The Role of Attention in Simple Choice

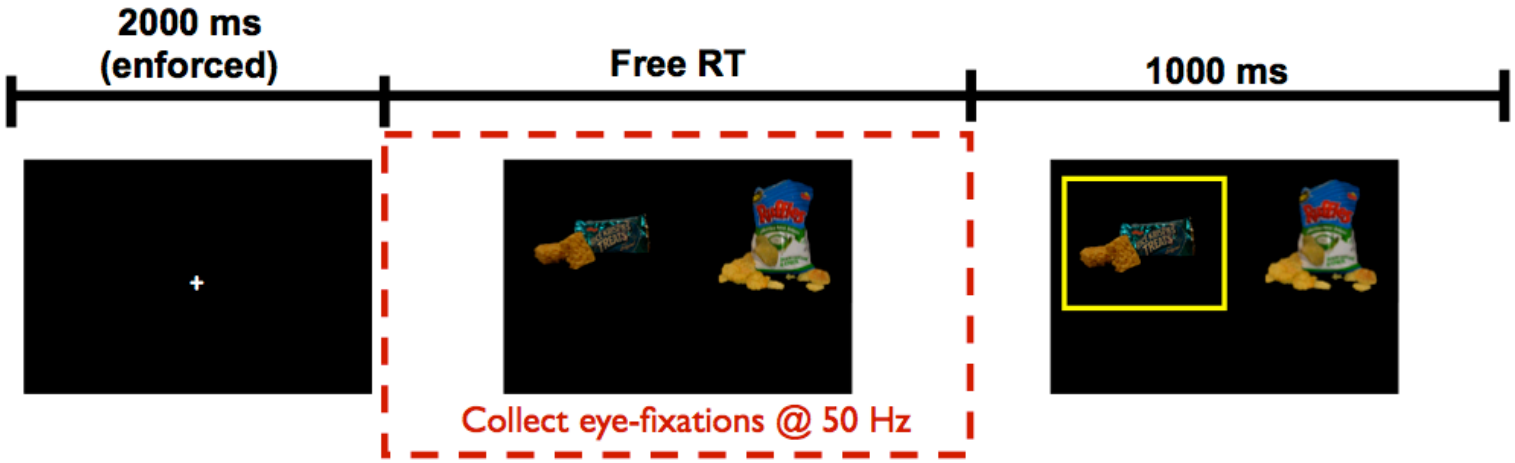
Antonio Rangel
Caltech

?

Left button press

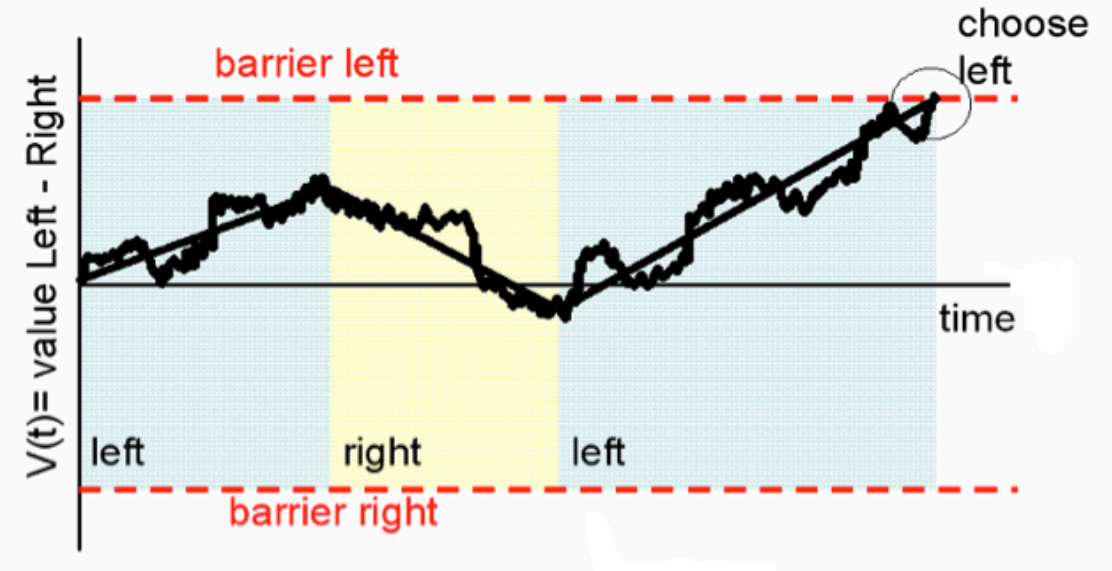
Right button press

I
Attention across options



Krajbich, Armel, Rangel, Nature Neuro, 2010

Attentional Drift Diffusion Model (aDDM)

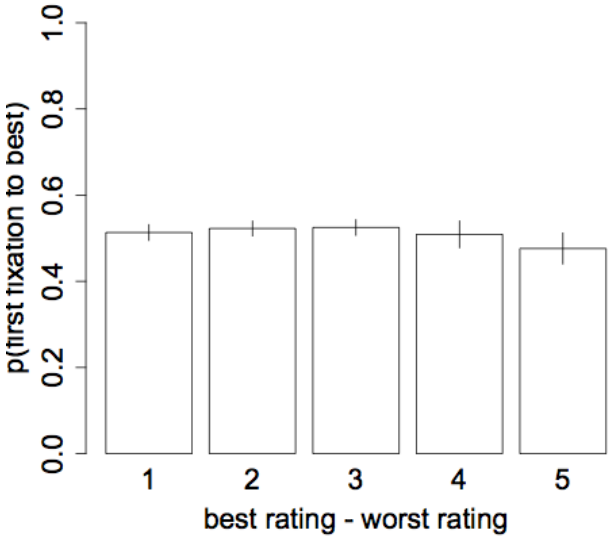


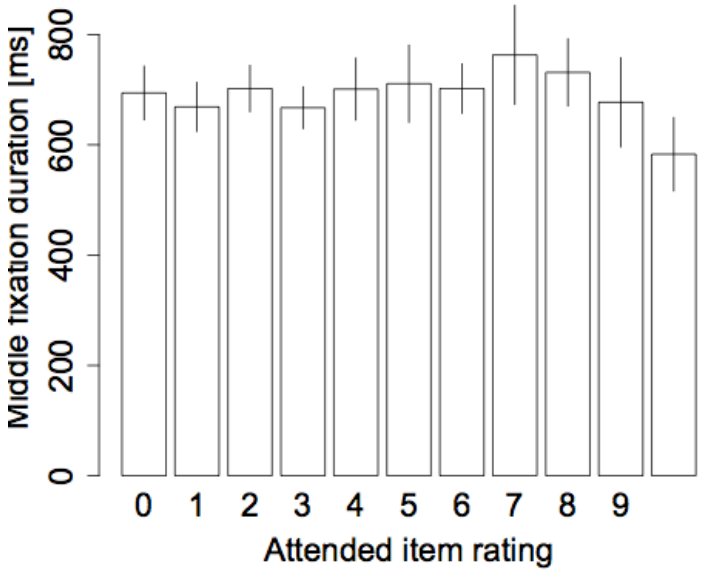
$$V(t)=V(t-1)+a(v_{target} - \theta v_{non\text{-}target})+u_t$$
$$u_t \sim N(0,s^2)$$

Fixation process exogenous to choice process

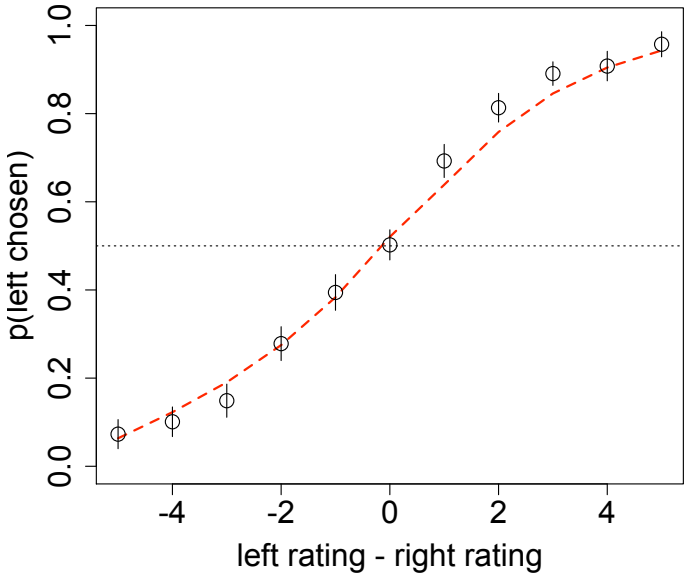
Krajbich, Armel, Rangel, Nature Neuro, 2010

