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

Malia F. Mason,[1]*† Michael I. Norton,[2] John D. Van Horn,[3] Daniel M. Wegner,[4] Scott T. Grafton,[5] C. Neil Macrae[6]

Gilbert et al. suggest that activity in the default network may be due to the emergence of stimulus-oriented rather than stimulus-independent thought. Although both kinds of thought likely emerge during familiar tasks, we argue—and report data suggesting—that stimulus-independent thought dominates unconstrained cognitive periods.

Gilbert et al. (1) propose that activity observed in the default network (2) when participants are given unconstrained cognitive periods (i.e., while "resting" or performing easy tasks) is associated with monitoring the external environment (e.g., waiting for upcoming task-relevant stimuli or attending to scanner noise), or stimulus-oriented thought (SOT). They suggest that the results reported in Mason et al. (3)—increased default network recruitment when participants performed tasks that allowed for concurrent stimulus-independent thought (SIT)—may be better explained by the possibility that this network is involved in the generation of SOT. Below, we review the rationale for the Mason et al. paradigm, consider whether mind-wandering in our study was more likely to consist of SOT than SIT, and challenge the claim that the relationship between performance measures and default network activity is indicative of the occurrence of SOT rather than SIT.

A key difficulty associated with empirical investigations of SIT is that instructing participants to monitor their thoughts for task and stimulus relevance may compromise the very nature of this unconstrained form of mental activity. Indeed, as soon as a participant is aware that their SIT will be assessed periodically, these thoughts may in some sense become SOT, since they are now linked to the performance of an experimental task (reporting on one's mind-wandering). In functional magnetic resonance imaging (fMRI) studies, this active monitoring of thought is particularly problematic because it makes it difficult to distinguish blood-oxygenation-level–dependent (BOLD) activity that arises from unconstrained mind-wandering from activity that is associated with (constrained) monitoring for this type of thought. To avoid these potential problems, we first established that certain tasks were associated with an increased incidence of SIT outside the scanner—through thought probes—and then scanned participants while they performed these tasks absent such probes. Of course, the extent to which thought probes turn SIT into SOT remains an interesting empirical question worthy of further investigation.

Gilbert et al. (1) contend that because both SIT and SOT occur when people are given unconstrained cognitive periods (4, 5), measuring the incidence of each type of thought is required to support the conclusion that the default network is associated with SIT and not, as they suggest, SOT. If SOT accounts for activity in this network, then the occurrence of SOT should be high, and the occurrence of SIT low when participants perform routinized (versus unfamiliar) tasks. Daily experience and an extensive literature tend to suggest, however, that this is unlikely to be the case (6–8). Highly routinized behavior is generally associated with reduced awareness of the external environment and increased mind-wandering, whereas behavior that requires conscious supervision tends to be associated with the opposite pattern: increased awareness of the external environment and decreased mind-wandering (9). In addition, while this SOT account predicts increased recruitment of the default network when attention is allocated to the external environment, increased processing of externally presented information has been associated with decreased default network activity (10).

Still, we agree that both SIT and SOT are likely to emerge during unconstrained cognitive periods, but are they equally present? We conducted postscan interviews [not reported in (3)], which indicated that although many participants remembered spending time engaged in SOT, the majority of thoughts they reported were unbound to the external environment (Fig. 1). One participant remarked, "I would try to focus on the '+' sign in anticipation of the next task. After a few seconds, however, my mind would wander to other thoughts (e.g., I wondered how much longer the experiment would take, what I'd do tonight, and considered how much my head hurt). Also, I had a song in my head during the easier tasks; it was 'Just What I Needed' by the Cars." We did not intend to suggest that SIT is the only psychological process that ensues when people are "doing nothing," and these reports clearly contain incidences of SOT. Although these self-reports of mind-wandering may contain thoughts from both constrained and unconstrained periods, and although such retrospective reports may not constitute perfect recall of all thoughts experienced during task performance, they do suggest that SIT accounts for some of the activity observed in this network during periods of unconstrained thought, especially in combination with the correlation we observed between self-reported SIT frequency and default network activity.

