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Divergent Cortical and Subcortical Organization of the Human Reward Network

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The reward network plays a key role in motivation and decision-making and is known to be disrupted in numerous psychiatric conditions. Despite its functional importance, a comprehensive microstructural characterization of this network, including both its interacting cortical and subcortical components, remains sparse. Recent research, including findings from humans and non-human primates, suggests that cortical brain regions with similar microstructure are more likely to be interconnected. Accordingly, understanding human cognition, drive, and affect may benefit from integrating local microarchitectural features with the brain's macroscale functional organization. Advances in digitized human brain datasets, including post-mortem 3D histological resources, now allow for more detailed analyses that support and refine magnetic resonance imaging (MRI)-based findings. This study provides a multimodal characterization of the cortical and subcortical components of the reward network by combining structural and functional MRI with histological data as supporting evidence.

Twelve participants (7 females, mean age = 26.7, SD = 4.2) underwent three sessions of ultra-high-field (7T) MRI. Participants first completed a T1 relaxometry scan (MP2RAGE; 0.5mm isovoxels), which was used to segment the cortical gray matter and subcortical structures. Image intensities sensitive to intracortical myelin content were extracted from locations within a reward network mask defined a priori using the NeuroSynth database (Fig1A). We divided the mask across 20 uniform T1 intensity bins to capture spatial variation in the network myeloarchitecture. The data were then use to examine relationships between myelin content and intrinsic functional connectivity within the reward network.

T1 image intensities separated cortical and subcortical components of the reward network, with cortical regions generally showing higher T1 than subcortical structures (Fig1B). In the cortex, structural and functional measures were tightly coupled, with higher similarity in intracortical myelin predicting stronger intrinsic functional connectivity across bins (mean r = -0.34, SD = 0.16, $p < 0.001$). Subcortical areas, in contrast, showed a more heterogeneous pattern of structure-function coupling, with both positive and negative correlations between myeloarchitectural similarity and functional connectivity (mean r = 0.004, SD = 0.14, p = 0.383) (Fig1C). To further probe these patterns at a cellular level, we used the 3D BigBrain dataset to extract high-resolution staining intensity profiles. Across all vertices and voxels, BigBrain-derived intensities positively correlated with myelin-sensitive image intensities (r = 0.37, $p < 0.001$), supporting the sensitivity of our imaging measures to microarchitectural variation. This pattern was also evident in subcortical regions (Pearson: r = 0.36, $p < 0.001$).

Together, these findings demonstrate that the reward network is not a uniform system, but is composed of cortical and subcortical components that differ in their microstructural profiles and association to large-scale functional network architectures.

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