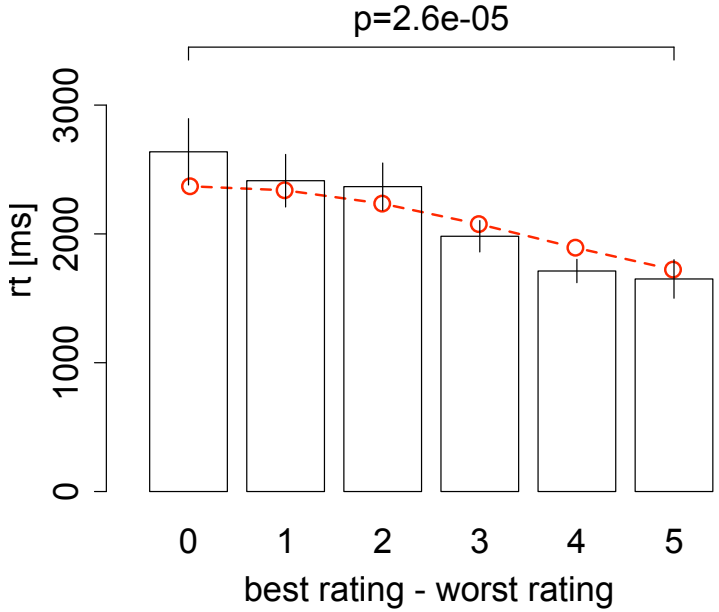
Basic fixation patterns



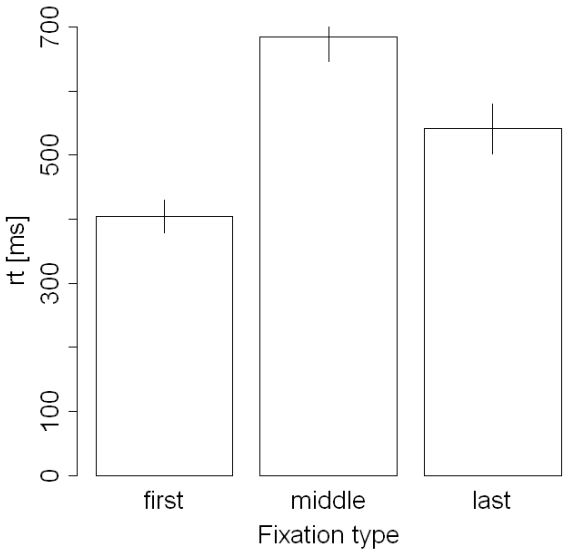


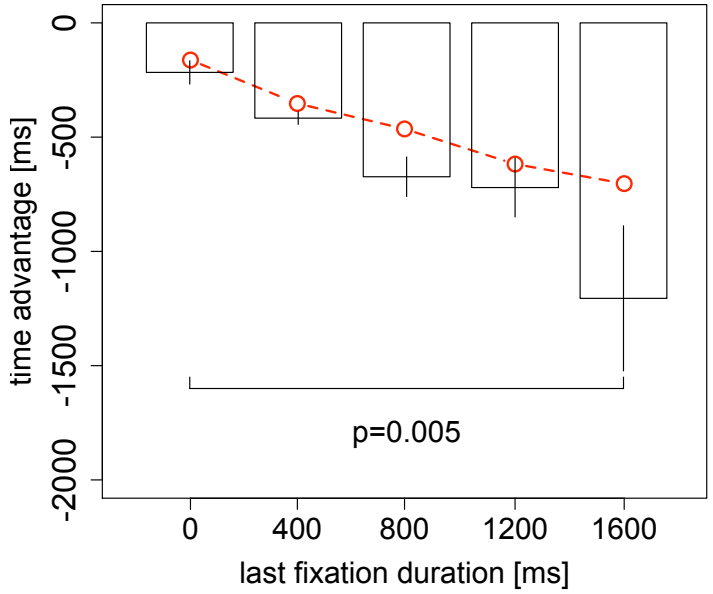
Basic psychometrics

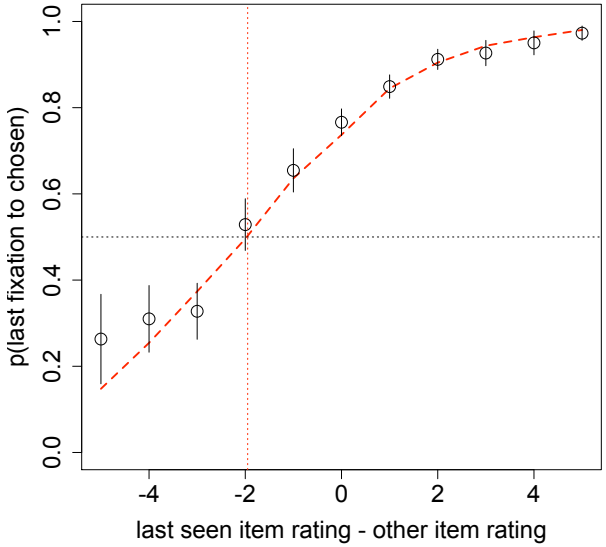




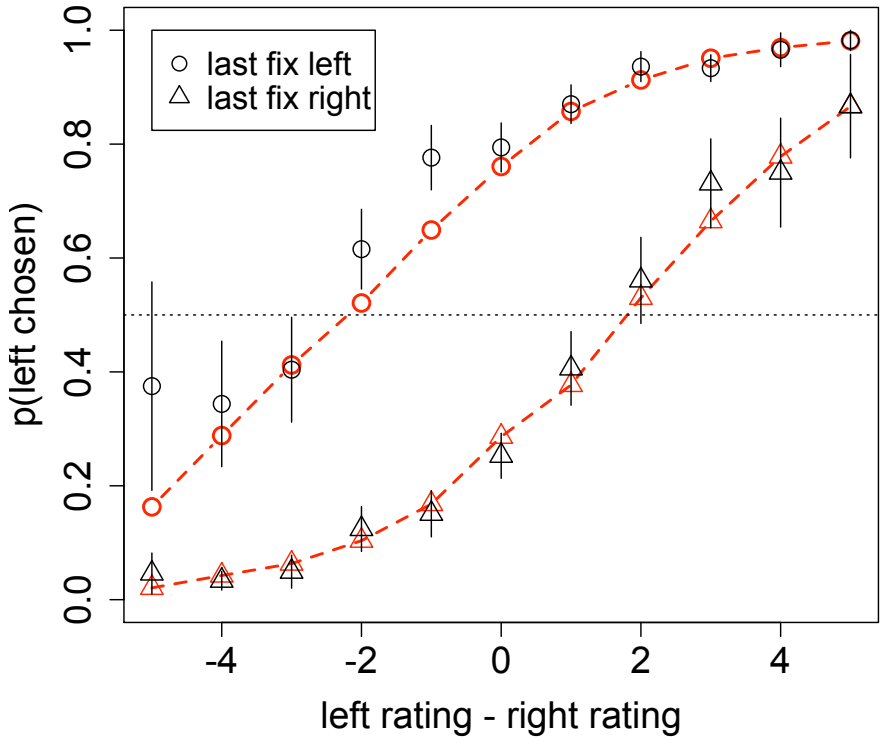
Key tests of the model

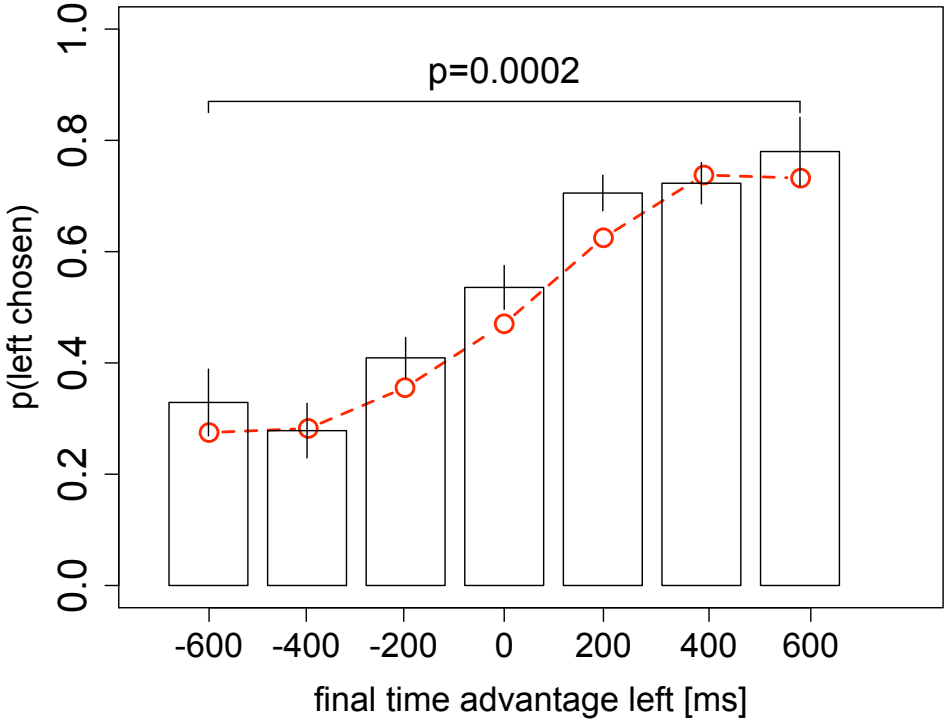


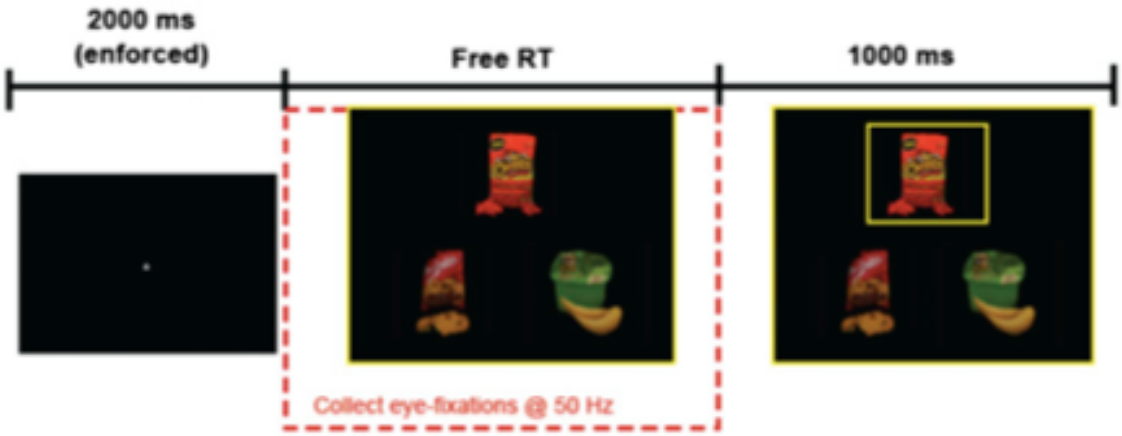


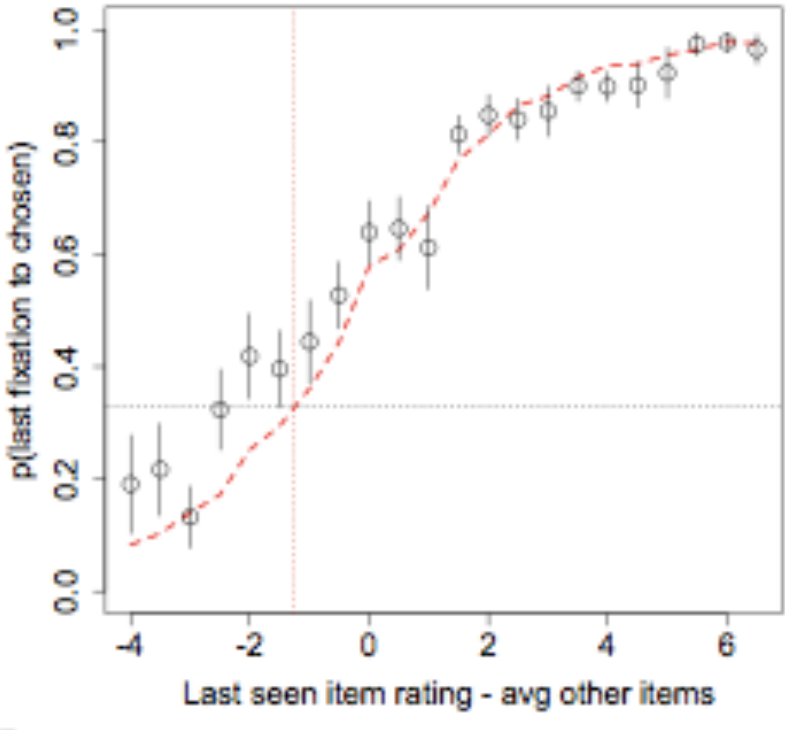


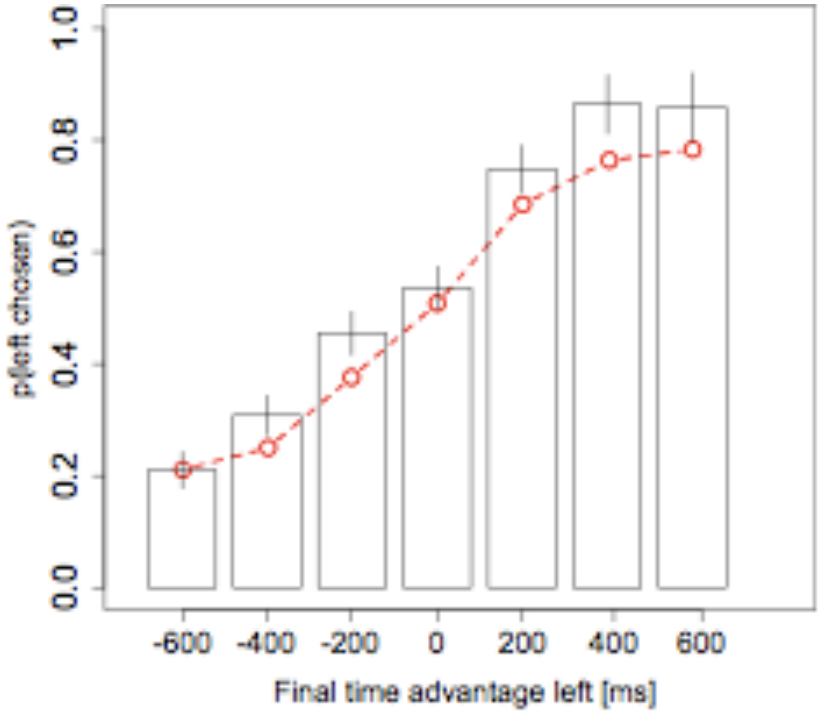
Predicted choice biases





