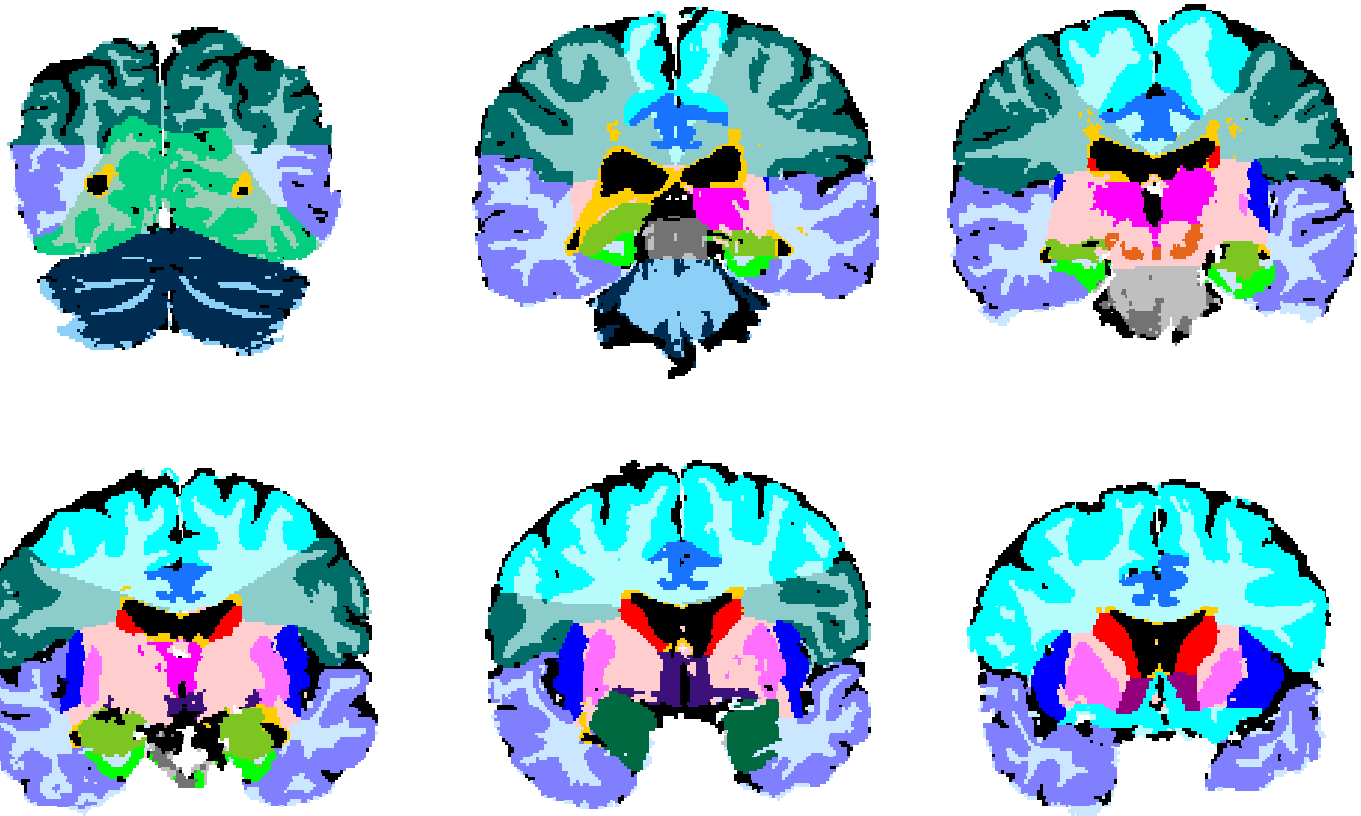
Neuroanatomical Effects of Alcohol Exposure in Development and Adulthood

Terry Jernigan
UCSD and University of Copenhagen

How does the regional pattern of abnormalities produced by fetal alcohol exposure differ from the pattern produced in the adult brain?



Cerebral Lobes

- Frontal Cortex/White
- Temporal Cortex/White
- Parietal Cortex/White
- Occipital Cortex/White
- Cerebellar Cortex/White

Subcortical Regions

- White Matter
- Basomesial Diencephalon
- Caudate Nucleus
- Lenticular Nucleus
- Nucleus Accumbens
- Thalamus
- Substantia Nigra

