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How the brain responds to choices

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Choices, it is commonly understood, lead to action—but how does this happen in the brain? Intuitively, we first make a choice between the options. For example, when approaching a yellow traffic light, we need to decide either to hit the breaks or to accelerate the car. Next, the appropriate motor response is selected and carried out, in this case moving the foot to the left or to the right. Traditionally, it is assumed that separate brain regions are responsible for these stages. Specifically, it is assumed that the motor cortex carries out this final response selection without influencing the choice itself.

Two Tübingen Neuroscientists, Anna-Antonia Pape and research group leader Markus Siegel of the Werner Reichardt Centre for Integrative Neuroscience (CIN) and MEG Center, have found evidence that challenges this intuitive division between a 'deciding' and a 'responding' stage in decision making. The results of their study have been published in the latest *Nature Communications*.

While recording brain activity using magnetoencephalography (MEG) to monitor activity in motor areas, Pape and Siegel set 20 human subjects the simple task of deciding whether or not a field of dots on a screen was slowly moving together. The subjects could respond "yes" or "no" by pressing a button with either their left or their right hand. The mapping from choice (yes/no) to response (left/right button) changed randomly on each trial, with a short cue telling subjects the current configuration. This ensured the participants' brains could not plan a motor response, i.e. the correct button press, during choice formation. Astonishingly, while the test subjects were able to press the 'correct' button most of the time, subjects still showed a strong tendency towards motor response alternation. In other words, they often simply pressed the button they had not pressed in the trial just prior to the current one. This tendency was pronounced enough to detract from subjects' overall decision task performance.

In their MEG data, Pape and Siegel found a neural correlate of this tendency in the motor cortex itself. They showed that the upcoming motor decision can be predicted from the status of motor areas even before decision formation has begun. This pre-decisional motor activity to a large extent originates from the neural residue of the previous motor response. How often the subjects alternated between response alternatives is predicted by how pronounced the previous response's vestiges in the motor cortex still are. Together, these results suggest that the status of the motor cortex even before decision making can influence the formation of a given choice.

These results challenge the traditional view of decision making. According to this view, decisions are formed in the prefrontal cortex and fronto-parietal cortex, brain regions that are associated with 'higher' brain functions that are essential for memory and problem solving. The motor cortex is seen as the structure merely executing the behaviour that those 'higher' brain regions have determined. Contrary to this view, Pape and Siegel's findings suggest that the motor cortex also plays a role in informing decision-based behaviour.

Does that mean the way we respond to our environment is not a matter of choice after all? Do we just randomly 'decide' what to do based on the state our motor cortex happens to be in? Anna-Antonia Pape, who recorded and analysed the data, does not think so: "The effect is there, yes, but I wouldn't link it to the question of free will by any means! Higher brain areas are still very important for the decision making process, but now we know that motor areas can tip the scales."

More information: Anna-Antonia Pape, Markus Siegel: Motor Cortex Activity Predicts Response Alternation during Sensorimotor Decisions. *Nature Communications* (2016); dx.doi.org/ncomms13098

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