Comment on "Wandering Minds: The Default Network and Stimulus-Independent Thought"

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Mason *et al*. (Reports, 19 January 2007, p. 393) attributed activity in certain regions of the "resting" brain to the occurrence of mind-wandering. However, previous research has demonstrated the difficulty of distinguishing this type of stimulus-independent thought from stimulus-oriented thought (e.g., watchfulness). Consideration of both possibilities is required to resolve this ambiguity.

One of the most intriguing puzzles in cognitive neuroscience is the existence of a set of brain regions—the default-mode network—that exhibit greater signal during baseline or "rest" periods of functional neuroimaging studies than during performance of effortful cognitive tasks. These regions are predominantly located medially, including the precuneus/posterior cingulate and a large expanse of medial rostral prefrontal cortex (mPFC) (*1*). Although there is general consensus that these brain regions support mental processes that are more common during low-demand conditions, the exact nature of these mental processes is unclear. Activity in the default-mode network may reflect the occurrence of mind-wandering, i.e., cognitive processes unrelated to the current task and decoupled from current sensory information (*2*). We refer to this as the stimulus-independent thought (SIT) hypothesis. Alternatively, activity in this network may reflect enhanced watchfulness toward the external environment (e.g., waiting for upcoming task-relevant stimuli or attending to scanner noise and incidental light) (*3*). We refer to this as the stimulus-oriented thought (SOT) hypothesis. Of course, activity in the default-mode network may reflect a combination of both SIT and SOT, i.e., "surveillance of the internal and external environments" (*4*). These alternative accounts are difficult to distinguish empirically, but consideration of both possibilities is necessary if potentially erroneous conclusions are to be avoided.

Mason *et al*. (*5*) demonstrated that a set of default-mode brain regions showed greater activity during a fixation baseline condition compared with a working memory task, and during task performance using practiced rather than novel stimuli. Self-report of SIT was higher in the practiced than the novel condition, and the difference in default-mode activity between these conditions correlated with participants' self-reported propensity toward SIT. Based on these findings, they argued that default-mode brain regions are implicated in mind-wandering.

We argue that (i) low-demand situations may provoke an increase in both SOT and task-unrelated SIT, compared with other tasks; (ii) because Mason *et al*. only considered SIT incidence, not SOT incidence, it is not possible to evaluate whether their results are better explained by the occurrence of SIT than SOT; (iii) one measure that is able to distinguish moment-by-moment occurrence of SIT versus SOT is reaction time (RT); and (iv) studies that have investigated RT support a link between activity in default-mode brain regions and the occurrence of SOT, not SIT. We conclude that the data presented by Mason *et al*. are insufficient to unambiguously link the default-mode network with SIT alone.

It is important to note that Mason *et al*. (*5*) did not obtain any measure of the moment-by-moment occurrence of SIT during scanning sessions. Instead, their conclusions were based on self-report during an earlier training session. The baseline condition, requiring participants to watch a fixation cross waiting for task-relevant stimuli to appear, was associated with greatest SIT self-report. However, it is plausible that this condition was also associated with a higher degree of watchfulness, that is, "trying to get something from the external world" (*3*), compared with the working memory tasks. Likewise, it is plausible that practiced working memory tasks afford increased environmental attending (because of stronger stimulus-response links). This may potentially underlie signal change in default-mode brain regions, rather than mental experiences unrelated to task performance. The correlations reported by Mason *et al*. between self-report of daydream frequency and default-mode activity are intriguing. However, a propensity to mind-wander may provoke increased effort to remain alert toward the environment, making it difficult to interpret the relationship between this measure and brain activity. Furthermore, the authors' questionnaire measure of daydream frequency correlates positively with other measures, e.g., distractability, which may relate more strongly to SOT (*6*). It cannot therefore be considered a pure measure of SIT.

An alternative approach to distinguish SOT and SIT is to investigate correlations between fluctuations in brain activity and fluctuations in behavioral performance (*7*). Gilbert *et al*. (*3*) investigated performance of a simple-RT baseline task (pressing a button as quickly as possible whenever a stimulus was presented), along with three other tasks with greater cognitive demands. Default-mode brain activity was greatest in the baseline task. They went on to investigate correlations between mPFC activity and baseline-task performance. If mPFC signal in baseline conditions reflects SIT (i.e., mind-wandering), signal should be greater on those trials with worse performance, because activity will reflect disengagement from the task. Alternatively, if mPFC signal in baseline conditions reflects SOT (i.e., watchfulness), greater signal should be associated with those trials with better performance because this region contributes functionally to performance. Brain-behavior correlations were consistent with the latter hypothesis (Fig. 1): Greater signal in mPFC was significantly correlated with faster reaction times (RTs), on a trial-by-trial basis, consistent with similar results from other studies (*7*–*9*). In some tasks, trials with faster RTs may index increased mind-wandering if such trials have reduced cognitive demands, for example, when participants disregard an additional task rule (*10*). However, in the present task, stimuli, responses, and stimulus-response mappings were identical on every trial, ruling out this possibility.