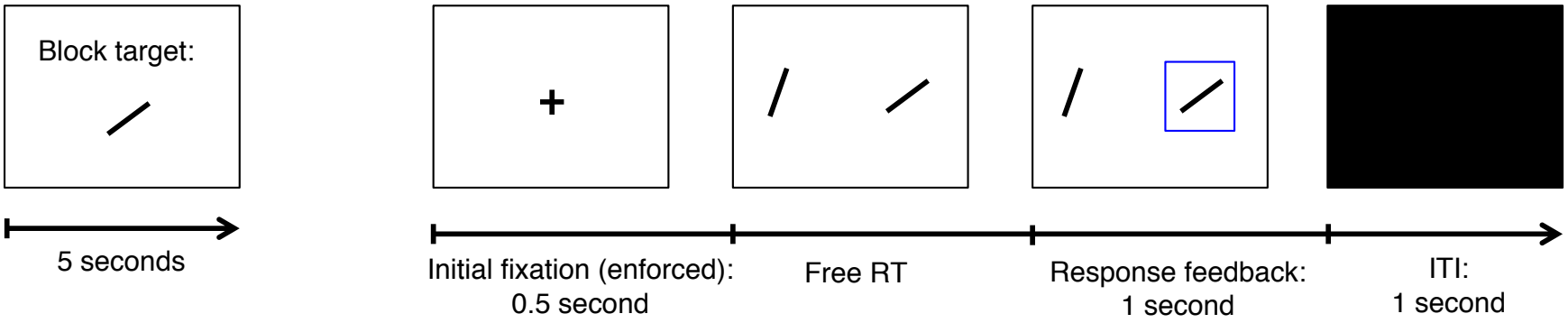




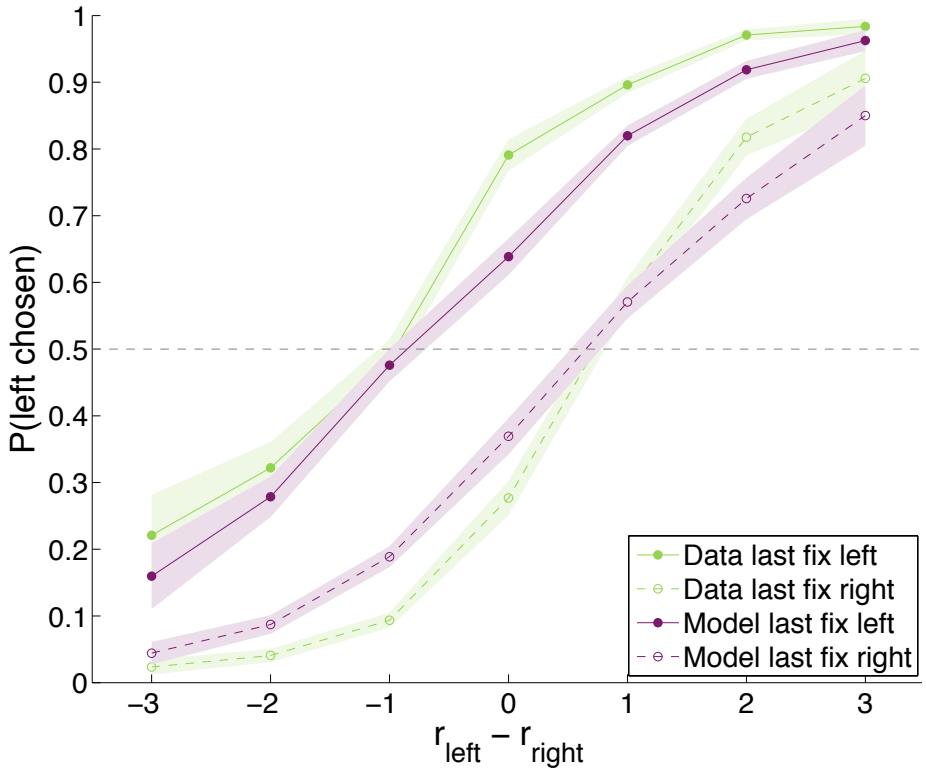


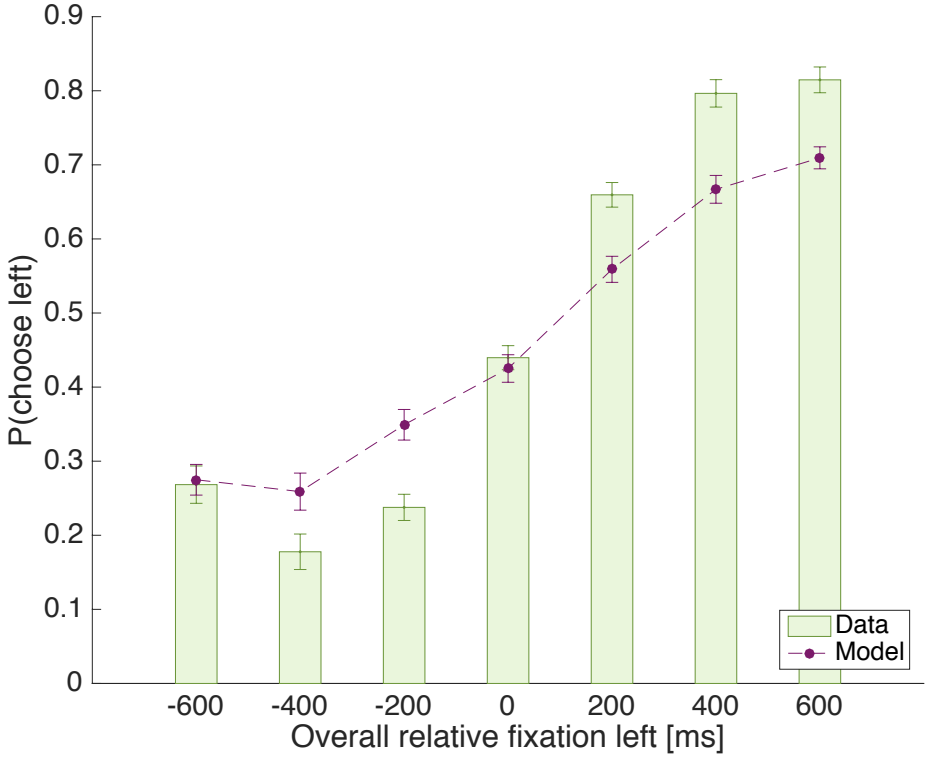
Krajbich & Rangel, PNAS 2011

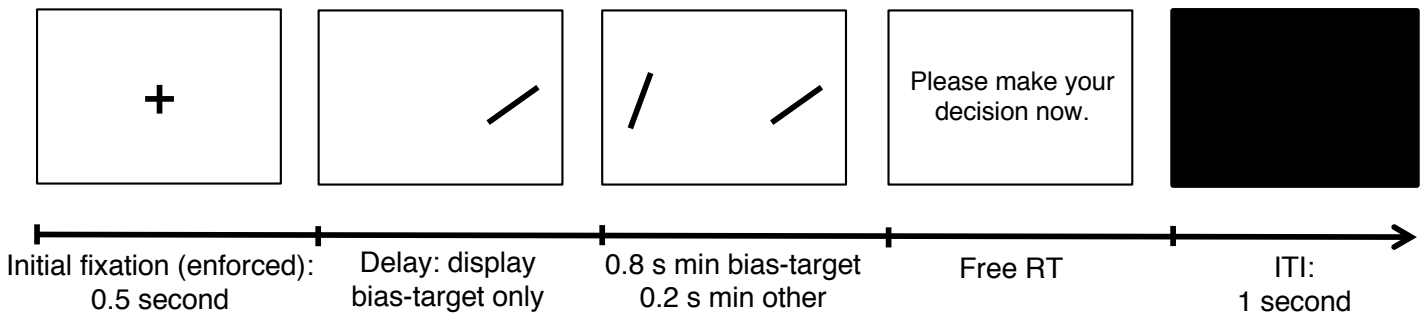
aDDM and perceptual choice

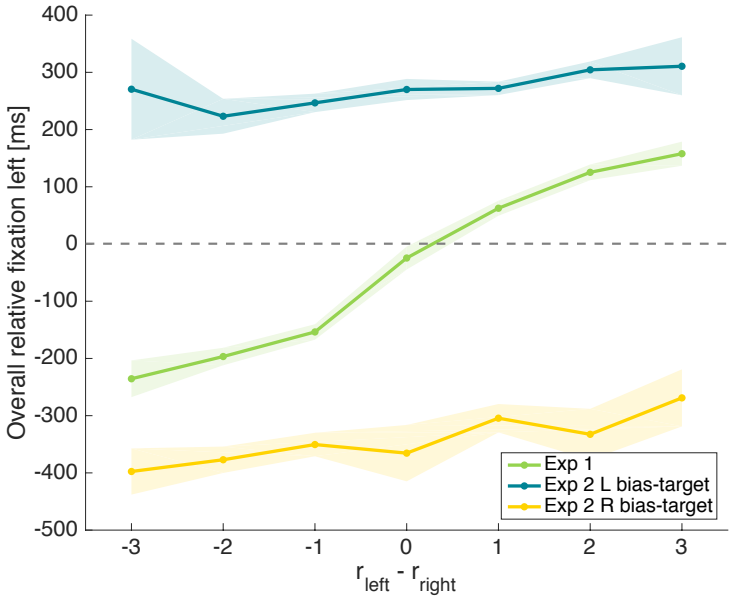


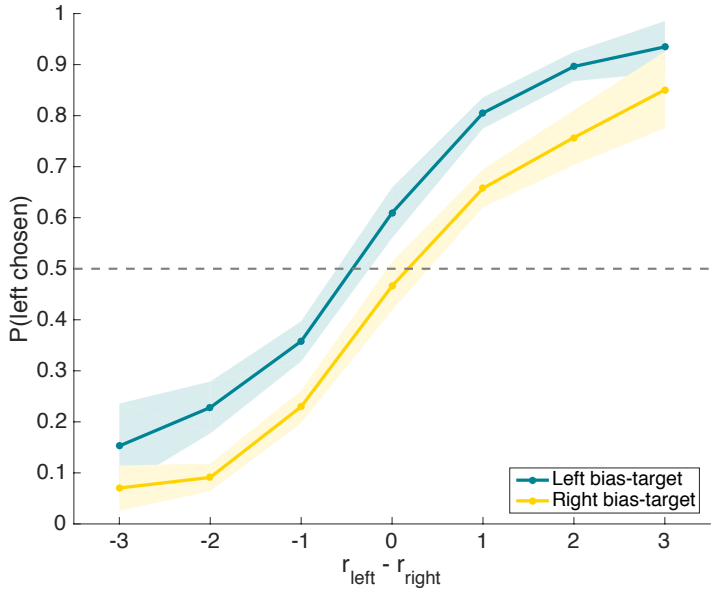
Tavares, Perona & Rangel, Frontiers in Neuroscience, 2017

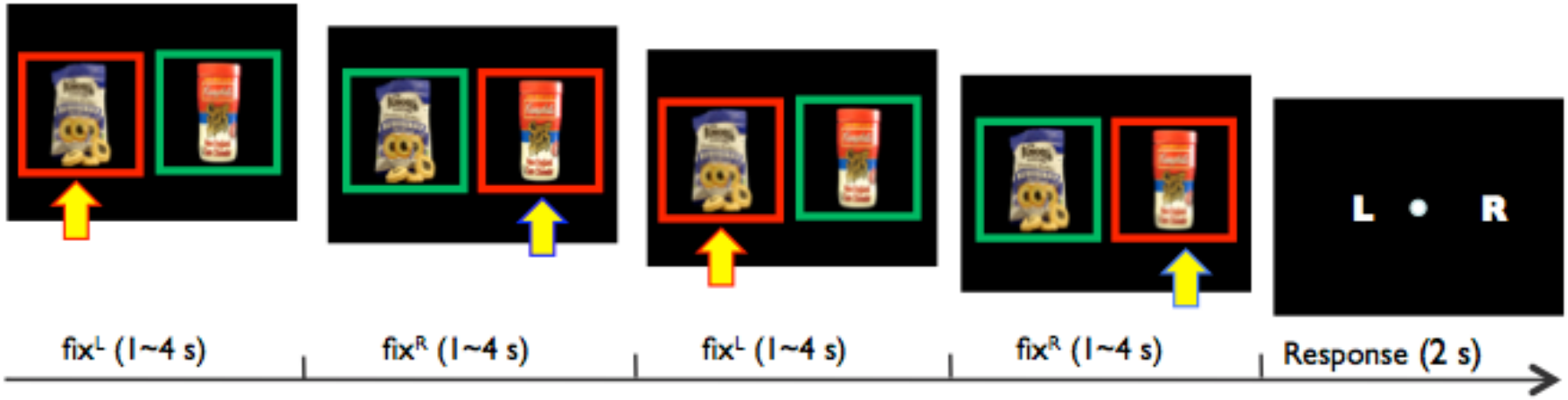

P(left chosen)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
–3
–2
–1
0
1
2
3
