Parieto-Occipital Dysfunction in FASD - Time for a New Neurodevelopmental Approach?

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Dumfries & Galloway
Extent: 6.200km²
Population ~151,000
Presentation Outline

1. Review of evidence for parieto-occipital dysfunction in FASD
2. Brief overview of higher order visual processing; dorsal and ventral streams
3. Evidence for dorsal stream dysfunction (DSD) in FASD
4. What can we learn from other groups with DSD?
5. Paediatric Balint’s syndrome in a child with DSD—existing case report
6. Recognition and diagnosis of DSD in children; use of the standardised visual behaviour interview (CVI Inventory)
7. Dorsal stream dysfunction in ASD/FASD
8. Examples
9. Conclusions

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## Effects of Alcohol on the Foetus

**FAS //Partial FAS//ARND +/- ARBD**

Confirmed foetal antenatal exposure to alcohol plus

<table>
<thead>
<tr>
<th>Growth deficiency</th>
<th>Craniofacial anomalies</th>
<th>Abnormal neurodevelopment</th>
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</thead>
<tbody>
<tr>
<td>(pre and/or post natal)</td>
<td>Narrow palpebral fissure, Premaxillary zone abnorms: Flat midfacies, Upper lip thinning, Reduced/absent philtrum</td>
<td>Impairment in 3 or more CNS domains that include: Hard and soft neurological signs, Brain structure, Language, Social communication, Cognitive- attention, memory, learning</td>
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(Chudley et al, 2005; Autti-Ramo, 2007; Spadoni, et al, 2006; Spadoni et al, 2009)

Abnormal neurodevelopment is common to all diagnostic categories of FASD
Parietal and Cerebellar Abnormalities on MRI in FASD Autti-Ramo et al, 2002

Subjects:

17 children with learning difficulty, confirmed prenatal alcohol exposure
  Mean age 13y
  Mean IQ 84 (Verbal 87.9; Performance 88.7; WISC III)
  FAS - 5
  Partial FAS - 7
  FASD - 5

MRI outcomes:

  5 children: atrophic cortical change in
    • parietal (FASD, partial FAS)
    • fronto-parietal (FAS)
    • parieto-occipital (partial FAS)
    • fronto-parieto-occipital (FAS)
    • grade 1 PVL

  10 children: atrophy of cerebellar vermis
    (5 associated parietal atrophy including 1 PVL)
# Dorsal and Ventral Specialisation - Separate Streams within Optic Nerve

**Dorsal**
- Magnocellular
- Through retina
- High temporal frequencies – motion
- Visual guidance of body through space
- Silent on colour
- Short-term memory storage (VWM)
- Egocentric frame of reference
- Ventral layers LGN
- Lateral placing in VI
- Posterior parietal cortex
- STS

**Ventral**
- Parvocellular
- Central retina (Foveal and extrafoveal)
- High spatial frequencies-details, colour
- Long term stored representations, form recognition
- Object –centred frame of reference
- Dorsal layers LGN
- Medial placing in VI
- Inferotemporal cortex
- STS

Both needed for higher order visual perception and vision for action

(Milner & Goodale, 1992, 1995, 2008)
Reduced cell body size of M-neurons in LGN following foetal alcohol exposure in non-human primates

Pregnant vervet monkeys

EtOH intake: 10% solution, voluntarily drank on average 2.418 ± 0.296 g/kg/day
Duration/timing: x4/wk each week during 3rd trimester
Blood levels: equivalent to 3-5 standard drinks for human female.

Histological study:
Estimate of neuronal & glial populations M and P layers of LGN at age 1-35 days
Total volume and numbers neurons stable
17% of M neurons reduced cell body size to P

In humans soma size M only = P at 24 weeks gestation, thereafter size increases
FMRI BOLD Response
During Spatial Working Memory
Spadoni et al, 2009

Subjects:
6 - full criteria for FAS
2 - partial FAS
1 - unrated for physical characteristics

Age: 14.7±1.9 (FASD)
   13.6±2.6 (Controls)
IQ: 87 ± 12 (FASD)
   106 ± 15 (Controls)

Vigilance reaction time (ms):
Controls 617 ± 47
FASD 684 ± 73
P=0.03

SWM accuracy & reaction time:
Controls=FASD

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FMRI BOLD Response During Spatial Working Memory in FAS (Spadoni et al, 2009)

Both groups: Dorso-lateral-frontal cortex and parietal cortex activated for both tasks

Increased activity for FAS: SWM>Vigilance

FASD difference due to increased activation fronto-temporo-occipital areas in SWM
Statistical significance found for activation differences between groups for fronto-temporo-occipital zones activated in FAS

Evidence for increased reliance on ventral visual pathway
Cerebral Visual Impairment in Children

(Dutton et al., 2003)

• 364 children with visual dysfunction associated with cerebral pathology
• 40 cases with acuities 6/60 or better

Neurological diagnoses:
• 15 spastic diplegia
• 6 hemiplegia
• 18 normal motor development
• 1 ataxic gait
Associated Conditions

- Prematurity
- Posterior cerebral infarction
- Head injury
- Primary hydrocephalus (expansion of lateral ventricles into the occipital lobes)
- Meningitis
- Neonatal hypoglycaemia (multifocal occipital damage)
- Learning disability
Visual Features