Gilbert et al. (1) review evidence that faster performance on stimulus detection tasks is associated with increased default network activity (4), a finding they claim is difficult to reconcile with the possibility that the default network subserves SIT. Although we agree that reaction time constitutes a clever means of assessing attentiveness, we take issue with their suggestion
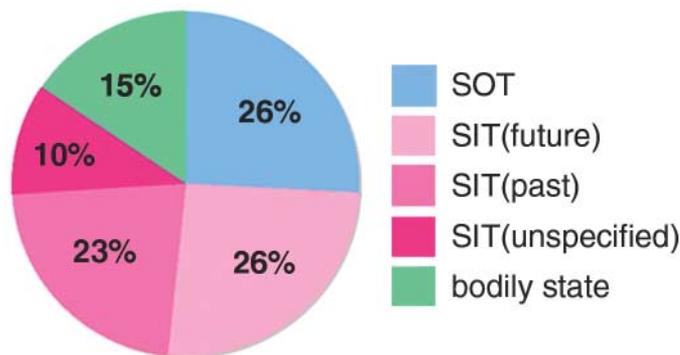
[1]Martinos Center for Biomedical Imaging, Massachusetts General Hospital, Charlestown, MA 02129, USA. [2]Harvard Business School, Harvard University, Boston, MA 02163, USA. [3]Department of Neurology, University of California, Los Angeles, CA 90095, USA. [4]Department of Psychology, Harvard University, Cambridge, MA 02138, USA. [5]Department of Psychology, University of California, Santa Barbara, CA 93106, USA. [6]School of Psychology, University of Aberdeen, Aberdeen AB24 2UB, Scotland.

*Present address: Columbia University, Uris Hall, 3022 Broadway, New York, NY 10027, USA.

†To whom correspondence should be addressed. E-mail: malia.mason@mail.gsb.columbia.edu

Fig. 1. Classification of thoughts participants reported (in postscan interviews) experiencing during fixation in (3). SOT, attending toward the external environment (e.g., anticipating the onset of the task, listening to the sound of the scanner); SIT(future), planning of future events (e.g., weekend plans); SIT(past), reflections on past events; SIT(unspecified), imprecise reports of SIT (e.g., "I mind-wandered"); bodily state, thoughts about one's physical state (e.g., feeling tired, hungry).

that our interpretation is invalid because they observed a positive correlation between response time and task performance in a small area of an expansive region of the medial prefrontal cortex (mPFC) that typically exhibits "default state" properties. In fact, it is not the case that rapid responding is invariably associated with greater default network recruitment. Not only have several investigations reported the opposite (*11–13*), but evidence indicates that accurate performance depends on successful suspension of activity in default network regions (*14*). The relationship between task performance and default network activity likely depends on the nature and difficulty of a task and the precise cortical region in question.

Finally, Gilbert *et al.* take issue with our treatment of the default network as functionally homogenous. As we mentioned in the conclusion of (*3*), it is likely that areas differentially contribute to the SIT experience. Although some regions may play a role in the general production of these thoughts, others might mediate people's awareness of SIT (*15*) or subserve phenomenological aspects of SIT (e.g., whether mind-wandering includes visual imagery), whereas still others (e.g., the mPFC) might mediate shifts in attention between exogenous and endogenous stimuli. Elucidating how the brain allocates attention between internal and external information and specifying how default network subregions contribute to the many forms that mind-wandering assumes are both exciting areas for future research.

References and Notes

1. S. J. Gilbert, I. Dumontheil, J. S. Simons, C. D. Frith, P. W. Burgess, *Science* **317**, 43 (2007); www.sciencemag.org/cgi/content/full/317/5834/43b.
2. M. E. Raichle *et al.*, *Proc. Natl. Acad. Sci. U.S.A.* **98**, 676 (2001).
3. M. F. Mason *et al.*, *Science* **315**, 393 (2007).
4. S. J. Gilbert, J. S. Simons, C. D. Frith, P. W. Burgess, *J. Exp. Psychol. Hum. Percept. Perform.* **32**, 45 (2006).
5. G. L. Shulman *et al.*, *Cereb. Cortex* **7**, 193 (1997).
6. J. Smallwood, J. W. Schooler, *Psychol. Bull.* **132**, 946 (2006).
7. J. L. Singer, *Daydreaming* (Random House, New York, 1966).
8. J. D. Teasdale *et al.*, *Mem. Cognit.* **23**, 551 (1995).
9. J. M. Smallwood, S. F. Baracaia, M. Lowe, M. Obonsawin, *Consciousness Cognit.* **12**, 452 (2003).
10. K. A. McKiernan, J. N. Kaufman, J. Kucera-Thompson, J. R. Binder, *J. Cognit. Neurosci.* **15**, 394 (2003).
11. D. H. Weissman, K. C. Roberts, K. M. Visscher, M. G. Woldorff, *Nat. Neurosci.* **9**, 971 (2006).
12. S. P. Drummond *et al.*, *Sleep* **28**, 1059 (2005).
13. N. S. Lawrence *et al.*, *Cognit. Neurosci.* **15**, 1028 (2003).
14. F. E. Polli *et al.*, *Proc. Natl. Acad. Sci. U.S.A.* **102**, 15700 (2005).
15. J. W. Schooler, *Trends Cognit. Sci.* **6**, 339 (2002).
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