r left – r right
Data last fix left
Data last fix right
Model last fix left
Model last fix right

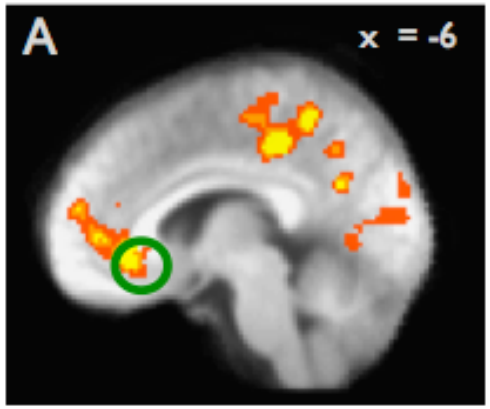

P(choose left)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-600
-400
-200
0
200
400
600
Overall relative fixation left [ms]
Data
Model

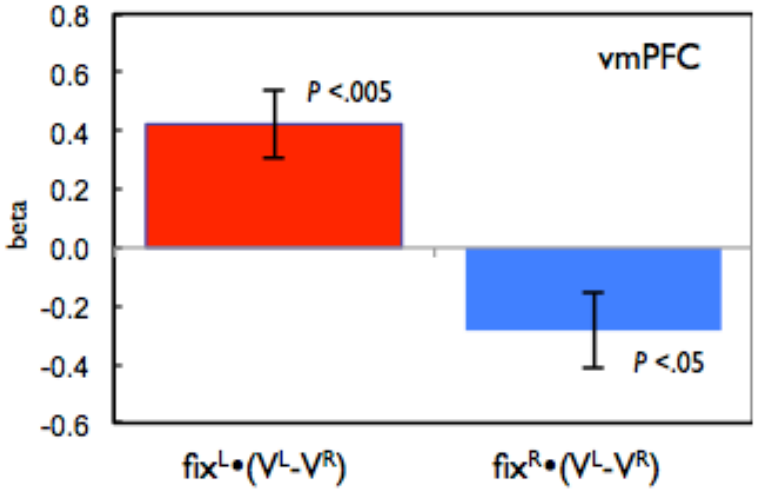

Please make your decision now.
Initial fixation (enforced): 0.5 second
Delay: display bias-target only
0.8 s min bias-target 0.2 s min other
Free RT
ITI: 1 second


