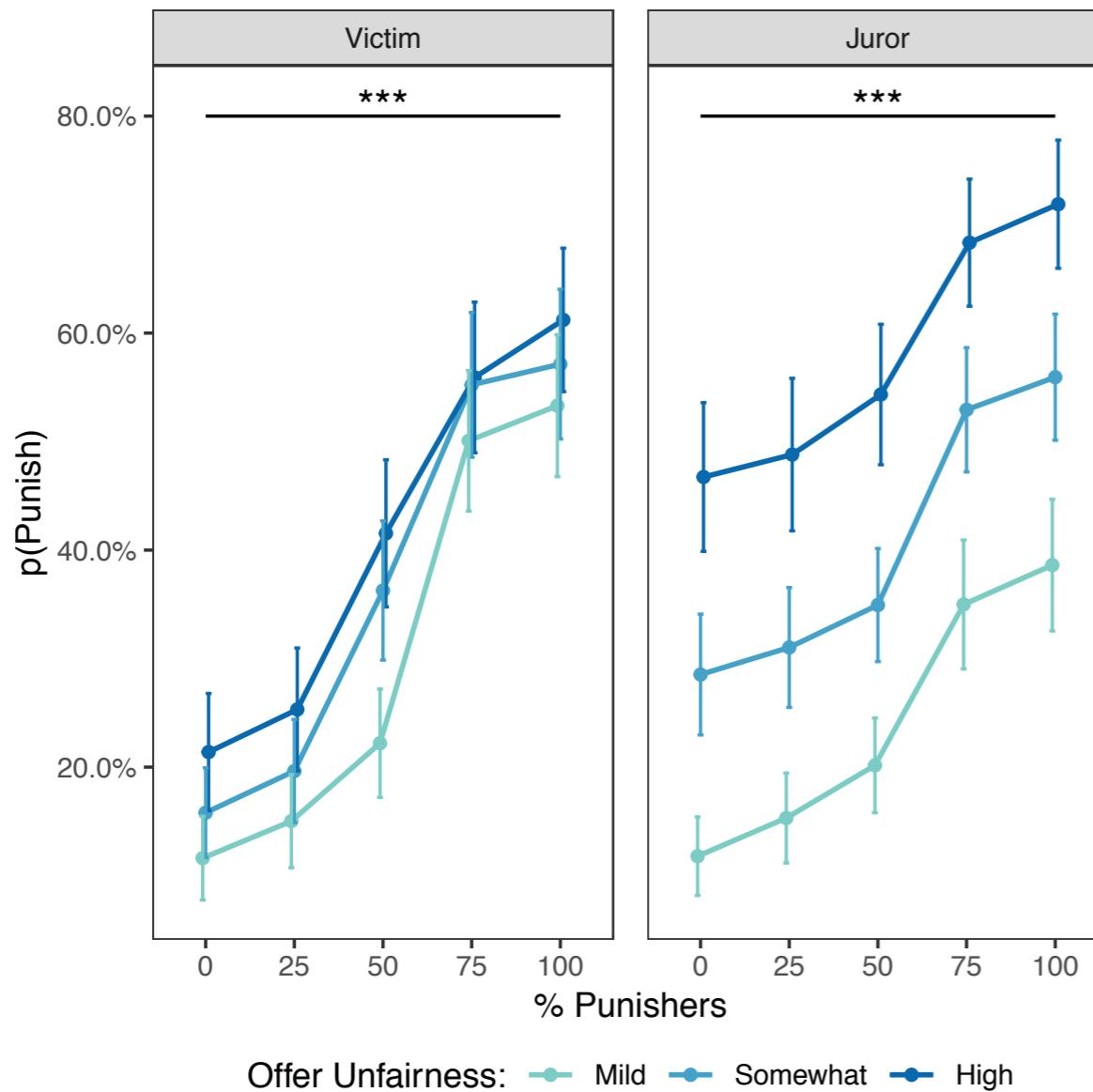


Victim: Was harmed by the perpetrator's moral violation, punishment decision affects how much money they earn



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

Behavioral results:



