Human Claustrum Activation During Pain

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Introduction

- Little is known regarding the exact function of the claustrum and it remains to be an extremely difficult brain region to study
- This is due to its irregular shape well as being concealed on the inner surface of the neocortex.
- Additionally, two other important brain regions, known as the putamen and insula, also surround the claustrum.
- Analysis of a pre-existing fMRI data set found that at the onset of pain, the left claustrum of healthy controls had transient activation while subjects suffering from chronic pain saw bilateral activation of the claustrum[1].
- It has been hypothesized that claustrum dysfunction underlies altered cognitive network recruitment in individuals with chronic pain[2].

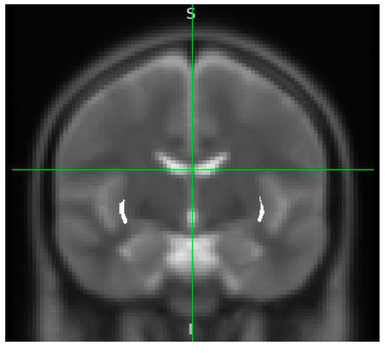

Figure 1. Left and Right Claustrum

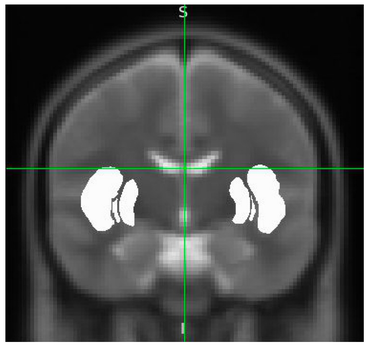

Figure 2. Insula and Putamen Surrounding the Claustrum

Objective

- Reproduce the findings from the existing fMRI data using healthy controls.

Methods

- 50 healthy controls where recruited to participate in this study.
- While patients were being informed on the study procedure, they where exposed to varying levels of heat in order to determine their pain sensitivity.
- After noting each participants pain sensitivity, the heat conditions where calibrated to ensure minimal pain.
- Subjects were then placed inside the fMRI machine, where an audio cue would sound prior to the onset of each heat stimulus via thermode.
- These heat conditions where classified as Warm, Slight, Moderate, and Intense.
- Each heat condition and its duration occurred in a pseudo-random order for 10 trials per run for five total runs.
- After each stimulus, subjects rated the pain they felt on a 0 to 100 scale.
- Data for 14 subjects where omitted from our analysis due to either technical difficulties or comorbidities found during the scan which may have influenced our results.

	Run 1 (sec)	Conditions_start8sec_cue.mat	
Audio_cue	0	179.8	418.3
Intense_Onset	8.8	190.8	429.3
Intense_Offset	14.8	200.8	452.3
Pain_rating	16.8	202.8	454.3
Intense_Duratio	20.8	27	40
Audio_cue	33.3	219.3	294.3
Moderate_Onse	44.3	230.3	305.3
Moderate_Offse	50.3	240.3	343.3
Pain_rating	52.3	242.3	345.3
Moderate_Durat	23	27	55
Audio_cue	108.3	365.8	
Slight_Onset	119.8	376.8	
Slight_Offset	157.3	399.8	
Pain_rating	159.3	401.8	
Slight_Duration	55	40	
Audio_cue	68.8	258.8	
Warm_Onset	79.8	269.8	
Warm_Offset	89.8	275.8	
Pain_rating	91.8	277.8	
Warm_Duration	27	23	

	Run 2 (sec)	Conditions_start8sec_cue.mat	
Audio_cue	50.3	253.3	380.8
Intense_Onset	61.3	264.3	391.8
Intense_Offset	84.3	274.3	401.8
Pain_rating	86.3	276.3	403.8
Intense_Duratio	40	27	27
Audio_cue	102.8	292.8	420.3
Moderate_Onse	113.8	303.8	431.3
Moderate_Offse	123.8	326.8	437.3
Pain_rating	125.8	328.8	439.3
Moderate_Durat	27	40	23
Audio_cue	142.3	345.3	
Slight_Onset	153.3	356.3	
Slight_Offset	163.3	362.3	
Pain_rating	165.3	364.3	
Slight_Duration	27	23	
Audio_cue	0	181.8	
Warm_Onset	8.8	192.8	
Warm_Offset	31.8	230.8	
Pain_rating	33.8	232.8	
Warm_Duration	37.8	55	

Table 1. Run 1 and 2 conditions and timings

Preliminary Results

- Based on preliminary findings it would appear that although the claustrum is responding to the heat stimuli, it is also activating in response to the audio cue.
- Furthermore, it appears that there is bilateral claustrum activation rather than unilateral in response to the heat stimulus.
- Additionally, claustrum activation to the varying heat conditions appears to be prolonged rather than transient.

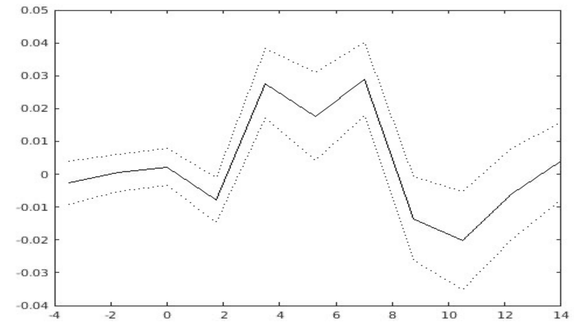

Figure 3. Left Claustrum all Conditions

Next Steps

- Perform a PPI-SRCC analysis in order to control for claustrum signaling and remove influence from putamen and insula.
- Conduct a regression analysis to determine the relationship between our dependent variable (BOLD fMRI signal) and our independent variables (audio cue and heat stimuli).

References

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2. Seminowicz, D. A., Wideman, T. H., Naso, L., Hatami-Khoroushahi, Z., Fallatah, S., Ware, M. A., Jarzem, P., Bushnell, M. C., Shir, Y., Ouellet, J. A., & Stone, L. S. (2011). Effective Treatment of Chronic Low Back Pain in Humans Reverses Abnormal Brain Anatomy and Function. *Journal of Neuroscience*, *31*(20), 7540–7550. https://doi.org/10.1523/jneurosci.5280-10.2011