Further evidence for a role of mPFC in SOT comes from a meta-analysis of functional neuroimaging studies reporting activation of rostral prefrontal cortex (*11*). Increased mPFC signal was associated with tasks with relatively fast RTs but not with long response-stimulus intervals (when mind-wandering might occur between one trial and the next). These findings are consistent with extensive evidence from neuroimaging (*3*, *7*–*9*) and electrophysiology (*12*) implicating default-mode brain regions in perceptual functions. By contrast, recent studies of mind-wandering have implicated brain regions outside the default-mode network, such as the lateral rostral PFC (*13*).

We suggest three steps that may contribute to a fuller understanding of the functions of default-mode brain regions. First, both SOT and SIT hypotheses should be considered empirically by future investigations. Second, it is important to obtain concurrent behavioral measures of hypothesized cognitive processes (*14*). Third, further studies are required to investigate differing contributions of subregions within this network, rather than treating it as functionally homogenous (*15*).

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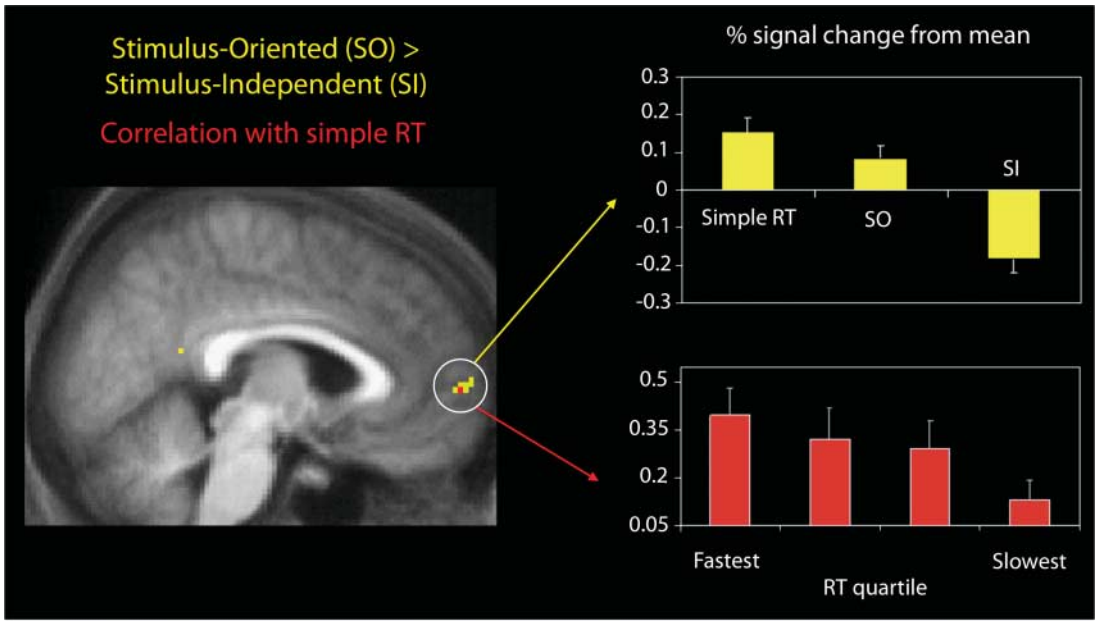

Fig. 1. Brain regions showing greater signal during stimulus-oriented attention than stimulus-independent attention (yellow), and those showing a significant correlation with reaction time (RT) in a separate simple-RT baseline task (red), at the conservative threshold of $P < 0.05$ corrected for whole-brain volume. The mPFC was more active in stimulus-oriented than stimulus-independent conditions; an overlapping region was most active on those trials of the baseline task with fastest RTs (peak co-ordinate: 2, 62, 4), suggesting a functional role in performance of the task. These results are inconsistent with the hypothesis that activity in this part of the mPFC reflects stimulus-independent mind-wandering. Adapted from figure 4 in (*3*).

References and Notes

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