Biology | Kazuo Nishimura

The way we think is reflected in our brain activity

People think and act differently. The ability to visualise things, to read newspapers upside down, to mentally rotate objects, to remember faces or phone numbers, or to perform any other daily task, differs from one person to another. Everyone is unique, and yet, despite these individual differences people interact, communicate and understand each other. Professor Kazuo Nishimura at Kobe University, together with his collaborators, uses magnetoencephalography (MEG) to examine brain activity, and test whether individual differences in abilities are reflected in how the brain functions.

Every day, we interact with people whose opinions differ from ours, and who react differently than we do. Indeed, our personalities and experiences define the way we perceive and interact with the world, and make us all unique. Our abilities also differ; while some people are good at maths, for instance, others are better at learning foreign languages. Even the way we think varies from one person to another.

And yet, even though we all are different, we manage to communicate. It is difficult to explain how we can understand the thoughts of others. Considering the diversity of people's personalities and behaviours, advanced communication techniques are required to understand the other person's personality and sensitivity, and to read the other person's mind. For example, we try to gather information about the other person's behaviour, and to infer the other person's personality, by exchanging information over time.

Explicitly addressing individual differences is important to understand why people think and act the way they do, but still, the scope of research on this subject has been limited. It is difficult to objectively study individual differences in how thoughts are formed and processed, and how this impacts the decisions we make. Specially Appointed Professor at Kobe University in Japan, Kazuo Nishimura, and collaborators have examined brain activity to see if individual differences are reflected in differences in the way the brain works.

MEASURING BRAIN ACTIVITY

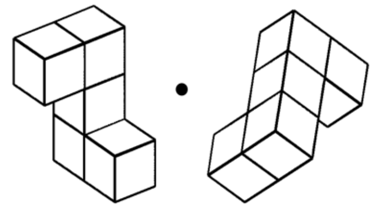
The brain is organised in interconnected regions that carry out specific functions and interact. Overall, all human brains are similar, but if we look closely, differences can be observed. The way our brain is wired depends on our genes and our experiences. As a result, the pattern of brain areas that are activated during a specific task varies from one person to another.

Different techniques allow the measurement of brain activity and to observe these different patterns. The Kobe University team uses magnetoencephalography (MEG). As neurons are activated, electrical currents occur in the brain, and this electric activity generates magnetic fields. By measuring these magnetic fields over the surface of the subject's head, activated neurons can be localised. MEG is a functional neuroimaging technique used to map brain activity by recording magnetic fields. With this technique, it is possible to know which brain areas are activated at rest or while performing a specific task. The researchers conducted the experiment at the National Institute of Advanced Industrial Science and Technology (AIST) in Ikeda City, Osaka Prefecture, using a 122-channel planar magnetoencephalography system operated by Dr Sunao Iwaki.

Data from different individuals can also be compared, so that differences in brain activity between groups of individuals can be detected. This is what Professor Nishimura and his collaborators did: participants were separated into two groups that he compared.

SPONTANEOUS THINKING

When there is no external task to perform, thoughts often flow in a spontaneous and unconstrained manner. This is called spontaneous thinking. A spontaneous thought is any thought, memory, feeling, daydream or fantasy disconnected from ongoing tasks or sensory experience. Understanding differences in spontaneous thinking would be interesting to understand why people make the decisions they do, but because it is spontaneous, it is tricky to study. Professor Nishimura has developed a clever way to shed light on the subject: he examines brain activity during spontaneous mental imagery tasks. More specifically, the tasks include spontaneous visual imagery and verbal recollection. These involve visual and verbal thinking, which are two components of the spontaneous thought process.



Examples of visual stimuli.
3-dimensional objects are used for the mental rotation task.

Spontaneous visual imagery, like any kind of spontaneous thinking, is clearly distinct from the perception of external stimuli: spontaneous visual imagery consists of mentally visualising something, in the absence of visual stimuli. In these experiments, during spontaneous visual imagery tasks, participants were asked to make a mental image of monuments that are very famous in Japan. This task evaluates visual thinking.

