Should One Hand (Paw) Really Not Know What the Other Is Doing? Focus on “Reducing Contralateral SI Activity Reveals Hindlimb Receptive Fields in the SI Forelimb-Stump Representation of Neonatally Amputated Rats”

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Neural plasticity is one of several mechanisms used by the nervous system to assure that information for efficient and effective actions necessary for survival is coherent. In mammals, if not all animals, plasticity is related to different processes and components in the brain that vary in their magnitude, extent, and duration, all of which are highly dependent on developmental stage. In this issue of the Journal of Neurophysiology (p. 1727–1732), Pluto et al. 2005 provide evidence for active suppression of irrelevant communication within one cerebral hemisphere originating from the contralateral hemisphere. This extends a significant body of work from these same authors showing a strong role for ipsilateral, intracortical connections between limb representations in mediating inhibition to shape relevant (wanted) neural activity by reducing confusing (unwanted) neural activity in the somatosensory area (SI) of the rat cerebral cortex after neonatal forelimb amputation (Lane et al. 1997; Pluto et al. 2003; Stojic et al. 2001).

Early work in mice provided evidence that ipsilateral whisker inputs activate barrel cortex at longer latencies than stimulation of the contralateral whiskers. Furthermore, the activation of ipsilateral SI from the whiskers is lost when contralateral SI is removed (Pidoux and Verley 1979). Patterns of connections between homologous cortical areas of the two sides of the brain vary. For instance, in contrast to many association areas, direct connections between motor, visual, and somatic cortices of the primate are sparse (Karol and Pandya 1971). As in primates, rats and mice have relatively few direct callosal connections between SI in the two hemispheres, which is in stark contrast to the dense direct projections from the somatosensory thalamus to the granular somatosensory cortex that defines the body map (Killackey and Ebner 1973). Information from different somatic regions—face, back, leg, etc.—is communicated between them in the same hemisphere and across the midline through the dysgranular cortex that surrounds granular cortex (Koralek et al. 1990).

After neonatal forelimb amputation, 30% of multi-unit recordings in contralateral stump cortex can be activated by hindlimb stimulation after blocking GABA_A+_B receptors (GRBs) with topical bicuculline methiodide/saclofen hydrochloride, indicating that ipsilateral hindlimb inputs are suppressed by inhibition. This is in distinction to the 12% found in normal animals (Pluto et al. 2005). Earlier studies from the same group showed that pathways from the hindlimb cortex are routed through interposed dysgranular cortex (see Fig. 5 of Pluto et al. 2003). In this study, inputs from functionally identified forelimb region in the opposite hemisphere were suppressed with topical lidocaine. As a result, slightly more than one-half of the stump cortical sites that were activated by hindlimb after ipsilateral GRBs were activated by hindlimb stimulation after anesthesia of the opposite cortex, presumably through the dysgranular cortex (Pluto et al. 2005).

Clinicians had puzzled for many years as to why some adults with misaligned eyes in childhood should be virtually blind in one eye but not the other when both eyes were otherwise normal (Hohmann and Creutzfeldt 1975). Similar misalignments in adults cause double vision. Study of the bases for this phenomenon led Hubel and Wiesel (2005) to conduct a series of groundbreaking studies on neural plasticity of the visual cortex. While many of these findings have been attributed to altered connections, they also reflect changes in the balance of activity carried over different connections to effectively modulate excessive or confusing information (Ito 2002; Knott et al. 2002; Markram et al. 2004; Simons and Land 1987).

There is precedent, especially with lesions to the periphery in the neonatal period, for significant changes in cortical connections (Miller et al. 2001). Pluto et al. 2005 indicate that they are presently evaluating connections in their model. Whatever they find, this study makes clear the impact of interhemispheric connections in the inhibition of abnormal, confusing inputs. Its precise basis can be understood, in part, because of the simple organization of the rat SI cortex, anatomical markers that define its components and postnatal development of its connections (Woolsey 2003).

Inhibition plays a major role in shaping responses and actions in the normal brain. Pluto et al. (2005) document elegantly such interactions in normal and altered rat somatosensory cortex. Virtually all neural systems use this strategy, such as to suppress unwanted movements while permitting the desired ones (Mink 1996) or to focus attention where it is needed (Posner 1986). It is perhaps not surprising, therefore, that there is a strong role for converging inhibition in the functional adjustments in the brain after major perturbations such as limb amputations, eye misalignments, sensory deprivation, and physical constraints in developing systems. Inhibition, despite early views that it did not play a role in brain function (i.e., Ramón y Cajal 1995) and its considerable metabolic costs, ultimately saves energy in the operation of the energetically expensive brain (Shulman et al. 2004). Pluto et al. provide compelling evidence that, in the somatic sensory system, inhibition from several sources plays a key role in the effective functional recovery from early trauma. Rats with an amputated forelimb can and do go about their lives almost as

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if they were normal. Evidently rats heed not the admonition, “. . . let not thy left hand know what thy right hand doeth” (Matthew 6:3).

REFERENCES


