Samples from past experience set a starting point for perceptual inference.

Aaron M. Bornstein[1*], Mariam Aly[1,2], Samuel F. Feng[3], Nicholas B. Turk-Browne[1,2], Kenneth A. Norman[1,2], Jonathan D. Cohen[1,2]

[1]Princeton Neuroscience Institute & [2]Department of Psychology, Princeton University, [3]Khalifa University, Abu Dhabi

Background

How do expectations influence perceptual decisions?

Sequential sampling models describe both recognition and sensory decisions.
(Ratcliff 1978; Gold, Shadlen 2002)

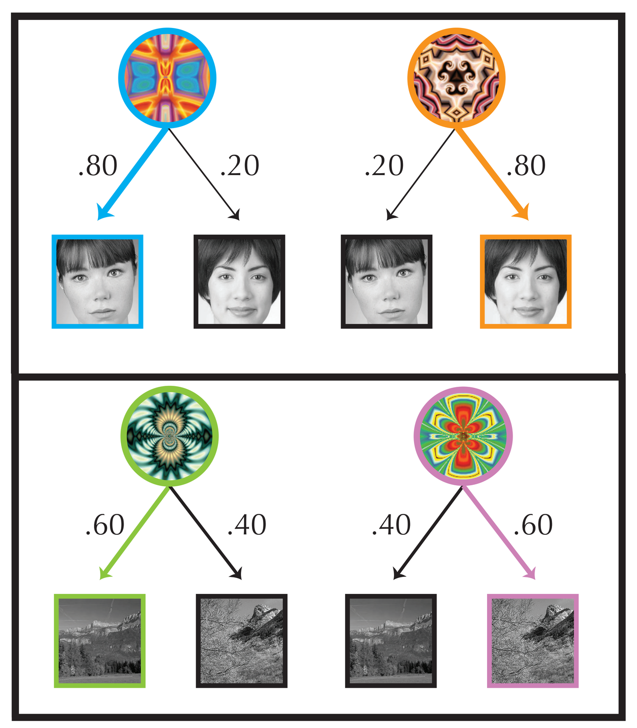
These models can incorporate expectations to bias sensory inference.
(Hanks et al. 2011)

Expectations are modeled as a static change, to starting point or drift rate.
(Gold et al. 2008)

Reminder cues can trigger samples from memory that anticipate upcoming stimuli and bias individual choices.
(Bornstein et al. 2016; Bornstein & Norman 2016)

Can samples from experience set a dynamic starting point?

