Social neuroimaging meta-analysis through the RDoC lens yields distinct context-driven cliques

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Introduction

The ultimate goal of the NIMH's Research Domain Criteria (RDoC) [1] is a multidimensional approach to precision medicine for psychiatry [2]. This includes a diagnostic system based on core criteria, yet the correspondence of RDoC domain definitions to existing neurobiological data has not been fully established. Evolution from an organizational framework to diagnostic implementation necessitates characterizing how RDoC domains map onto the healthy human brain. RDoC designates social processing as one of five domains of mental function, and is fractionated into four constructs : affiliation and attachment, social communication, perception of self, and perception of others. Our present objective was to unpack these social processing constructs from a data-driven perspective in order to: (1) investigate the feasibility of neuroimaging task classification under RDoC domain definitions, (2) ascertain if the RDoC framework corresponds to different or overlapping social brain regions using brain meta-analysis, (3) evaluate the correspondence between the specialized function-structure relationships of the social brain across all domains of brain function and social task themes.

Methods

Experiment Classification

For each published experiment, the task was identified, assigned a task label, and categorized according to the RDoC social processing construct definitions.

ALE Meta-Analysis

Whole-brain coordinates were extracted, meta-analyzed using ALE, and significance tested at a cluster-level corrected threshold of $p<0.05$ (cluster forming threshold at voxel-level $p<0.001$) [3].

Neurosynth Functional Decoding

Neurosynth [4] functional decoding was performed on the ALE maps, providing a broad range of associated mental function terms.

Graph Theoretical Analyses

Term-based network analysis was performed using R to identify the strength of thematic associations between task labels assigned during the literature search and Neurosynth terms, thus creating a data-driven exploration of the correspondence of RDoC constructs to broad function-structure relationships in the social brain.

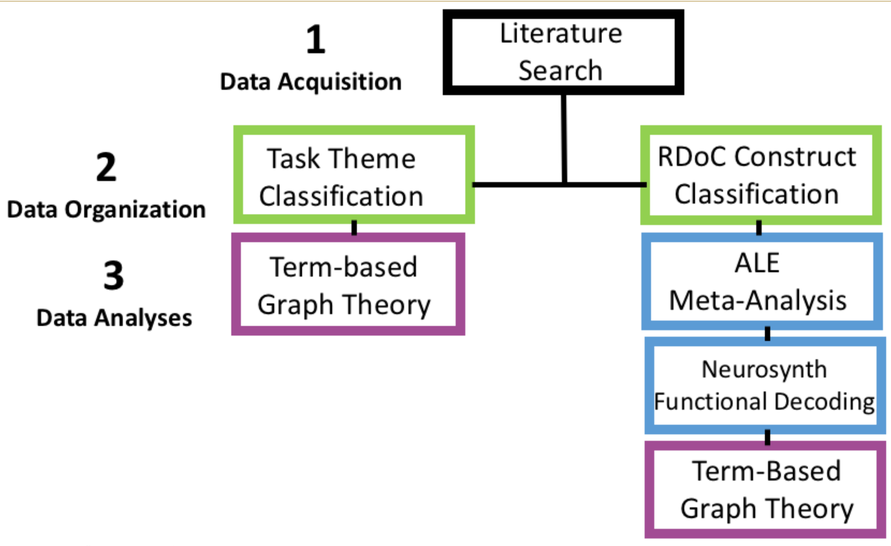

Figure 1. Step-wise methods for data acquisition, organization, and analysis are shown.

Results

Result 1: RDoC ALE Meta-Analysis

- The social neuroimaging corpus included 100 experiments reporting 1,425 foci. The ensuing meta-analysis results revealed different regions of convergence across RDoC social constructs
- Amygdala and bilateral temporo-occipital cortex for **affiliation and attachment**
- Dorsolateral PFC extending into Broca's area, fusiform gyrus, and cerebellum for **social communication**
- Medial PFC, right insula and claustrum for **perception of self**
- Left dorsomedial PFC, medial PFC, and medial posterior cortex for **perception others**

Result 2: Neurosynth Functional Decoding Graph Theoretical Analysis

- Functional roles were found to be unique to each construct (e.g., reward, autobiographical, language), as well as versatile functional attributions shared between constructs (e.g., social, emotion, faces)

Result 3: Social Neuroimaging Task Theme Graph Theoretical Analysis

- Analysis of construct thematic task associations revealed distinct collections of social task themes (e.g., mother view infant, imitation) as well as thematic task associations that were linked to multiple RDoC social constructs (e.g., gesture intent, face discrimination, beliefs of friends)

Result 4: Global Network Topological Comparison

- Whole network analysis revealed commonalities in topological patterns in connectedness among constructs
- Self and Other are graphically represented at opposite graphical ends, and are significantly fractionated both from each other and other constructs
- Affiliation and Attachment and Social Communication are highly connected and exhibit centrality among constructs

