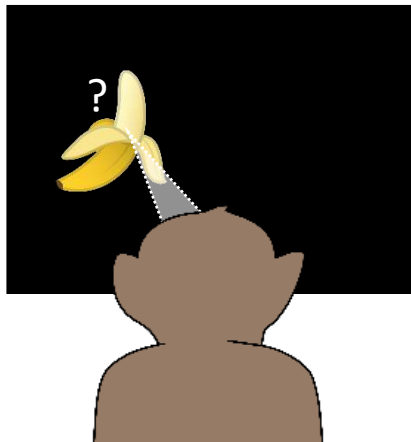
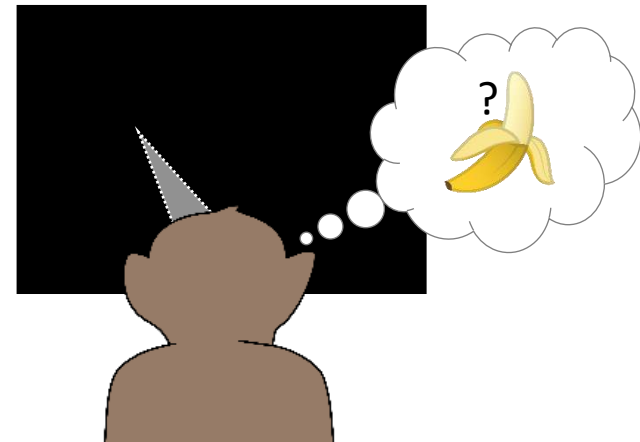


Economic decision-making in the brain: how does gaze relate to the activity of orbitofrontal cortex neurons?

Presentation time



Delay time



Demetrio Ferro^{1,2,*}, **Tyler Cash-Padgett**³, **Maya Zhe Wang**³, **Benjamin Hayden**³, **Rubén Moreno Bote**^{1,2,4}

¹Center for Brain and Cognition (CBC), Universitat Pompeu Fabra (UPF), 08002, Barcelona – ES;

²Department of Information and Communication Technologies, Universitat Pompeu Fabra (UPF), 08002, Barcelona – ES;

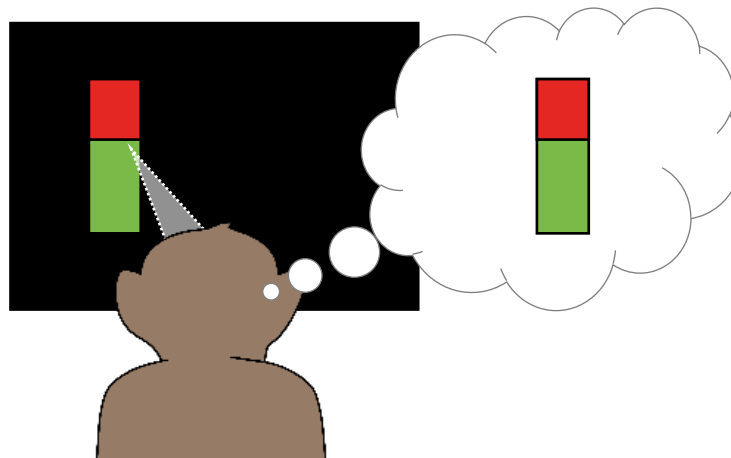
³Dept. of Neuroscience, Center for Magnetic Resonance Research, Center for Neuroeng., University of Minnesota, MN55455, Minneapolis – USA;

⁴Serra Hünter Fellow Programme, Universitat Pompeu Fabra, Barcelona, Spain

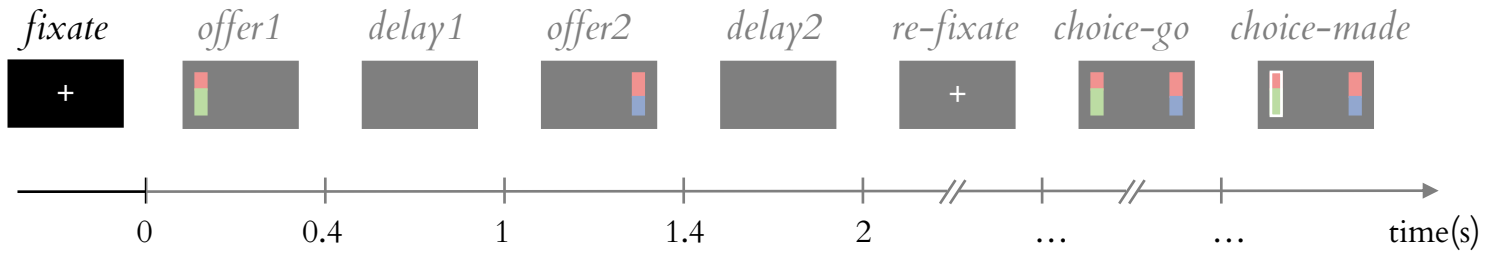
*demetrio.ferro@upf.edu

Motivations

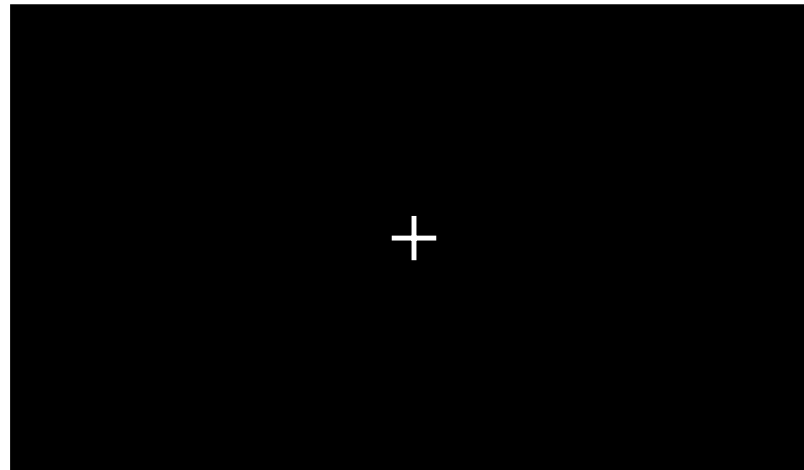
- Is the gaze position relevant for the reward gambling task execution?
- Can we use the gaze position as a marker of what is the animal mentally picturing during task execution? in particular, can we do so during delays?