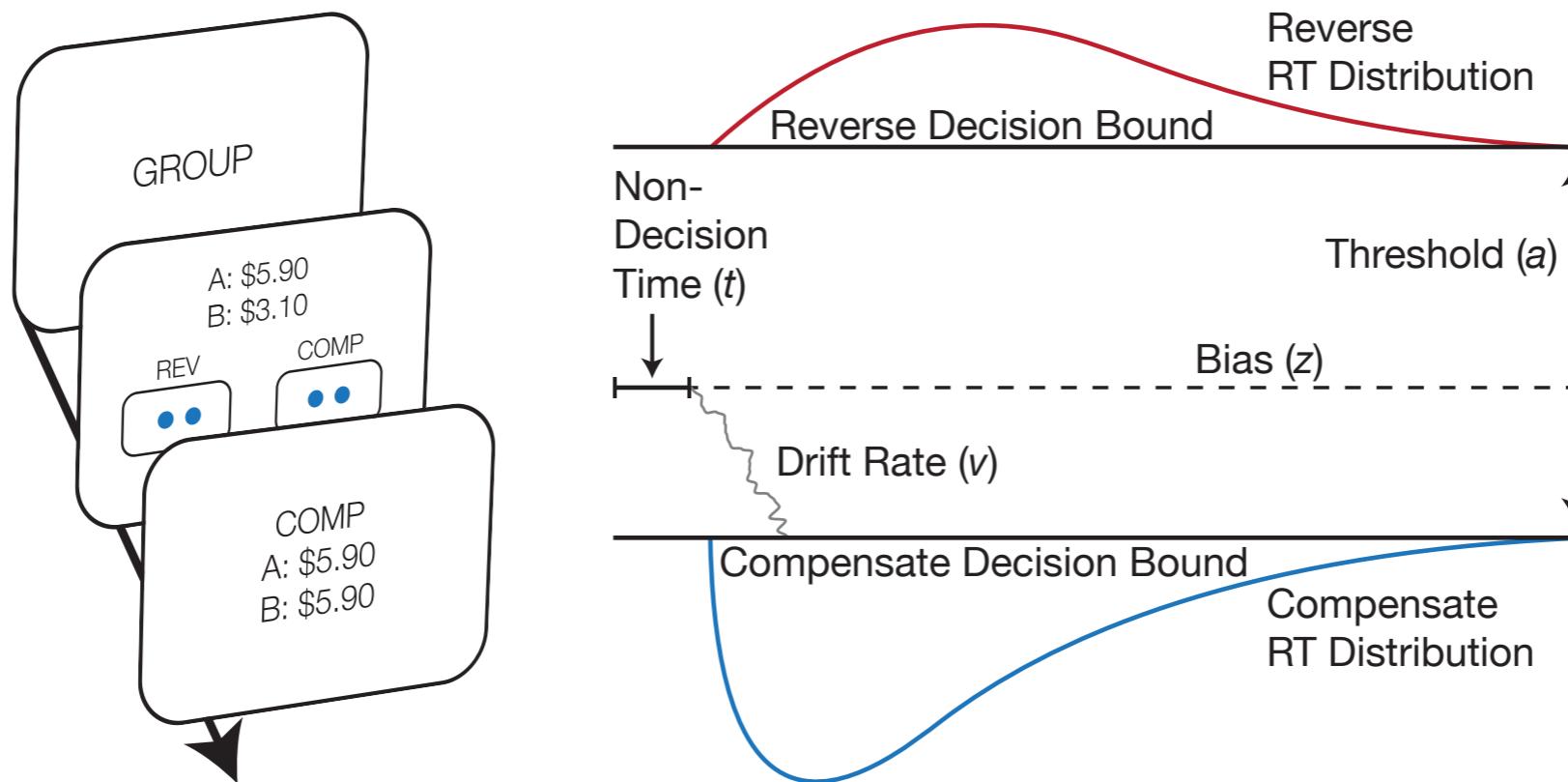
Two longstanding hypotheses about why people conform:

