Ruminating on Rumination

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Hamilton *et al.* (1) reported some very interesting and important findings in their article "Default-Mode and Task-Positive Network Activity in Major Depressive Disorder: Implications for Adaptive and Maladaptive Rumination." In the article, the authors explored dominance of the default-mode network (DMN) over the task-positive network (TPN) and how that dominance might be related to depression and rumination. Dominance of the DMN over the TPN was defined for time points where the DMN blood oxygen level dependent signal was greater than the TPN blood oxygen level dependent signal. This calculation was performed across the whole brain where the DMN and the TPN were defined from seed-based approaches of Fox *et al.* (2) during eyes-shut resting state scans. The authors found that subjective reflection scores from the Rumination Response Scale (RRS) of Treynor *et al.* (3) correlated negatively with DMN dominance. That is, for participants with major depressive disorder (MDD), the more they reflected, the less dominance there was of the DMN over the TPN. By contrast, depression sub-scales of the RRS correlated positively with DMN dominance for participants with MDD. The authors did not find reliable correlations between DMN dominance and RRS measures for the healthy control (HC) group. Therefore, DMN dominance might be a reliable measure of depression severity.

With a spatial frequency analysis, the authors also found that a region of the right frontal insular cortex (RFIC) was more likely included in the TPN for MDD subjects, relative to the HC subjects. Interestingly, the RFIC has been implicated in switching between DMN dominance and TPN dominance (4). In a separate region-of-interest analysis on the RFIC, the authors found voxels that interacted by group and network. These voxels in RFIC increased in activation during DMN dominance (i.e., DMN peaks) for MDD subjects, but they activated in the opposite condition for HC subjects during TPN dominance (i.e., TPN peaks). Although the authors could not examine what role the RFIC might be playing psychologically, they proposed a potential mechanism. If one role of the RFIC might be to monitor for the presence of undesired bodily states (5), then when MDD subjects are in a ruminative state represented by DMN dominance, the RFIC might jumpstart the TPN-based affect regulation mechanisms (1). By contrast, for HC subjects, activation of the RFIC might get participants out of analytical and cold cognitive processing represented by TPN dominance and into more creative processes such as mind wandering and daydreaming (1,6,7), which might be represented by DMN dominance. These findings are novel and important in that they point to a potentially important neural marker of psychological dysfunction and rumination. Surprisingly, no overlap in voxels was found in RFIC between this analysis and the spatial frequency analysis (an issue that merits further attention).

These results are related to recent work exploring the relationship of default-network connectivity to rumination in depression (8). In that study, MDD and HC participants performed a valenced working memory task. Before and after each task epoch, there was a 16-sec rest break, and there were 24 such rest breaks throughout the scanning session. These rest breaks were concatenated together to form a single resting state run. In an exploration of default network connectivity with a procedure similar to Fox *et al.* (1), MDD participants exhibited increased default network connectivity in the subgenual cingulate cortex (SCC) relative to HC subjects during these rest periods. Other studies have linked SCC hyper-connectivity and hyper-activation to depression (9,10). Importantly, connectivity of the SCC was correlated reliably with RRS measures across both participant groups as shown in Figure 1. This finding implies that connectivity in the SCC during rest might be a neural indicator of depressive rumination. In addition, Berman *et al.* (8) found that hyper-connectivity in the DMN, particularly in the SCC, only differed between MDD subjects and HC subjects during periods of quiescence and not during task engagement itself. That finding demonstrates that, whereas MDD participants might engage in ruminative processes during rest, engaging in a task might be distracting and therefore mildly therapeutic. On the basis of the findings of Hamilton *et al.* (1), an additional interpretation might be that engaging the TPN, as a working memory task does, might increase dominance of the TPN over the DMN and therefore interfere with the neural circuitry that is involved in ruminative processes. Furthermore, the relationship between rumination scores and DMN connectivity was not found reliable during working memory task epochs of Berman *et al.* (8), again corroborating the idea that the link between rumination and connectivity might be restricted to off-task periods.

Unlike the results of Hamilton *et al.* (1), the results of Berman *et al.* (8) demonstrated that the relationship between rumination and DMN connectivity exists across both MDD and HC groups. We wonder, then, when effects will be restricted to specific populations and when they will be continuous across groups. Second, researchers have found that TPN nodes and activation might vary with task and task demands more so than the DMN (11,12). Although this is not problematic for the definition of the DMN, it might be problematic for the definition of the TPN in Hamilton *et al.* (1). Therefore, it would be important to explore DMN dominance both off-task and also on-task where the TPN might be defined via task engagement and not necessarily by anti-correlation with the DMN, as done by Hamilton *et al.* (1). In all, the results of Hamilton *et al.* (1) are important and indicate a new measure to study the neural mechanisms of depression and rumination.

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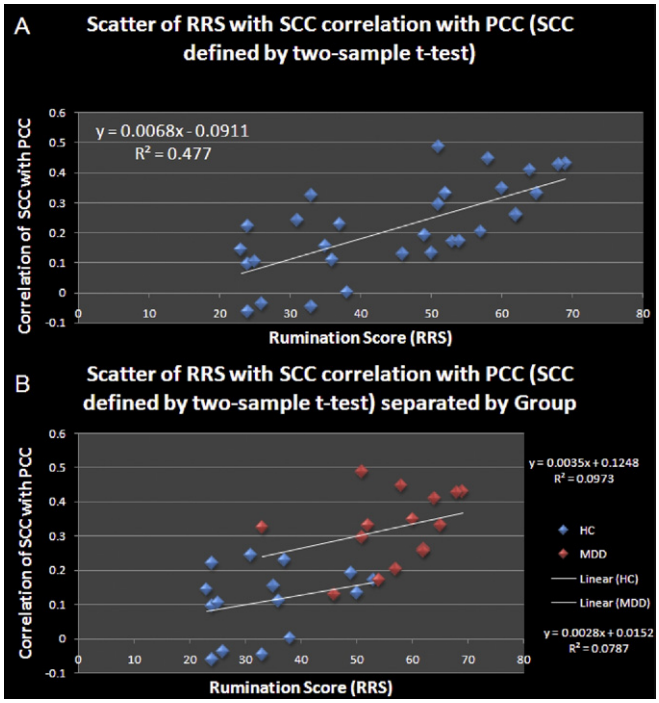

Figure 1. (A) Correlations drawn from the resulting subgenual-cingulate region of interest from a two-sample *t* test comparing the groups at rest. Subgenual cingulate cortex (SCC)–posterior cingulate cortex (PCC) connectivity correlates positively with subjective rumination scores across groups ($r = .068$, 95% confidence interval: .044–.85). **(B)** Correlations drawn from the resulting subgenual-cingulate region of interest from the two-sample *t* test comparing the groups at rest. The SCC–PCC connectivity correlates positively with subjective rumination scores for both major depressive disorder (MDD) subjects and healthy control (HC) subjects. The linear relationship equation is shown in the upper right for MDD subjects and lower right for HC subjects. RRS, Rumination Response Scale. Reprinted from Berman *et al.* (2010): Depression, rumination and the default network [published online ahead of print September 19]. *Soc Cogn Affect Neurosci*, by permission of Oxford University Press (8).

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