Recovery of Function after Focal Cerebral Insult

A Pet Activation Study

MURRAY GROSSMAN¹, LETICIA PELTZER¹, MARK D'ESPOSITO¹, ABASS ALAVI², and MARTIN REIVICH¹

Nelson Butters is world-renowned for his investigations of human cognitive disorders. Butters' seminal explorations of subhuman primate cognition with his collaborators Donald G. Stein and Jeffrey J. Rosen, while not as well-known, have been equally influential in directing another important area of research. These investigators were pathbreaking in their examinations of the mechanisms underlying recovery of function following lesions of dorsolateral frontal cortex in monkeys. Butters and his colleagues [e.g. 1973, 1974; Rosen et al, 1971] hypothesized that cortex immediately adjacent to a cortical lesion, as well as more distant association cortices, play a critical role in recovery and reorganization of function following cortical ablation in the adult. This work anticipated more recent investigations of CNS plasticity and reorganization following insult in subhuman primates [e.g. Kaas, 1992]. As we suggest below, the lessons derived from Butters' prescient observations of primates may also provide powerful constraints on modeling in human cognitive neuroscience.

¹ MURRAY GROSSMAN, M.D., LETICIA PELTZER, MARK D'ESPOSITO, M.D., MARTIN REIVICH • Department of Neurology, University of Pennsylvania School of Medicine
² ABASS ALAVI • Department of Radiology, University of Pennsylvania School of Medicine


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Cognitive neuroscientists have typically assumed that the residual cognitive architecture following a lesion is the normal system minus the lesioned component. This view has been articulated most elegantly by Caramazza [1986] as his "transparency assumption". Briefly, Caramazza stated that the effects of brain damage on a cognitive system must leave the remaining components undamaged, and that new processing structures must not be created as a consequence of brain damage. Indeed, he felt that normal cognitive processes could not be informed by neuropsychological investigations unless the neural network remaining after insult reflected the normal state except for the ablated element. The conservation of function inherent in the "transparency assumption" has been adopted without challenge by several different theoretical approaches within cognitive neuroscience. For example, flow diagrams often characterize information processing models of neurologically impaired performance simply by deleting the abnormal process or connection from the model [McCarthy & Warrington, 1991]. Similarly, parallel distributed processing models of cognitive functioning attempt to replicate abnormal behavior by "lesioning" a trained system, that is, by removing some proportion of the units from a fully functional model [Hinton & Shallice, 1991; Patterson et al, 1989b].

Counter-examples to the "transparency assumption" have been suggested from time to time. For example, deep dyslexia is said to follow a large lesion in the left hemisphere, and the peculiar pattern of reading errors associated with this syndrome has been attributed to the intact right hemisphere or to non-lesioned regions within the left hemisphere [e.g. Coltheart, 1980; Landis et al, 1983; Patterson et al, 1989a]. Explanations for deep dyslexia such as these imply that the remaining brain regions supporting reading do not reflect only the normal reading system, but the unusual errors may mirror the contribution of brain regions that do not ordinarily participate in reading. The reading process thus may have been reorganized in an attempt to compensate in part for the impairment. Examples such as these are potentially important since they may provide important neurophysiological constraints on the nature of modeling in cognitive neuroscience. In the context of observations such as these, investigators such as Kosslyn and van Kleek [1990] have called to question Caramazza's "transparency assumption", and have emphasized the importance of understanding the cerebral basis for neuropsychological functioning. In vivo neurophysiological monitoring of cerebral functioning during the performance of a cognitive task in a brain-damaged state has been rare [e.g. Grady et al, 1990; Weiller et al, 1992], however, so it has been difficult to marshall support for this alternative. We present preliminary evidence from a PET activation study of a stroke patient that challenges the "transparency assumption". If accurate, our preliminary observations begin to suggest that additional components must be incorporated in models of cognitive functioning to make them biologically more plausible.