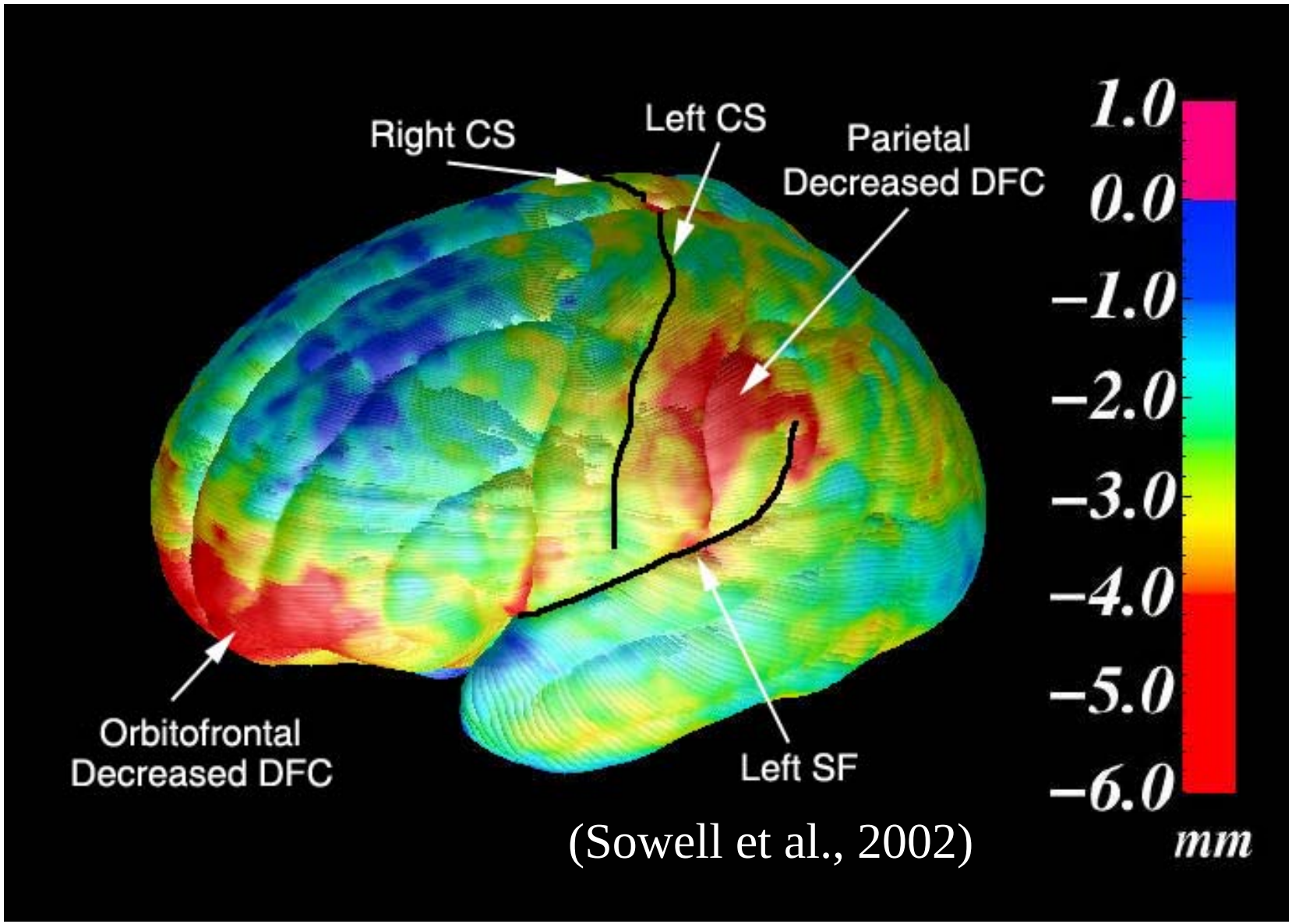
Other Structures

- Insular Cortex
- Cingulate Cortex
- Hippocampus
- Amygdala
- Parahippocampal Gyrus
- White Matter w/ Elevated Signal

Regional Pattern of Brain Hypoplasia in FAS
(Archibald et al., 2001)

- Cerebellar hypoplasia is relatively greater than cerebral hypoplasia.
- White matter hypoplasia exceeds gray matter hypoplasia.
- The parietal lobe is disproportionately smaller.
- Striatal structures are disproportionately smaller than hippocampus.

Decreases in Distance from Center in Fetal Alcohol Exposure



(Sowell et al., 2002)

Regional Pattern of Tissue Loss in Chronic Alcoholism

- Modest but widespread cortical gray matter and white matter losses in cerebrum.
- Loss of gray matter volume in striatal, diencephalic, and limbic structures.
- Significant volume loss in cerebellum.
- Disproportionate frontal neuron loss and white matter loss (in older patients).
- Evidence for reversibility of some changes, especially in white matter, with abstinence.

Regional Pattern of Tissue Loss in Korsakoff's Syndrome

- Cerebellar losses are somewhat more pronounced than cerebral losses.
- White matter loss is more pronounced in both cerebrum and cerebellum.
- Temporal lobe is disproportionately affected (gray and white).
- Amygdala and diencephalic structures are relatively more affected than striatum.

Consistent Effects of Alcohol Exposure

- Vulnerability of cerebellum
- Disproportionate effects on white matter (may be reversible, but persist in Korsakoff's Syndrome)
- Effects in diencephalic structures and amygdala are pronounced

Contrasting Effects

- Fetal Effects:
  - Are more pronounced in caudate than other subcortical structures (including hippocampus)
  - Are significantly more pronounced in parietal lobe gray and white
- Korsakoff Effects:
  - Are less severe in striatal structures than in other subcortical structures
  - Are absent in parietal lobe gray, but severe in temporal lobe gray and white

some conclusions…

- Given the pattern observed in FAS, the focus on hippocampal effects in animal studies and the presumption of a hippocampal basis for spatial learning deficits in FAS, should perhaps be reconsidered.

- The disproportionate effects of fetal alcohol exposure on caudate nucleus, and on parietal lobe (and perhaps orbitofrontal) structures within the cortex is unexpected and warrants further scrutiny.

- Since increased vulnerability of parietal lobe is not observed in adult populations, the mechanisms underlying this effect may depend on specific developmental cofactors.

more conclusions…

- White matter is highly vulnerable to the effects of heavy alcohol exposure in all contexts; however it appears that exposure very early in development, and very late in the course of alcoholism, may lead to more enduring effects than exposure earlier in adult alcoholism.

- Although the cerebellum appears to show increased vulnerability to alcohol effects in all contexts, there is still no explanation for this.

- The mechanisms by which diencephalic and temporal lobe structures are disproportionately affected in alcoholics who develop amnesia is also not understood.