Addressing individual differences is important for understanding why people think and act the way they do.

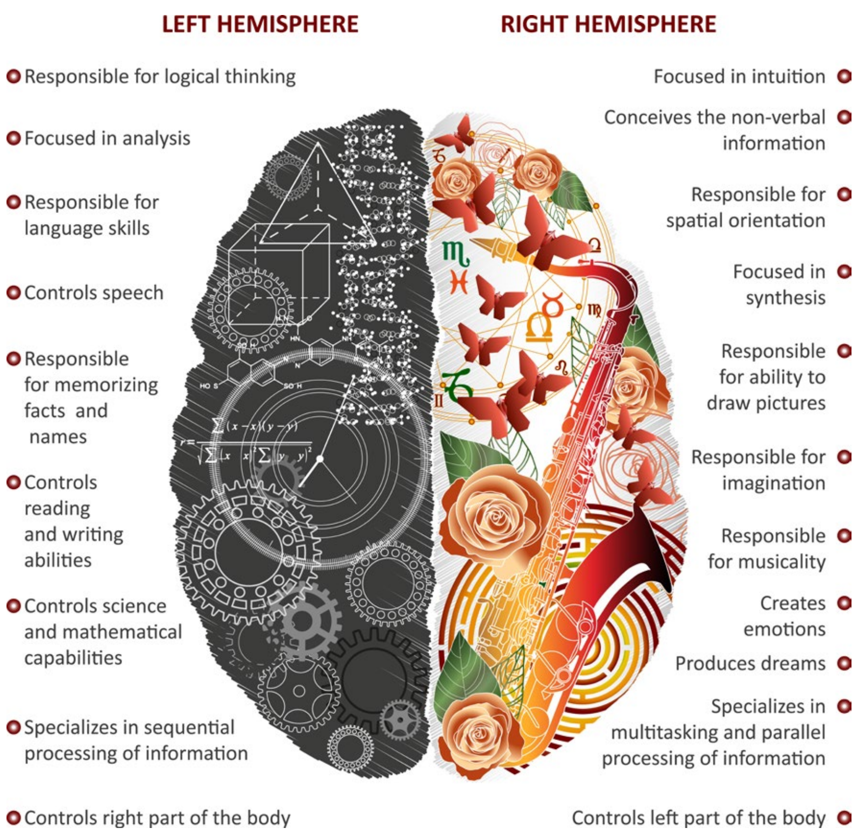
Magnetoencephalography (MEG) is a neuroimaging technique used to map brain activity by recording magnetic fields. The equipment in the photo was used for experiments at the AIST, Ikeda City.

The second part of the spontaneous mental imagery tasks consisted of verbal recollection. To evaluate verbal thinking, participants were asked, for example, to recite to themselves the 12 animals of the oriental zodiac.

VISUAL VS VERBAL THINKERS

Recall a conversation you had recently. What comes to your mind? Words that were exchanged, or scenes or other mental pictures? This was one of the five questions asked by them to separate participants into two groups: strong visualisers and weak visualisers.

Using MEG, the team recorded brain activity while every participant



The brain is organised in interconnected regions that carry out specific functions and interact. Overall, all human brains are similar, but if we look closely, differences can be observed.

performed the same spontaneous mental imagery tasks. Brain activity of strong visualisers was then compared to brain activity of weak visualisers.

Data showed differences in brain activation. In both visual imagery and verbal recollection tasks, the visual area was more strongly activated in strong visualisers. In contrast, in the verbal recollection task, the activation of the frontal language area was stronger in weak visualisers. These results indicate that the two groups differ in the way their brains work. Strong visualisers are visual thinkers whose visual area is more active even in the verbal recollection task; when asked to recite to themselves the 12 animals of the oriental zodiac, these visual thinkers are more likely to mentally visualise pictures of the animals than their names. On the contrary, weak visualisers are verbal thinkers.

