EDITORIAL

Attention following stroke

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Deficits of attention frequently accompany brain damage. An article in this issue of *Neurology*® provides evidence that a computerized measure may help the clinician to determine which aspects of attention are affected and suggest some directions for remediation.[1]

ATTENTIONAL NETWORKS Evidence favors separate brain networks related to alerting, orienting, and executive control.[2] The Attentional Network Test (ANT) was developed to measure individual differences in these 3 networks[3] and requires only a response to a central arrow by pressing one key if it points right and another if it points left. To measure executive control, the central arrow is surrounded by flankers that either point in the same (congruent) or opposite (incongruent) direction. By measuring the reaction time on incongruent trials and subtracting from it the reaction time in congruent trials one measures the extra time needed to resolve the conflict between target and flankers. The resolution of conflict is a central function of executive control. Cues indicate when and where the target will occur in order to measure alerting and orienting. Imaging studies of normal persons show that these networks involve mostly separate brain areas.[4]

STROKE PATIENTS Rinne and associates[1] recruited 110 stroke patients and 62 controls. They found that, compared to controls, patients had slower reaction times and an alerting deficit, mainly associated with lesions of the anterior thalamus; those with an orienting deficit, lesions in the right pulvinar and temporal-parietal cortex; and those with executive deficits, lesions mainly involving bilateral white matter tract associated with the anterior cingulate.

All 3 of these results fit well with previous imaging findings.[4] Lesions of the right temporal-parietal junction produce neglect of space opposite the lesion. The thalamic noradrenergic system is central to the alert state. The observation that lesions of the anterior corona radiata disrupt executive control is concordant with the executive network correlating with the efficiency of this pathway in diffusion tensor imaging studies in controls.[5] While imaging studies indicate whether a particular brain area or white matter tract is involved in the network, these lesion data add to the evidence that these areas are critical for the efficient operation of the networks.

The results of the ANT with stroke patients suggest important clinical applications, but this will require careful thought by the clinician. The Rinne et al. study involves a comparison of a group of patients with controls, while the clinician is confronted with an individual case. The form of the ANT used in the study involved targets above and below fixation, while many patients have unilateral lesions. The lateralized ANT[6] involves targets to the left and right of fixation and may be more useful in studying patients by comparing targets in the damaged and undamaged hemispheres. By using fingers on the unaffected hand and larger displays, the clinician may accommodate weakness and sensory deficits caused by the stroke.

Apart from stroke, many forms of normal aging, dementia, and psychopathologies of adults and children involve specific problems in these same attentional networks,[7] and may therefore also benefit from use of the ANT. Because the ANT can be employed multiple times, it can be used to follow recovery or to examine the effects of drugs, training, or other forms of intervention.

USES FOR A CLINICAL LAPTOP Since half of the unselected stroke patients can be classified as having a deficit of one network, the ANT may be useful in suggesting the form of remediation to use. Improvement in performance in normal persons occurs from using commercially available video games[8]; the effects are largest for the orienting network but may also improve executive functions. Specific training in attention also improves orienting and executive attention in brain injury and stroke[9] and can generalize to related cognitive functions.[10] The ANT could be used to evaluate the influence on attention of drugs or other therapies used to enhance recovery. Changes in brain state induced by 2–4 weeks of mindfulness training can improve executive attention by changing the connectivity of a set of pathways around the anterior cingulate important for self-regulation.[11] Whether this would improve performance of participants with lesions

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of this area is unknown. In these ways, computerized programs may clarify deficits, and assay and train attention, thus providing a service to the physician and patient.

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