Key
Affiliation & Attachment Social Communication
Perception of Self Perception of Others

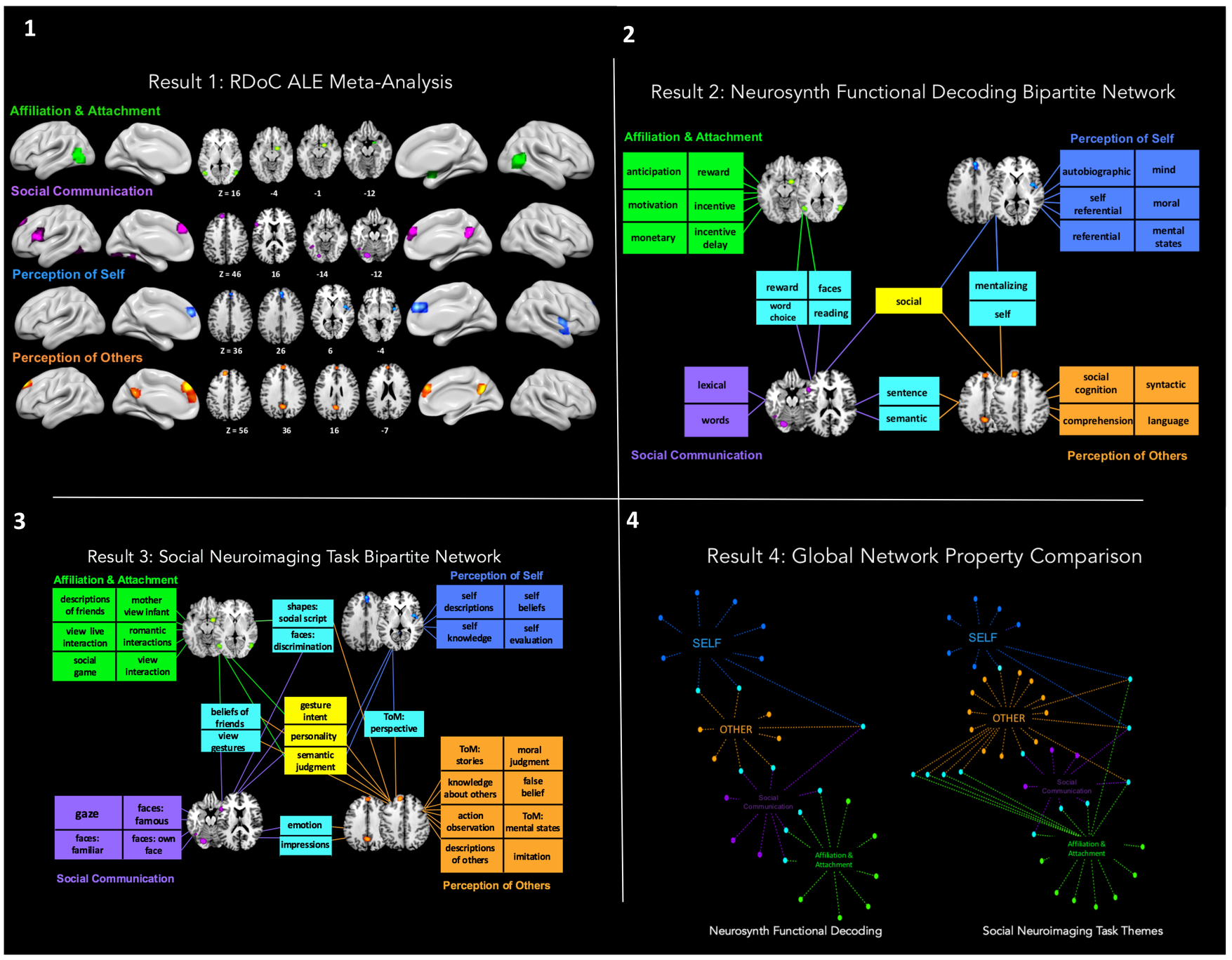

Figure 2. Results for ALE meta-analytic results and task-based graph theoretical analyses are shown. Bipartite networks utilize two classes of nodes to detect association and centrality, RDoC Social Processing nodes and term (Neurosynth decoding/tasks) nodes.

Conclusion

We observed that classification of the neuroimaging literature according to distinct social processing constructs within the RDoC framework consistently activates separate nodes within the extended social brain. Moreover, the combined functional decoding and SNA demonstrated that activation of cliques within the social brain are context-driven and rely on the unique experimental design and task selection of a given neuroimaging study. Our results establish a comparison of specialized tasks utilized in social neuroimaging with the full range of automated terms comprising human mental function, thus providing a comprehensive window into differences between theory driven specialization and large scale, data-driven reverse inference. In utilizing data-driven methods to characterize and validate RDoC social processing constructs, we advance RDoC towards the ultimate goal of precision medicine for psychiatry.

References

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