Task

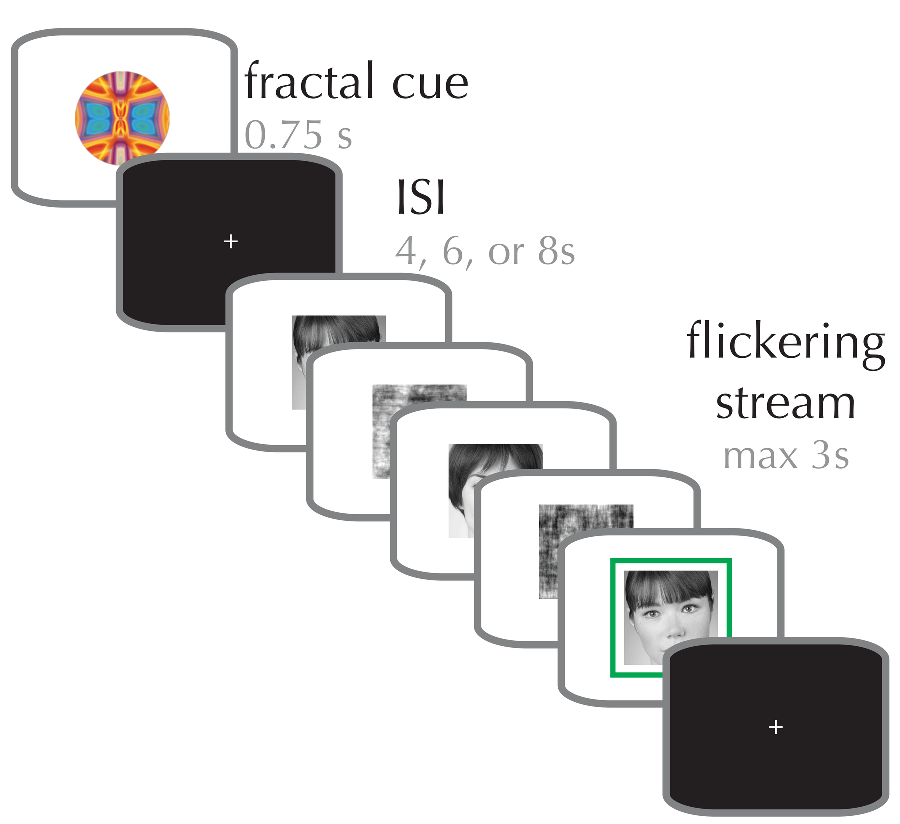


Cued perceptual inference task: Trial-by-trial variation in (1) The predictiveness of cue-stimulus associations; (2) The coherence of perceptual information.

Phase 1: Learning. Learn which [face,house] picture is predicted by each fractal cue.

100 trials/block, 4 cues & 4 pictures - 2 scenes, 2 faces - per block

Cue predictiveness: 50/50; 60/40; 70/30; 80/20



Phase 2: Cued inference. Identify the predominant image in a noisy, "flickering" stream.

80 trials/block, immediately post-learning.

Time window for response starts at cue onset ("early" – pre-stimulus – responses allowed).

Perceptual coherence (mixture proportions) calibrated to low (65%) or high (85%) accuracy.