Reward gambling task

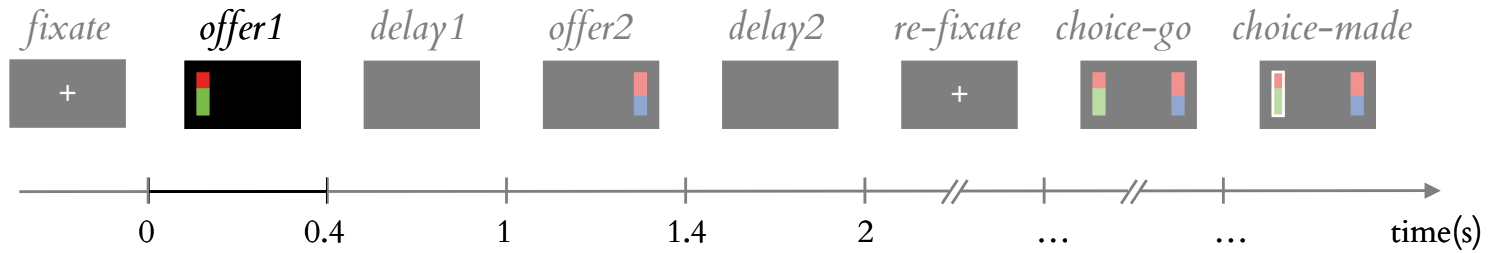


Fixate



acquire fixation at center of the screen

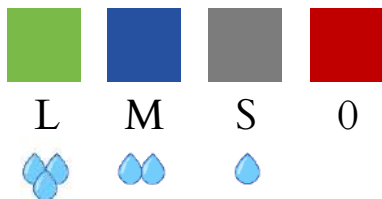
Reward gambling task



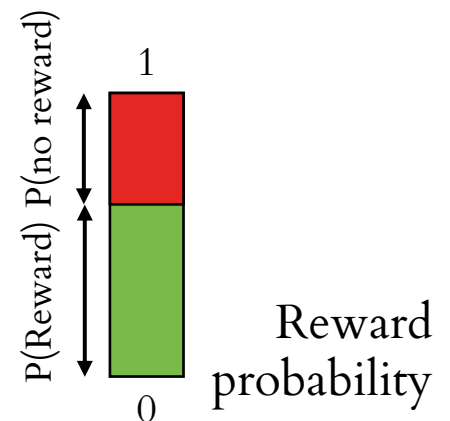
Offer 1



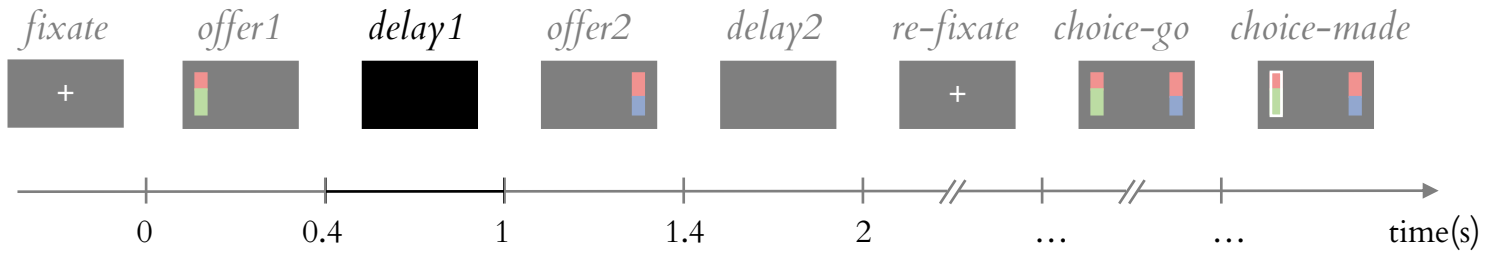
Reward magnitude



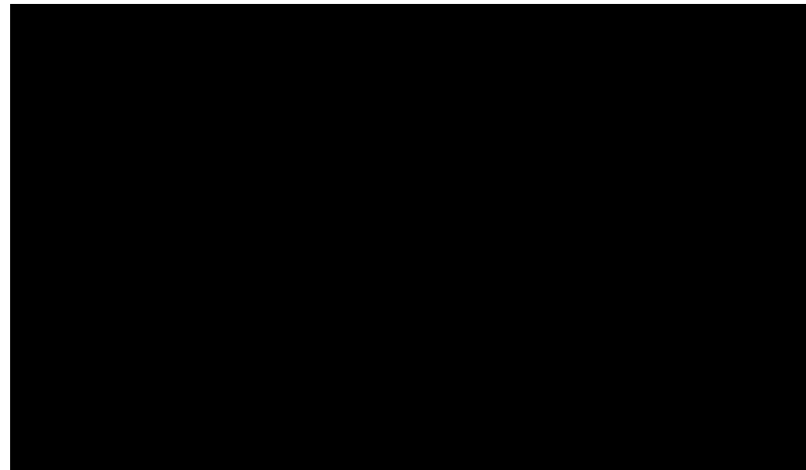
first offer is presented



Reward gambling task

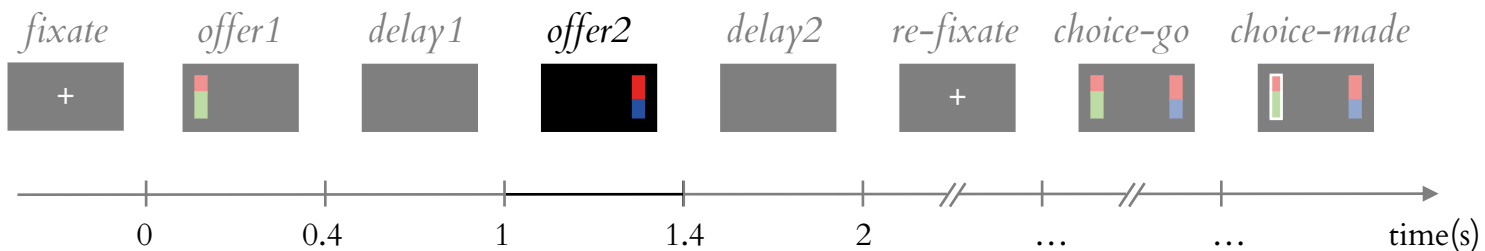


Delay 1

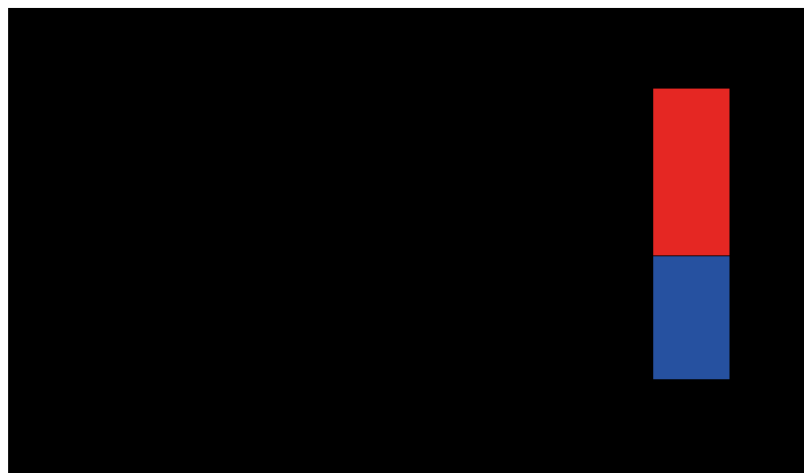


blank screen

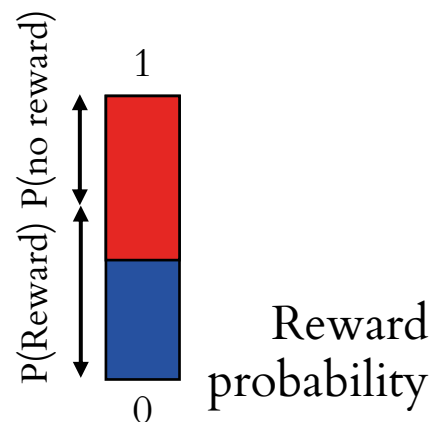
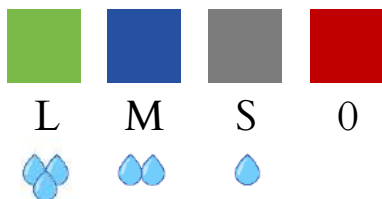
Reward gambling task