Overall relative fixation left [ms]
400
300
200
100
0
-100
-200
-300
-400
-500
-3
-2
-1
0
1
2
3
r left - r right
Exp 1
Exp 2 L bias-target
Exp 2 R bias-target


P(left chosen)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-3
-2
-1
0
1
2
3
r left - r right
Left bias-target
Right bias-target







Lark, O'Doherty, Rangel, JNeuro, 2011

Neuron
Article

Orbitofrontal Cortex Value Signals Depend on Fixation Location during Free Viewing

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[2]Division of the Humanities and Social Sciences, California Institute of Technology, Pasadena, CA 91125, USA
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http://dx.doi.org/10.1016/j.neuron.2016.04.045

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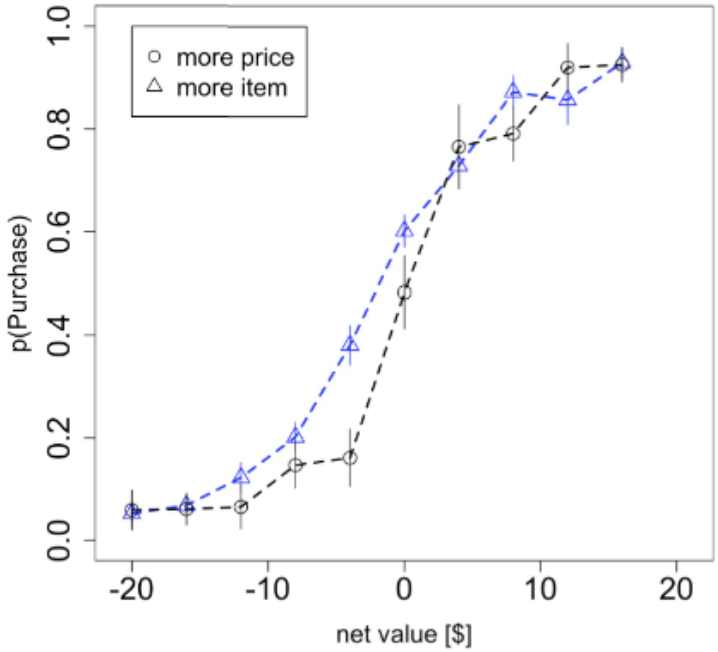
Attention across attributes



Krajbich et al, Frontiers Cog Sci, 2012

Self-control and speed of attribute computation

?

Left button press

Right button press

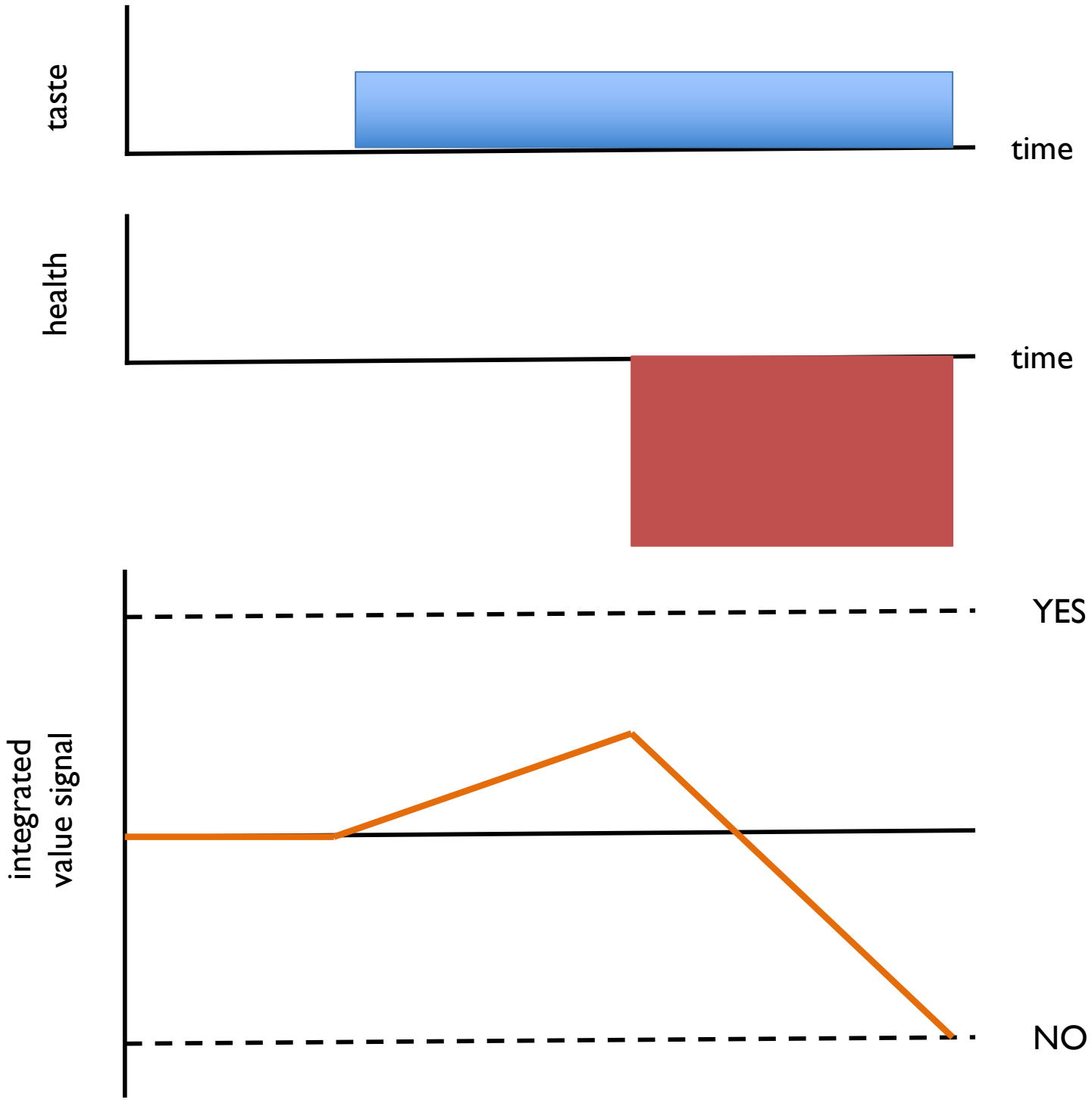
taste

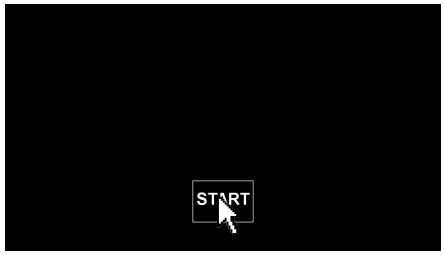
Value taste

health

Value
health

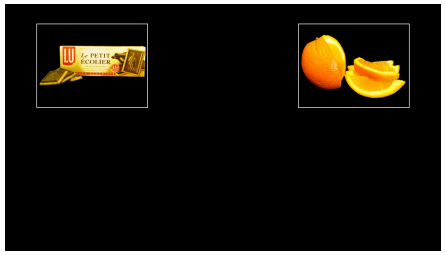
Value apple
=
Value
taste
+
Value
health


taste
time
health
time
integrated
value signal
YES
NO

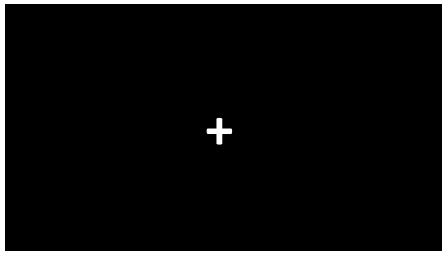


Start button

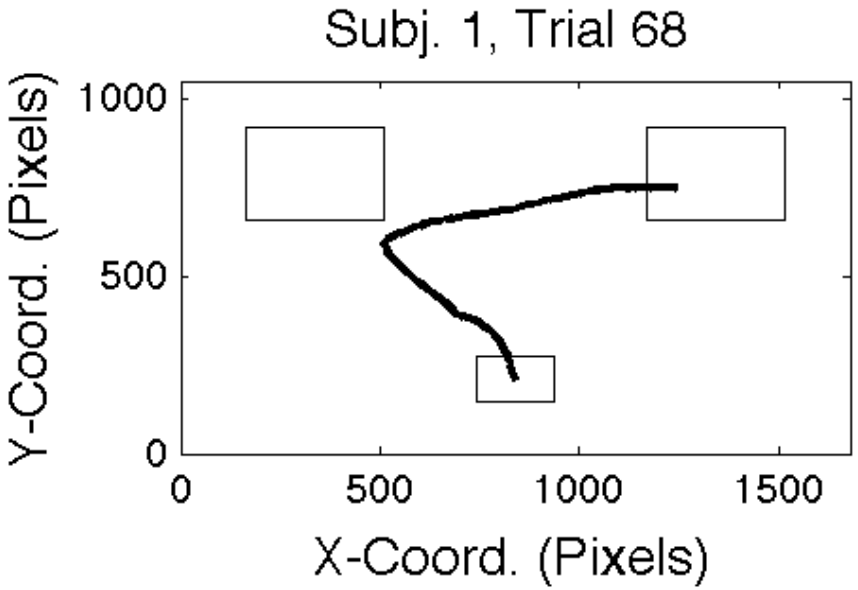
Jittered blank screen
(Mean .3 sec.)



