4-1

Linguistic Diversity and Brain Plasticity: From Reading to Neuron

Ovid J. L. Tzeng

Academia Sinica, Taiwan

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To many scientists, one important question of this century is how the brain enables the mind in its various creative functions, including scientific thinking itself. During the 1990s, at the molecular level, neuroscientists unraveled a great deal about the brain's intricate, interconnected cascade of electrical impulses and chemical processes. Similarly, at the cognitive level, scientists, with the help of many newly developed techniques of visualizing the neuronal activities on-line, have also mapped much of the elaborate geography of the brain and traced its sensory and cognitive pathways. Advances have been made especially in the identification of how the brain uses discrete systems for various types of leaning and of how and where memories are stored. Moreover, in recent years, some plausible explanations have been offered for the nature of dream, emotion, and consciousness. A new scientific endeavor, dubbed the cognitive neuroscience, is making its way to solve the old mind-body problem. One of the important issues in the new science concerns with the brain activities during language processing.

Cross-linguistic studies of brain functions permit us to separate universal mechanisms from language-specific contents. By uncovering the range of variations that are possible under normal and abnormal conditions, cross-language studies also address the critical issues of behavioral and neural plasticity. Chinese languages, in both spoken and written forms, provide important and interesting points of reference for comparative language/brain relationships due to their unique linguistic properties. For example, the Chinese language has what may be the simplest and most austere grammatical system in the world. While most of the world's languages offer a wealth of different markers on nouns, pronouns, adjectives and/or verbs, Chinese has essentially no verb conjugations and no noun declensions of any kind. Furthermore, although the Chinese grammar does provide for a set of standard word orders, it is also the case that word order can be varied in a number of ways, if the speaker wants to emphasize one element more than another. These properties of Chinese grammar raise some fascinating questions concerning grammatical impairment in Chinese aphasics: Since it is possible to produce sentences with no grammatical markers of any kind, how can we identify the symptom patterns that characterize Broca's and Wernicke's aphasia in other languages? Thus, by examining the patterns of language breakdown from a cross-linguistic viewpoint, we can learn a great deal about the relationship between brain and language. Indeed, recent years have witnessed important advances of Chinese neurolinguistics in which results of experimental as well as clinical observations have challenged traditional conceptualization of linguistic deficits associated with aphasic patients.

In addition, the peculiar script/speech relationship embedded in the Chinese writing system has also provoked many cognitive neurolinguistic inquiries on the brain-language relationship, as compared to the data cumulated from the studies of reading alphabetic texts. In this respect, our laboratory were able to use modern neurophysiological research tools such as EYELINK to trace the eyemovements during reading a text and TMS to create a specific virtual lesion in a normal subject. The measurement of eyemovements allows us to examine the impact of text arrangement (i.e., vertical vs. horizontal) on the easiness of reading with various physiological indices (e.g., perceptual span, launch path, landing sites, etc.). It also allows us to explore the effect of phonological consistency in a Chinese phonogram on the activation of phonological information in the peripheral view area. With the TMS's ability to create a virtual lesion in a specific cortical site, researchers from our laboratory could test directly various models of visual information processing at the eye-field receptor of the right hemisphere. These investigators propose a reverse hierarchical model of cortical interaction for vision and awareness. New experiments with TMS are planned to look into the dynamic nature of a bilingual brain with respect to the issue of brain plasticity.

In recent years, our laboratory also applied brain-imaging techniques such as fMRI, ERP, and MEG to provide new and converging information about the functional neuroanatomy of reading Chinese. In particular, our imaging studies had sought to link specific orthographic, phonological, syntactical, and semantic components of word identification to specific locations in inferior frontal cortex, the left temporoparietal cortex, the fusiform gyrus, and the left basal temporal cortex (near the occipital-temporal boundary). The search for an area that was dedicated to Chinese characters had led to an area near the occipito-temporal border, the left middle fusiform gyrus. In addition, the premotor area was found to be involved in the recognition of low frequency characters with an inconsistent phonetic component. These are important findings for they appear to provide a major part of the functional neuroanatomy underlying the knowledge components (graphemic, orthographic, syntactic, phonological and semantic) that are needed in reading Chinese texts.

Moreover, a recent study with the ERP measurement traced the time-courses of brain activities associated with different types of information processing (e.g., graphemic, phonological, semantic, and interpretive) during character recognition and mapped them onto different brain locations. A further study with the MEG technique allowed us to examine the dynamic nature of the information integration within the time window between m150 and m450. Comparing these data to those obtained with word recognition in alphabetic scripts, one can only be impressed by a general similarity, with very few differences, in the brain activities associated with word recognition across different writing systems.

Indeed, more needs to be learned from the genetic make-up to the developments of neuronal system, and to the cognitive capability of various behavioral manifestations. However, from a biological viewpoint, results from our laboratory can be interpreted in the following way: One brain for all languages in the basic mapping; however, differences in the time course of graphic, phonological, and semantic activation reflect how the basic pattern is modified to accommodate various script/speech relations in different writing systems.

There is much to be done in Taiwan in the scientific pursuit for the understanding of brain/mind relationship. An infant laboratory is a must. Indeed, infant study has been neglected in Taiwan and no serious basic research work in infant's neurocognitive developments has ever been carried out. We aim to change such a situation. So, together with Dr. Steven Crain of the University of Maryland and Dr. Hisashi Kado of the Kanazawa Institute of Technology, we are creating an infant MEG lab. Hopefully, in the near future, we will know more about the neurocognitive developments of Taiwanese infant.