How does the attentional pointer work in prefrontal cortex?

Naoyuki Osaka
Department of Psychology, Graduate School of Letters, Kyoto University, Kyoto 606-8501, Japan. **Osaka@psy.bun.kyoto-u.ac.jp**
http://www.psy.bun.kyoto-u.ac.jp/~osaka/

Abstract: The current model, based on event-related potential (ERP) studies, posits that the working-memory system is a state of activated long-term memory; this appears comprehensive, but it needs further detailed analysis of functional neural connectivity analysis within the prefrontal cortex (PFC) and between the posterior and prefrontal cortex. Specifically, the role of dorsolateral PFC and anterior cingulate cortex (ACC) is probably critical for PFC's attentional controller. Neural implementation of the executive function in working memory appears critical to build a firm model.

The issues regarding how short-term storage is neurally implemented, and how it is related to long-term memory, are critical for modeling working memory (Baddeley 1986). By introducing the working-memory system as a state of activated long-term memory, Ruchkin et al. have reviewed models that explain how "short-term storage mechanisms involve an increase in neural synchrony between prefrontal cortex and posterior cortex and the enhanced activation of long-term memory representations of material held in short-term memory" (target article, Abstract). Ruchkin et al. insist there is no need to posit specialized neural systems whose functions are limited to those of short-term storage buffers in connection with the role of prefrontal cortex's (PFC) attentional pointer for maintaining activation in the posterior processing systems. My first argument is based on the modality- and material-specific buffers in the posterior cortex, and the second one is based on neural correlates of PFC's attentional controller.

I agree with the views (e.g., Cowan 2001; Crowder 1993) that short-term memory stores are constituted by an activated subset of long-term memory. However, an activated subset appears to somehow involve modality- and material-specific properties. In two functional magnetic resonance imaging (fMRI) studies, using the reading and listening span tests (RST and LST) which measure verbal working-memory capacity by reading (listening), we (M. Osaka et al. 2003; N. Osaka et al. 2003b) asked the subject under fMRI investigation to retain the specified word, while judging as true or false the semantics currently in process (dual task). We found the activated brain areas in the posterior (BA18/19) and superior temporal/inferior parietal (BA22/42) during the RST and LST tasks, respectively. However, interestingly enough, we also found commonly activated loci, which are located in the PFC's dorsolateral preferontal (DLPFC), inferior frontal gyrus (IFG), and anterior cingulate cortex (ACC) (M. Osaka et al. 2003; N. Osaka et al. 2003b). These data suggest modality- and material-specific areas in the posterior brain are still at work, in coordination with PFC, even if these are a portion of an activated subset of long-term memory. Because of the low temporal resolution of the system, our fMRI data could not provide the comparable data for material that is heard or read, as mentioned (Penney 1989; Ruchkin et al. 1990).

The second argument is based on the neural basis of PFC's attention pointer system. Ruchkin et al. refer to PFC's attentional pointer system for maintaining activation in the appropriate posterior processing system, and the number of pointers involved in the PFC determines the attentional constraint of the working memory. In my view, attentional pointers are likely the resource-limited agent of the executive functions, which work in a coordinated fashion to achieve task-defined goals (cf. M. Osaka et al. 2002). The authors of the target article did not show, in detail, how the pointer system works under specified neural implementations in PFC. Our fMRI data show that DLPFC, IFG, and ACC are the distributed executive areas in PFC which work together to control posterior brain functioning in a task-dependent manner. We also showed a critical role for individual differences in PFC functions: Individuals having higher working-memory capacity show higher functional connectivity between ACC and DLPFC (M. Osaka et al. 2003), whereas individuals having lower working-memory capacity show lower connectivity among ACC, DLPFC, and modality-specific posterior regions.

Thus, our fMRI investigation is likely to support the idea that the posterior cortex provides the representational basis for most short-term memory operations, and the PFC provides the attentional control, as the target article authors argue. The other example, suggesting PFC's top-down control that extends activation into the posterior cortex, was shown in an fMRI experiment in which an onomatopoeic word, suggesting visual images of strong laughter heard by the ear, evoked top-down visual awareness of the laughing face in the brain (N. Osaka et al. 2003a). The laughter word clearly activated the lingual gyrus/fusiform gyrus area, commonly known as the "face area." Further neuronal network-based connectivity studies are needed to establish a model describing working-memory systems as a state of activated long-term memory.

Will the unitary view survive the short- and long-term?

Michael D. Patterson and Bart Rypma
Psychology Department, Rutgers University, Newark, NJ 07102.
patterson@psychology.rutgers.edu **rypma@psychology.rutgers.edu**
http://psychology.rutgers.edu/users/rypma

Abstract: In this commentary, we focus on four points. First, we discuss the assertion that the unitary model explains dissociations that implicate multiple systems. Second, the distinct nature of information utilized in immediate- and delayed-recall supports the distinct memory systems view. Third, the variable nature of capacity limits corroborates this view. Finally, we review event-related fMRI results that suggest support for multiple systems.

Ruchkin and his colleagues argue that, in contrast to the multiple-component view of memory proposed by Baddeley and Hitch (1974), a unitary-system view provides a better and more parsimonious account of data in the extant literature. In this view, working-memory (WM) retention involves the activation of long-term-memory (LTM) representations, mediated by binding circuitry in prefrontal cortex (PFC). We will comment on several claims made by Ruchkin et al. The first is a plausibility claim: Specifically, that key empirical findings (e.g., neuropsychological data showing STM/LTM dissociations) are readily interpretable within a unitary-system framework. The second claim is that data from event-related potentials (ERPs), with superior temporal resolution, provide evidence that permits critical tests of the unitary- and multiple-component views. The third claim is that fMRI evidence complements the ERP data to further support a unitary-system account of WM.

The plausibility claims made by Ruchkin et al. underscore the fact that experimental results may be variably interpreted to support more than one theoretical system. The authors point out, for instance, that the double dissociation, wherein some patients demonstrate STM deficits (e.g., Shallice & Warrington's 1970 patient, KF) in the presence of preserved LTM, whereas others demonstrate LTM deficits in the presence of preserved STM (Scoville & Milner 1957), may be accounted for by a deficit in binding processes that activate LTM representations. There are two lines of evidence that render this account problematic. First, it is troubling for the binding-deficit explanation that patients with these deficits have lesions in focal, but distinct, brain regions. Additionally, these patients' lesion sites do not match the regions implicated in an fMRI study of binding (Prabhakaran et al. 2000). Second, Baddeley and Wilson (2002) have observed that amnesics apparently are able to integrate information in LTM to remember

https://doi.org/10.1017/S0140525X03460160 Published online by Cambridge University Press