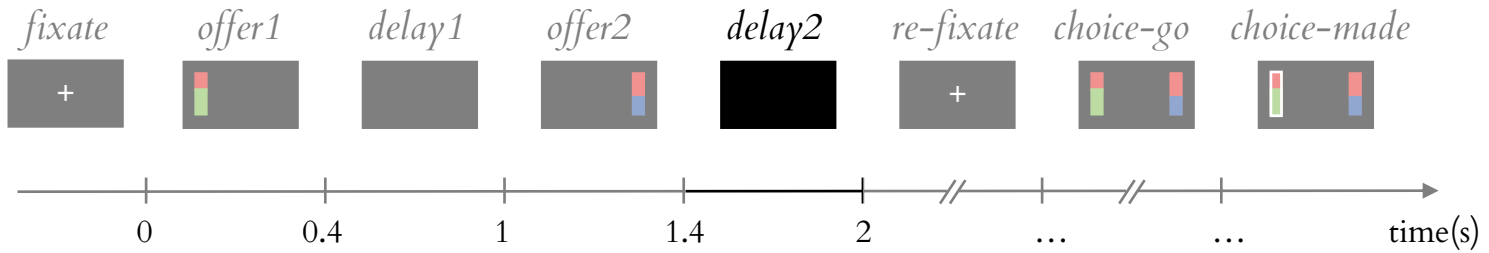
Offer 2



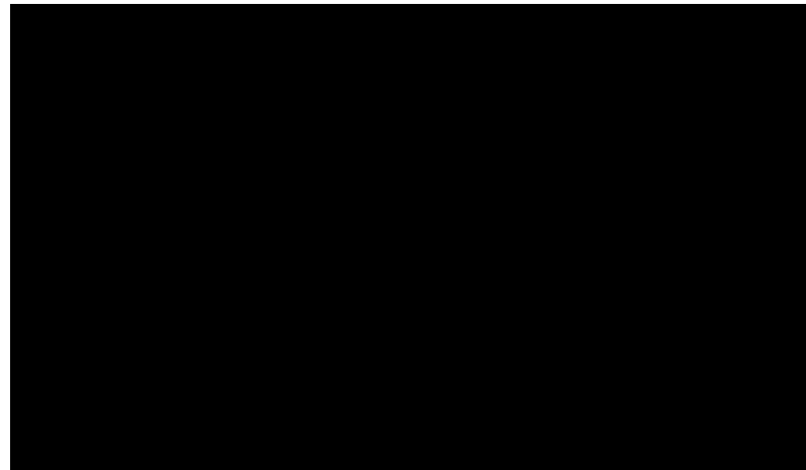
Reward magnitude



Reward gambling task

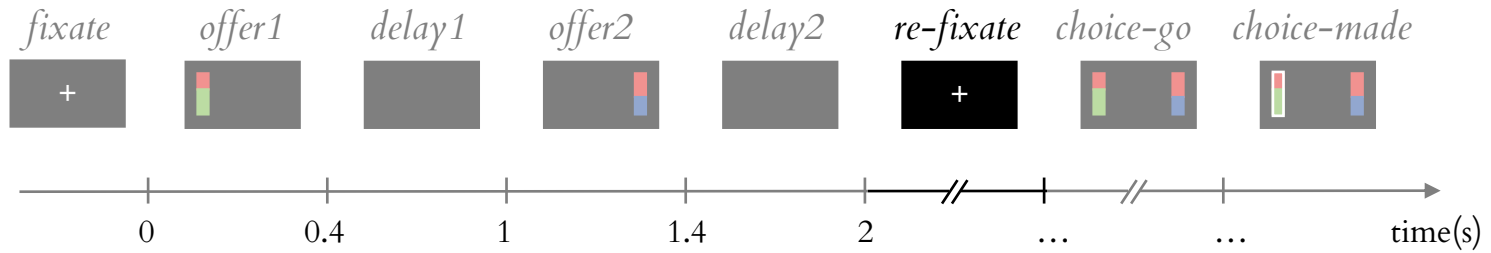


Delay 2

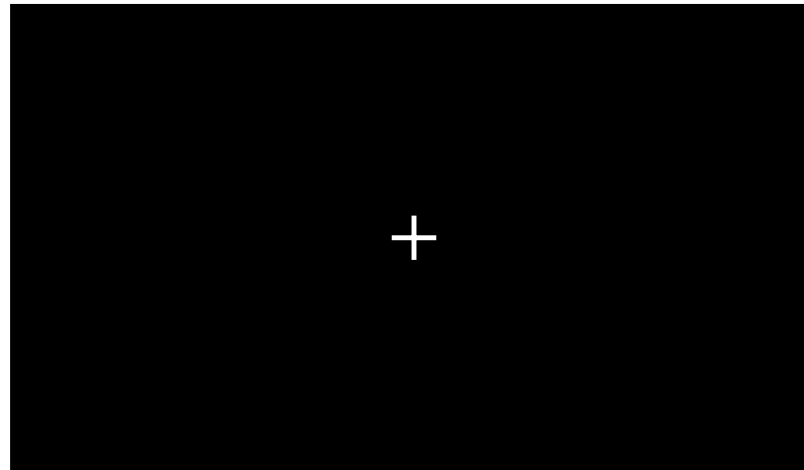


blank screen

Reward gambling task

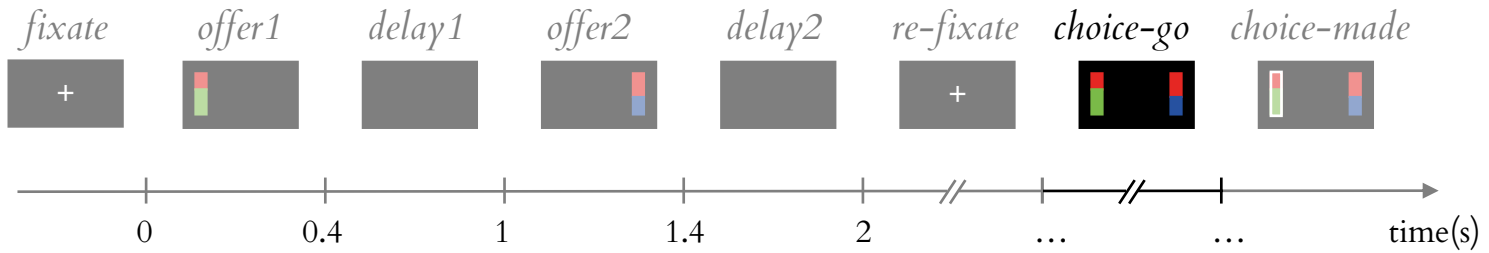


Re-fixate



re-acquire fixation at center of the screen

Reward gambling task

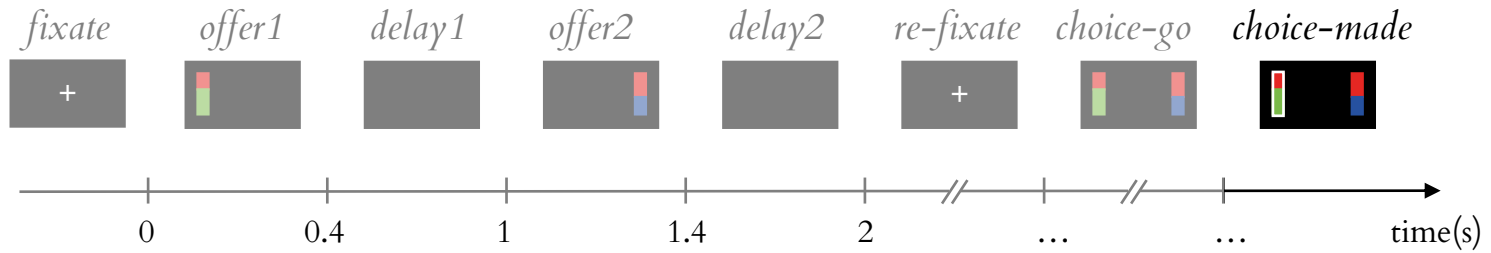


Choice-go



saccade to chosen offer side

Reward gambling task

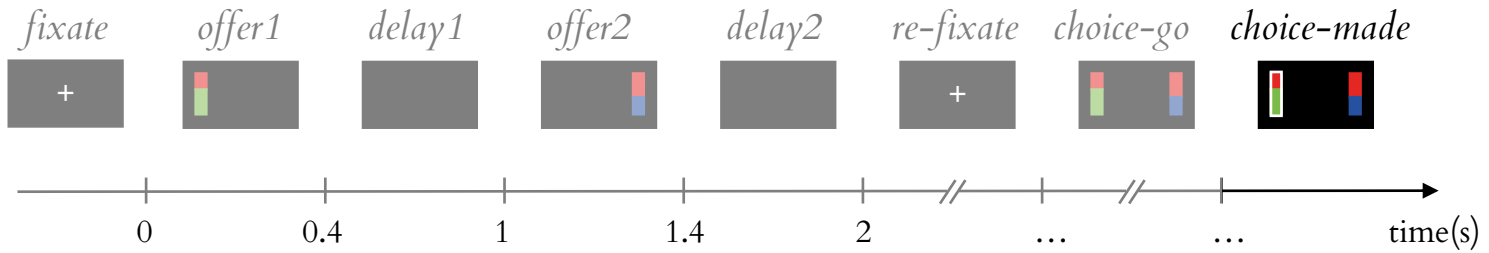


Choice-made



hold chosen offer side for at least +200ms

Reward gambling task



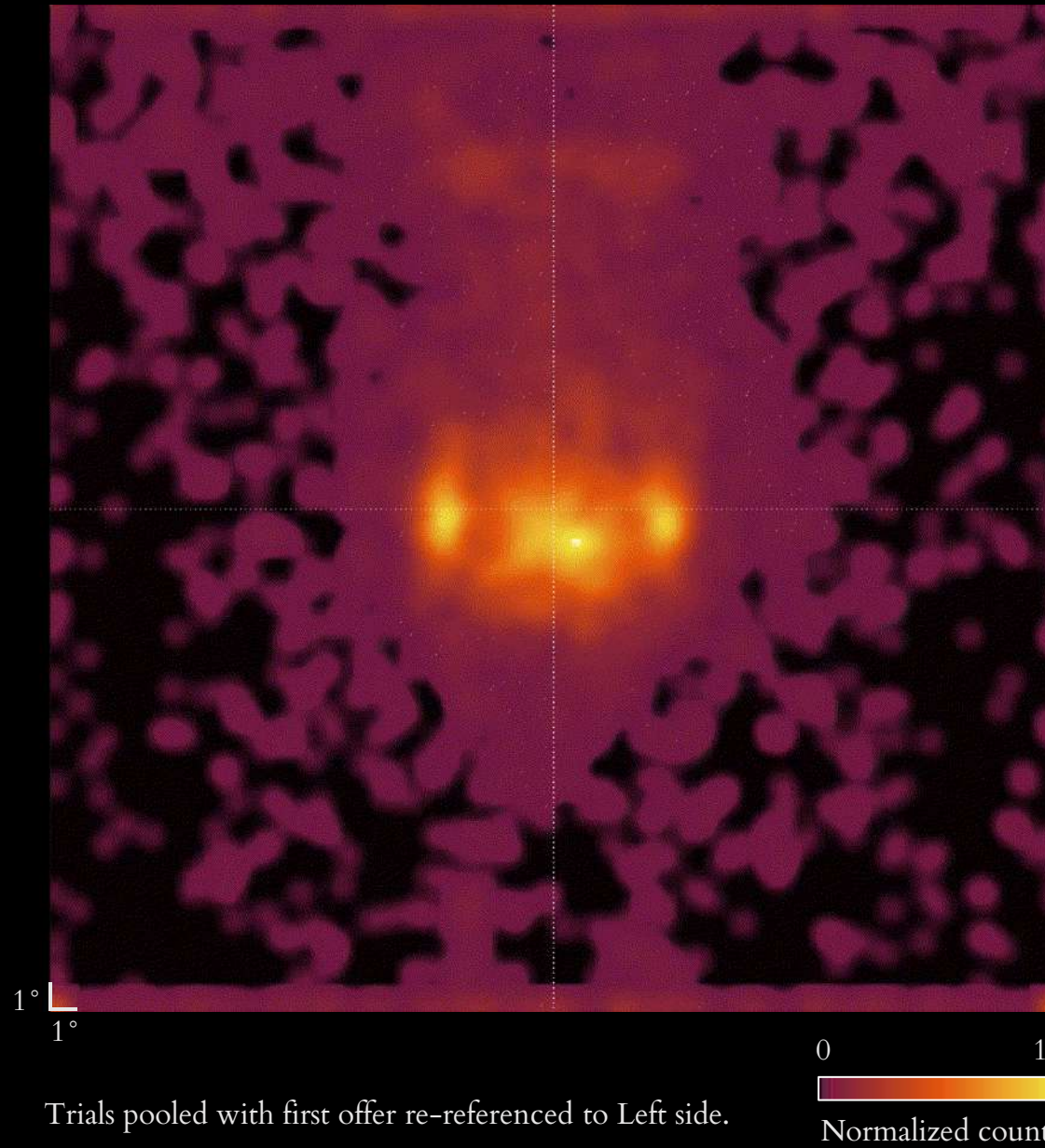
Reward



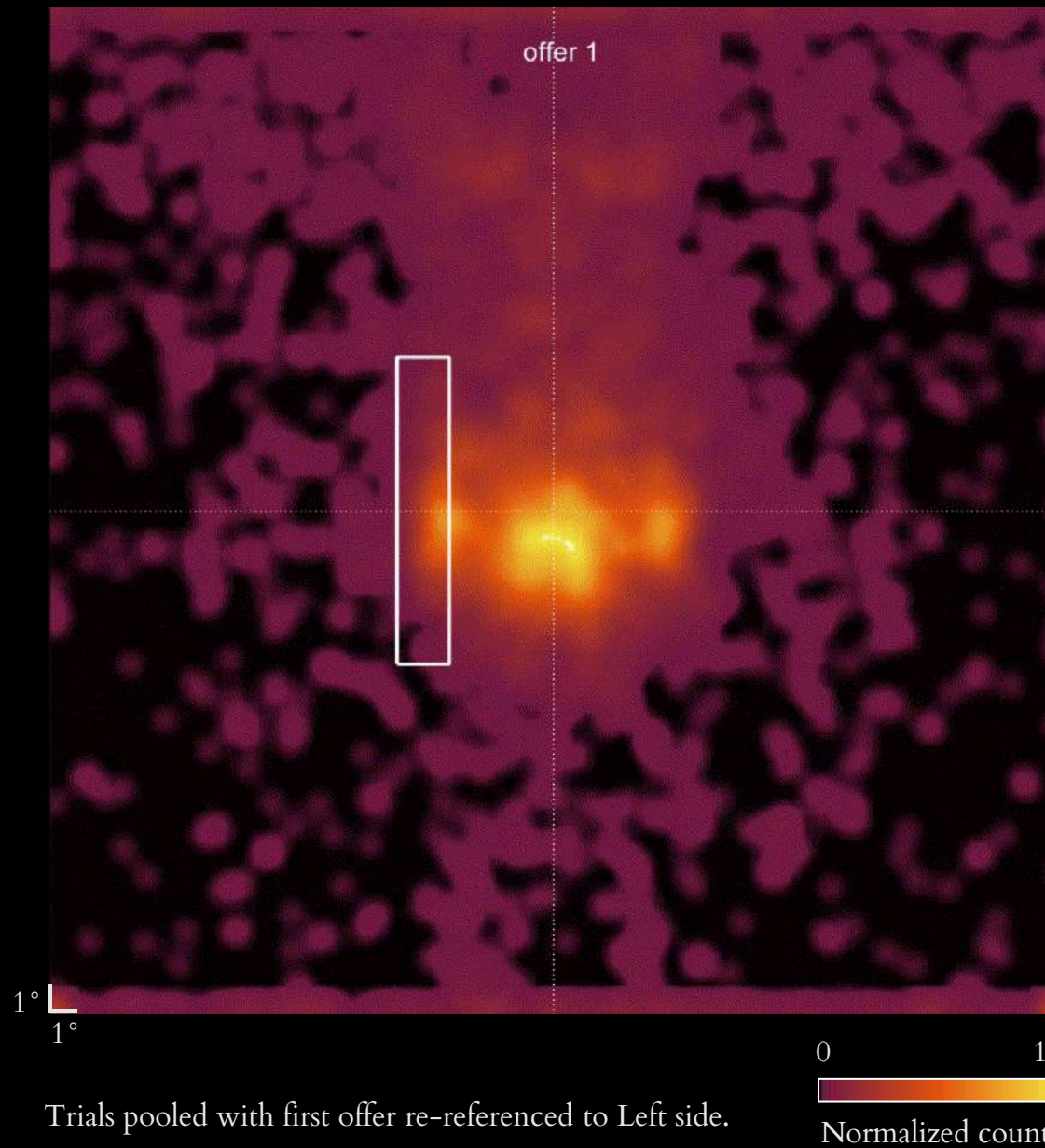
reward is provided



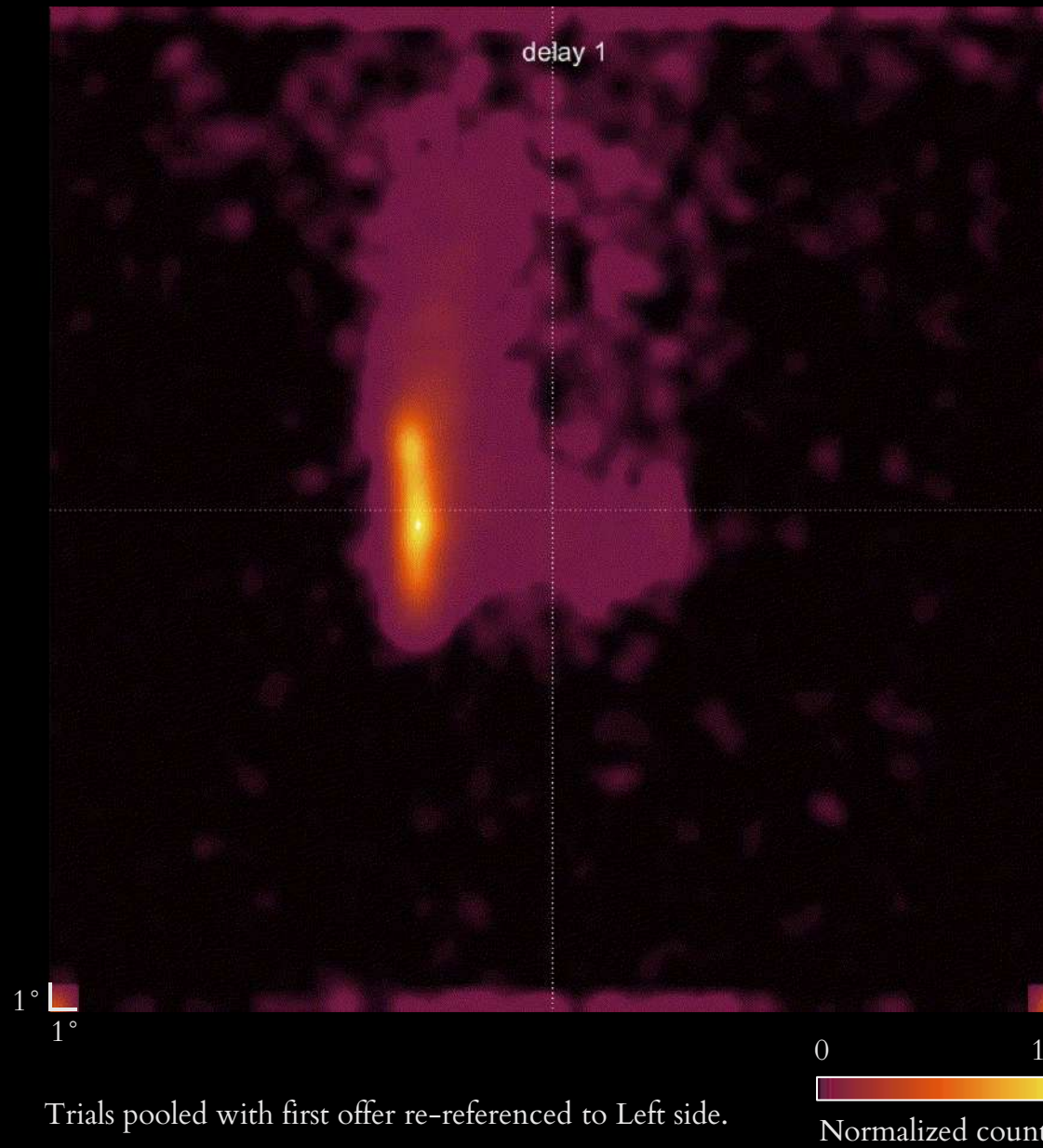
Eye movements during task execution



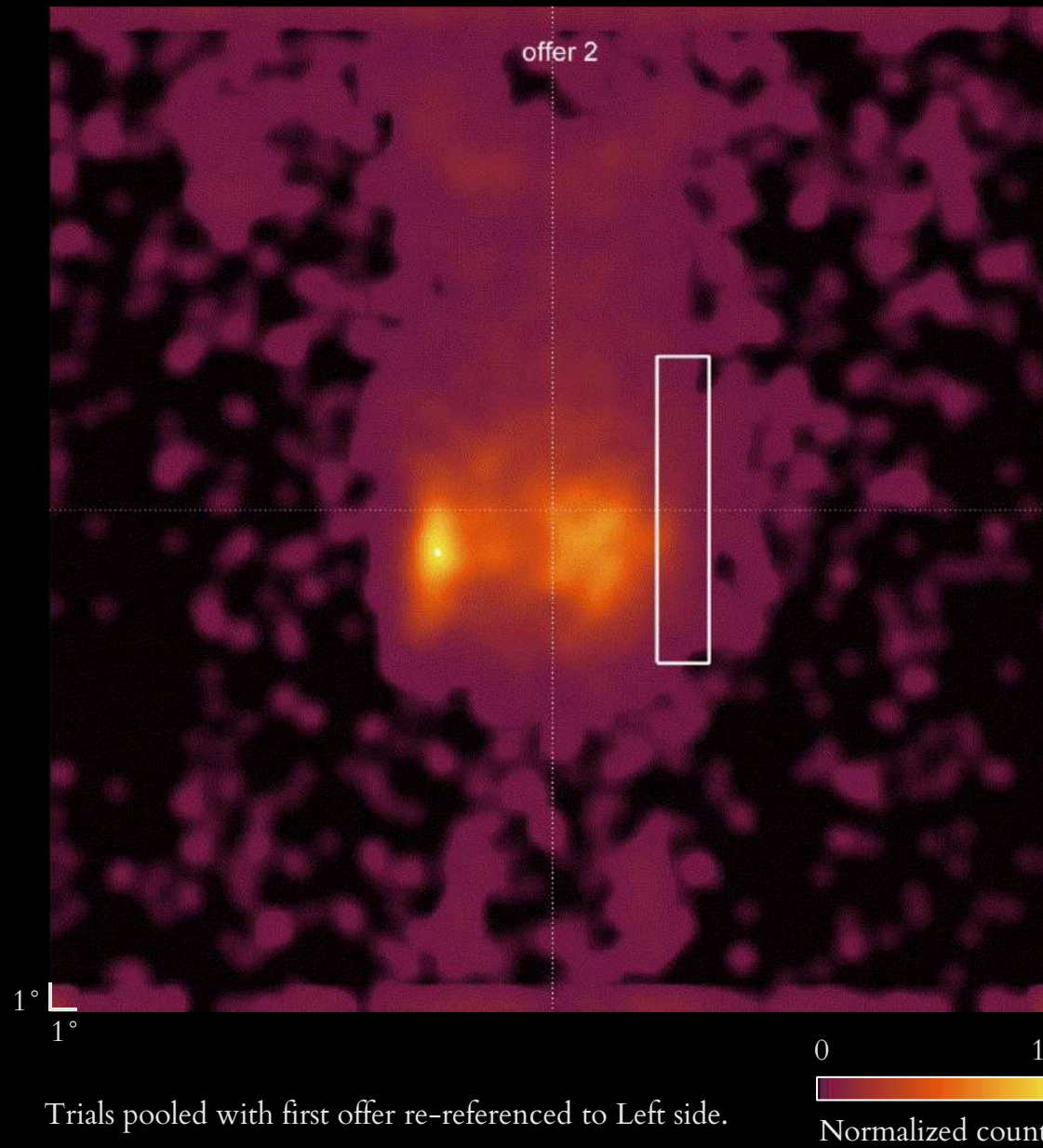
