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Separable decoding of cue, intention, and movement information from the fronto-parietal grasping-network

B. Dann[1*], J.A. Michaels[1], H. Scherberger[1]
[1]*Deutsches Primatenzentrum GmbH, Neurobiology Lab, Göttingen, Germany*

*[1]Deutsches Primatenzentrum GmbH, Kellnerweg 4, 37077 Göttingen, Germany. E-mail: benjamin.dann@gmail.com

Introduction: Neurons in premotor and parietal cortex are known to represent a broad variety of different cognitive processes including visual, decision, intention, and movement signals. Recent experiments revealed that several cognitive features are mixed-coded within and between individual neurons, and can be studied by analyzing the neuronal population dynamics (Raposo et al., 2014). Furthermore, different cognitive features might be represented in different dimensions in the population code (Kaufman et al., 2014). Such a coding scheme allows a broad variety of information being present simultaneously in the same network as well as selective decoding of specific information with high reliability, provided the code is understood.

Material, Methods and Results: Here we investigated the processing of hand grasping in the fronto-parietal grasping network (areas F5 and AIP) in two macaque monkeys while performing two grip types (power or precision grip) either by visual instruction or by following a decision rule (Michaels et al., 2015). At the level of single trial population dynamics, we could disentangle visual information from intentional and movement information in this task. We estimated linear separation planes in the full neuronal state space of all neurons from each area in order to selectively extract the information (visual, intentional, and movement) of each category (Figure 1).

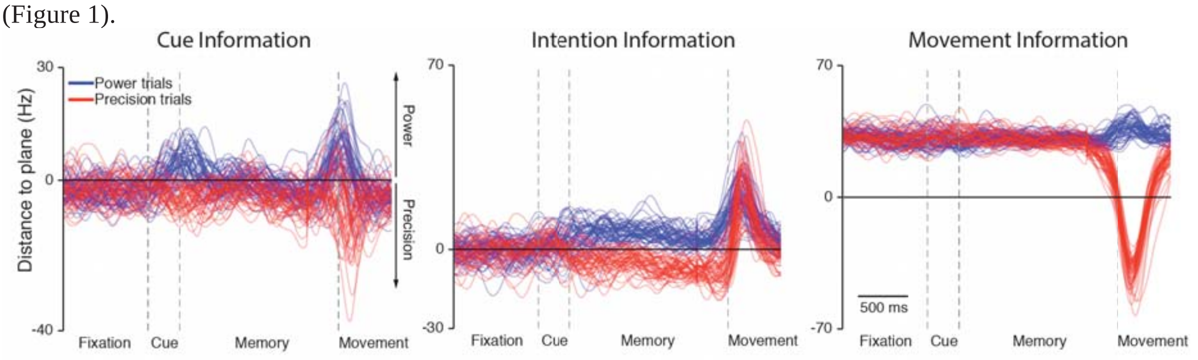

Figure 1. *Visual, intention and movement information of the same neuronal population of one example dataset for area F5. Units are distance (in Hz) to n-dimentional seperation plane, with n = number of units recorded in parallel. Only visual instructed trials are shown. Pannels for cue, intention, and movement information are based on the same neuronal population activity but show the distance to different seperation planes. Each line represents one trial color coded by the performed movement. Positive and negative values correspond to decoded information (visual, intentional, and movement). Note that the presence of offset shift are due to population rate shifts that contain no grip information.*

In both areas, the angles between the separation planes were nearly orthogonal to each other (F5, AIP: visual to intention: 86˚, 81˚; visual to movement: 93˚, 87˚; intention to movement: 77˚, 83˚), confirming the simultaneous presence of independent information in the same neuronal circuit. Both areas also showed a clear presence of all three categories.

Discussion: Instead of analyzing selectivity in the fronto-parietal grasping network separately for individual single units, we extracted information about cue, intention, and movement information from the population dynamics. This approach allowed us to access these different information categories separately, in particular the grasping movement intention, which could lead to better decoding methods for reliable robot hand control.

Significance: The possibility to independently and reliably extract cue-, intentional-, and movement information from single-trial population activity is crucial for future neural interfaces that can function robustly in natural environments, e.g., with sensory disturbances and in varying contexts. To know in advance which movements are possibly intended for execution also allows for more accurate and faster prosthetic control.

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References

[1] Kaufman MT, Churchland MM, Ryu SI, Shenoy KV (2014) Cortical activity in the null space: permitting preparation without movement. Nature Publishing Group:1–12.
[2] Raposo D, Kaufman MT, Churchland AK (2014) A category-free neural population supports evolving demands during decision-making. Nature Publishing Group 17:1784–1792.
[3] Michaels JA, Dann B, Intveld RW, Scherberger H (2015) Predicting Reaction Time from the Neural State Space of the Premotor and Parietal Grasping Network. J Neurosci 35:11415–11432.