Theory of Mind and Cerebral Visual Impairment

Some reflections with John Ravenscroft and Amanda Lueck
With thanks to

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• Gordon Dutton  (Prof - Ophthalmology)
• Karen Goodall  (Dr - Psychology)
• Martin Toye  (Dr - Psychology)
• Lea Hyvärinen  (Prof – Ophthalmology)
• Helen St Clair Tracy (Parent of child with CVI)
• Simon Hayhoe  (Dr – Education)
What is this talk about..........?

• Good Question

• My ideas and ramblings about CVI and Theory of Mind (TOM) and the nature of representation

• I will look at what is ToM as try and connect this to children and adults with CVI

• I may be entirely wrong – partially wrong – partially right – entirely right

• But the issue is – no one knows for sure – especially me!
The Nature of Representation

• “What is it like to be a bat” (Nagel 1974)
• An organism has conscious mental states if and only if there is something that it is like to be that organism – something that it is like for the organism to be itself.

• the mind-body problem is not just a local problem, having to do with the relation between mind, brain and behaviour in living animal organisms, but that it invades our understanding of the entire cosmos and its history. (Nagel, 2012:P.3)
A Question to John Locke

A man being born blind and having a globe and a cube, nigh of the same bigness, committed into his hand, and being taught or told, which is called the globe and which the cube, so as easily to distinguish them by touch or feeling; then both things taken from him, and laid on a table. Let us suppose this sight restored to him; whether he could, by his sight, and before he touch them, know which is the globe and which the cube? So whether he could not reach them though they were removed 20 or 1000 feet from him?

- Letter from William Molyneux to John Locke, 7th July 1688. From the correspondence of John Locke, The John Locke Collection, Bodleian Library, Oxford University.

• When he was just out of the hospital, and his depression was but occasional, he would sometimes prefer to use touch alone when identifying objects. We showed him a simple lathe (a tool he had wished he could use) and he was very excited. We showed it him in a glass case at the Science Museum in London, then we opened the case so that he could touch it. With the case closed, he was quite unable to say anything about it, except that the nearest part might be a handle (which it was— the transverse feed handle), but when he was allowed to touch it, he closed his eyes and placed his hands on it, when he immediately said with assurance that it was a handle. He ran his hands eagerly over the rest of the lathe, with his eyes tight shut for a minute or so; then he stood back a little, and opening his eyes and staring at it, he said: 'Now that I've felt it I can see'

Words taken from *Disorders of the brain and how they can affect vision.* In A. H. Lueck & G. N. Dutton (Eds.), *Vision and the brain: Understanding cerebral visual impairment in children* (p. 78-79).
Key Questions to ask

• How is perception (self and of others) tied to cognition for children who have CVI ((in all of its varying expressions))

• Can Theory of Mind (ToM) tell us anything about CVI?

• Can CVI tell is anything about ToM?

• Are Mirror Neurons important in this story?
Theory of Mind (Recap)
What is ‘Theory of Mind’ (ToM)?

- Term introduced by Premack and Woodruff (1978)
- The ability to attribute mental states (thoughts, beliefs, desires) to others, and to use this to predict and explain their behaviour.
- An innate cognitive module which gradually develops in childhood in typically developing children.
- Known as a ‘theory’ because it involves a system of inferences about states that are not observable.
ToM can help us to...

- Relate to others
- Empathise
- Predict likely behaviour
- Understand others’ intentions
- Correct others’ misunderstandings

Mislead
Exclude others
Deceive
Manipulate

Important to the life of children and others who have CVI
Perceptions of others’ states of minds: knowing what other people are thinking

• A key social skill or ability

• Multiple examples in everyday life

• Necessary for effective social functioning, otherwise:

• Mindblindness

• Relatively new concept: ToM described in the 1970s/80s

• More recently, provides bridge between child development, education and (social, cognitive and developmental) psychology
What is ‘social cognition’?

The cognitive capacities that underlie the ability to interact socially – to understand and reason about other people, in terms of factors such as how people think, feel and react (see Hala, 1997; Tager-Flusberg & Sullivan, 2000).

**Metarepresentational ability**

“The ability to represent the knowledge states (mental representations) of the self and others.”

(Goswami, 2008: 221).
How CVI may affect Social Cognition

- perceive the direction of sounds
- see moving objects
- understand the composition of crowded environments
- take in the full environment if there is visual neglect
- watch something being moved if there are issues such as apraxia of gaze, smooth pursuit difficulties
- holistic vs focal processing
- face blindness
- Inability to interpret the language conveyed by facial expression
- orientation in space (i.e., getting lost in space when cannot perceive and organize landmarks)
Development of ToM in typically developing children

• Begins to develop around 3 years of age

• Firmly in place for most by 4/5 years of age.
  o Tager-Flushberg & Sullivan (2000)

• So...most children by primary 1 will have ToM ability.

• But...some later than others

• Some earlier than others too...
Factors that influence how early we achieve ToM?

Differences in Neglected/LAC?

• Pears & Fisher (2005) studied ToM in children in foster care (aged 3-5 years old)

• Children in foster care were significantly less able to pass ToM tasks even when taking account of age and intelligence. Deprivation appears to play a role.

• Argue a case for interventions to target these children to help ToM and emotion understanding (which they also found impaired)

• CVI and Social Deprivation (Ravenscroft)
Factors that influence how early we achieve ToM?

Cultural differences in ToM?

• Consensus is no...ToM is universal

EG

• Sabbagh et al. (2006)
• Studied EF and ToM in American and Chinese preschool children.
• Chinese children better on EF tasks but not better on ToM tasks.
Factors that influence how early we achieve ToM?

