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

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Background

How do expectations influence perceptual decisions?

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

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

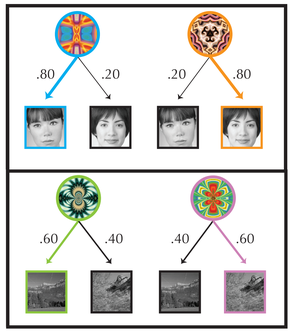
This influence is usually modeled as a static offset to the starting point or drift rate.
(Gold et al. 2008)

Samples from memory, triggered by reminder cues, anticipate upcoming stimuli, and can bias decisions.
(Bornstein et al. 2016; Bornstein & Norman 2016b)

Can samples from experience set a dynamic starting point?

Task

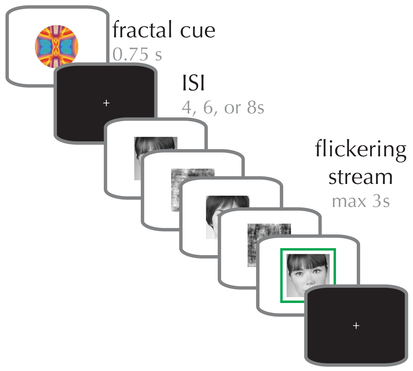
Cued perceptual inference task: Trial-by-trial variation in (1) The predictiveness of cue-stimulus associations; (2) The coherence of perceptual information.



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 responses allowed).

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

Predictions

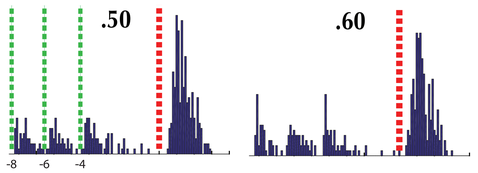
1. Cue predictiveness and perceptual coherence will have separable and interacting influence on response times.

2. These influences will be well-described by a *multi-stage* DDM (Srivastava, Feng, Shenhav, 2015).

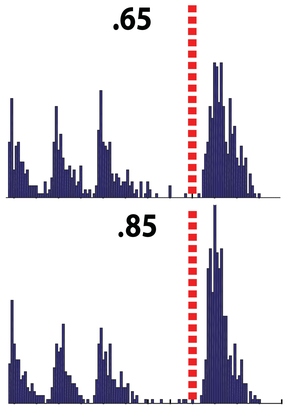
3. fMRI pattern evidence will show that that pre-stimulus reinstatement activity predicts post-stimulus RT.

Behavior: Analysis

Pre-stimulus responses increase with cue probability...



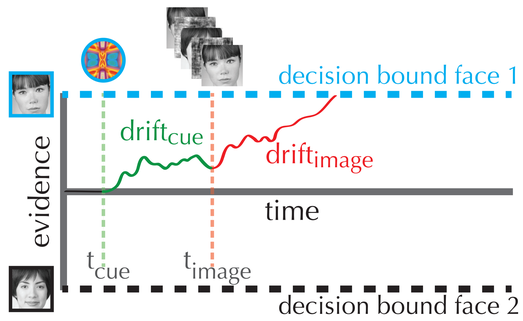
... and decrease with perceptual coherence



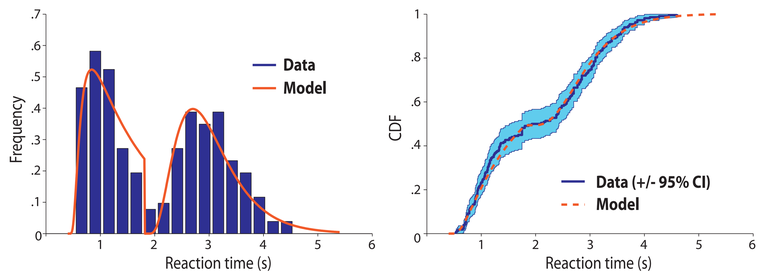
Behavior: Two-stage DDM

Each stage has a separate 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 end of the first stage.



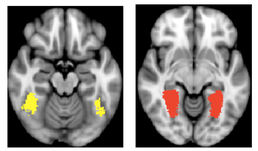
Model fit



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

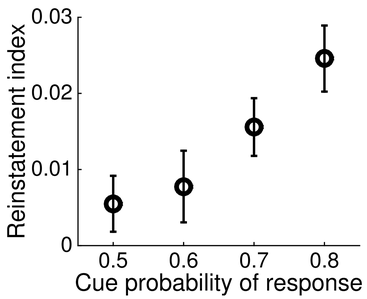
MRI: Analysis

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**: Across pre-stimulus and pre-reponse TRs, the average difference between the correlation for the responded picture's pattern, and its opposing pattern (e.g. F1*gt*F2, S1*gt*S2).

MRI: Results



Reinstatement index increases with cue probability.

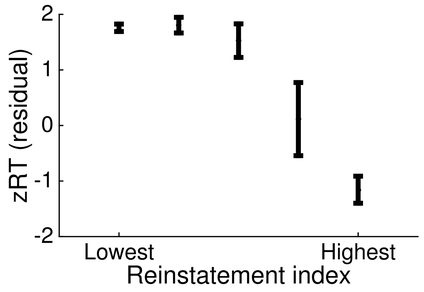
As the cue becomes more predictive, subjects' reinstatements of the upcoming picture became more decisive.

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.



The resulting *residual* zRTs are correlated with the reinstatement index on that trial ($p = 0.003$).

Summary

Visual cues trigger reinstatement of previously associated stimuli.

These reinstatements are signatures of anticipating the upcoming stimulus.

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

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

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