The default brain network – insights from machine learning applied to brain scanning from 10,000 human individuals

What happens in the brain when we are not doing anything in particular? In other words, what is going on when the human brain is 'at rest'? One might think the brain's functional activity decreases to a low-maintenance baseline – similar to the screen saver of a computer. In the early 2000s, neuroscientist noticed for the first time a coherent set of brain regions that systematically increased (not decreased!) in idling humans. In contrast to the computer screen saver, in the baseline of the brain, some regions remain highly active and potentially never really "stop working". Together these energy-hungry regions subserve a yet-to-be-uncovered baseline function of the human brain - which became known as the 'default mode network' (DMN).

Many neuroscientists think that the brain is organized as a hierarchical pyramid of differently sophisticated layers of neural processing. At the bottom level, we have relatively simple functions, such as sensory processing in the visual or auditory system. On the top level of brain function, we have the evolutionarily recent *default mode network*. Recently emerging neuroscientific evidence situated the default mode network as a central hub at the heart of the various network patterns in the brain. With its possibly widespread influence on global brain dynamics, the default mode plays an important role in many complex types of thinking, such as moral reasoning, imaging complex hypothetical situations, and introspecting other people's minds.

Researchers around Prof. Danilo Bzdok at the Department of Psychiatry, Psychotherapy and Psychosomatics, RWTH Aachen University have conducted one of the largest brain-imaging studies to date in collaboration with the Jülich-Aachen Research Alliance and the International Research Training Group (IRTG) 2150. The IRTG student and first-author Julius Kernbach leveraged emerging machine-learning techniques to cleanly isolate how the default mode network modulates the subordinate brain systems based on functional and structural arguments. In 10,000 participants of the UK Biobank population datasets (https://www.ukbiobank.ac.uk/), the authors detailed how the DMN parts, combining the potentially most highly evolved areas of the association cortex, is robustly linked to specific white-matter fiber tracts with the more primitive limbic brain systems, especially the hippocampus known to process memories and locations. Indeed, when the brain is at rest, the mind often starts to wander and typically internally-oriented thoughts start to emerge. The authors now showed that this type of spontaneous thought subserved by the default mode such as recalling random autobiographical memories is potentially enabled by incoming information from distinct limbic regions. Further, the authors used innovative pattern-learning algorithms to demonstrate that the DMN parts modulate functional communication between major brain network networks. Specific functional states inside of the DMN were linked to distinct functional states in the whole human brain.

Bringing together machine learning technology and the currently largest biomedical resource, Kernbach and colleagues have shown that some of the most human-defining mental capacities may be realized by the DMN by orchestrating information flow across neural processing levels.

Kernbach, J.M., Yeo, B.T.T., Smallwood, J., Margulies, D.S., Thiebaut de Schotten, M., Walter, H., Sabuncu, M.R., Holmes, A.J., Gramfort, A., Varoquaux, G., Thirion, B., Bzdok, D., 2018. Subspecialization within default mode nodes characterized in 10,000 UK Biobank participants. Proc Natl Acad Sci U S A.