Data utilization and analytics platform

Center for Information and Neural Networks

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The Center for Information and Neural Networks (CiNet) conducts fundamental research integrating neuroscience and information and communications technology (ICT). It operates around a core of NICT, Osaka University, and the Advanced Telecommunications Research Institute (ATR), and engages in widespread collaboration with other universities, research institutes, and enterprises.

The human brain is the most complex information and communication apparatus known to man. In our fourth Medium- to Long-Term Plan, we have set a goal of establishing technology able to measure brain activity related to cognition, perception, and movement, and to encode and decode it efficiently. Our ultimate goal is to create a new generation of ICT that will help improve health and welfare. To achieve this, we are analyzing high-order brain information processing and applying it to tasks such as designing information processing architectures and discovering biomarkers. We are also promoting R&D on technologies to improve the physical, sensory, and social capabilities of individuals. We are also conducting basic research to evaluate appropriateness and safety based on brain information technologies, and promoting basic technologies to infer human emotion and cognition, based on human responses to multi-sensory fluctuations and changes in brain data.

Brain information decoding technologies

Brain information decoding technologies read details of perception and cognition from brain activity. We expect that basic technologies like the brain-machine interface will play an important role, but to make such technologies practical, it is necessary to read the complex and varied content of perception produced in the real

Movie contents

Perceptual contents decoded from brain activity

noun	verb	adjective
hair	wear	cute
blond hair	talk	close
hairdo	like	friendly
face	divulge	young
appearance	play	wanted
woman	socialize	scary

Likelihood

Fig.1 : Decoding brain activity while watching video and estimating perception content

world. In earlier research, technologies to identify what is being viewed, or to infer the content of dreams, from brain activity have been developed, but they have not been able to visualize more than an extremely small subset of the complex and varied perceptions arising from the real world. This research has focused on language itself as a means of expressing varied perceptions, and we have conceived a technology that decodes perception details from brain activity by incorporating feature spaces of language in a brain-information decoder. We used this approach to analyze brain activity while watching advertisement videos, and were successful in inferring details of perception and cognition induced by the video, in the form of objects (nouns), actions (verbs), and impressions (adjectives), using a vocabulary of several tens of thousands of words (Fig.1).

Technology to predict depression using fMRI

We have established a technology able to predict tendencies toward depression, current and in the following year, from patterns of activity in the amygdala, which responds to comparison of one's situation relative to another (social value orientation). This has been reported in the journal Nature Human Behaviour. Specifically, 94 subjects performed the Beck Depression Inventory II, which is a test for depressive tendencies, and were then given a task called the Ultimatum Game while undergoing an MRI scan. In the Ultimatum Game, one person has the role of proposer, and proposes a way to distribute a sum of

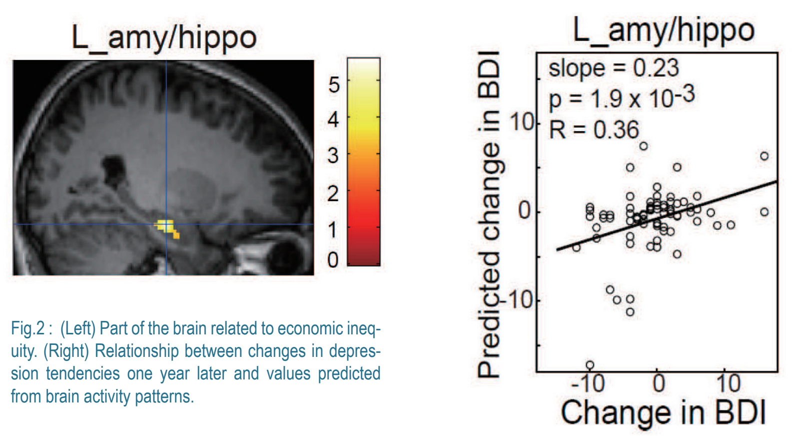

Fig.2 : (Left) Part of the brain related to economic inequity. (Right) Relationship between changes in depression tendencies one year later and values predicted from brain activity patterns.

