Advances and limitations in our knowledge of cortical reorganization in cerebral palsy

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This commentary is on the original article by Nevalainen et al. To view this paper visit http://dx.doi.org/10.1111/j.1469-8749.2011.04165.x.

Early in life, the brain demonstrates amazing plasticity, which allows it to readily reorganize in the face of injury.1 Brain lesions acquired either prenatally or before the second year of life are associated with excellent recovery of motor function2 and reorganization of language to the right hemisphere without obvious behavioral manifestations.3 Although some of the mechanisms behind these neuroplastic processes have been hypothesized,1 it is still not clear why these processes result in good recovery in some and limited recovery in others. In the last decade, researchers have used a variety of techniques to study brain reorganization in children with cerebral palsy, including functional magnetic resonance imaging, magnetoencephalography (MEG), transcranial magnetic simulation, diffusion tensor imaging, and near infrared spectroscopy.1 These studies (like the MEG study by Nevalainen et al.) help us understand cortical reorganization in cerebral palsy and provides a glimpse of the clinical consequences of neuroplasticity processes.

Studies of brain reorganization in children with cerebral palsy have primarily focused on reorganization of the motor pathway. Studies have demonstrated that motor control of affected limbs can remain in the affected contralateral hemisphere, switch to the ipsilateral hemisphere, or be shared by both hemispheres, with the propensity for the development of these patterns different for children with hemiplegia and diplegia.1,2 Aside from atypical hemispheric dominance of motor control, other evidence demonstrates atypical interactions between hemispheres through transcallosal fibers.2 Additional studies, such as the Nevalainen et al. MEG study,3 have examined cortical somatosensory reorganization in children with cerebral palsy. Such studies suggest that somatosensory representation of the affected limb can be represented bilaterally, by both the affected and unaffected hemispheres,5 although other patterns of somatosensory reorganization have been reported.4,5 Despite the information gained from these studies, understanding the interaction between reorganization of the motor and somatosensory systems, and which patterns of reorganization facilitate or inhibit development of motor function is still limited.

We must understand the difficulties to be surmounted in order to perform these studies. First, several factors are difficult to control in this area of research. For example, lesions in the left hemisphere will typically result in changes in hemispheric dominance and left-handedness. The correct method for controlling for handedness is not clear, since children who are naturally left-handed are so because of a genetic predisposition; while children that are left-handed due to left hemisphere damage are so because of the complicated dynamics of brain reorganization. Second, a homogenous group of children with lesions of the same size, location, and etiology is near impossible to find. Selecting a heterogeneous group of participants adds variability to the data, while selecting a more homogenous group limits the ability to generalize the findings to a wide variety of clinical cases. Third, most studies use behavioral tasks that require cooperation by the child. Thus, children with behavioral problems or intellectual disabilities and younger children may be excluded from studies. Studies of cerebral palsy but, however, fail to account for the variability and intensity of therapy used across participants. Fourth, the sensitivity of the methodology used to localize brain activation must be considered. For example, the coordinated activity from approximately 10 000 juxtaposed neurons is required to produce a recordable MEG signal. Normally, this coordinated activity results in distinct evoked magnetic field waveforms with characteristic waveform components. However, cortical reorganization can change the number and organization of neurons dedicated to a particular response, which can alter waveform morphology, resulting in an evoked response with idiosyncratic waveform components. Thus, the validity of waveform components analysis can be limited. Similar issues can be considered for other functional imaging techniques.

Despite limitations, such studies have provided significant advances in our understanding of brain reorganization after injury that occurs early in life. Hopefully, future studies will provide information to help us understand how established therapies promote compensatory changes in brain reorganization and why therapies do not work in some cases. Such information will help us develop novel therapies or combinations of therapies that can promote optimal recovery in children with early brain injury.1

REFERENCES