Abstract:

In economic decision-making, alternative options are often evaluated sequentially before a final choice is made. However, models of neuroeconomics generally do not exploit the rich, dynamic nature of the evaluation process, overlooking important simultaneous indicators like eye gaze behavior. In this project we used neural and eye gaze data from two male macaque subjects trained to perform a value-based decision-making task in which two risky choices were sequentially presented at opposite sides of the visual screen. Each offer was followed by a delay during which the offer visual cues were no longer visible. Strikingly, during such delay intervals, the subjects tended to fixate on the empty locations where the offers had been previously displayed, with longer fixation durations increasing the likelihood of selecting the corresponding option. While this tendency was previously only approached at the behavioral level, we extended the investigation of its effects on the simultaneous offer value encoding at the neural level in the orbitofrontal cortex (OFC). We found that gazing at given screen side corresponds to the dynamical gating of the gaze-centered offer value encoding at the neural level. Intriguingly, a reactivation of such gaze-centered value encoding was also found during delay times when the gaze reached back to the side of the offer previously displayed - though empty at delay time -, even if it was not the most recent. This reactivation suggests a process of gaze-centered neural evaluation, with neural activity fluctuations correlating with the choice preference of the subjects.

Background

Value-based decisions require the comparison of alternative options, based on sensory evidence, and on subjective evaluations[1]. While initial models of decision-making behavior typically assumed – often implicitly – that the cognitive processes involved could rely on unlimited resources[2], it has become clear that finite-size constraints and that subjective cognitive biases play a crucial role in decision-making[3,4].

Two primary competing theories propose different ways in which decisions are formed in the brain. One view posits that evidence for alternatives is accumulated in parallel across multiple partially overlapping processing streams[5,6]. This theory stems from findings in perceptual decision-making tasks, where evidence for competing options can be integrated concurrently, and potential motor responses are prepared in parallel, particularly in fixed gaze tasks, with two[7] or more[8] alternatives. In contrast, the second theory suggests that evidence accumulation mainly occurs for one of the options at a time, thus the evaluating them in sequence[9]. This latter view is supported by studies of the relationship between fixation patterns and choices suggesting that the evaluated alternative tends to be the one currently fixated or attentionally active, and that such alternative is dominantly represented at the neural level during decision-making[10–12].

Research in the field of neurophysiology has made significant strides, suggesting that the orbitofrontal cortex (OFC), the ventromedial prefrontal cortex (vmPFC), the dorsal anterior

cingulate cortex (dACC), and the ventral striatum (VS) are functionally involved in decision-making[13–18]. These results are also supported by evidence from brain lesion studies[19–21]. While different studies point to some degree of functional specialization within these areas, their exact roles and their mechanistic interplay remain subject of debate[17].

The idea that evaluation is serial is supported by studies of the relationship between fixation patterns and choices[10,22]. Evidence from neural studies is consistent with the idea that the core value regions, vmPFC, OFC, and VS encode the value of the single attended option[23–26]. Among most relevant previous works, one study has shown that OFC neurons encoide the value of fixated options, while the anterior cingulate cortex (ACC) encodes the value of options that have not been fixated, located in peripheral vision[27]. Interestingly, another study in OFC revealed that ensembles of neurons alternate between encoding only one of the two available options rather than encoding both at the same time[28]. Notably, in this study, the encoding was not combined with the eye gaze position on the screen, but assumed that the locus of attention could determine which option is evaluated. This is highly indicative since the role of eye gaze has been linked to focal attention for covert evaluation processes emerging through value-based learning[11,26]. More direct evidence supporting the role of gaze comes from more recent studies showing that the value of offers encoded by OFC neurons is modulated by spatial gaze proximity to the offer[23], emphasizing the potential influence of gaze in the evaluation process. Taken together, these studies suggest a sequential evaluation process in the OFC. However, it remains unclear whether this sequential processing results from continuous visual input as the eyes move, or if it reflects another underlying mechanism. Thanks to the availability of rich data including both eye gaze data and neural spiking recordings, this project specifically targeted the study of eye gaze as a potential influence on decision-making and evaluation processes.