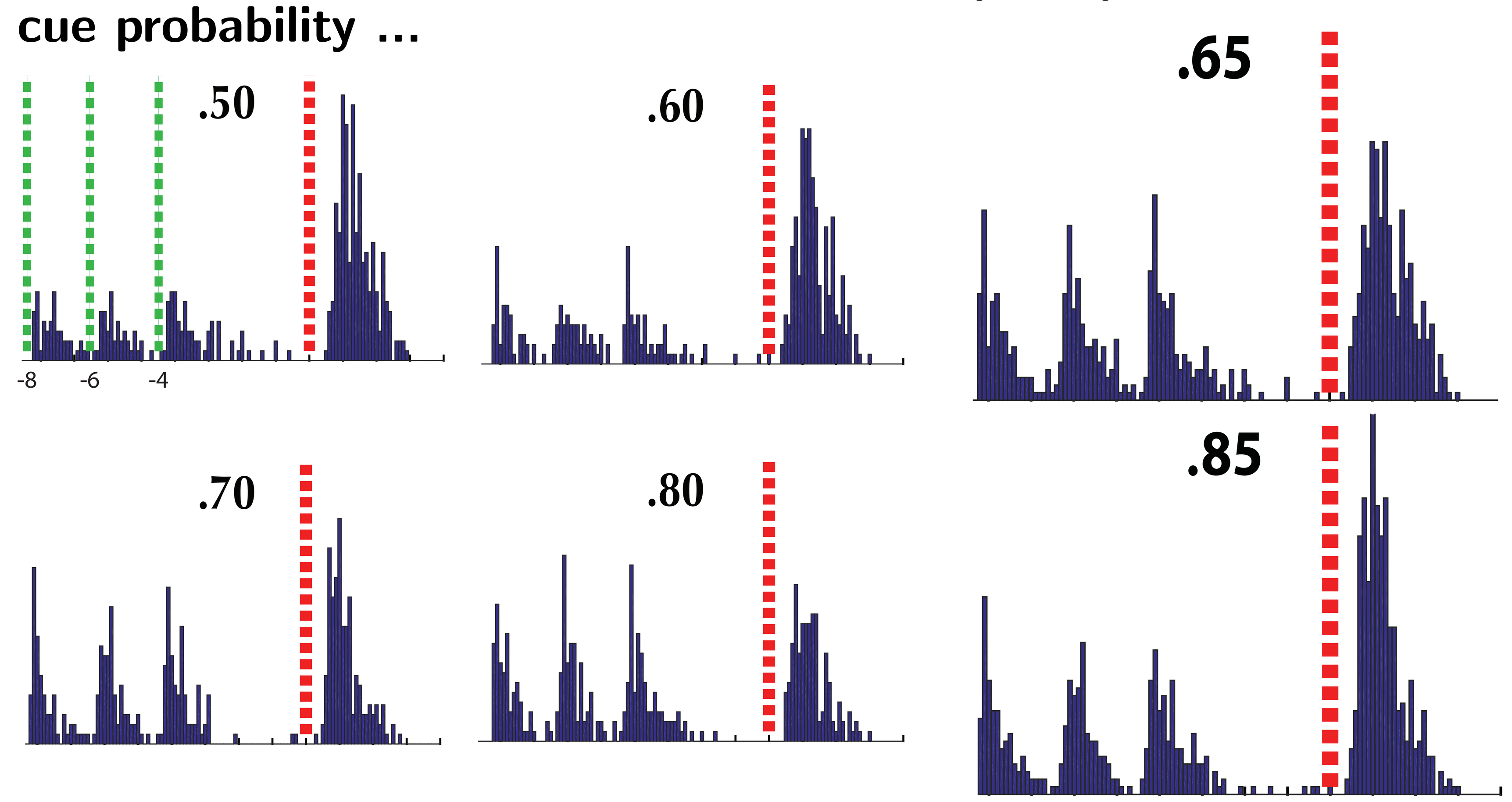
Predictions

1. Cue predictiveness and perceptual coherence will have separable and interacting influence on response times.
2. These influences will be well-described by a *multi-stage* DDM.
(Srivastava, Feng, Shenhav, 2015)
3. fMRI pattern evidence will show that that pre-stimulus reinstatement activity predicts post-stimulus RT.

Behavior: Response times

Pre-stimulus responses increase with cue probability ...

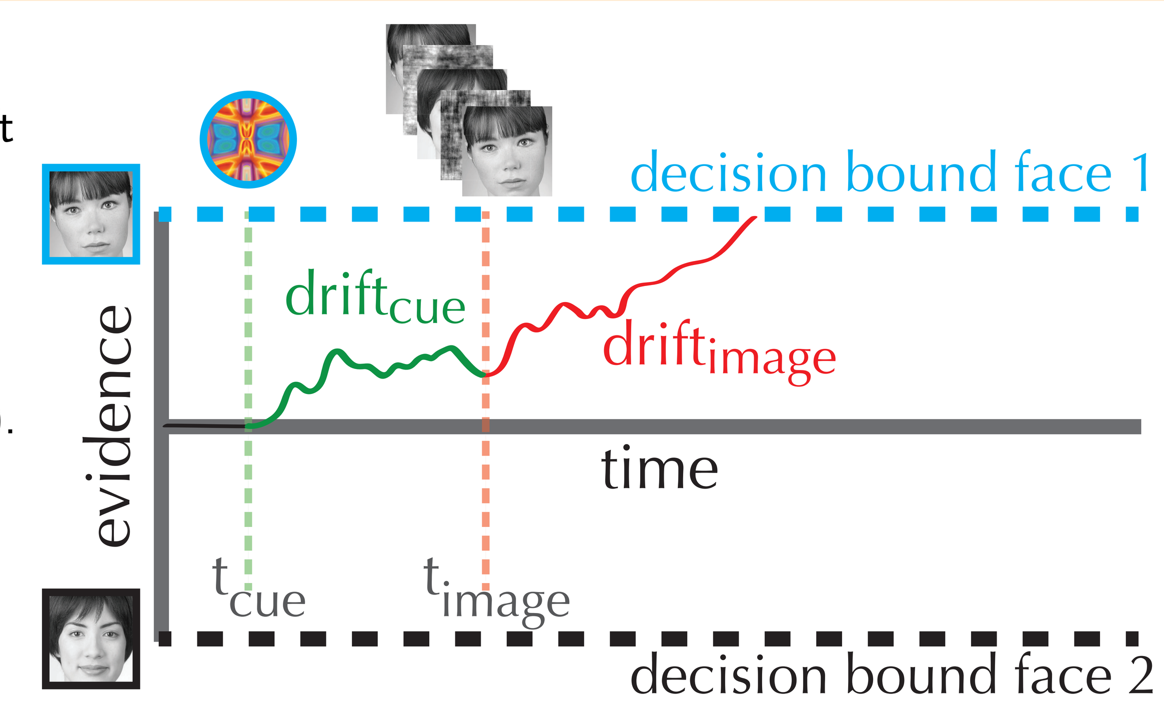
... and decrease with perceptual coherence



