The workings of metacognition in decision-making

Sprawozdania

Informacje na temat projektu

Meta_Mind

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Podsumowanie kontekstu i ogólnych celów projektu

Decision-making is one of the most fundamental parts of our daily life. From the moment we wake up until we fall asleep we encounter a multitude of situations in which we have to select a course of action among several alternatives and foresee which decision is best. Based on previous experiences, we are able to predict upcoming events and internally test decision alternatives at the speed of light

allowing us to adequately anticipate what comes next and what to do next. Undoubtedly, estimating the quality of our decisions (metacognition) is of crucial importance in many situations. For instance, when a doctor is not certain about the quality of a medical decision additional tests can be considered, or less consequential, when playing a drop shot in tennis the estimate of the quality of the shot determines where to go next.
At the moment, the mechanisms underlying our so-called 'metacognitive system' are not well understood. It remains unclear how our metacognitive system operates or what kind of information is being used for metacognition. In addition, it currently also remains unknown how metacognition is affected by daily appearing factors such as drowsiness or sleepiness. The known fragmentation of cognition during drowsiness makes this transitional state an interesting test ground for decision-making and metacognition from both a psychological and neuroscientific perspective as well as from a practical point of view (e.g. until when are we still capable of controlling and knowing how we perform?). The overarching aim of the project is to expose the psychological and neural mechanisms of metacognition and decision-making, thereby intersecting the relationship between cognition, consciousness and wakefulness. I combine state-of-the-art methods from neuroscience and experimental designs from cognitive psychology and sleep research.

More specifically, we asked the following questions.
- How does forecasting and metacognition operate? What information is being incorporated and evaluated? What are the psychological and neural mechanisms?
- How do daily fluctuations in cognitive performance induced by drowsiness affect decision-making and metacognition? What are the psychological and neural mechanisms?

The answers to these questions could provide valuable input into understanding i) how decision-making can be improved (e.g. in clinical populations), and under what circumstances we should be cautious for overconfidence, ii) how daily fluctuations in alertness affect our decision process (how are we able to determine that we are too drowsy to drive, or how do we know that we can still make adept decisions at the end of a night shift in a hospital?).

By combining modeling, the most innovative methods from electroencephalographic recordings (EEG), brain stimulation, fMRI analyses, and recent developments in sleep research I am investigating the psychological and neural mechanisms that underlie prediction and metacognition during decision-making and aim to lay out practical implications that will flow out of the research.

Prace wykonane od początku projektu do końca okresu sprawozdawczego oraz najważniejsze dotychczasowe rezultaty

We conducted four experiments, that involved brain stimulation, EEG, fRMI and novel behavioral experimental designs. This variety of experiments approached metacognitive decision-making from different angles, allowing us to construct a model of metacognitive decision-making at the end of the project. Below I will highlight the main results achieved so far, as well as the ongoing work and expected progress.

- In daily life, our decisions are frequently guided by regularities in our environment. However, such contingencies are not always explicitly present and sometimes need to be inferred. In our experiment, we showed how predictive (contextual) information in the environment influenced decision-making despite a lack of awareness of the meaning (or presence) of this information. These implicit inferences emerge through changes in internally and externally oriented neural networks. Our results demonstrate that the prefrontal cortex plays an important role in the transformation of externally driven stimulus–outcome events into predictive internalized models of the world (see https://www.jneurosci.org/content/jneuro/39/26/5183.full.pdf)

- To follow up on the above-described results, we aimed to causally test the involvement of prefrontal cortex in internally oriented processes (metacognition, predictions). What happens when neural activity in prefrontal cortex becomes 'abnormal' or altered? Interestingly, we observed that participants were no longer able to use predictive contextual information to adjust decision-making when activity in prefrontal cortex was altered. (manuscript in preparation)

- Our next experiments addressed what kind information is being used to compute an estimate about the quality of our decisions. Considered together, our results demonstrate that post-decisional information contributes to metacognition, thereby evaluating not only what one perceives (e.g. strength of perceptual evidence) but also how one responds towards perceptual events. In this way, metacognition can be seen as an internalization of external feedback processing and error monitoring https://www.nature.com/articles/s41598-020-60382-y and https://www.jneurosci.org/content/jneuro/37/4/781.full.pdf

- To examine the mechanisms of metacognitive decision-making further, and investigate how sensory and 'higher-order' areas (such as prefrontal cortex) interact we used fMRI and brain stimulation (participants performed a total of 6 sessions in six different weeks). Results of this experiment are expected to provide great insight into the workings of metacognitive decision-making, and will be important in arbitrating a currently fiercely held debate within the literature. This rich dataset will be useful for many (European) researchers interested in decision-making (including medical doctors, psychologists, and neuroscientists). (manuscripts in preparation)

- To uncover how daily fluctuations in cognitive performance induced by drowsiness affect decision-making we are currently examining the depth of the effects of drowsiness. For this, we are investigating how drowsiness alters decision-making on a 'low-level' (can you tell the difference between an arrow pointing leftwards or rightwards?) and 'high-level' (are you able to stop an ongoing action, are you able to ignore irrelevant information, or are you able to estimate how well you are performing), and whether an over-arching effect of drowsiness can be observed in a series of 8 experiments. (in preparation)

Innowacyjność oraz oczekiwany potencjalny wpływ (w tym dotychczasowe znaczenie społeczno-gospodarcze i szersze implikacje społeczne projektu)

Adequate decision-making is crucial in our every day life. To elucidate how our decision process operates and how we are able to internally monitor the quality of our decisions has the potential to impact a broad range of fields. For instance, towards the end of the project I will contact the European Sleep and traffic awareness associations and discuss with several think tanks (e.g. governmental institutes related to medical decision-making, police, airport security) the best strategy to implement the results obtained from the project at a practical level. In this way, the project does not only create new fundamental knowledge in a relatively unexplored research field, it will also create a series of direct practical applications.

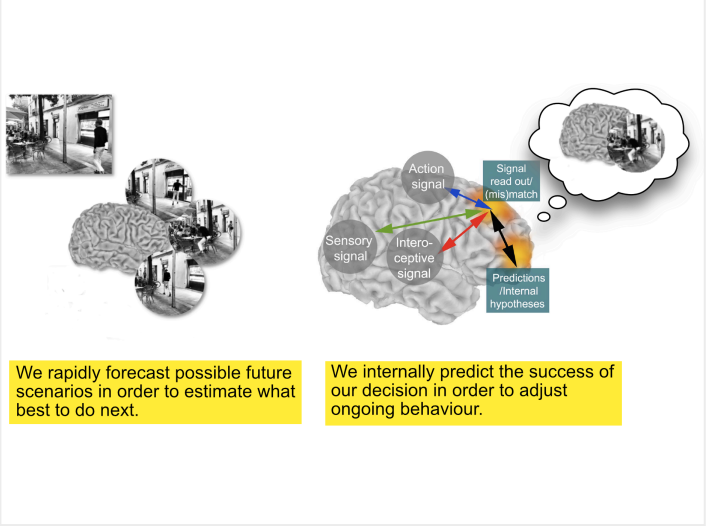

Figure 1

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