To tackle our main questions about whether evaluation is influenced by gaze, and if it follows a parallel or sequential neural encoding, we employed an experimental framework where gaze can be decoupled from the evaluation and encoding of offers throughout the task. We resorted to the "look-at-nothing" effect[29–31], a visuomotor tendency to fixate on locations where previously relevant stimuli were presented, even when the stimuli are no longer visible. One interpretation of this behavior is that individuals look at empty locations to aid in memory retrieval and imagination, thereby reassessing the mental image of previously presented offer or of its value, in turn supporting choice computation. Our investigations were directly targeted at the identification of value encoding in OFC and whether gaze position could mediate enhancement of encoding strength, with particular focus on task epochs where we found look-at-nothing behavior, as we found this was particularly relevant to investigate the role of gaze for cognitive decision-making computations in absence of visual input. We studied data from two monkey subjects and developed new theoretical models to track the encoding of two alternative offer values in OFC, revealing that gaze has an important role for offer evaluation in this brain area. We used a paradigm where offers were presented in sequence, followed by empty screen delay times, where we could detect the look-at-nothing tendency. By aligning neural data to the time where subjects shifted their gaze towards the location of visible (during offer presentation epochs) or no longer visible offers (during empty screen delay epochs), we reported time-locked increases in gaze-centered value encoding, showing that gaze has an important role in activating value encoding, and in reactivating it when gaze reaches back to the location of an initially encoded option, even when the encoding of the alternative option is activated in the between the two gaze fixation epochs. Our investigations also focused on the overlap between neural populations encoding the two options, to address whether the value of multiple options could be

encoded by the same cells, revealing that most cells encoding each option do so in alternation, in line with the sequential encoding of options hypothesis. Lastly, we investigated the tuning properties of cells encoding offer value, revealing that gaze-centered offer encoding also aligns with choice preference, in a way that increased encoding strength mediated by gaze favors decision for the corresponding offer.

Aims

Based on recent advances in the field of neural economic evaluation[9,23,26,28,32,33], this project primarily targeted the following research questions: (i) When and how is offer value encoded in orbitofrontal cortex and how is it related to gaze behavior? (ii) Are neural cells in OFC encoding the value of only one alternative option at a time or does the encoding occur simultaneously across neural populations? (iii) How does eye gaze and value encoding impact the final choice?

Methods

Experimental Procedures and Neural Recordings
Experiments were conducted at the University of Minnesota and of Rochester by Prof. B. Hayden and members of his research group. All procedures were approved by the University Committee on Animal Resources at the University of Rochester and at the University of Minnesota and were designed and conducted in compliance with the Guide for the Care and Use of Animals of the Public Health Service. Two male rhesus macaques (*Macaca mulatta*) served as subjects. Recorded brain areas are Brodmann Areas 11 (*BA11*) and 13 (*BA13*), covering OFC and using V-probes. Data include *n=5971* trials correctly performed (*n=2986* in subject 1, *n=2985* in subject 2) and at least n=248 cells (*n=163* in subject 1, *n=85* in subject 2). The data include an average of 746.38±87.29 (mean ± s.e.m.) trials and 31±5.85 (mean ± s.e.m.) cells per session.

Behavioral Task
The task consisted of the sequential presentation of two visual stimuli at the two sides of the screen, prompting to gamble between two alternative probabilistic rewards to be chosen by saccading and holding fixation on target location[24,34]. The task starts with a first offer presentation (*offer 1*, 400 ms), followed by a first empty screen delay (*delay 1*, 600 ms); the same timings are used for a subsequent, second offer presentation (*offer 2*), respectively followed by a second, empty screen delay time (*delay 2*). After fixating a central cross (*re-fixate*), for at least 100 ms, the choice could be indicated by the animal after the *choice-go* cue, which consisted of the simultaneous presentation of both offer stimuli in the same locations where they were previously shown. Choice was reported by shifting gaze to either offer location, and holding fixation on it for at least 200 ms (*choice-hold*). The trial follows with the gamble outcome resolution, consisting in the reward delivery for a successful outcome and lack of thereof for an unsuccessful outcome. Subjects were left free to direct their gaze during all time during task execution.