Eye movements during task execution



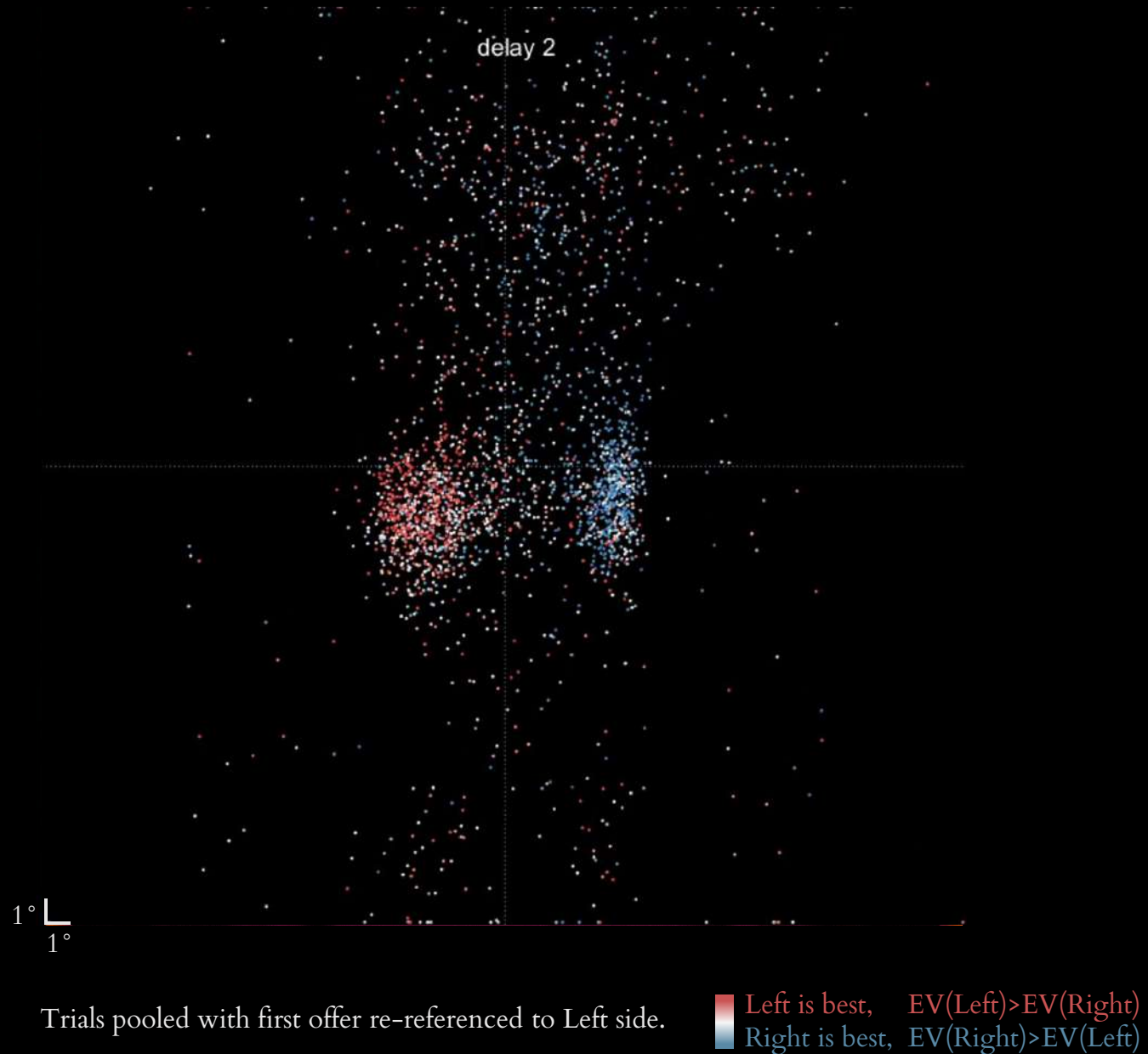
Eye movements during task execution



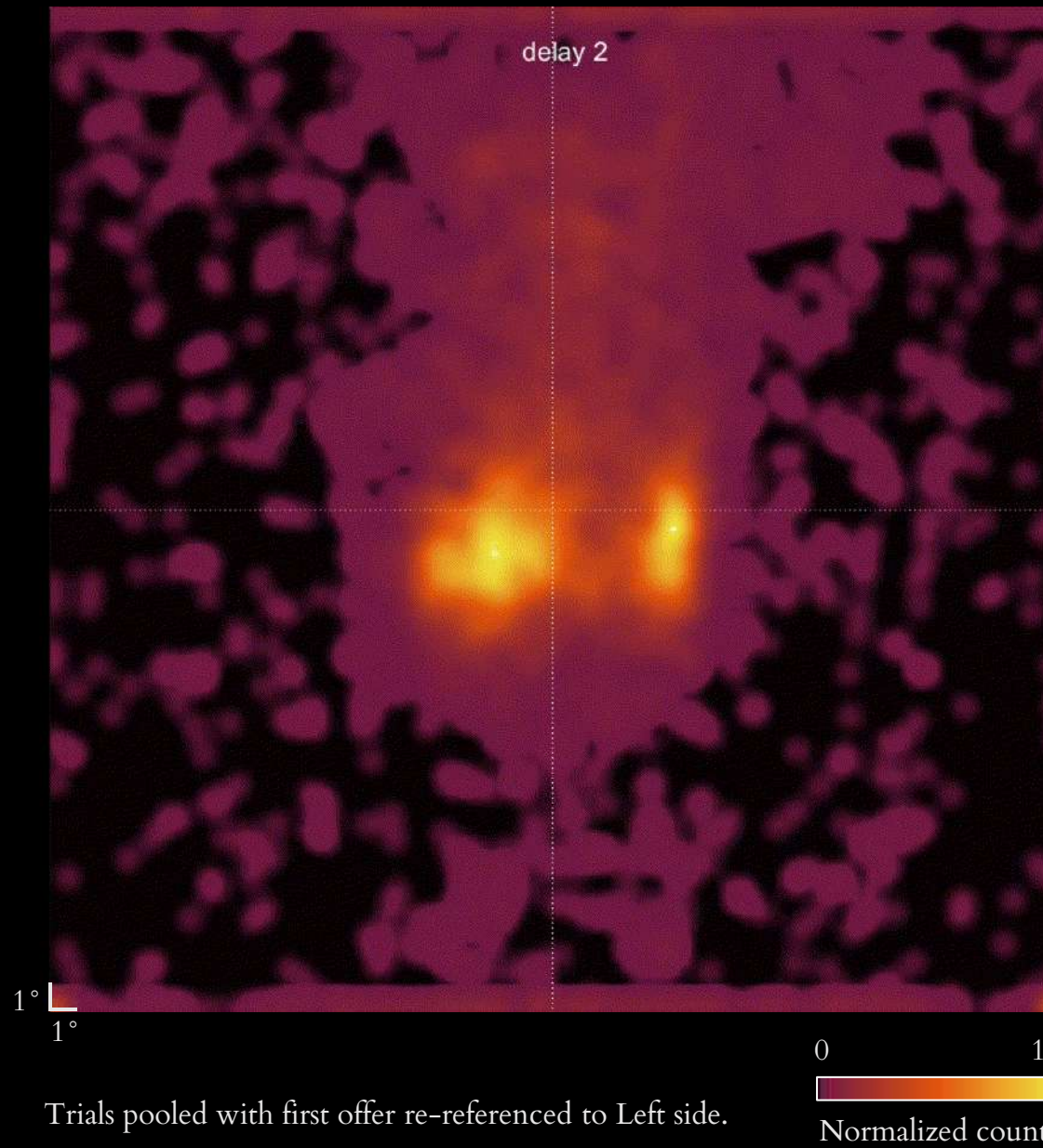
Eye movements during task execution



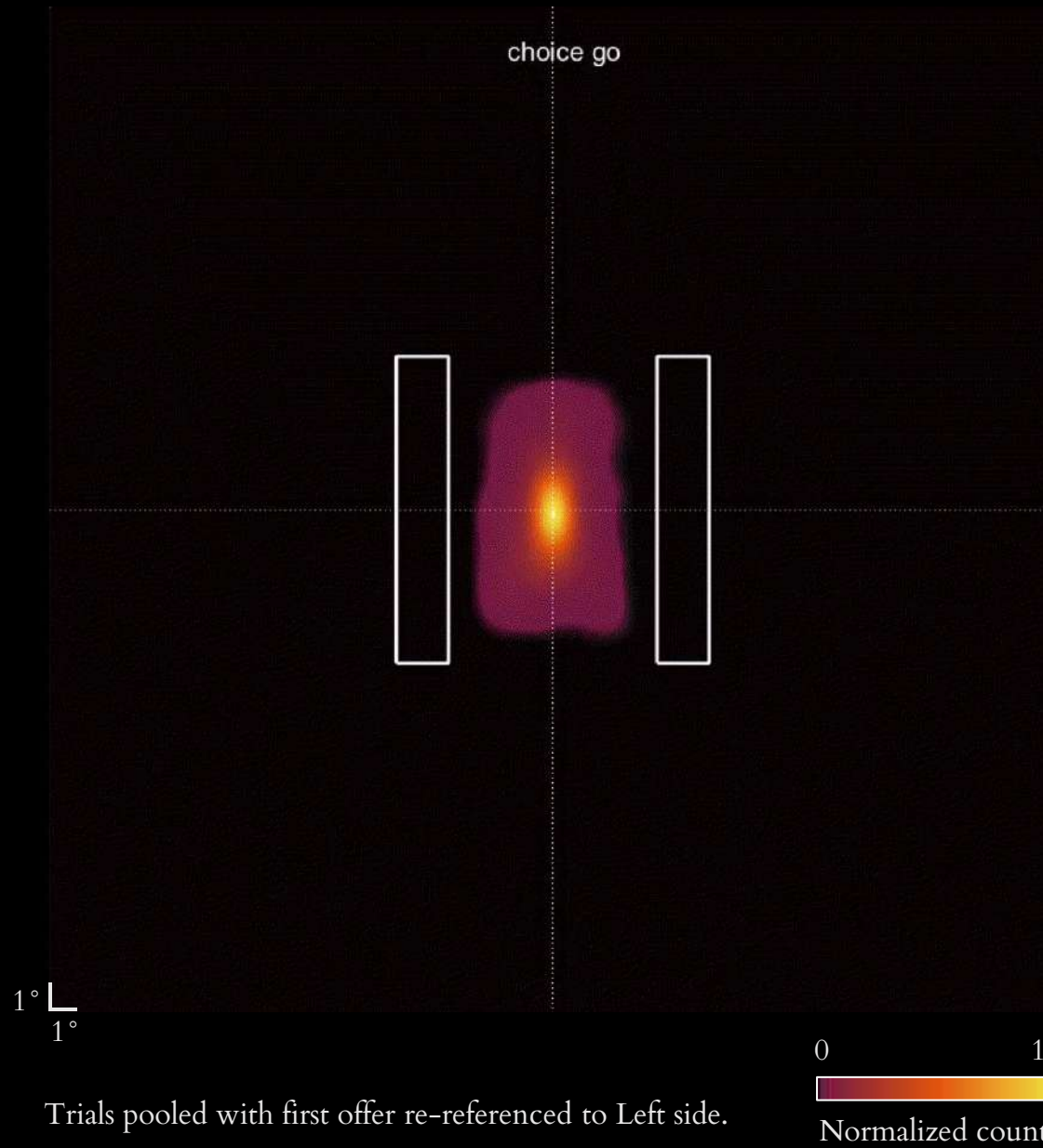
Eye movements during task execution

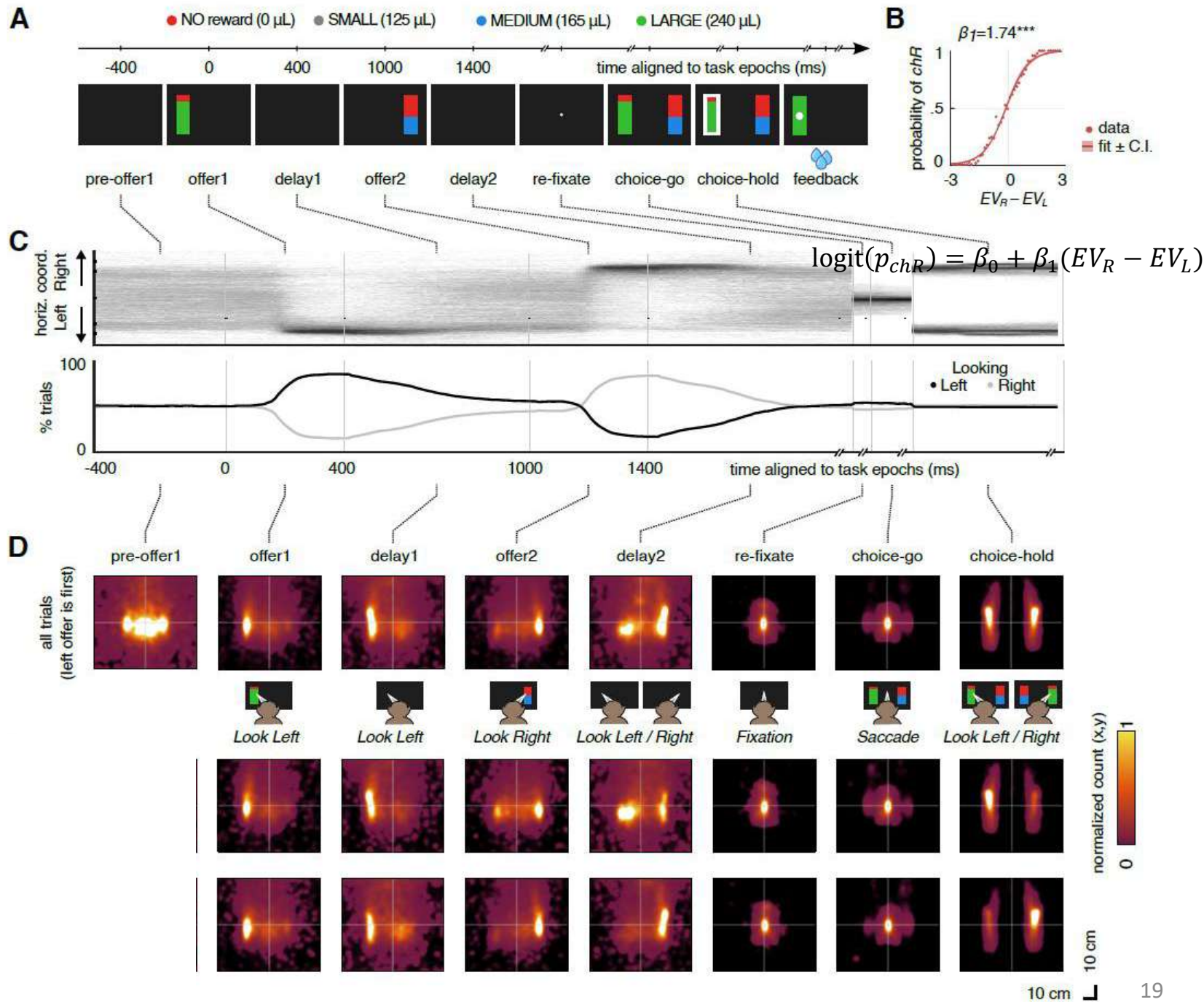


Eye movements during task execution



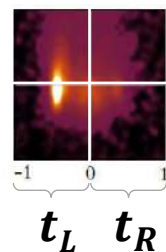
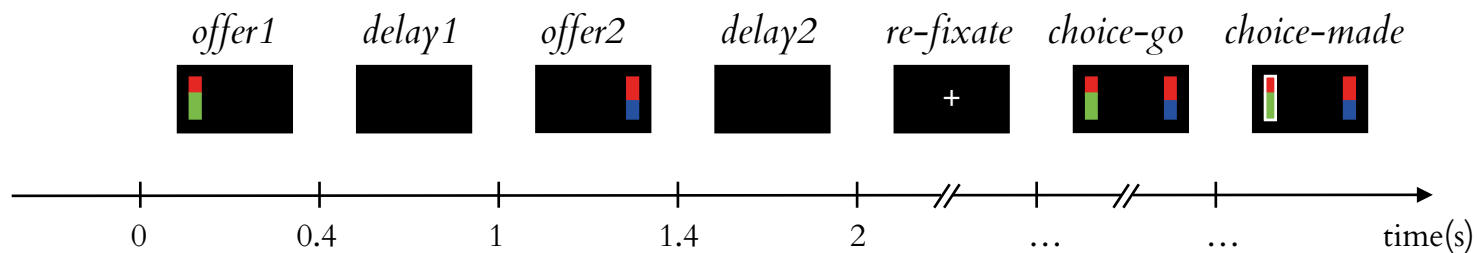
Eye movements during task execution





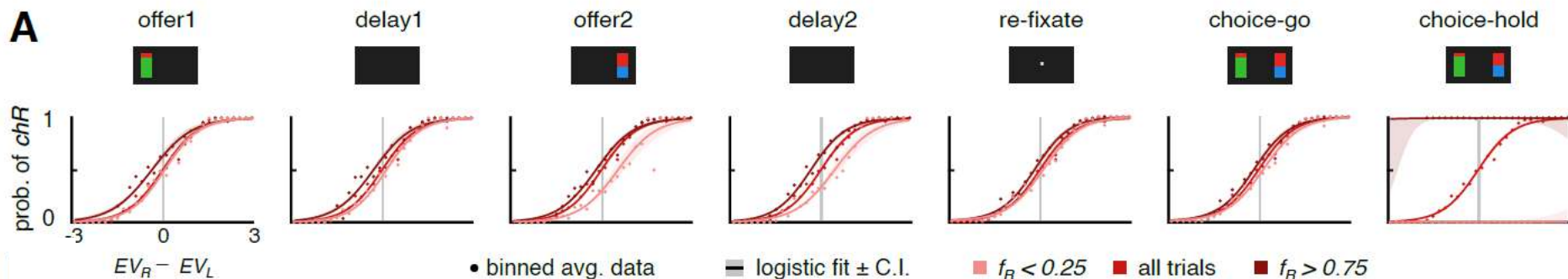
Motivations

- Is the gaze position relevant for the reward gambling task execution?
 - Let us look how the time spent looking to either screen side affects the choice



$$f_R = \frac{t_R}{t_R + t_L}$$

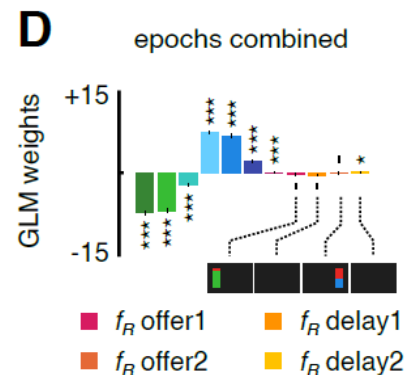
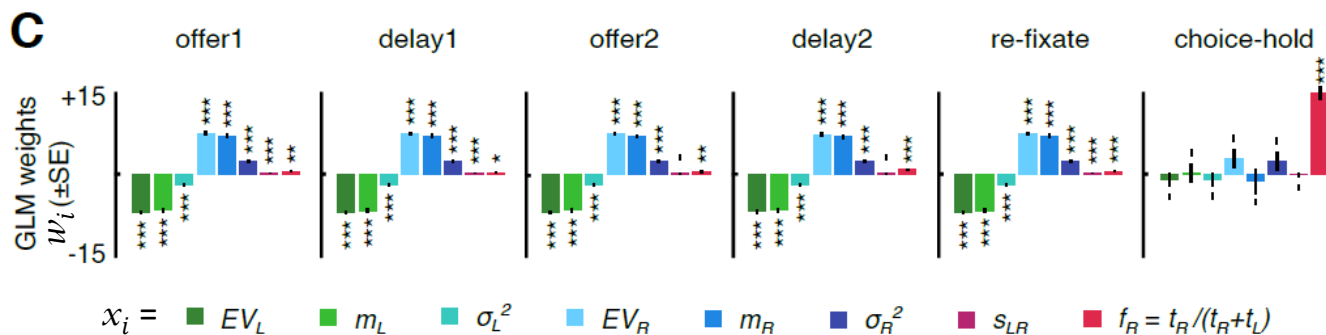
Fraction of time spent looking at the Right screen side



