Functional connectivity of the human hypothalamus using meta-analytic connectivity modelling

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INTRODUCTION

The human hypothalamus is an intersection between several neural systems and is implicated in numerous processes and disorders related to homeostasis. Despite its vital role in autonomic regulation, very few studies have assessed its neural connectivity and associated functional relationship with the rest of the brain. In this study, we examined the functional connectivity of the human hypothalamus using a robust meta-analytic technique.

METHODS

ROI SELECTION

We generated a bilateral ROI (figure above) generation using Mango’s Talairach Loader plugin, and then created separate left and right hypothalamic ROIs.

BRAINMAP META-ANALYSIS

We used Sleuth to query the BrainMap database, with the above ROIs, and limited our results to include studies reporting normal activation in healthy populations.

ACTIVATION LIKELIHOOD ESTIMATE (ALE)

We used GingerALE to perform ALE on the coordinates generated by the BrainMap search, providing map of probabilistic coactivation.

BEHAVIORAL ANALYSIS

With Mango, and its Behavioral Analysis plug-in, we performed regional behavioral analysis on the ALE maps defined in Talairach, reporting the behavioral domains representative of the true probability distribution of each domain and sub-domain’s activation locations.

RESULTS

Bilateral Hypothalamus (see figure, right) Coactivation with the

- Left insula
- Bilateral inferior frontal gyri
- Bilateral superior temporal gyri
- Bilateral parahippocampal gyri
- Right anterior cingulate

Significant behavioral association with

- Limbic hub – emotion, cognition, perception, interception
- Hate circuit – emotion and cognition (language, attention, memory)
- Language cluster – Language and emotion
- Somatosensory cluster – Somesthesia

Right Hypothalamus Coactivation with the

- Bilateral thalamus
- Bilateral superior temporal gyri
- Left parahippocampus
- Right amygdala

Significant behavioral association with

- Right limbic (hub) – emotion, cognition, perception, interception
- Left basolimbic – diverse emotional processing, cognition
- Bilateral thalamus – emotion/cognition and attention
- Language cluster – Language and emotion

Left Hypothalamus Coactivation with the

- Left inferior and superior frontal gyri
- Right middle frontal gyrus
- Right parahippocampus
- Right anterior cingulate

Significant behavioral association with

- Bilateral basolimbic – emotion and interception (sexuality)

DISCUSSION & CONCLUSIONS

Our data reveal distinct patterns of functional connectivity between the hypothalamus and regions of cognitive and emotional processes. Nearly every region connected to the hypothalamus that shows significant association with any behavioral domain also showed a significant association with behavioral processes. The recurrent association of regions with both cognition and emotion suggests an inherent entanglement in the hypothalamic processing of these behaviors.

The hypothalamus is intimately involved with autonomic and neuroendocrine responses and connectivity patterns may reveal potential regions of intervention for disorders in which it is implicated such as posttraumatic stress disorder. Future research should use resting state and diffusion tensor imaging to extend our understanding of the neural connectivity of this structure and consider possible alterations of functional connectivity in disease states.

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