The first offer presentation site was randomized so that the it could be presented with equal probability to either side of the screen and the second was presented on the opposite side. The stimuli consisted in two vertical bars whose color indicated the probabilistic reward magnitude m, and whose height indicated the probability p to achieve such reward. The bar stimuli were split in two colored portions such that the color of the bottom part indicated reward magnitude (gray: small, 125μL; blue: medium,165μL; green: large, 240μL), the height indicated successful gamble probability p, whereas the top portion (in red) indicated the complementary probability $1 - p$ of unsuccessful gamble outcome. We defined the expected value of an offer as

the product of its probability times its magnitude: $EV = mp$. Offers with small rewards (125μL) were always be sure, $p = 1$ (safe option). Reward probabilities were randomly and independently drawn from a uniform distribution in the [0,1] interval. Reward magnitudes (small, medium, or large) of the first and second offer were randomized across trials. Throughout task execution, eye movements were recorded by an infrared camera system (SR Research) and sampled at 1000 Hz. We considered gaze patterns to be mostly interesting during the delay periods, since there was no visual stimuli, in these epochs the evaluation process could be decoupled by the sensory input processing, also considering that the fraction of time looking right or left during the second empty screen delay epoch (*delay 2*) correlated with the probability of choosing the looked side option.

Behavioral Data Analysis

We will used logistic regression models $\text{logit}(chR) = \beta_0 + \beta_1(EV_R - EV_L)$ to predict choices ($chR = 1$ if chosen offer is on Right side; $chR = 0$ if chosen offer is on the Left side) based on the expected value difference $EV_R - EV_L$ in each task epoch. Within each task-related time epoch and in each trial we computed the fraction of time looking at the right screen side, $f_R = t_R/(t_R + t_L)$, where t_R is the total time within the trial that the animal spends looking at the right screen side, and t_L is the total time looking at left screen side. Using this regressor, along with the expected values and others, we predicted choice through the 'logistic model of the choice' $\text{logit}(chR) = w_0 + w_1 EV_L + w_2 m_L + w_3 EV_R + w_4 m_R + w_5 \sigma_L^2 + w_6 \sigma_R^2 + w_7 s_{LR} + w_8 f_R$, with the regressors: expected value of left and right offers EV_L and EV_R, computed as $EV = mp$; variance of left/right offers, σ_L^2 and σ_R^2, computed as $\sigma^2 = mp\,(1-p)$; order of offers presentation s_{LR} (+1 if first offer is left, −1 first offer is right); and fraction of time looking at right screen side $f_R = t_R/(t_R + t_L)$. Significance in all behavioral and neural analyses (see below) was based on *F*-statistics tests on the magnitude of the regression weights $w_i, i = 1,..,8$, testing the hypothesis that the full model gives a significant advantange in terms of explained variance with respect to an alternative model where the *i*-th regressor is omitted.

Neuronal Data Analysis

For each recorded cell, we will compute the spike count η in a time window of 200 ms, slided in steps of 10 ms within every task-related epoch. The spike count per neuron and per time window is fit to the linear model $\eta = \beta_0 + \beta_1 EV$, where EV is either the expected value of the left offer EV_L, or the expected value of right offer EV_R. The above cell-by-cell time-resolved analysis is performed using three different set of trials based on the average gaze position within each time bin: (1) '*LookL*' using only trials where the animal mainly looked at the left side of the screen in that time bin (average gaze position within that time bin lower than zero: average < 0), (2) '*LookR*' using only trials where the animal mainly looked at the right side (average > 0), and (3) using all trials, that is, neglecting where the animal is looking at within that time bin. The sets of trials (1) '*LookL*' and (2) '*LookR*' allowed us to study the modulatory effect of gaze on the encoding of the value of the offers by distinguishing trials where subjects mainly *'Look Left'* from trials where subjects mainly *'Look Right'* in each bin, respectively. To control for multiple comparisons in the per-bin analysis described above, we will perform a cluster-based run-length analysis[27,34]. As expected, we found that gazing to the left side of the screen enhanced encoding of EV_L, and viceversa for right screen side. These results were also found during the delay epochs where stimuli are absent. In addition, we run these analyses by time-locking the neural data to the time when gaze was shifted towards left/right side of the screen, revealing that significant neural encoding of the offer EV followed shifts of the gaze over the respective offer side.