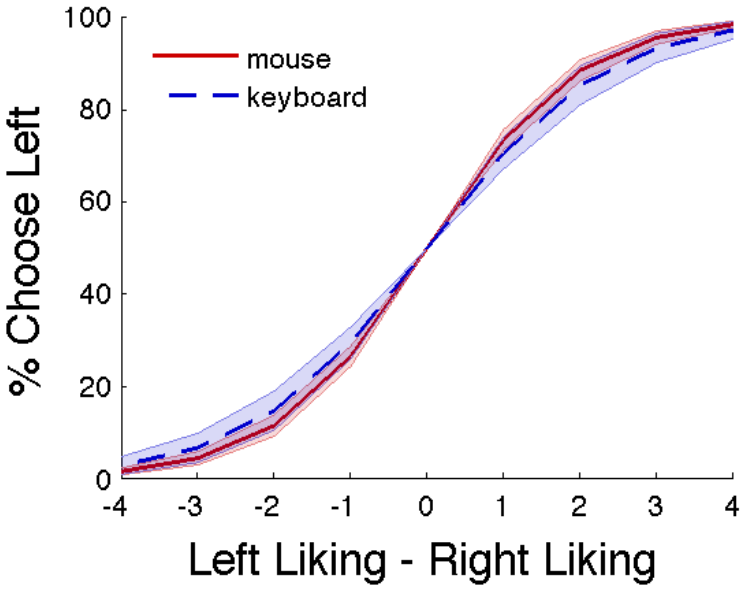
Choice screen
(Free RT)

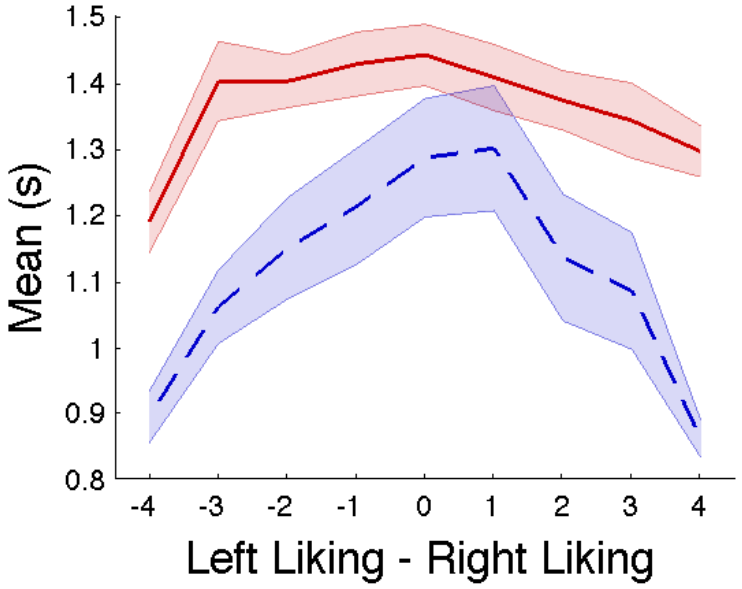


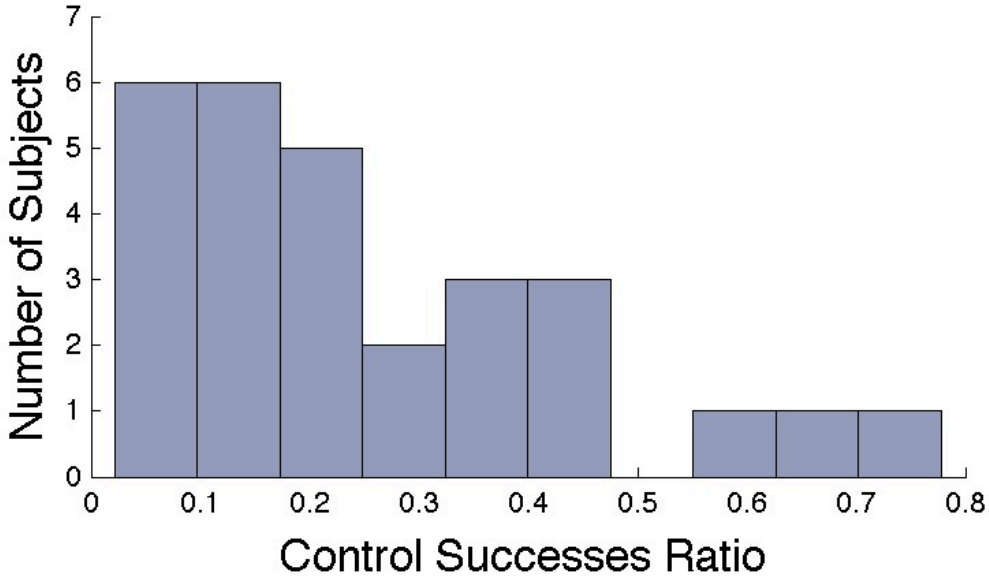
Jittered fixation
(Mean .55 sec.)

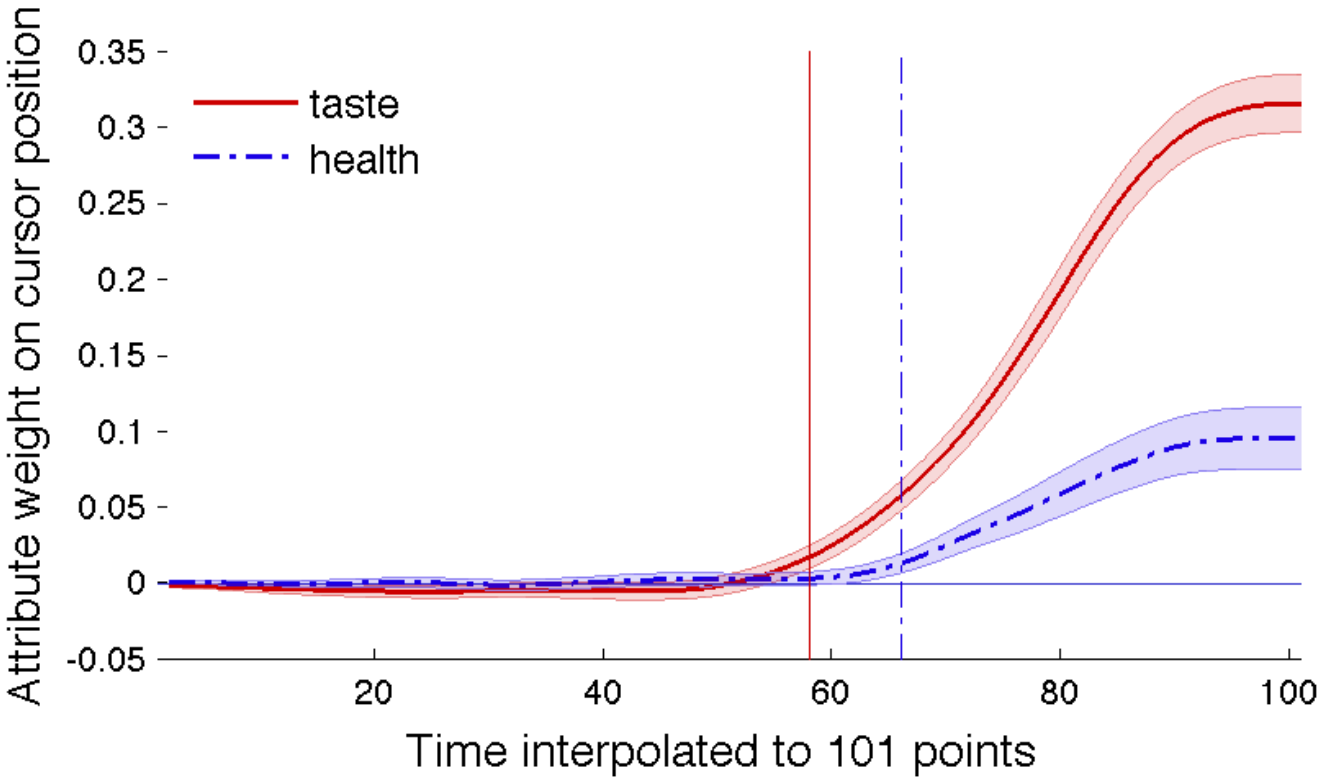


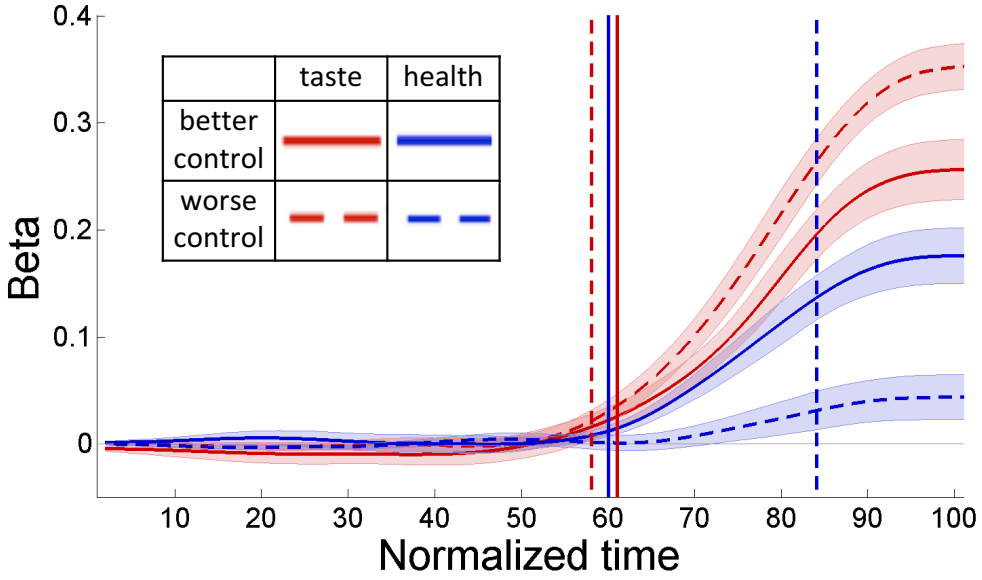
Sullivan et al, Psychological Science, 2015

