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Granularity in brains and cognition: toward a unified model of ASD

ASD exhibits a wide spectrum of behavioral symptoms. A number of researchers have tried to find a unified model behind the phenotypical diversity; however, any plausible model that well-explains that diversity has not yet proposed. We here describe our on-going attempt at modeling ASD in a unified way from the viewpoint of "cognitive granularity". Cognitive granularity represents the size of the basic elements that are operable in one's cognitive system. In other words, it represents the size of semantic units (schema, basic level categories, etc.) to articulate and recognize the environment. While it is constrained by one's perceptual and motor resolution, cognitive granularity determines the level of abstraction at which one can efficiently predict and control the physical and social world. From anatomical studies of ASD brains, Casanova reported that mini-columns in ASD brains have higher density than that of TD. A mini-column is a columnar structure with approximately 100 neurons that align vertically in the cerebral cortex. Mini-columns are considered to be the smallest functional unit of the brain. Higher density of mini-columns in ASD suggests that an ASD brain employs a larger number of mini-columns in information processing. It also suggests that ASD brains process information in less integrated way because the smaller mini-columns reduce long-distance connection between them. The characteristic granularity and connectivity in ASD brains explain the information processing styles of ASD population. ASD people acquire linguistic categories with finer and specific distinction. ASD people have difficulties in integrating information that are represented by distantly distributed mini-columns, resulting in the failure of sensory integration, motor coordination, or acquiring "central coherence". Finer granularity in ASD also explains their difficulties in mentalizing other's behavior: a variation of human goal-directed actions would look like arbitrary causal sequences of micro-actions without shared invariants, namely, "intentions". This suggests that "theory of mind" or "mentalization" would be based on the shared "coarser" cognitive granularity, which enables TD people to see the mental gestalt in other's physical behavior.

Biography

Hideki Kozima has completed his PhD in Computer Science from the University of Electro Communications (Tokyo, Japan) in 1994, and then he joined National Institute of Information and Communications Technology (Tokyo/Kyoto, Japan) as a Researcher and Senior Researcher, where he developed "Keepon", a therapeutic robot for autism. In 2008, he joined Miyagi University (Miyagi, Japan) as a full Professor at School of Project Design and appointed as a Vice President in 2013. In 2017, he joined Tohoku University (Miyagi, Japan) as a full Professor of Graduate School of Educational Informatics and in 2018 as a full Professor of Graduate School of Education.

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