Given the interest in combining multiple factors, i.e., reward magnitude, EV and risk, we tested multiple models to assess the best definition of value used by the subjects to perform the choice. To do so, we predicted the choice of subjects by testing multiple logistic models: (1) $logit(chR) = w_0 + w_1 p_L + w_2 m_L + w_3 EV_L + w_4 \sigma_L^2 + w_5 p_R + w_6 m_R + w_7 EV_R + w_8 \sigma_R^2$; (2) $logit(chR) = w_0 + w_1 m_L + w_2 EV_L + w_3 \sigma_L^2 + w_4 m_R + w_5 EV_R + w_6 \sigma_R^2$; (3) $logit(chR) = w_0 + w_1 EV_L + w_2 \sigma_L^2 + w_3 EV_R + w_4 \sigma_R^2$; (4) $logit(chR) = w_0 + w_1 EV_L + w_2 EV_R$, and found that model (2) relies significantly higher decoding accuracy (87.74±0.59%) compared to other models (1: 86.98±0.62%; 3: 83.14±0.65% 4: 75.43±0.71%, cross-validated over k=4 subsets[34]). This guided us to define the 'Subjective Value' of the offers as $SV = w_1 m_L + w_2 EV_L + w_3 \sigma_L^2$, that we used in a full linear model of firing rate regression: $\eta = \beta_0' + \beta_1' SV_L + \beta_2' SV_R + \beta_3' ch$, where ch is a choice variable ($ch = +1$ if choice is right, -1 if left). With this model we showed that considering further factors in value encoding yields enhanced encoding strength, and replicates all gaze-centered activation and re-activation results. In addtion, in this model we also included a choice regressor, to show that choice formation significantly starts at *delay 2* epoch, and is strongest at *choice-hold* time. Finally, we performed a Receiver Operator Charachteristics (ROC) analysis where we predicted the subject's choices by using the regressions residuals of the model $\eta = \beta_0' + \beta_1' SV_L + \beta_2' SV_R$, as in the previous model but omitting the choice variable, to show that choice-related neural tuning properties align with value encoding tuning[34].

Results

The effect of eye gaze behavior on task performance
Subjects most often chose the offer with the higher EV (subject 1: 72.19%; subject 2: 75.72%), and their gaze most always followed the locations of the offers, especially during their presentation. Notably, during delay epochs, the 'look-at-nothing' effect emerged, with subjects tending to gaze at the locations where the offers were previously displayed. This occurred irrespective of the first offer's position and was more pronounced towards the location of offers with best EV, in a way that longer fixations also coincided with higher probability of choice. By comparing the influence of task variables EV, m, σ^2, s_{LR} and f_R in different task epochs via the logistic model of the choice, we found that EV, m and σ^2 have the strongest impact, and that the impact of f_R is always significant, more prominent at *delay 2*. These results showed that the gaze has an important role in choice behavior, even when factoring out the influence of other task variables, and even when the screen is empty.

The effect of gaze behavior on the neural encoding of value
The core of this project was to investigate how gaze direction influences the encoding of offer values in the OFC of macaque subjects performing a visually cued, two-alternative forced choice task. We found that during the presentation of the first offer, neurons significantly encoded its value, and as the second offer was presented, the value of the second offer was significantly encoded. Importantly, the encoding of both offers decreased during delays imminently after the respective offer presentation, with the first offer decay temporally coinciding with the onset of second offer encoding. By combining the neural encoding analysis with gaze data, we found the important result that neural cells in OFC encoded the value of offers when the subjects gazed at their respective screen side, corroborating results from previous gaze-centered encoding studies.

By aligning neural encoding analyses to the timing of gaze shifts, we could further detail that during offer presentation epochs the neural encoding started to ramp up and reached significant levels only after the respective offer was visually reached, while the encoding of the alternative (non-gazed) offer did not reach significant levels. During delay epochs, we observed

that if subjects kept gazing at the offer displayed during the imminently preceding offer epoch, the encoding of such offer value was maintained steady during the delay epoch. Conversely, if the subjects switched their gaze away from the most recently presented offer, the encoding of its value would decay to non-significant levels. Strikingly, we also found that if during the delay 2 subjects gazed back at the location of the first offer, its value encoding would be significantly reactivated, thus suggesting a reevaluation of the first offer since it was not the most recent.

To tackle questions about the sequential nature of value encoding in OFC, we found a significant correlation between the encoding weights of neurons encoding the value of the two offers in their respective presentation times ($\rho = 0.84$, $p < 0.001$), and that 1/3 of the neurons asynchronously encoded the two offers in the two epochs. This result revealed that 2/3 of the cells tend to encode one offer at a time, but there is a fraction of cells that significantly encode the two offers in parallel. Similar considerations could be made when considering the encoding of the first offer during its presentation, and its reactivation during *delay 2*. We found a significant correlation between the neural encoding weights for the first offer when subjects looked at its location and when they looked at its empty location during *delay 2* (offer 1: $\rho = 0.55$, $p < 0.001$), and that approximately 1/5 of cells asynchronously encode the value of the offer both during the initial presentation and during reactivation. Conversely, when subjects looked at the opposite location during delay 2, encoding weights for the two offers were either negatively correlated or not significantly correlated (offer 1: $\rho = -0.21$, $p < 0.001$; offer 2: $\rho = -0.12$, n.s.), coinciding with low or non-significant encoding of the respective value of offers.