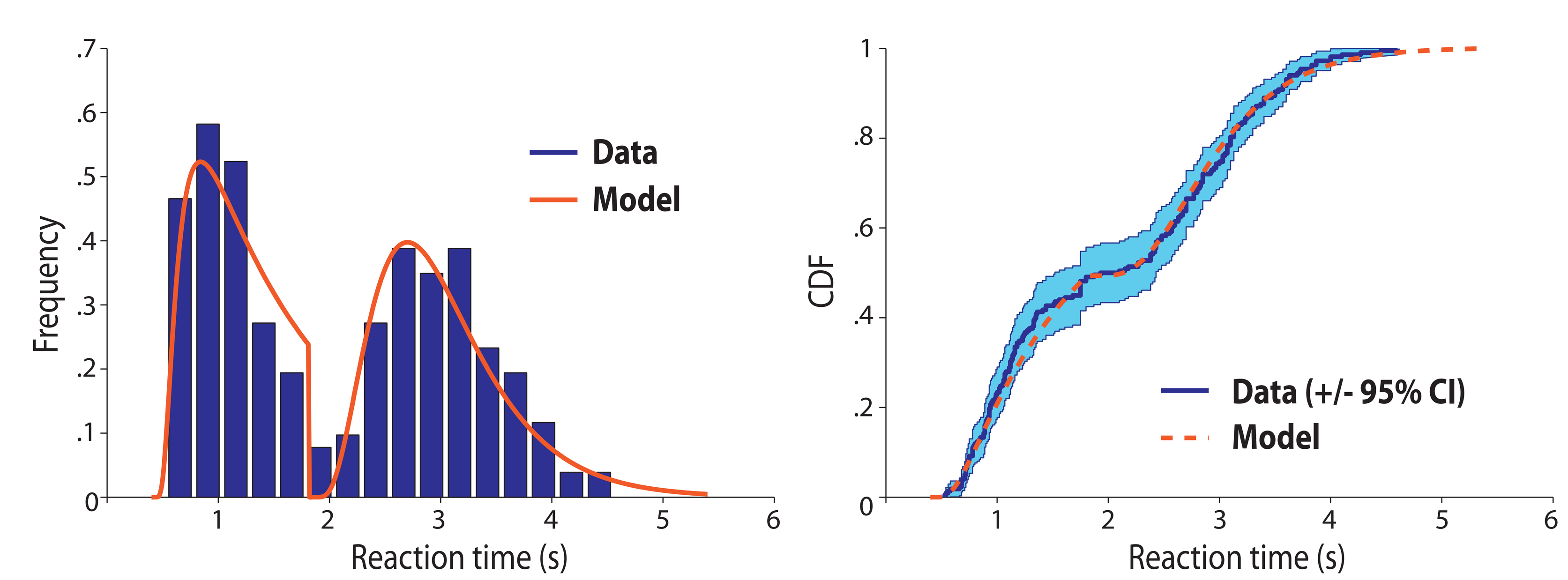
Behavior: Two-stage DDM

Each stage has its own drift rate: One for samples from experience (before stimulus onset), and the second for sampling from perceptual input (after stimulus onset).

The starting point for the second stage is set by the endpoint of the first.

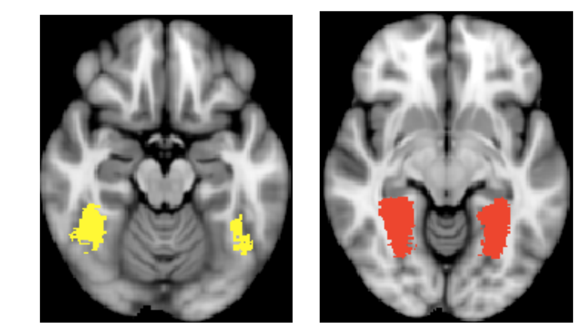


Model fit



MSDDM fit is superior to all tested comparison models, including two unconnected "single" DDMs (all BIC $\geq$ 30.)