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

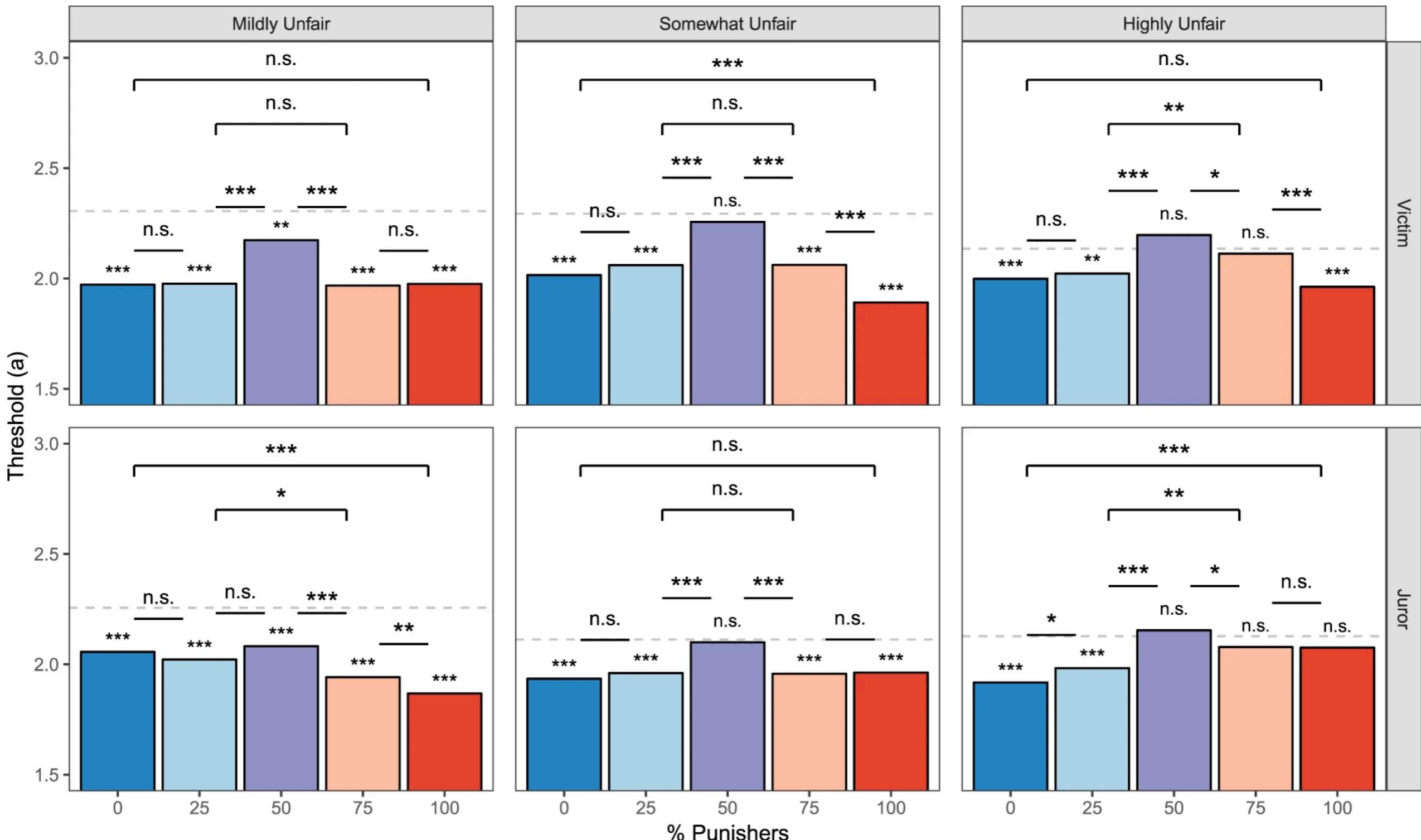
Problem: our behavioral data can't tell us WHY people are conforming to others' punitive preferences!

How does DDM help us?

