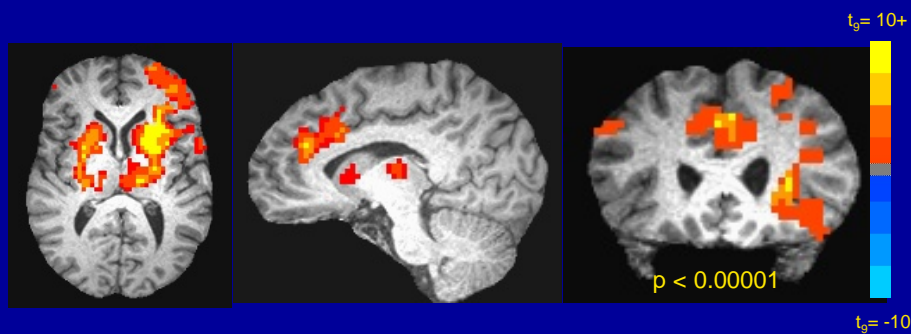


Basal Ganglia *Functional Connectivity* in GW Illness

- *Basal ganglia* implicated in GW illness
 - Hom, Haley, and Kurt, 1997; Haley et al, 2000
- *Dorsal striatum* has strong connections with attention, associative, salience monitoring networks (Postuma, et al., 2006, Williamson, 2007, Fox, et al., 2005)
- *Ventral Striatum* has strong connections with orbitofrontal cortex and limbic systems and weaker connections with attention and self-monitoring areas (Postuma, et al., 2006, Haber, et al., 1995)
- We used fMRI to measure resting state connectivity of the *dorsal & ventral striatum* in GW veterans with fMRI