MRI: Pattern analysis

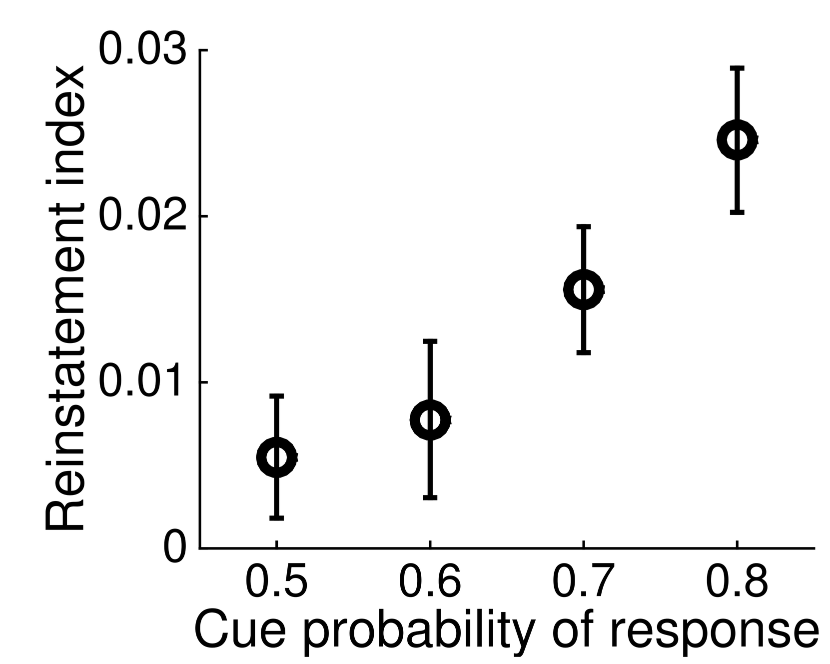


Pattern analysis

(1) For each picture, define the **item pattern**: Average pattern of activity in response to this picture in the corresponding ROI (FFA or PPA), over the last five trials of response training.

(2) For each trial, measure the **reinstatement index**: For each TR between cue and stimulus onset (or cue and early response), take the correlation with the item pattern and subtract off the correlation with the opposing same-category pattern (e.g. F1>F2, S1>S2).

MRI: Results



Reinstatement index increases with cue probability.

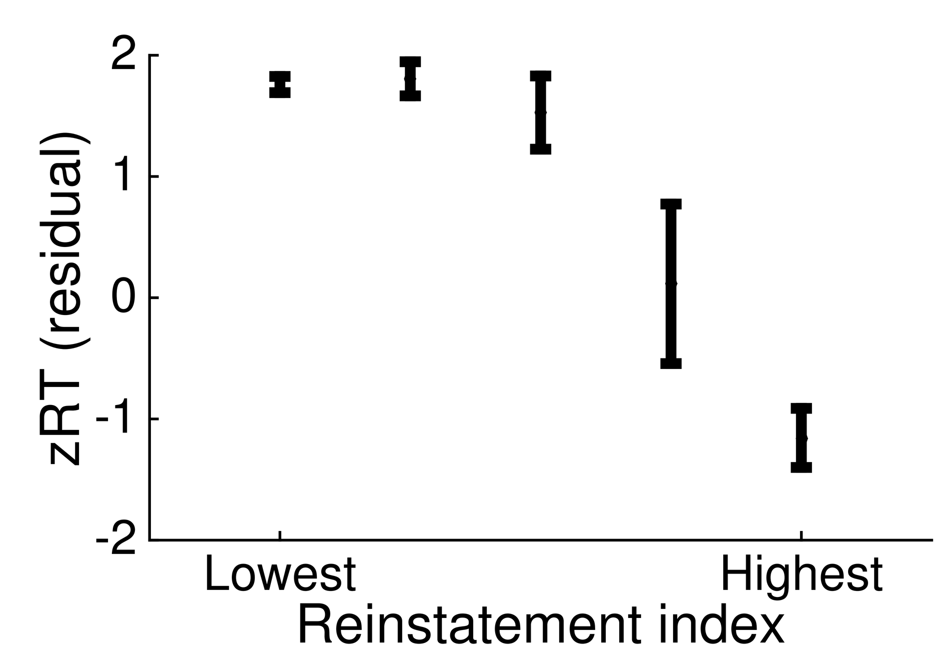
As the cue becomes more predictive, subjects' reinstatements of the upcoming picture became more decisive.

We reasoned that these reinstatements could be driving response time; more specifically, that they could mediate trial-by-trial variations in response time.

Reinstatement predicts response time.

Within each subject, we take response times for accurate trials, log-transformed and z-scored within each type (pre- and post- stimulus onset).

Next, using linear regression, we subtract off other factors that affect response time: ISI, cue probability, and the coherence of perceptual information.



Pre-stimulus reinstatement predicts trial-by-trial reaction time ($p = 0.003$).

Summary

Visual cues trigger reinstatement of previously associated stimuli.

These reinstatements are signatures of anticipating the upcoming stimulus.

When the subsequently presented stimuli is uncertain, these reinstatements guide the perceptual decision.

Expectations are themselves the result of a sequential sampling process, one that infers the content of experience, rather than sensory input.

Correspondence: aaronmb@princeton.edu

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