The effect of gaze behavior on the neural encoding of choice

In this analysis we considered the definition of Subjective Value (SV), i.e., an aggregate measure of the offer magnitude, EV, and risk, defined as a weighted sum of the three variables. By extending the previous neural encoding model, we regressed the spike rate to regress the two SVs in the model: $\eta = \beta_0' + \beta_1' SV_L + \beta_2' SV_R$ and examined residual fluctuations in neural activity during reactivation in *delay 2* to assess whether these fluctuations correlated with the subject's choice. We found that positive residual fluctuations during reactivation in neurons with positive tuning to the SV of the first offer were associated with a higher probability of choosing the first offer. This suggests that increased neural activity represents a more accurate or updated estimate of the subjective value of the first offer. From this, we designed the Choice Probability (CP) analysis, consisting in predicting the choice of the subjects based on the neural residual fluctuations of the firing rate model (equivalent to ROC analysis). We found that the CP was significantly greater than 0.5 for cells positively tuned to the SV of the left offer during left-gaze trials (n = 205 cells, CP median = 0.56, $p = 1.44 \times 10^{-41}$, one-tailed Wilcoxon signed-rank test), indicating that neural fluctuations during reactivation were predictive of the choice. In contrast, for cells positively tuned to the SV of the right offer, CP was significantly lower than 0.5 during reactivation, suggesting that increased activity in these cells predicted a preference for the right offer (n = 212 cells, CP median = 0.44, $p = 1.08 \times 10^{-48}$, one-tailed Wilcoxon signed-rank test). Lastly, an independent analysis of trial-averaged residuals supported the finding that reactivation during the look-at-nothing period plays a role in reevaluation, with significantly larger residuals for the preferred choice during left-gaze trials for neurons tuned to the subjective value of the left offer ($p = 0.0155$, one-tailed paired Wilcoxon signed-rank test). However, no significant effect was found during right-gaze trials ($p = 0.405$), which align with the previously observed patterns. Overall, these results suggest that the OFC not only encodes the value of offers during their presentation but also participates in ongoing reevaluation during the look-at-nothing period, where the neural activity reflects the updated subjective value that influences choice.

Conclusions

In an economic choice task with sequential offer presentation and unconstrained gaze, we found that gaze influences decision-making by reactivating neural responses related to previously presented offers. Gaze biases choice beyond the subjective value of visual stimuli, both when subjects look longer at presented offers, and when subjects "look-at-nothing", i.e., they direct their gaze at empty screen sides where offers were previously shown.

Our findings show that gaze reactivates the neural encoding of offer values, particularly in the orbitofrontal cortex (OFC). Specifically, gaze toward an empty screen side where an offer was presented reactivates its value encoding, and the reactivation correlates with choice, with overlapping neural populations involved in encoding and reactivating the value of offers. These results extend existing research showing that gaze plays an active role in decision-making by facilitating value encoding reactivation and reevaluation. Gaze shifts influence how the value of offers is encoded, supporting the idea that gaze acts as a spatial indexing mechanism for encoding maintenance or recollection. Furthermore, the reactivation of previously presented offers during look-at-nothing gaze is not just a simple retrospective memory trace, but also includes a prospective component, predicting upcoming choices.

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Published work resulting from the project supported with the present grant separated in abstracts (proceedings and meetings), full papers and contributions included in books:

Peer-reviewed papers:

2024 Gaze-centered gating, reactivation, and reevaluation of economic value in orbitofrontal cortex
D. Ferro, T. Cash-Padgett, M. Zhe-Wang, B.Y. Hayden, R. Moreno-Bote
Nature Communications, **15**:6163, 2024
DOI:10.1038/s41467-024-50214-2; Data and code: repository;

2023 <u>The role of gaze for value encoding and recollection in orbitofrontal cortex</u>
D Ferro, A Rifé Mata, T Cash-Padgett, M Zhe-Wang, BY Hayden, R Moreno-Bote
Conference on Cognitive Computational Neuroscience (CCN), Oxford (UK), 2023
DOI:<u>10.32470/CCN.2023.1122-0</u>;

Conference presentations (posters/talks)

2024 Talk: D. Ferro, *"Economic decision-making in the brain: how does gaze relate to the activity of orbitofrontal cortex neurons?"*, International Conference on Thinking (*ICT2024*), June 2024 (Milan, Italy).