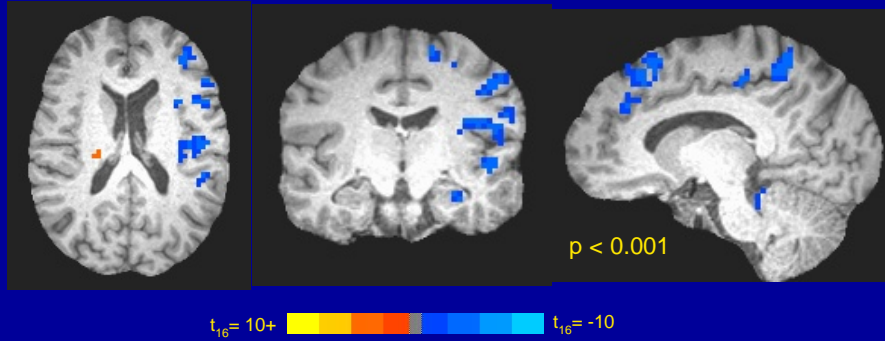
GWS: Dorsal Striatum Connectivity



Group B Dorsal Striatum connectivity appears normal for the age group

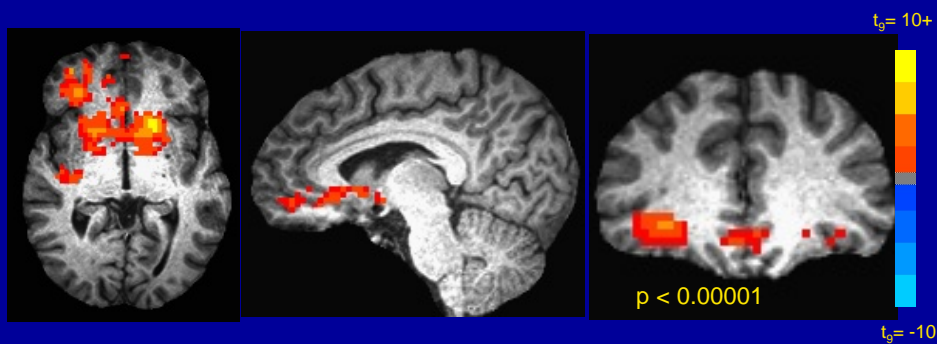
Jiang, et al., ISMRM 2009

GWS: Dorsal Striatum B-A

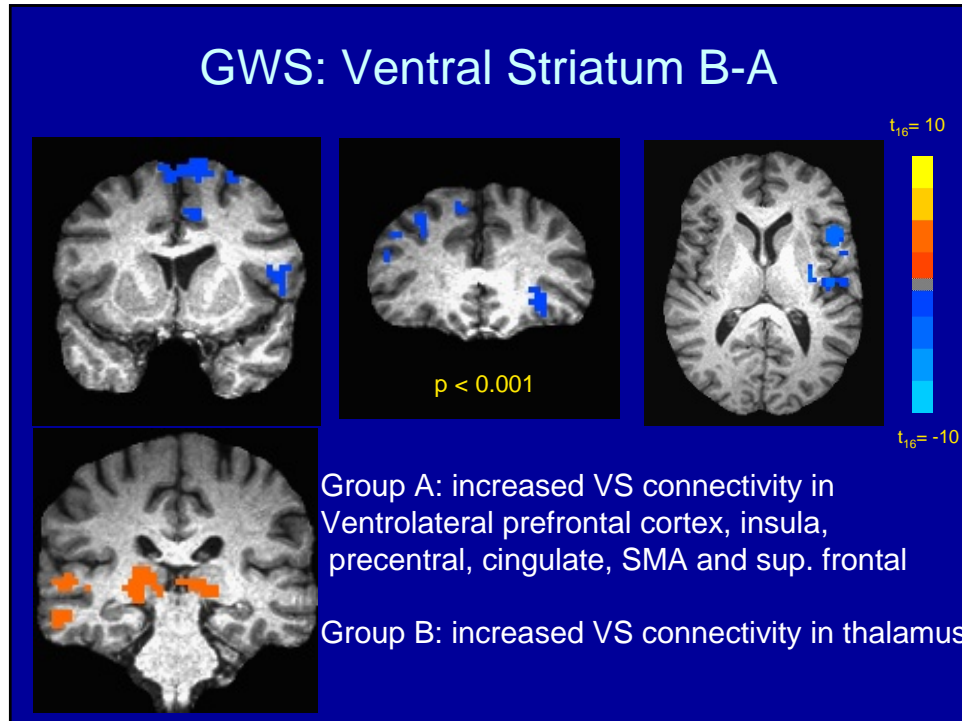


Group A showed increased DS connectivity: Medial Frontal, parietal cortex, STG, post-central gyrus and insula.
Group B: right thalamus

GWS: Ventral Striatum Connectivity



Group B Ventral Striatum connectivity appears normal for the age-group



Dorsal Striatum Activation Summary

GROUP A ($p < 0.0001$)

- Bilateral basal ganglia, thalamus, DLPFC, BA 10, 44, 45, 46, DMPFC, VMPFC, left VLPFC, lateral BA 11, BA 32, ACC, cingulate gyrus, PCC, M1, S1, lateral parietal cortex (BA 7), insula

GROUP B ($p < 0.0001$)

- Bilateral basal ganglia, thalamus, DLPFC, BA 10, 44, 45, 46, DMPFC, left VLPFC, lateral BA 11, BA 32, ACC, cingulate gyrus, M1, S1, lateral parietal cortex (BA 7), insula

A > B ($p < 0.01$)

Left: hippocampus, DLPFC, BA 38, ACC, paracentral lobule, M1, S1, insula medial BA6; Bilateral: DMPFC, VLPFC

B > A ($p < 0.01$) in right thalamus

Ventral Striatum Activation Summary

GROUP A ($p < 0.0001$)

- Bilateral basal ganglia, thalamus, DMPFC, VMPFC, VLPFC, lateral BA 11, BA 32, sub-callosal gyrus, orbitofrontal cortex ACC, cingulate gyrus, left amygdala, left insula, BA6

GROUP B ($p < 0.0001$)

- Bilateral basal ganglia, thalamus, VMPFC, VLPFC, lateral BA 11, BA 32, sub-callosal gyrus, orbitofrontal cortex, ACC, right insula

A > B ($p < 0.01$) left: VLPFC, lateral BA 11, BA 32, BA 38, large parts of insula, amygdala, M1, S1

B > A ($p < 0.01$) in in bilateral posterior thalamus

Summary

- In Group A the neural connections of the dorsal and ventral striata with areas in attention and self-monitoring networks are functioning excessively even at rest compared with those of Group B.
 - Indicates constant hyper-arousal and hyper-vigilance at rest
 - This constant overactivity could relate to the chronic fatigue described by ill GW veterans.
 - Connectivity findings may inform other GW neuroimaging findings.

Initial Correlations with Abnormal Findings of Other Gulf War Neuroimaging Studies

- **Group A showed enhanced dorsal and ventral striatal connectivity with areas in attention and self-monitoring networks**
 - Indicates hyper-arousal/hyper-vigilance at rest consistent with findings from other studies (e.g. QST fMRI, Emotional Circuits in GWS)
- **Increased Group A ventral striatum connectivity with left lateral BA 11**
 - Corresponds to brain areas in which Group A anomalously fails to suppress
- **Increased Group A dorsal striatum connectivity with left fronto-parietal networks**
 - Corresponds to increased Group A activity in these areas in studies of attention and executive
- **Increased Group A dorsal striatum connectivity with left hippocampus**
 - Corresponds with anomalous Group A activity in left hippocampus observed in the GWS memory projects
- **Decreased Group A basal ganglia connectivity to thalamus indicates impairment of basal ganglia thalamocortical circuits**