Generalized Linear Model (GLM) for behavioral choice

p_{chR} = probability of *chR*

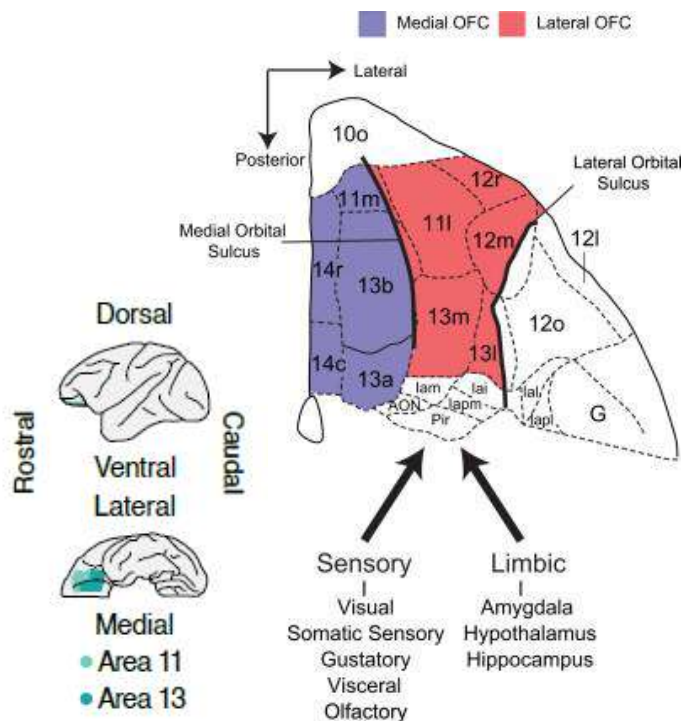
$$\text{logit}(p_{chR}) \approx w_0 + \sum_i w_i x_i$$



Motivations

- Is the gaze position relevant for the reward gambling task execution?
- Can we use the gaze position as a marker of what is the subjects mentally picture during task execution? in particular, can we do so during delays?
 - Are task-relevant variables encoded by OFC cells?

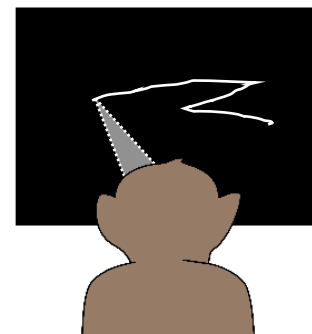
Neural Data



Carmichael, S.T., and Price, J.L. (1994).
Architectonic subdivision of the orbital and medial prefrontal cortex in the macaque monkey. J. Comp. Neurol. 346, 366–402.

Subject 1

area	session	#cells	# trials
BA13	12/07/17	51	643
BA13	12/08/17	59	700
BA11	12/09/17	24	697
BA11	12/10/17	29	603
Total		163	2643



Subject 2

area	session	#cells	# trials
BA11	3/06/19	18	1015
BA11	3/07/19	32	323
BA11	3/08/19	9	1084
BA11	3/11/19	26	906
total		85	3328

- 2 Subjects
- 8 Sessions
- 248 Cells

Data acquisition



Tyler Cash-Padgett, Maya Zhe Wang, Benjamin Hayden,
 Hayden Lab, Dept. of Neuroscience, Center for Magnetic Resonance Research,
 Center for Neuroengineering, University of Minnesota, Minneapolis, USA;



Two adult male rhesus macaques (macaca mulatta) served as experimental subjects. All procedures were approved by the University Committee on Animal Resources at the University of Rochester and at the University of Minnesota, conducted in compliance with the Public Health Service's Guide for the Care and Use of the Animals.

$$EV = \begin{matrix} \text{L} & \text{M} & \text{S} & 0 \\ \text{Reward magnitude} & * & \text{Reward probability} \end{matrix}$$

P(Reward)