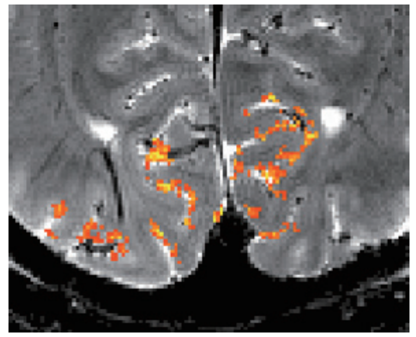

Fig.4 : Ultra-high-resolution fMRI under visual stimulation with 0.6 mm voxels (capturing the brain activity localized in the visual cortical structure)

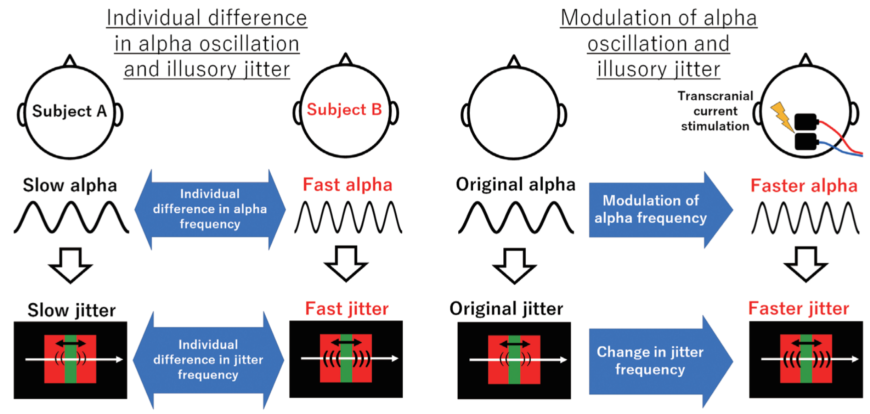

Fig.3 : When alpha waves are changed by electrical stimulation, the rhythm of illusory jitter also changes

money (500 yen in this case), while our subject decides whether to accept or reject the proposal. If the proposal is accepted, the money is distributed according to the proposal, but if it is rejected, both parties receive nothing. Earlier research has shown that most people would reject a proposal if their allocated portion was 20% or less. In this research, subjects made 56 decisions for differing proposers and proposals. Subjects also repeated the Beck Depression Inventory II one year later to study their depressive tendencies. We attempted to predict depressive tendencies, current and one year later, based on patterns of activity in the amygdala and hippocampus arising from differences when a proposal was offered, using Bayesian sparse regression with a kernel function (which is a machine learning method). We observed a significant positive correlation between the predicted and measured values (Fig.2). This positive correlation between predicted and measured values shows the potential for prediction. This result also hints at the importance to a person's mental state, of comparisons with other people (disparity), and shows that information processing in the amygdale and hippocampus is an underlying factor.

Explaining brain function and next generation ICT research issues

In this research, we focused on a phenomenon called illusory jitter, in which objects that are not actually moving appear to shake with a frequency of approximately 10 cycles per second. We first confirmed that differences among subjects in the rhythm of the perceived jitter reflect differences in the rhythm of their alpha brain waves. In other words, people with faster alpha wave rhythm tended to perceive faster jitter, while people with slower alpha wave rhythm perceived slower jitter. We also developed a technology able to artificially change the rhythm of alpha waves by applying weak, non-harming electrical stimulation to the back of the subject's head (transcranial stimulation). When this technology was used to change the rhythm of alpha waves, the illusory jitter perceived by the subjects also changed similarly (Fig.3). These results verify that the rhythm of alpha waves contribute to perception of illusory jitter, and suggest that the timing for synthesis of information about shape and movement, which are processed in different locations in the brain, is determined by alpha waves.

Brain function measurement technologies

Generally, the signals originating from brain activity that can be observed using fMRI are extremely weak, so the accuracy of the data is usually increased statistically by taking repeated measurements with an imaging technique called single-shot EPI, that has excellent time resolution. However, 7T-fMRI can produce stronger signals than earlier technologies, so we changed from the conventional approach of prioritizing time resolution, and used multi-shot EPI, which increases the accuracy of the signals collected themselves. We also increased the efficiency of measurements by rearranging how the tasks were given, and by capturing structured images, which have excellent histological contrast, we built an fMRI test system able to make detailed comparisons of structure and function. As a result, we were able to collect fMRI data with spatial resolution of 0.6 mm (Fig.4).