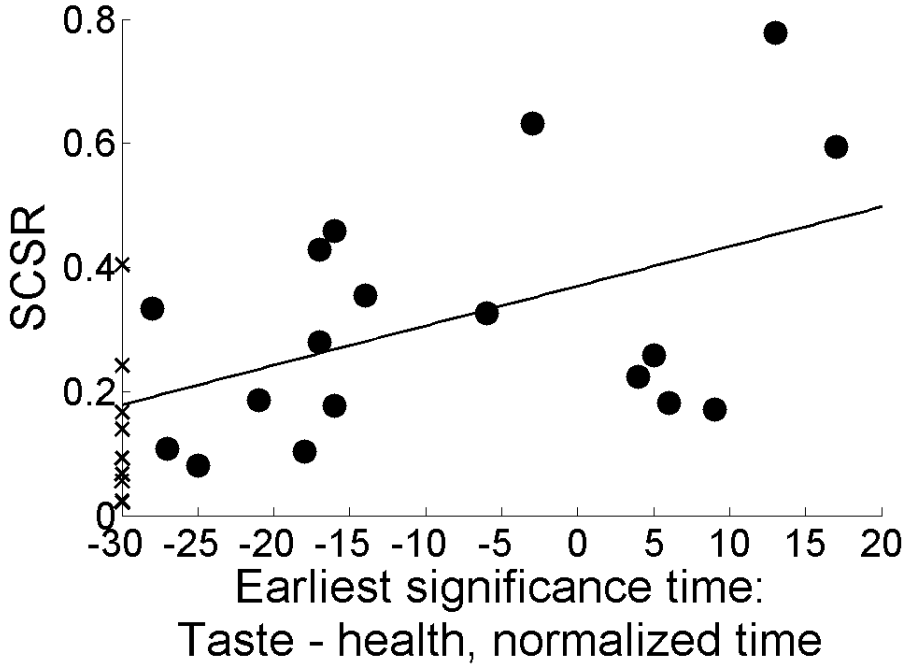

mouse
keyboard
% Choose Left
Left Liking - Right Liking


Mean (s)
Left Liking - Right Liking


Number of Subjects
Control Successes Ratio


Attribute weight on cursor position
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
taste
health
20
40
60
80
100
Time interpolated to 101 points

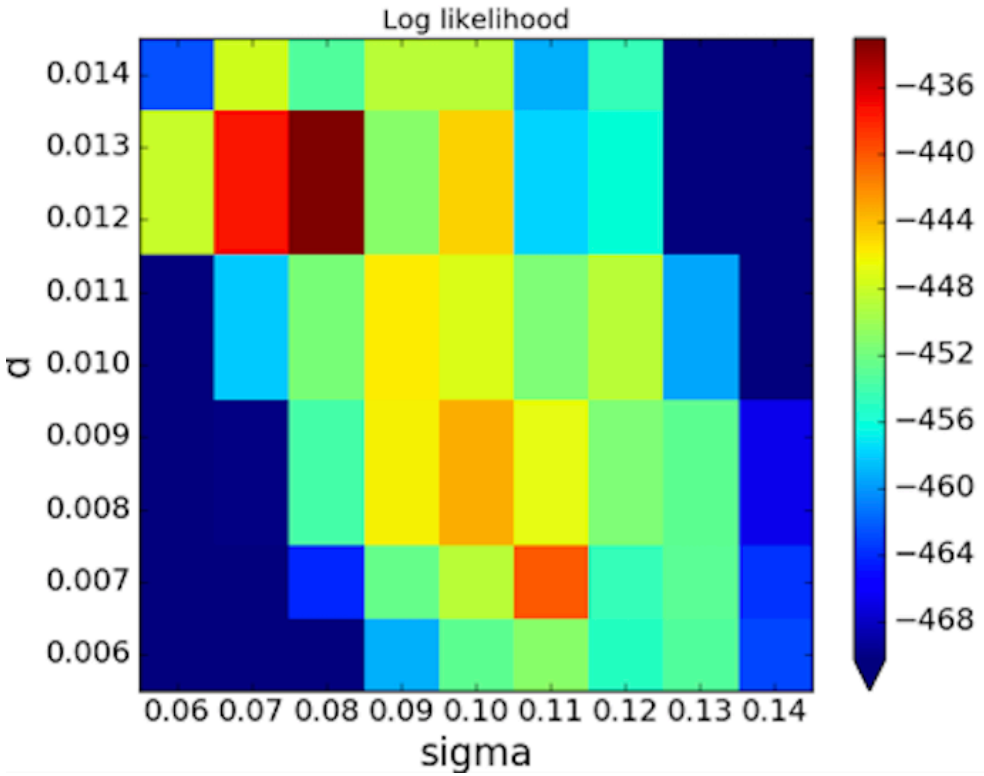

taste
health
better control
worse control
Beta
0.4
0.3
0.2
0.1
0
10
20
30
40
50
60
70
80
90
100
Normalized time


SCSR
0.8
0.6
0.4
0.2
0
-30
-25
-20
-15
-10
-5
0
5
10
15
20
Earliest significance time:
Taste - health, normalized time