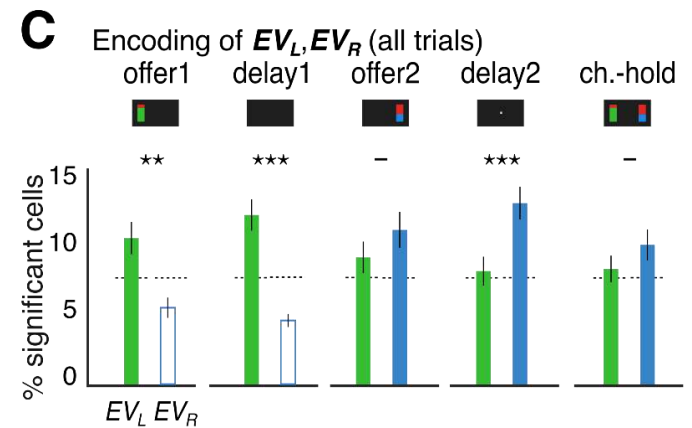
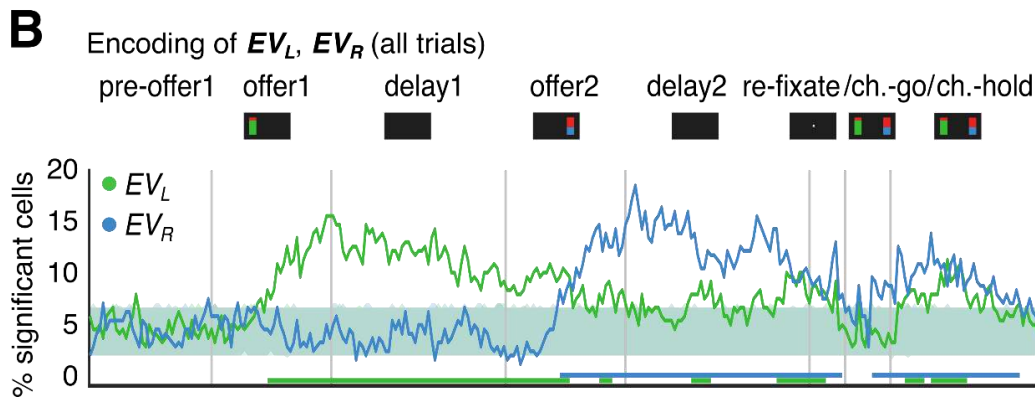
For each cell,

in each 10 ms bin:

$$\text{spike count } \eta = \beta_0 + \beta_1 EV$$

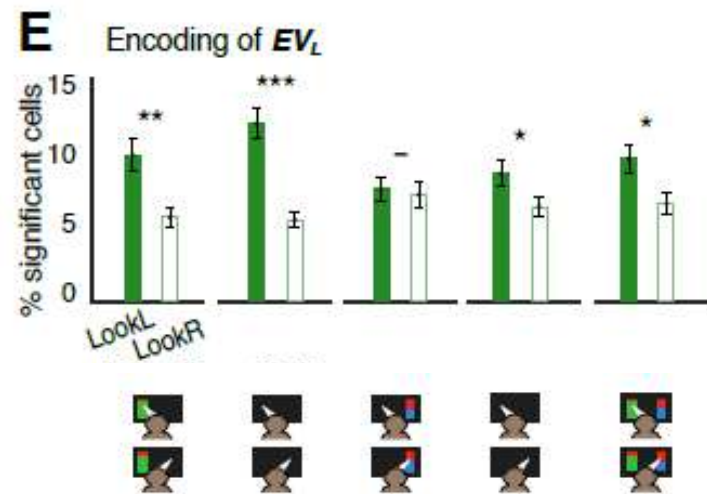
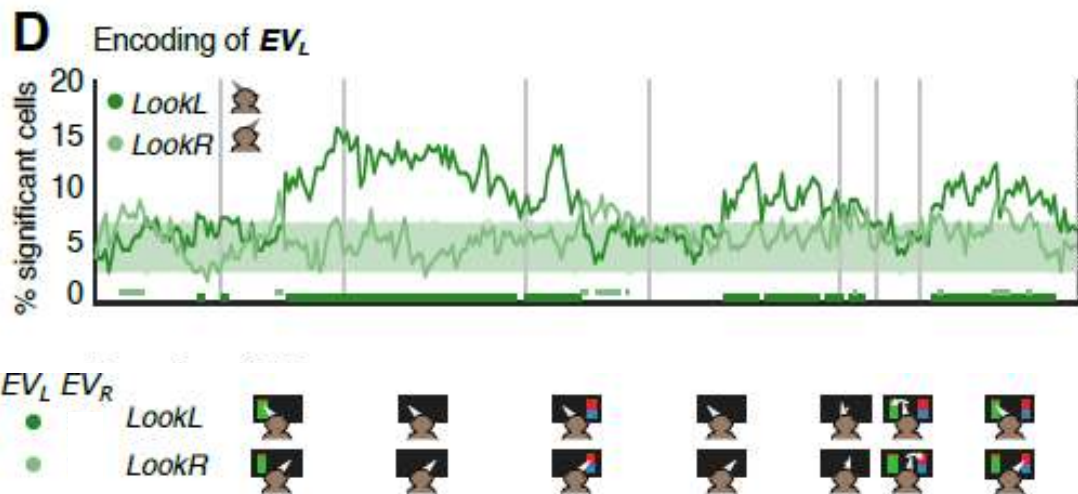
if $p < 0.05$ for β_1 , the cell is significantly encoding offer EV

(spike count starts at the start of current time bin and covers the following 200ms)



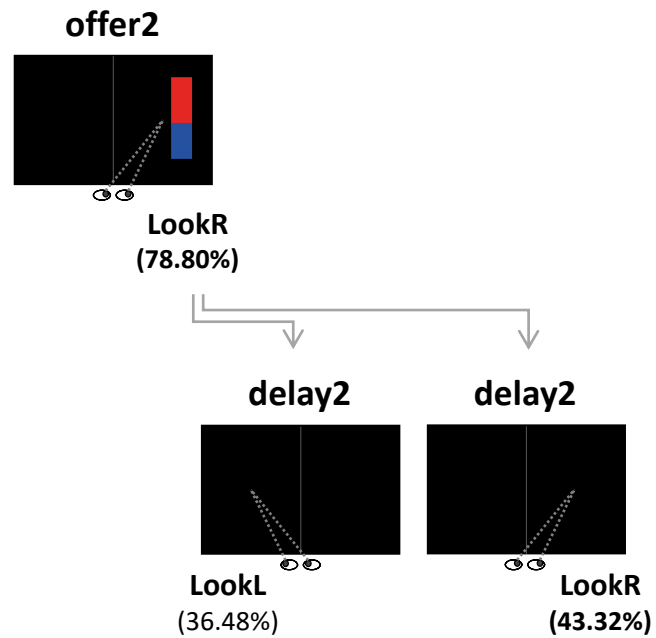
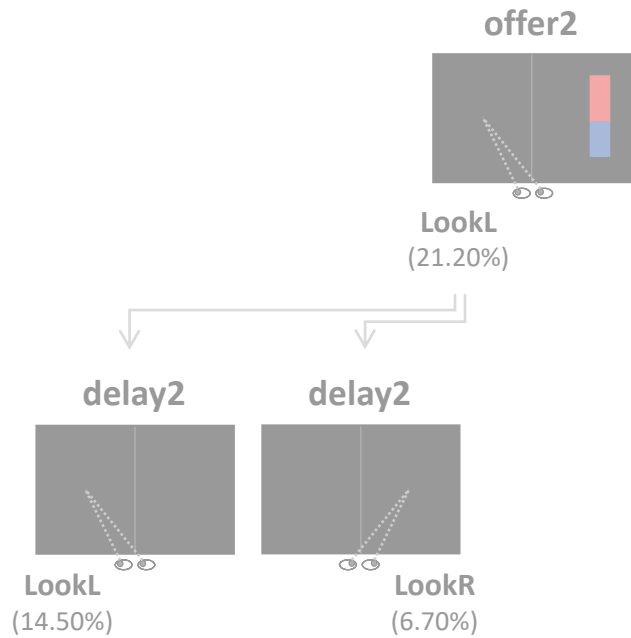
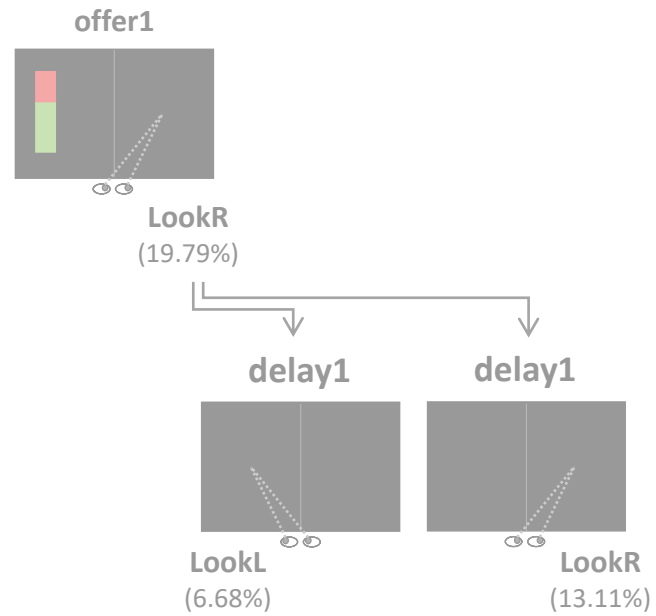
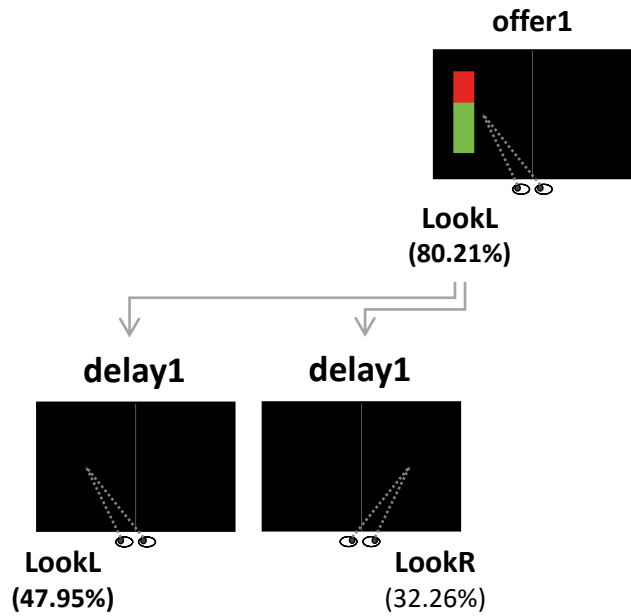
Motivations

- Is the gaze position relevant for the reward gambling task execution?
- Can we use the gaze position as a marker of what is the animal mentally picturing during task execution? in particular, can we do so during delays?
 - Are task-relevant variables encoded by OFC cells?
 - Is the gaze position relevant in the neural process of encoding the offer values?



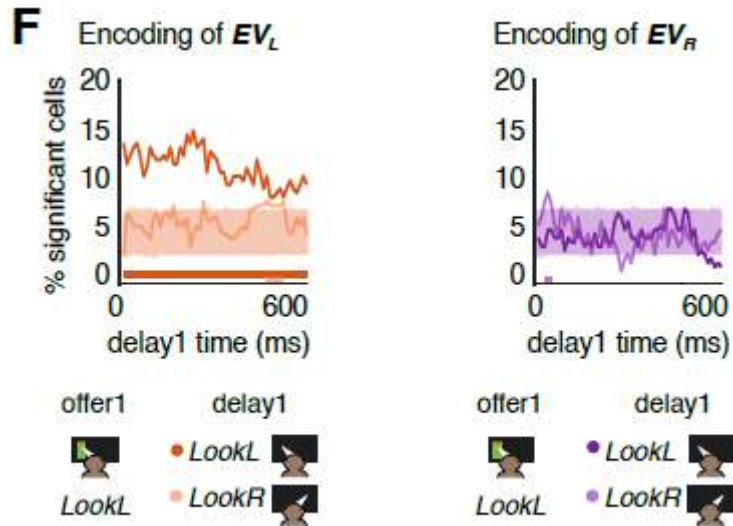
Motivations

- Is the gaze position relevant for the reward gambling task execution?
- Can we use the gaze position as a marker of what is the animal mentally picturing during task execution? in particular, can we do so during delays?
 - Are task-relevant variables encoded by OFC cells?
 - Is the gaze position relevant in the neural process of encoding the offer values?
 - What about encoding of values at delay time?



