Linking brain networks and behavioral variability to different types of mind-wandering

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Research focusing on mind-wandering (MW) has consistently shown that this mental state is accompanied by variable, error-prone behavior and increased activity within the default mode network (DMN) and the frontoparietal control network (FPN) (1–6). Given that the DMN has been implicated in internal mentation such as future planning or self-referential processing, whereas the FPN has been linked to cognitive control, the idea that activity within both networks is coupled with self-reported MW and poor behavioral performance has been widely accepted in this research field. In an intriguing new study in PNAS, Kucyi et al. (7) challenge this view by showing that hemodynamic responses in the DMN are strongest during periods of MW and stable, rather than variable, behavior. This remarkable result widens our knowledge on task-positive aspects of the DMN. Simultaneously, it remains rather puzzling how this network can be involved in MW and stable behavior at the same time, or why the authors found no relationship between behavioral measures and FPN activity (2, 3).

We believe that the apparent conflict between these findings and earlier reports can be resolved by highlighting that MW is not a unitary phenomenon. Recently, we proposed that aspects of MW may involve two hierarchically organized states that differ in their behavioral and neural signatures: an "off-focus" state characterized by less variable behavior and increased activity in core DMN nodes and an "active MW" state associated with more variable behavior and elevated hemodynamic signals in other DMN subcomponents such as the medial temporal lobe (MTL) subsystem (8). According to this model, off-focus states are more common in demanding tasks involving complex stimuli, and thus might have been dominant in the study by Kucyi et al. (7). The overrepresentation of off-focus states can explain why DMN activity was associated with both self-reported MW and stable behavior, and why there was no correlation between behavioral stability and activity in the MTL subsystem. Furthermore, the predominance of off-focus states can also account for the absence of MW-related FPN recruitment in this study, because the FPN has been linked to internally guided cognition (6), resembling active MW (8). From a different perspective, the distinction between deliberate vs. nondeliberate MW gained increasing interest recently, with deliberate MW being accompanied by elevated FPN activity (4, 9). Considering that deliberate MW is less frequent in demanding tasks (9), the paradigm of Kucyi et al. (7) might not have allowed extended periods of intentional MW, resulting in weaker FPN signals.

The study by Kucyi et al. (7) is unique because it not only underscores the diverse functional characteristics of the DMN but also convincingly shows that the interplay between neural networks, task performance, and self-reported MW is not straightforward. With the aim of extending their interpretation of results, we emphasize that heterogeneity not only applies to the function of the DMN but also to MW. In other cognitive domains, it has been argued that many-to-many mapping schemes are best suited to capture the correspondence between brain structure and function (10). It is very likely that the same applies to the relationship between brain networks and the multifaceted nature of MW.

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