Keynote speech

Sailing into the Neglected Sea of Cerebellum: A Brand New Two-Brain Theory of Human Cognition

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Abstract

Cerebral lateralization of cognitive functions had been recognized for a long time. Convincing clinical evidences for the hemispheric asymmetry in language processing appeared 150 years ago by medical doctors Broca (1861) in France and Wernicke (1876) in Germany. Experimental results from the split-brain patients and from normal subjects with visual-half field as well as dichotic listening paradigms in the 60's and 70's provided further support for the two-brain for one consciousness description of cerebral asymmetry. Tzeng and Wang (1984) characterized the dominant function of the left and right hemispheres in terms of superior temporal and spatial coding, respectively. With more and more specific cognitive functions being identified and localized in the two hemispheres, an architecture of functional lateralization and its relationship to callosal connectivity in the human brain was constructed (Kaloris, et al., 2019). However, in retrospect, an unfortunate misgiving in constructing a brain architecture regarding the various specific cognitive functions is its obvious neglect of the cerebellum, which sits at the back and bottom of the brain, behind the brainstem, and had long been recognized as responsible for several function relating only to fine movements and coordination, including maintaining balance, controlling eye movements, and facilitating motor learning. Since late 90's, our laboratory studies have consistently found the cerebellum is engaged during reading and differentially activates in response to phonologic and semantic tasks, indicating that it contributes to the cognitive processes integral to reading (Fulbright, et al., 1999). Lately, more and more recent studies, which focus on scanning the cerebellum, have clearly shown that it appears to play a critical role in cognitive functions such as working memory, cognitive control, action observation, language, decision making, emotion, and social cognition like daily planning. But so far, no theory has been provided to identify the functional role the cerebellum plays in its coordination with the cerebral cortex, which of course is the major player in performing the cognitive tasks. In this talk, I will present a new two-brain theory which specify the critical role of the cerebellum as the professional construction management (PCM) unit, setting up an internal model of the cognitive task at hand and monitoring the performing operations of the cerebral cortex with respect to the temporal and spatial bindings at the neuro-cellular level. It is speculated that the PCM-like control processor allows the cerebellum to provide a scaffolding role for the emergence of an efficient information processing architecture (Encoding, Organized Storage, Fast Retrieval) and make it possible for human being to be good at focus attention, divided attention and selective attention, in performing sophisticated poblem solving, innovation, and creativity. In sum, the new two-brain theory articulates the vital role of the cerebellum in transforming the cognitive operations of the whole brain from a simple shop (柑仔店) to become a complex corporate (e.g., 7/Eleven Super Market)

Selected recent publications:

1.Rueckl, J. G., Paz-Alonso Molfese, P. M., Kuo, W.-J., Bick, A., Frost, S., J., Hancock, R., Wu, D. H., Mencl, W. E., Duñabeitia, J. P., Andoni, J. Lee, J.-R., Oliver, M., Zevin, J. D., Hoeft, F., Carreiras, M., Tzeng, O. J. L., Pugh, K. R. and Frost, R. (2015). Universal brain signature of proficient reading: Evidence from four contrasting languages, Proceedings of the National Academy of Sciences of the United States of America (PNAS), 112(50), 15510-15515.

2.Tzeng, O. J.-L., Lee, C. Y., Lee, J. R., Wu, D. H., Lee, R. R.-W., & Hung, D. L. (2017) Neurolinguistic studies of reading in Chinese. New Directions for Child and Adolescent Development, 158, 55-168.

3.Yu, A., Chen, M, Hung, D., Tzeng, O., Cherodath, S., & Wu, D. H. (2019). Neuroimaging evidence for sensitivity to orthography-to-phonology conversion in native readers and foreign learners of Chinese. Journal of Neurolinguistics, 50, 53-70.

4.Huang, H.W., Nascimben, M., Wang, Y.Y., Fong, D.Y., Tzeng, O.J.L., Huang, C.M. (2021). Which digit is larger? Brain responses to number and size interactions in a numerical Stroop task. Psychophysiology, 58(3), e13744.

5.Wang, S., Zhan, X., Hong, T,.Tzeng O. J. L., Richard, A. (in press). To p -down sensor y prediction in the infant brain at 6 months is correlated with language development at 12 and 18 months, Brain and Language.