- Impaired simultaneous perception
- Inaccuracy of visually guided movements
- Inaccuracy of eye movements
- Impaired recognition and/or route finding
Visual features correlated with MRI pathology

PVL or Occipital Damage (15):
Universal impairment of simultaneous visual perception (S) and visually guided movement (M) (mainly lower limb)

Hydrocephalus (7):
As above[S(6) M(7)] plus face recognition and/or topographical agnosia
Cerebral Visual Impairment in Children

• Visual behaviours are similar to adults with pathology in same area
• May exist with normal lower vision apparatus and normal visual acuity

“Children experience no loss of function and know no alternative form of vision”

(Dutton, 2007)
Bilateral Parieto-occipital Injury

Historical contributions from Ophthalmology:
Inouye, 1904-5, Russo-Japan
Holmes, 1918, First World War
Riddoch, 1918, First World War

Medicine: Balint, 1909, patient with progressive stroke disease

Neuropsychology: Luria, Second World War

Diagram showing position of wounds

A.R. Luria, 1973
Balint’s Syndrome

- “Psychic paralysis of gaze” (oculomotor apraxia)
- Impaired hand reaching to visual target (optic ataxia)
- Inability to integrate information from central gaze with periphery (simultanagnosia)

“Miss the forest for the trees”
(Marcel Mesulam, 2002)
“Balint’s Syndrome in a 10-Year-Old Male”  
(Gillen & Dutton, 2003)

Boy, 10-years referred with reading difficulties

Past history:

- 3yrs
- Infective endocarditis with widespread septic emboli
- Mycotic aneurysms in the right and left parietal lobes → intracerebral haemorrhage requiring craniotomies
- Outcome good, deemed full recovery
Examination, Glasgow at 10yrs

- VA, colour vision, stereopsis, normal
- Visual fields full to confrontation
- Unable to fix steadily and simultaneously perceive the peripheral target
- Impaired voluntary saccades

Difficulty with:
- Reading long words,
- Copying from the blackboard.
- Negotiating busy environments e.g. shopping centres:
- Walking into people (as if they were not there)
- Following moving objects (e.g. cars, aeroplanes)
- Going down stairs and escalators → specific dorsal stream disturbance
  ➢ posterior parietal lobe insult?

MRI:
Visual Behavioural Interview: The CVI Inventory (Macintyre-Beon, C et al, 2012)

49 questions, 5 forced choice responses: 
never/rarely/sometimes/often/always.

7 sub sections for impairments including:
- Visual hemifield/lower field inattention (DS)
- Handling the complexity of the visual scene (DS)
- Perception of movement (DS)
- Visual guidance of movement (DS; OA)
- Visual task attention (e.g. face-gaze + listen) (DS)
- Behavioural difficulties in crowded environments (DS)
- Recognition and orientation using landmarks (VS)
Summarised findings on CVI Inventory (Macintyre-Beon, 2012)

Child A - Partial FAS, 6 yrs        Child B - ASD, confirmed alcohol exposure
Child C and Child D - ASD, unconfirmed alcohol exposure

<table>
<thead>
<tr>
<th>Area of difficulty</th>
<th>Child A</th>
<th>Child B</th>
<th>Child C</th>
<th>Child D</th>
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<tbody>
<tr>
<td>Seeing information below what is looked at directly</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
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<tr>
<td>Seeing information on one or other side</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
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<tr>
<td>Seeing things which are moving quickly</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
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<tr>
<td>Processing complex visual scenes &amp; behavioural problems</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
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<tr>
<td>problems associated with crowded environments</td>
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<tr>
<td>Visually guided body movement</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
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<tr>
<td>Impaired visual attention</td>
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</tr>
<tr>
<td>Recognising what is being looked at, &amp; with navigation</td>
<td>✔️</td>
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</table>
Simultanagnosia: Bilateral Severe Field Limitation in Child N, 9yrs
Girl, 12 yrs. High functioning autism, severe attentional constriction of peripheral field (simultanagnosia) (b) & (c). Extracts from fine motor subscale, GMDS-ER 2-8 (Luiz, D. 2006), reproduced with permission of ARICD.
Criteria Used to Identify Optic Ataxia

- An abnormality of hand reach and grasp with impaired trajectory and/or
- A slow, hesitant hand reach to target (Perenin & Vighetto, 1988) with possible overshoot (Jeannerod, 1994) and/or
- Mismatch may include adjustments of grasp (Jakobson, 1991; Goodale, 1992)
Additional Developmental Criteria for Optic Ataxia

• The ataxic hand may seek proprioceptive/tactile information to facilitate approach
• The condition must not be attributable to other sensory impairment or neuromuscular disorder although any of these may co-exist
Asperger’s syndrome, 13yrs. Severe simultanagnosia and bilateral OA, Central Vision
Conclusions

• MRI evidence from individuals with normal IQ FASD suggests vulnerabilities of the parietal cortex and cerebellum

• Animal studies and FMRI data support the existence of dysfunction of the dorsal visual stream in FASD with possible compensatory development along ventral stream pathways

• Parieto-occipital dysfunction may produce a spectrum of neurodisability in FASD

• Effective strategies exist to promote the habilitation of affected children, improving self-esteem and achievement.
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Most of all, thanks to the children, and to their parents

Isobel Hay  NHS  Dumfries and Galloway
Thank you for listening