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Atsushi IRIKI is now a Head of Laboratory for Symbolic Cognitive Development at RIKEN Brain Science Institute since 2004. He has been a visiting professor of Nanyang Technological University (Singapore), University College London (UK), an adjunct professor of Keio University, Tokyo University, Tokyo Medical and Dental University, a research professor of Kyoto University, a senior fellow of the Canadian Institute for Advanced Research, and the president and CEO of RIKEN ANALYSIS Corporation (RIKEN Venture, Tokyo). He is currently an Editor-in-Chief of Neuroscience Research, an official journal of Japan Neuroscience Society, and the president of Japan Neuroscience Society 2016 Annual Meeting.

Brain mechanisms of tool-use that advance our knowledge/world beyond the border

Western science has succeeded by pursuing unique principles through exclusion about the entity within boundary conditions, whereas Eastern ideation is organic and relational allowing principles inclusive, polysemous and transitional. How are these different conceptual frames emerged from the same biological brains? Taking the boundary of the “self” as an example, I ponder its neural representations in the brain, how the “tools” can cross such a border to result in alterations of conceptual relationships between “self vs non-self” or “self vs others”.

When monkeys were trained to use a rake, neurons of intraparietal cortex (normally coding body image) started to code the tool in a way equivalent with the hand holding it - thus, bistable or polysemous for the hand or the tool, which in turn demonstrates additional polysemic interpretations, that is, hands were extended towards tools (externalization of innate body), or alternatively, tools were assimilated into the body schema (internalization of external objects). And importantly, such tools can be shared with other individuals.

Thus, neural representation of the tools crosses the boundary of the self, by either belonging at the same time to the self, or the other or non-self environment - but, on the other hand, it could be exclusive between each other depending on the situations. This relativism might reflect on different conceptualization of the self, in relation to non-self or the others and eventually social structures, between East and West.

Tool use learning, in addition, induces expansion of the grey matter of above cortical area. Once a novel, alternative, bistable state was found to be useful, additional resources will be invested to stabilize the system. This newly acquired bistable state enables systems to be reused for completely different functions in the future, to cross beyond the border of existing knowledge and world. That is, expansion of the brain with additional functional areas would support extended brain functions that would drive rapid and drastic changes in the hominin ecological niche, which in turn demanded further brain resources to adapt to it. In this way, humans can construct a novel niche in each of the ecological, cognitive and neural domains, whose interactions accelerated their evolution through a process of triadic niche construction.