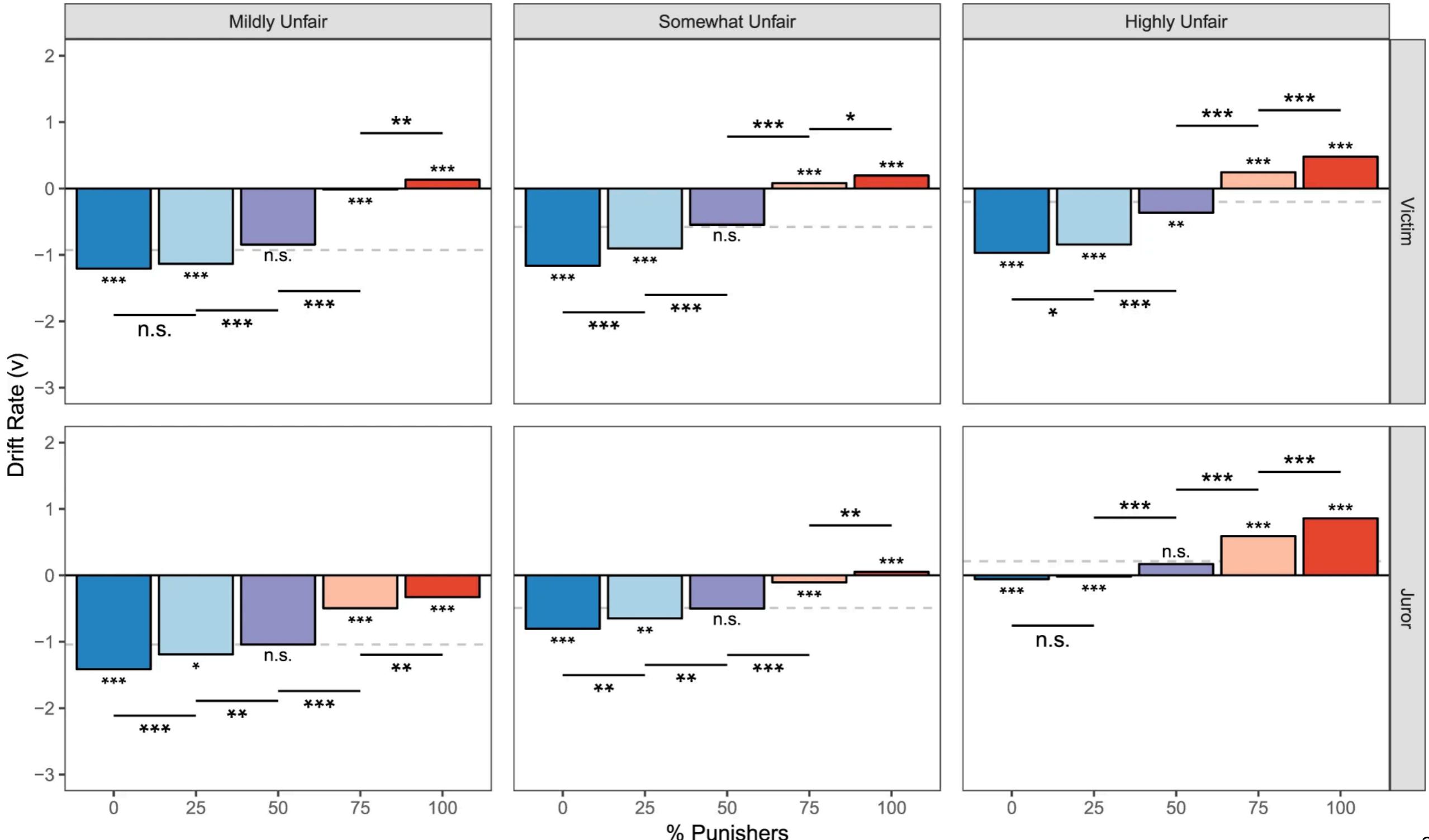
- Parameters are psychologically interpretable:
 - Bias z = how much individuals prefer punishment in the absence of group influence
 - Threshold a = the extent to which groups cause individuals to relinquish moral responsibility
 - Drift v = the extent to which groups provide evidence that punishment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



Results – threshold



Results – drift



Open resources and materials

HDDM tutorial here:

[https://github.com/psychNerdJae/
hddm_tutorial_carney_workshop](https://github.com/psychNerdJae/hddm_tutorial_carney_workshop)

Visit our Open Science Framework page here:

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

Read the paper here:

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