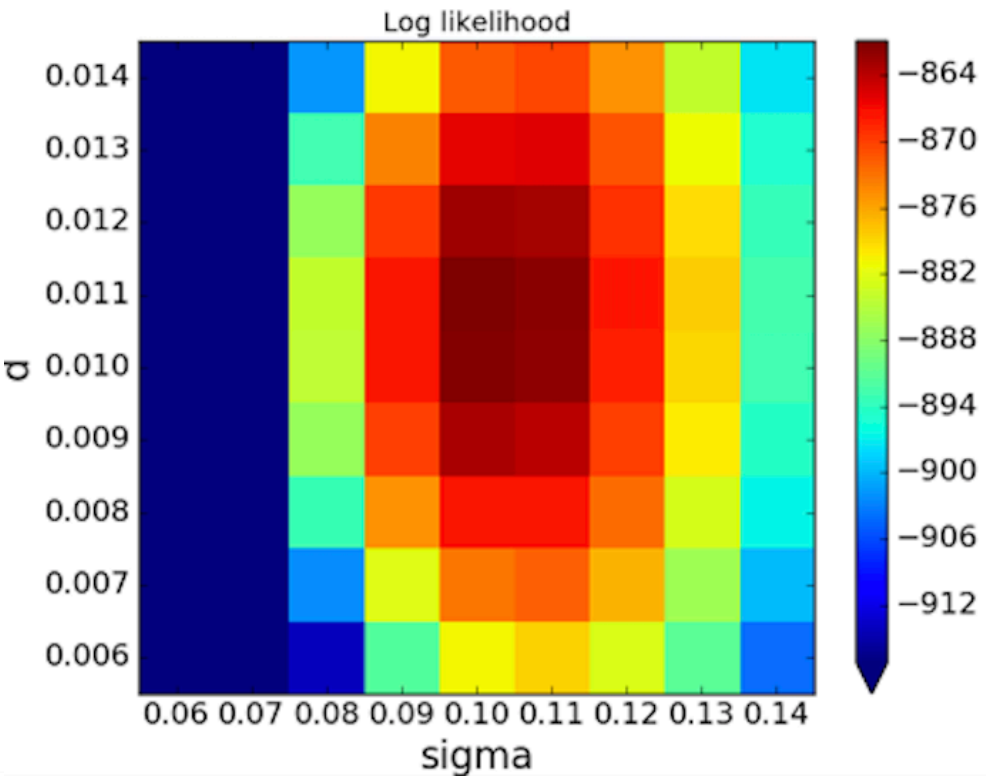
III
Methods

9x9 grid, 160 trials

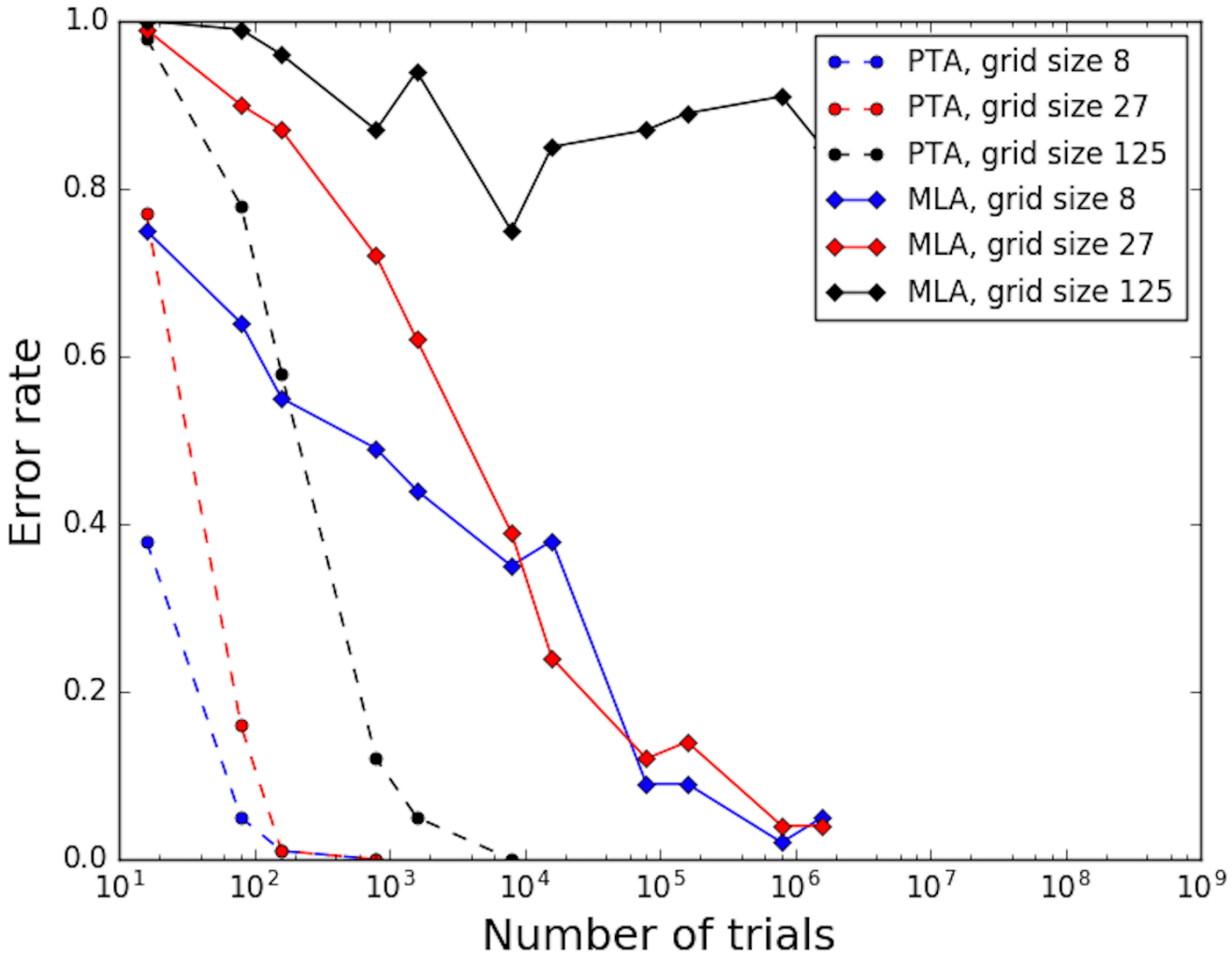
standard MLE



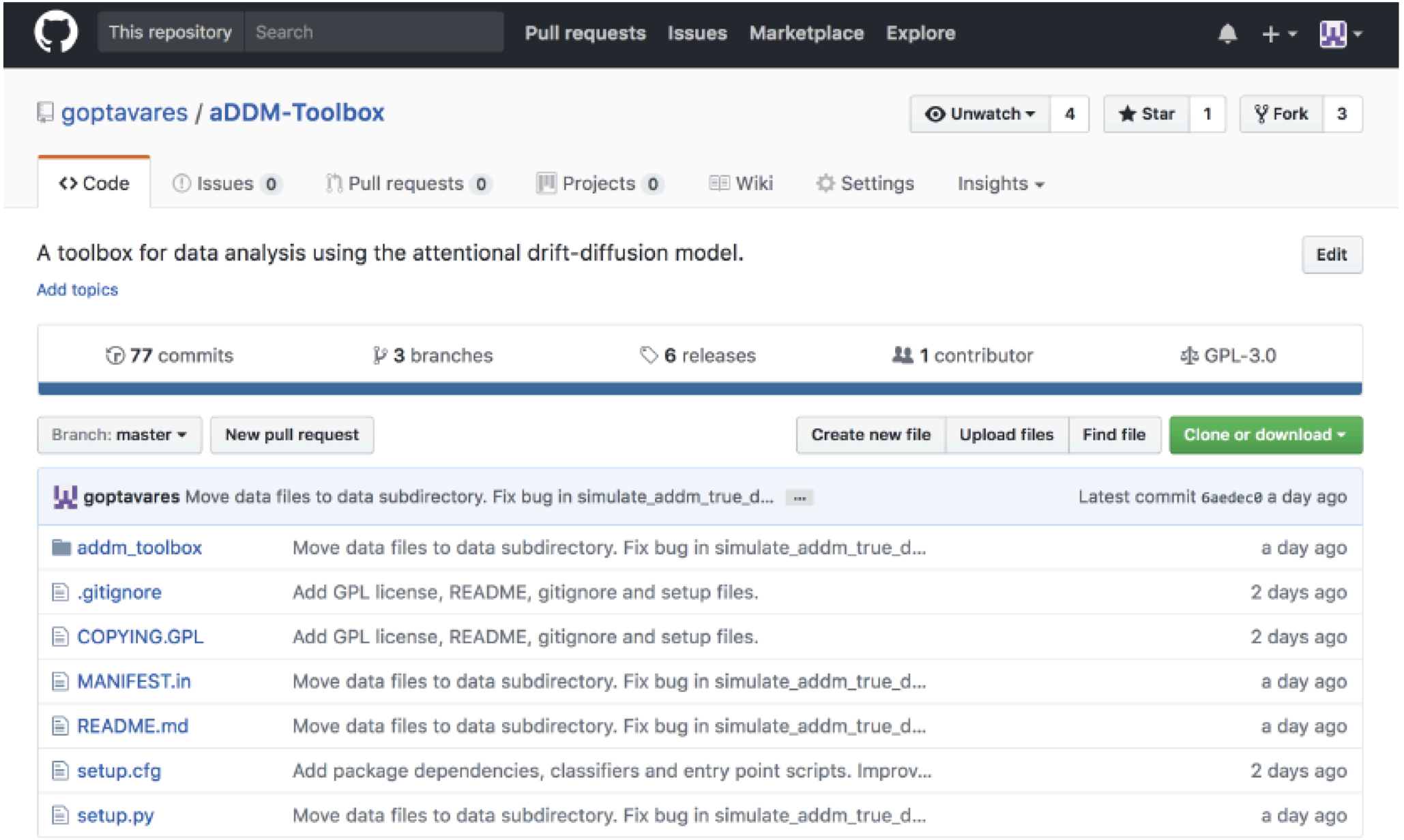
forward MLE



Tavares et al, in prep


PTA, grid size 8
PTA, grid size 27
PTA, grid size 125
MLA, grid size 8
MLA, grid size 27
MLA, grid size 125
Error rate
Number of trials
1.0
0.8
0.6
0.4
0.2
0.0
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
10^9

github.com/goptavares/aDDM-Toolbox



IV
Discussion

Key findings

- Exogenous fluctuations in visual attention have a causal effect in choices
- aDDM like models provide reasonable quantitative explanations of the choice-RT-fixation psychometrics
- Differences in the relative speed at which attributes are computed can drive differences in self-control, risk-taking, social preferences, ...

Open question:
multi- option & attribute choice

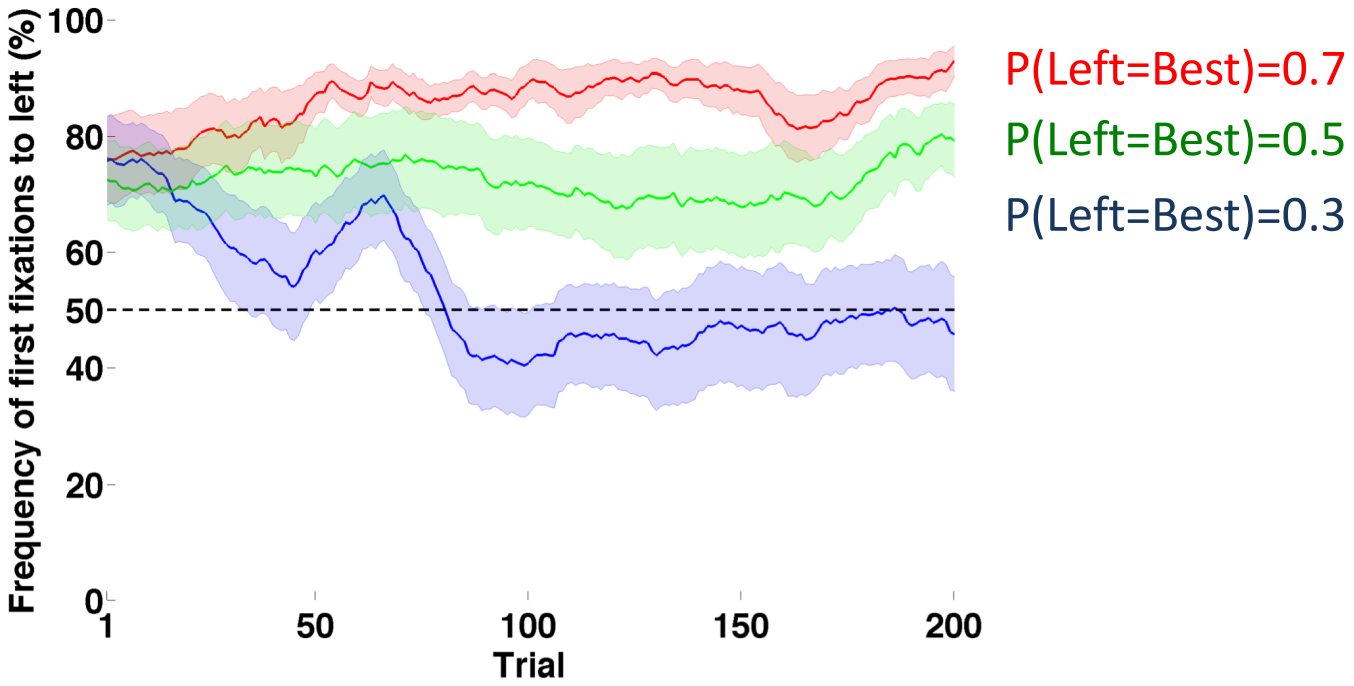
?

$1

$2

Open question:
endogeneous attention within decision trials

Open question: exogenous attention across decision trials



Open question:
medium and large choice sets

Open question:
neural code of value computation, value comparison and their modulation by attention

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