Journal Club

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Parietal Representations for Hand–Object Interactions

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Review of Naito and Ehrsson (http://www.jneurosci.org/cgi/content/full/26/14/3783)

The neuroanatomical correlates of tool and object use have become a compelling area of interest. Tool use and interactions with objects are functions that are generally taken for granted. However, persons with stroke can have a deficit in actual tool-use ability, generally referred to as apraxia. Ideomotor apraxia commonly arises from left-hemisphere parietofrontal damage. It generally manifests as a bilateral deficit in tool-use pantomime or gesture imitation and additionally may involve actual tool use (Hanna-Pladdy et al., 2003). Another similar form, conceptual apraxia, involves the lack of ability to manipulate tools based on a loss of tool knowledge. Studies of apraxia have suggested that the left hemisphere is integral, if not exclusively involved, with the entirety of motor praxis skills, including pantomime and object manipulation. Likewise, right-hemisphere damage rarely causes apraxia (Haaland et al., 2000). However, the brain regions involved in direct hand–object interactions have not received much attention.

In a functional magnetic resonance imaging (fMRI) study in *The Journal of Neuroscience*, Naito and Ehrsson (2006) asked what areas of the brain process interactions of objects. The authors used kinesthetic illusions of coordinated hand–object movements that arise from stimulation on tendons of wrist extensors to isolate areas of the brain involved in hand–object interactions. "Passively flexing" the wrist caused a hand–object movement illusion such that intention, effort, and force variability were removed as variables in this study design.

Naito and Ehrsson (2006) evaluated blindfolded right-handed male subjects by testing hand–object interaction illusion on the left and right hands separately. The subjects laid supine on the bed of an fMRI scanner with arms extended and in a prone position parallel to the trunk, with the hands passively flexed. Using a 2×2 factorial design, variables included whether there was a ball placed in the hand (contact or free) and stimulation on the muscle tendon or bone (tendon or bone). A vibratory stimulus delivered to the tendon of the extensor carpi ulnaris caused the illusion of palmar flexion of the wrist. In contrast, the same stimulus delivered to the bony processus styloideus ulnae caused no illusion of movement.

Behaviorally, stimulation in the contact–tendon condition caused the intended illusion of the ball moving with the hand in a flexion movement and confirmed the perceptual illusion based solely on sensory manipulation. There was no such sensation when the bone was stimulated. Accordingly, fMRI revealed predominant left inferior parietal lobule (IPL) activity in the contact–tendon condition compared with contact–bone, regardless of the hand tested. This activity was not present in free–tendon compared with free–bone. Additionally, in the contact–tendon condition, there was no activity in homologous right-hemisphere areas, and the activity in the left IPL was stronger than that of the right IPL. Illusory movements, caused by stimulation of the tendon, of either hand without the ball (free–tendon) elicited right-hemisphere activity. Based on these results, the authors proposed that the left IPL specifically mediates sensation of hand–object interactive movements by integrating kinesthetic information of the hand and object properties. The binding of the object properties and sensory feedback was robust, because the free–tendon condition was not enough to cause left IPL activation. This activity likely represents neuronal association of body-centered and object-centered information.

Until now, the idea of left-hemisphere dominance for praxis has largely been based on lesion localization in apraxia patients with bilateral deficits (Haaland et al., 2000). Praxis skills can be recovered through patient rehabilitation (Smania et al., 2006), but the neuroanatomical substrates responsible for this recovery are unclear. The right hemisphere may store poorly developed representations of tool–object interactions (Kertesz and Ferro, 1984), which may be useful in recovery of left-hemisphere damage. However, such representations may be incomplete, at best. This is demonstrated in patients who have undergone complete callosotomy to separate the left and right cortex for epilepsy treatment. If the left hemisphere is dominant for praxis, callosal disconnection should make such representations inaccessible to the left hand. Right-handed patients with a complete callosotomy were able to manipulate tools successfully with their left hand (under right-hemisphere control) but

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could not pantomime visually presented objects (Lausberg et al., 2003). Right-hand (under left-hemisphere control) pantomime and tool manipulation was intact. Left-hand tool-manipulation abilities may have been attributable to the length of time between the initial surgery for a complete callosotomy to testing (between 8 and 36 years); thus, reacquisition of left-hand tool-use tasks during this time from daily living is possible. Thus, even in this pathology, right-hemisphere praxis representations are incomplete.

The work of Naito and Ehrsson (2006) fits with lesion studies that suggest left-hemisphere dominance of complete motor praxis abilities (Haaland et al., 2000) and confirms the generally accepted notions based on patients with unilateral stroke or callosotomy. The study under consideration demonstrates well the notion that object–hand interactions are left-hemisphere dominant. Because illusory movements without the ball in hand produced right IPL activations, such regions are likely related to neuronal processing of one's own body.

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