White Matter Reorganization in Early Blind Humans

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Purpose

This study was conducted in order to discover more about the neuroanatomical connections in blind human beings or: “in order to examine the effect of blindness on the cerebral WM using DTI and DTT”

- Evidence of atrophy of geniculocortical tracts
- “Connections between visual cortex and the orbital frontal and temporal cortices were relatively preserved in the EB group” (1)
Introduction

- Proof through studies that there are rearrangements in the visual cortex of blind humans in response to the following stimuli:
  - Language
  - Memory
  - Perceptual processing of tactile and auditory stimuli
- This response is strongest in congenitally blind or those who lost sight soon after birth. “Thus, it is well established that visual cortex is functionally reorganized in blindness” (1)
Blindness and The Visual Cortex

In blind humans although the Lateral Geniculate Nucleus (LGN) and Optic Nerve have been found to have abnormalities the “evidence indicates that the visual cortex is grossly normal” (1)

An abnormal signal was noted in 2 of 12 cases in a study done by Breitenseher and others (1998), using magnetic resonance imaging
This Study was done with DTI and DTT

- **DTI**
  - Diffusion Tensor Imaging
- **DTT**
  - Diffusion Tensor Tractography

Both are used to construct images of the brain, together they provide the only way to image the major fiber bundles aside from dissection.
How it works

- Basically DTI involves the anisotropic diffusion of water in tissue
  - This means that a map can be generated based on the difference in diffusion in certain directions.
  - Diffusion is greatest parallel to nerve fibers
DTT and DTI were used to find a difference among early blind and normally sighted participants.

The diffusion parameters are altered in Early blind patients in the region of the calcarine sulcus and “absent or attenuated in geniculocortical tracts”
Calcarine Sulcus

The Calcarine Sulcus is located in the medial occipital lobe

This Image was taken from the Sylvius Website
Lateral Geniculate Nucleus

- Optic nerve
- Optic chiasm
- Optic tract
- Hypothalamus: regulation of circadian rhythms
- Pretectum: reflex control of pupil and lens
- Superior colliculus: orienting the movements of head and eyes
- Striate cortex
- Lateral geniculate nucleus
The Participants

The Early Blind (EB) group
- Blind since birth or early childhood (before they learned to read print)
- Cause of blindness in all was retinal pathology
- 5 individuals
- Neurologically normal

The Normally Sighted (NS) group
- Age matched to EB group
- 7 individuals
Results of the Study
Anatomical Differences

- Differences were found in the anatomy of Early Blind and Normal Sighted Individuals
  - Severely atrophied optic nerves/chiasm/tracts
    - Less so in the two early blind that reported light sensitivity
    - The geniculocalcarine tract was typical in 13 of 14 hemispheres of normally sighted individuals but only in 2 of 10 hemispheres of early blind individuals.
Geniculocalcarine Tract

- Connects the lateral geniculate nucleus to the primary visual cortex
  - The lateral geniculate nucleus is composed of tertiary sensory neurons
  - Primary visual cortex is located within the occipital lobe
This is a Tractogram
In the Study

Most abnormal of normally sighted

Typical Participant
Figure 4. Tractography results obtained by selection of tracks intersecting individually defined V1/V2 ROI (Fig. 2). Tracks traced to several locations are shown color coded as follows: LGN (dark blue), pulvinar/SC (light blue), anterior temporal lobe (green), orbitofrontal (yellow), commissural (red). All images show individual DTT results overlaid on the participant’s MP-RAGE. Sagittal, axial, and double oblique (inset key) views are shown on successive rows. One NS and 4/5 EB participants are included; EB1 was omitted because of a paucity of DTT fibers. Inspection results for all participants are given in Table 3.
Discussion

This research was done to study the changes in development of neuroanatomy in the absence of visual stimuli.

DTT although very useful has limitations:

- Not always clear
  - Gets more unclear when tracts bifurcate or cross
  - In areas of low anisotropy
  - Zones of low signal to noise

- The results are not equivalent to anatomical fiber count but do show that there is less connectivity in the early blind participants.
Conclusions

The team reached five conclusions from this study

1. Blindness leads to altered WM microanatomy as revealed by DTI and DTT
2. These abnormalities are most apparent in the occipital lobe and ventral splenium
3. Tractography suggests that attenuated V1/V2 connectivity predominantly affects thalamocortical connections
4. There is no evidence of a DTT feature present in blind but not sighted persons
5. Unanticipated observations suggest that gross morphological abnormalities may affect the LGN and occipital lobes of EB individuals
The anatomy

- Probably normal because there is competition for synapses in the higher cortex region
  - This is usually kept under control by a feedback loop
  - However, because these people have been blind since birth, synapses can form in the visual cortex from other stimuli than visual.
    - Applies only to blindness acquired past a certain developmental age (7)
Summary

- Most of the abnormality of connectivity in early blind participants involves the thalamus.
- There are irregularities in the white matter of the occipital lobe.
- The visual cortex is preserved and remains functional.
Sources


2. [http://www.med.yale.edu/caim/cnerves/cn2/cn2_4.html](http://www.med.yale.edu/caim/cnerves/cn2/cn2_4.html)