VISUOSPATIAL COGNITIVE ABILITIES

People differ in their ability to read newspapers upside down, to mentally rotate objects, to see the depth of a landscape, and to imagine the structure of an architectural structure. Professor Nishimura and collaborators tested these visuospatial cognitive abilities with a mental rotation task.

During this mental rotation task, pairs of figures were presented to the participants. These figures were three-dimensional objects that could be arranged at different rotation angles. For each pair, participants had to assess whether the two figures were identical (the same object seen from two different angles) or mirrored.

> ***Differences in our abilities are reflected in differences in the way our brain functions.***

Participants were this time separated into groups depending on their score, so that individuals who performed well at this mental rotation task could be compared to those who did not.

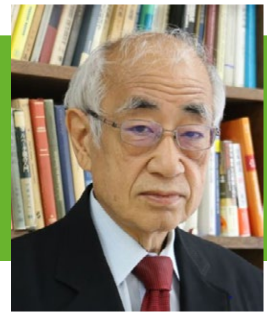
The research team recorded the participants' brain activity during the mental rotation task, but also while they performed the spontaneous mental imagery tasks. The aim was to clarify the relationship between visuospatial cognitive abilities (assessed by the mental rotation task) and spontaneous visual thinking characteristics – in other words, to see if the brain of individuals who are better at the mental rotation task functions differently when performing the spontaneous mental imagery task.

Data showed that, during the mental rotation task, two brain regions were more strongly activated in individuals with a good performance than in those with a bad performance. These brain regions are known as the inferior occipitotemporal area and the parietal area. The inferior occipitotemporal area is a visual area involved in object shape recognition. The parietal area is involved in visuospatial processing; it is responsible for the ability to tell where objects are in space, and to mentally rotate them.

During the spontaneous mental imagery task, differences in brain activity were also observed between individuals who performed well at the mental rotation task and those who did not. In individuals with a good performance, a stronger activation was visible in the left premotor cortex and in the supplementary motor area. Both of these regions receive information from the parietal area and are involved in complex visual processing.

WHAT THIS MEANS

Differences in our abilities are reflected in differences in the way our brain functions. Professor Nishimura and collaborators showed this was true for visuospatial cognitive abilities, but also for spontaneous visual and verbal thinking. Thinking is one of our most common activities, one of the processes which is at the basis of our behaviours, and yet, we are different even in the way our brain works when our thoughts flow spontaneously.



Behind the Research

Kazuo Nishimura

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Research Objectives

Professor Kazuo Nishimura's wide ranging research interests lie in the fields of humanities & social sciences and theoretical economics.

Detail

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Bio

Kazuo Nishimura received his PhD from the University of Rochester in 1977. Nishimura is widely known for pioneering contributions in the complexity economics and served as an external professor of the Santa Fe Institute, 2008-2017. He has taught at the State University of New York, Buffalo, University of Southern California and Kyoto University. He is currently a Specially Appointed Professor at Kobe University in Japan.

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- Michiyo Inagawa, Medical Welfare Center, St. Joseph Hospital
- Yoshikazu Tobinaga, Elegaphy, Inc.
- Sunao Iwaki, National Institute of Advanced Industrial Science and Technology

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Personal Response

What triggered your transition from economics to this fascinating research topic?

" I am still working on economic theory and have not switched to the field of brain research. Ever since I was young, I have been interested in and kept thinking about the difference between human spontaneous thought and action. Since my research field is the complexity economics, it seemed natural to expand my research to include the measurement of brain activity. I will continue this line of research in an interdisciplinary manner. In fact, our team consists of members from various fields, with Dr Iwaki working in brain science, Dr Aoki in physics and economics, Ms Inagawa in psychology, and Mr Tobinaga in engineering. "