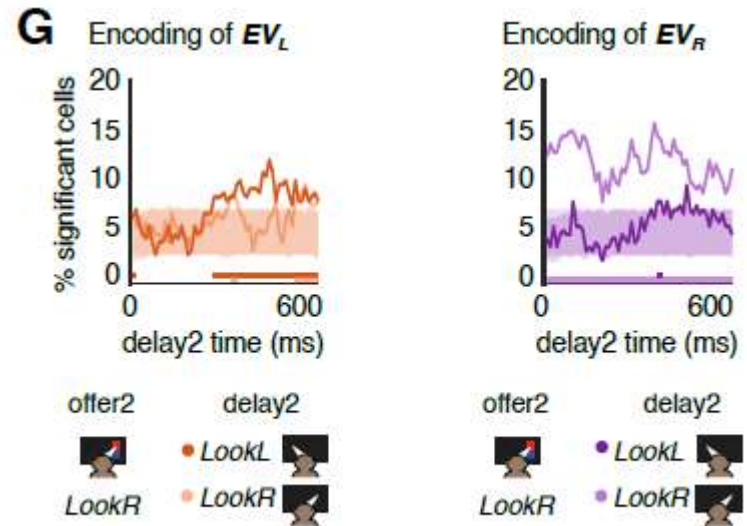
Let us consider the most frequent cases

**Offer 1 Look Left
Delay 1**



<i>offer1 LookL and delay1 LookL</i>	47.95%
<i>offer1 LookL and delay1 LookR</i>	32.26%
<i>offer1 LookR and delay1 LookL</i>	6.68%
<i>offer1 LookR and delay1 LookR</i>	13.11%

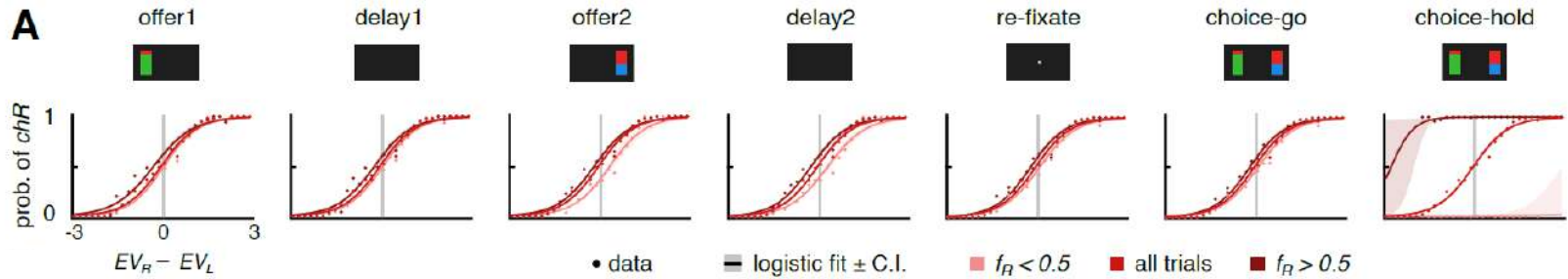
**Offer 2 Look Right
Delay 2**



<i>offer2 LookL and delay2 LookL</i>	14.50%
<i>offer2 LookL and delay2 LookR</i>	6.70%
<i>offer2 LookR and delay2 LookL</i>	36.48%
<i>offer2 LookR and delay2 LookR</i>	42.32%

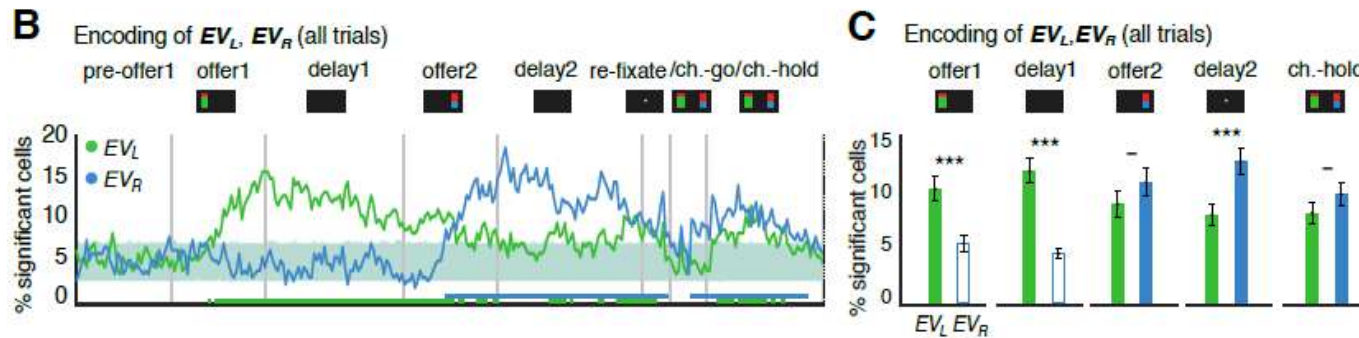
Conclusions

- The gaze position has a significant role in the reward gambling task execution: the fraction of time spent at either screen side is predictive of the chosen side;



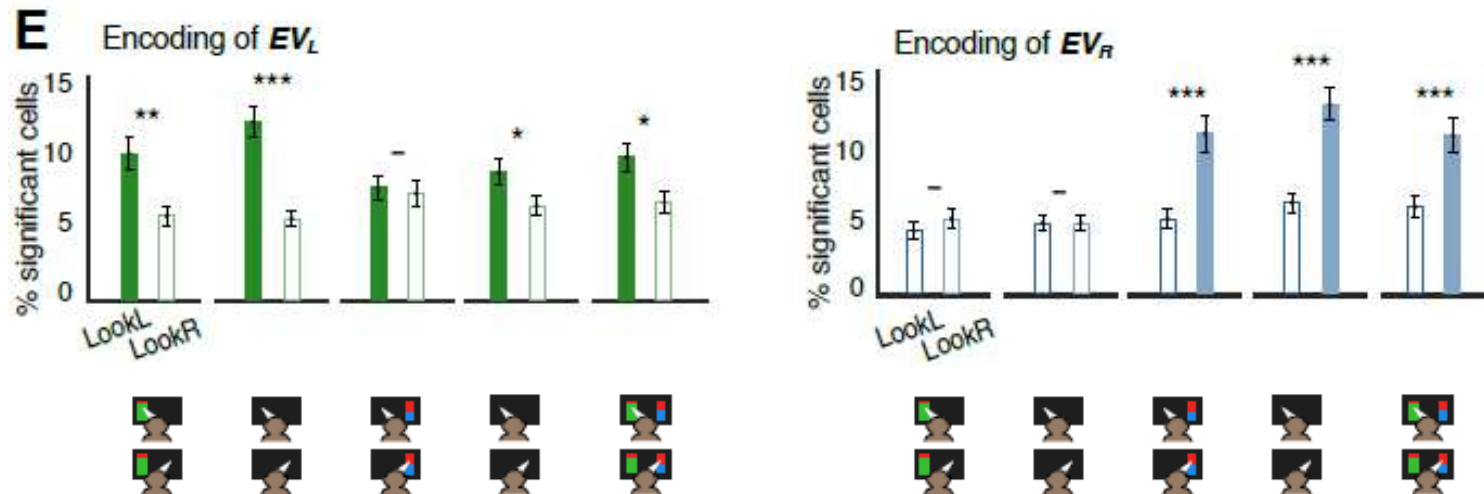
Conclusions

- The gaze position has a significant role in the reward gambling task execution: the fraction of time spent at either screen side is predictive of the chosen side;
- Task-relevant variables are encoded by a significant fraction of OFC cells, including the fraction of time spent inspecting either screen side;



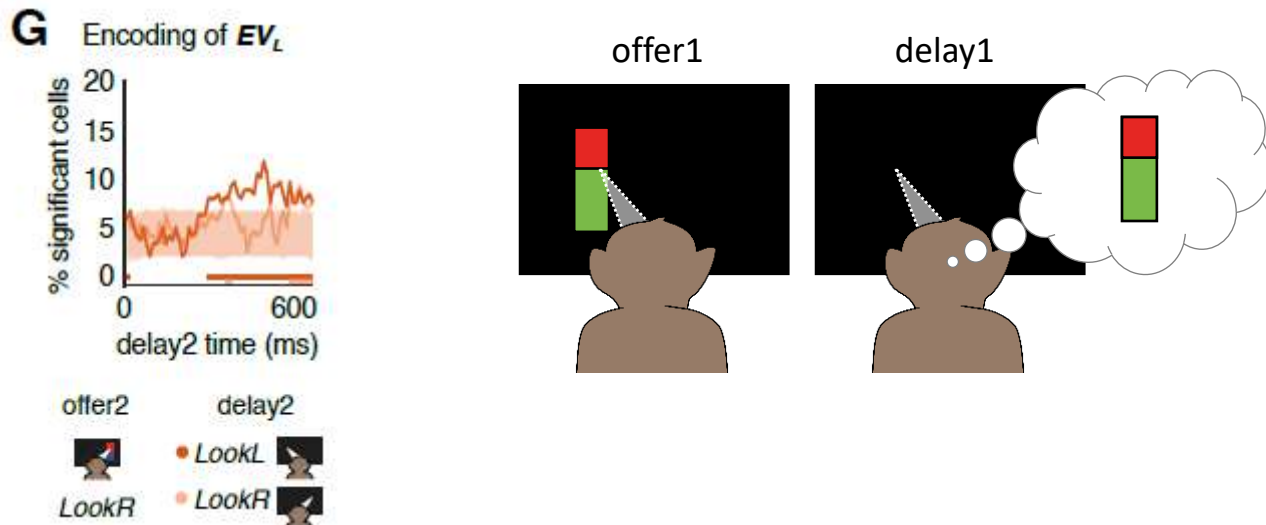
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- Task-relevant variables are encoded by a significant fraction of OFC cells, including the fraction of time spent inspecting either screen side;
- The gaze position is relevant in the process of encoding offer values: looking at either side possibly yields stronger coding of the ipsi-later offer EV.



Conclusions

- The gaze position has a significant role in the reward gambling task execution: the fraction of time spent at either screen side is predictive of the chosen side;
- Task-relevant variables are encoded by a significant fraction of OFC cells, including the fraction of time spent inspecting either screen side;
- The gaze position is relevant in the process of encoding offer values: looking at either side possibly yields stronger coding of the ipsi-later offer EV.
- During delays, looking back to earlier presentation sites exclusively re-activates the neural encoding of ipsilateral EV.



D. Ferro, T. Cash-Padgett, M. Zhe Wang, B. Hayden, R. Moreno Bote,
Gaze-centered gating and re-activation of value encoding in orbitofrontal cortex
bioRxiv, April 2023.



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TCN Lab

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Fundings



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Human Brain Project



Thank you for your attention.