2023 Poster: D. Ferro, A. Rifé-Mata, T. Cash-Padgett, M. Z. Wang, B. Y. Hayden, R. Moreno-Bote, *"The role of gaze for value encoding and recollection in orbitofrontal cortex"*, Conference on Cognitive Computational Neuroscience (*CCN*), August 2023 (Oxford, United Kingdom).

Talk: D. Ferro, *"Gaze-centered gating and re-activation of value encoding in orbitofrontal cortex"*, Human Brain Project Work Package 2 Meeting, June 2023 (Barcelona, ES)

Talk: Rubén Moreno-Bote, *"Gaze-centered gating and re-activation of value encoding in orbitofrontal cortex"*, Anatomy and function of the prefrontal cortex across species, Human Brain Project Workshop, March 2023 (Paris, France)

Poster: D. Ferro, A. Rifé-Mata, T. Cash-Padgett, M. Z. Wang, B. Y. Hayden, R. Moreno-Bote, *"Looking at previous cue sites reactivates value coding for serial evaluation in orbitofrontal cortex"*, Human Brain Project Summit 2023, March 2023 (Marseille, France)

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Final report

Table highlighting the differences between expected and achieved output indicators

Expected and achieved output indicators (number of actions)

Output indicators	Expected (according to application)	Achieved

PhD thesis	0	0
Master's thesis	0	0
Organization of seminar or conference	0	0
Book	0	0
Book chapter	0	0
Conference presentation	-	5 - <u>Talk</u>: D. Ferro, *"Economic decision-making in the brain: how does gaze relate to the activity of orbitofrontal cortex neurons?"*, International Conference on Thinking (*ICT2024*), June 2024 (Milan, Italy). <u>Poster</u>: D. Ferro, A. Rifé-Mata, T. Cash-Padgett, M. Z. Wang, B. Y. Hayden, R. Moreno-Bote, *"The role of gaze for value encoding and recollection in orbitofrontal cortex"*, Conference on Cognitive Computational Neuroscience (*CCN*), August 2023 (Oxford, United Kingdom). - <u>Talk</u>: D. Ferro, *"Gaze-centered gating and re-activation of value encoding in orbitofrontal cortex"*, Human Brain Project Work Package 2 Meeting, June 2023 (Barcelona, ES) - <u>Talk</u>: Rubén Moreno-Bote, *"Gaze-centered gating and re-activation of value encoding in orbitofrontal cortex"*, Anatomy and function of the prefrontal cortex across species, Human Brain Project Workshop, March 2023 (Paris, France) - <u>Poster</u>: D. Ferro, A. Rifé-Mata, T. Cash-Padgett, M. Z. Wang, B. Y. Hayden, R. Moreno-Bote, *"Looking at previous cue sites reactivates value coding for serial evaluation in orbitofrontal cortex"*, Human Brain Project Summit, March 2023 (Marseille, France)
Conference paper	0	1 <u>The role of gaze for value encoding and recollection in orbitofrontal cortex</u> D Ferro, A Rifé Mata, T Cash-Padgett, M Zhe-Wang, BY Hayden, R Moreno-Bote *Conference on Cognitive Computational Neuroscience (CCN)*, Oxford (UK), 2023 DOI:<u>10.32470/CCN.2023.1122-0</u>;
Journal article	1	1

		Gaze-centered gating, reactivation, and reevaluation of economic value in orbitofrontal cortex D. Ferro, T. Cash-Padgett, M. Zhe-Wang, B.Y. Hayden, R. Moreno-Bote *Nature Communications*, **15**:6163, 2024 DOI:10.1038/s41467-024-50214-2;
Other (specify)	-	Published in EBRAINS Knowledge Graph (HBP): Model of gaze-centered activation and reactivation of value encoding in orbitofrontal cortex D Ferro, B Y Hayden and R Moreno-Bote *Ebrains Knowledgegraph*, Human Brain Project, 2023. DOI: 10.12751/g-node.72yf9s

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List of publications

2024 Gaze-centered gating, reactivation, and reevaluation of economic value in orbitofrontal cortex
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Nature Communications, **15**:6163, 2024; DOI:10.1038/s41467-024-50214-2;

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