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Overall intelligence and localized brain damage

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Abstract

Overall mean performance on intelligence tests by brain-damaged patients with focal lesions can be misleading in regard to localization of intelligence. The widely used WAIS has many subtests that together recruit spatially distant neural "centers," but individually the subtests reveal localized functions. Moreover, there are kinds of intelligence that defy the localizationist approach inferred from brain damage.

The Parieto-Frontal Integration Theory (P-FIT) of intelligence: Converging neuroimaging evidence Jung Rex E.Haier Richard J. Departments of Neurology and Psychology, University of New Mexico, and The MIND Research Network, Albuquerque, NM 87106 rjung@themindinstitute.org www.themindinstitute.org www.positiveneuroscience.com; School of Medicine, Med Sc I; C237, University of California, Irvine, CA 92697-4475 rjhaier@uci.edu http://www.ucihs.uci.edu/pediatrics/faculty/neurology/haier/haier.html

Brain damage fragments cognition into numerous perceptual and cognitive units that can then be examined with an eye toward their functional localization in the brain. The 14 subtests of the Wechsler Adult Intelligence Scale (WAIS) are commonly employed to assess the effects of the damage on different aspects of intelligence. Each subtest relies on separate or overlapping brain functions, but together all subtests need the computational powers of the entire brain, not just the frontal-parietal axis. For example, what is required at the very minimum for performing the Information subtest of the WAIS test is intact auditory comprehension, namely Wernicke's Area complex in the left temporal lobe, as well as verbal output, namely Broca's Area complex in the left frontal lobe, together with long-term semantic memory, which includes the left hippocampus, the temporal and parietal lobes. To use another example, consider the Block Design, a subtest that measures spatial abilities: The frontal lobes in both the left and right hemispheres are required for foresight, the right parietal lobe for translating the two-dimensional diagrams of the blocks into three-dimensional construction of the blocks, not to mention sustained attention on the task by the left parietal lobe. But what specific brain regions control performance in the Picture Arrangement subtest (arranging individual pictures so they tell a unified story) besides the occipital lobes, the parietal lobes, commissural fibers, both hemispheres or only one hemisphere, is not known. All four lobes, in each hemisphere, and possibly subcortical regions, would be expected to contribute to intelligence as measured by the widely employed intelligence tests.

In section 7.1, Jung & Haier (J&H) cite studies that did not reveal striking alterations in overall IQ, or intelligence in general, or just verbal intelligence following localized brain damage, and they use the results as supporting evidence for their main thesis. However, such empirical outcomes should not be surprising considering the following: Performance on several subtests can compensate for the reduction on only one or two. It is not informative to declare that overall intelligence as measured by the WAIS or a similar test is reduced or not following focal damage. Likewise, with brain-damaged patients, reporting whether or not the Verbal Scale or the Performance Scale of the WAIS is affected, masks the compensatory contribution of intact regions. What is potentially meaningful in the context of brain lesions is the breakdown of scores in individual subtests, and, in tests such as the Raven's Progressive Matrices where subtest breakdown is not possible, the clustering of failed versus successful items, or item analysis results. Finally, the cognition measured by intelligence tests reflects the combined effects of diseased and healthy tissue. The effects of focal and lateralized damage could go against a large regional involvement such as the frontal-parietal axis.

Moreover, localized specialized brain regions form pathways and networks connected to each other in selective interactive ways, as J&H point out. However, the extent of their interconnectedness could be critical for optimal performance on intelligence tests. The issue of high intelligence versus average or low intelligence has not been fully addressed in the target article as a function of the interconnectivity. Number of functional axonal fibers and their myelin is a neglected issue in assessing effects of neural injury. Abundant connectivity among widely localized neuronal centers would be expected for above-average performance on intelligence tests, whereas for average intelligence only limited connectivity may be sufficient.

Further, there are kinds of intelligence that traditionally have not been subjected to many decades of scrutiny as the WAIS or the Raven's Progressive Matrices (Gardner 1993b; Sternberg 1985). These kinds are complex and cannot be measured easily, and consequently brain damage cannot illuminate their components sufficiently to provide clues to their localization, nor can functional magnetic resonance imaging (fMRI), positron emission tomography (PET), or Single Photon Emission Computerized Tomography (SPECT) help here.

One need only think of social intelligence, emotional intelligence, athletic intelligence, and artistic intelligence to realize their enormous complexity and their unamenability to numerical, analytic measures. There are other types of “intelligences” not defined yet in terms of cognitive units, and no neuronal “centers” or specific neural pathways have been uncovered for them (Rose 2004). Artistic intelligence, for example, relies heavily on specialized cognition, skill, practice, and talent, and is extremely resistant to a wide variety of brain-damage etiology (Zaidel 2005). To apply the frontal-parietal axis to this type of intelligence is wholly inadequate.

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