**Siblings**

- Sibling effects well documented
  - Zajonc (1983): Number of siblings correlates with IQ

- Perner et al. (1994): Children with siblings have better ToM
- Ruffman et al. (1998): older but not younger siblings?

Why?...Lewis et al. (1996) – apprenticeship?

- Dunn et al. (1991) Mothers’ narrative is also important
  - Apprentice to maternal social interaction as well as siblings?
  - Role of language  *(Role of Language in CVI – speed of input/processing/)*

- Child’s own characteristics important too
Attention v Perception ToM V CVI

• **Sustained attention** is the ability to focus on one specific task for a continuous amount of time without being distracted.

• **Selective attention** is the ability to select from many factors or stimuli and to focus on only the one that you want while filtering out other distractions.

• **Alternating attention** is the ability to switch your focus back and forth between tasks that require different cognitive demands.

• **Divided attention** is the ability to process two or more responses or react to two or more different demands simultaneously. Divided attention is often referred to as multi-tasking.
• Attention is a central process and perception is not possible without attentional processes.

• That means attention precedes perception.

• Attentional processes serve various functions in the organization of our perceptions and other cognitive functions.

• If you cannot attend then this has significant implications for ToM
Factors that influence how early we achieve ToM?

Precursors to ToM development?

• Earlier/other abilities?

• Cognitive abilities?
  o Cognitive abilities such as memory, attention, inhibition linked with how quickly we achieve ToM (Devine & Hughes, 2014). Sounds a bit like CVI

  o Particular focus on important role of executive (frontal lobe) functions – mediation of attention? Sounds a bit like CVI

  o EF>ToM>Social Behaviour: which EFs are important?
Assessing (or testing for) ToM

- False Belief Tasks
- Value Belief Tasks
- Desire-emotion tasks
- Not own Desire emotion tasks
- Ignorance tasks

False Belief
Commonly-used assessment of ToM

• Unexpected transfer test
  o Various versions of this kind of task
  o Original version: Sally Ann Task cf Maxi

• Deceptive box task
  (unexpected contents)
Sally Ann Task

- Ball placed into basket when both Sally and Ann present.
- Ann moves ball when Sally is out of the room.
- Does Sally know where the ball is when she returns?
- **Pass Response:** No, Sally does not know and checks where she left it.
- **Fail Response:** Yes, Sally will know where the ball is and will check in new location.
Sally Ann Task

• Developed by Baron-Cohen, Leslie & Frith (1985)
  o Prof. Dame Uta Frith > Prof. Simon Baron-Cohen

• Original study aimed to compare social understanding of children with Autism, Down’s Syndrome to healthy control children.

Findings:
• 85% of typical children passed ToM task
• 86% of children with down’s syndrome passed
• Around 80% of children with ocular impairment passed
• Only 20% of children with autism passed

Do not know re children with CVI
BUT........................

• Low acuity,
• Contrast sensitivity
• Visual field deficits
• Simultanagnosia
• Prosopagnosia
• Integrative agnosia

Can all preclude access to the visual elements of the scene required to both learn and exhibit theory of mind through this type of testing.
Issues with the task

• Gopnik (1993); Gopnik & Astington (1988)

• Need metacognition first (thinking about thinking)...need to think about what you think first...necessary before thinking about what someone else thinks. (think about developing metacognition as a priority in children with CVI??)

• Alison Gopnik: tests should be more simple
Metacognition issues with VI and CVI

• it may be harder to read and give social signals
• personal style may be less empathic;
• play will be less likely to include pretence (this is because imaginative 
  play may be dependent on understanding mental states);
• learning may be problematic at school, partly because of the literal 
  interpretation of language, and because of difficulties in adjusting 
  learnt behaviour to the context

Theory of Mind and Visual Impairment (Ocular)

It has been argued in the past that vision played a critical role in ToM

As such Children with VI were delayed in acquiring ToM

Minter et al (1998); Sonksen and Dale, (2002); Korkmaz (2001)
Green et al (2004); Brambring and Asbrock (2010)

Explanation: individuals had little experience in social integrations and therefore not learnt about others mental states – couldn’t see social interactions and not judge gap between experience and verbal interaction (Dyck et al 2004.)
However, Theory of Mind and Visual Impairment (Ocular Studies)

- Recent Studies
  - Beeger et al 2014,
  - Pijnacker et al 2012,
  - Various neuroimaging studies suggest that bilateral temporoparietal junction, medial prefrontal cortex, precuneus and anterior temporal sulci suggest that blindness does not effect ToM nor the development of it.

- Sak Wernica (2015) No differences were found with VI and Sighted in their first-order and higher-order ToM use.

- But the study shows that people who are blind may understand other people’s intentions, feelings and beliefs differently than people who are sighted
“Combined behavioural, anatomical and functional brain studies in sighted and in congenitally blind individuals are providing novel insights on the effects of (lack of) visual experience on the development and functioning of the human brain. A great deal of the brain cortical functional architecture appears to be programmed to occur even in the absence of any visual experience and able to process non-visual sensory information, a property that can be defined as supramodality”

• Ricciardi et al (2014) Mind the blind brain to understand the sighted one! Is there a supramodal cortical functional architecture? *Neuroscience & Biobehavioural Reviewes. Vol 41, p64-77*
Our View (Ocular Visual Impairment)

• Is seems there is no link between a delayed ToM and Ocular Visual Impairment

• Think of Daniel Kish – has excellent ToM but has no eyes – but a rewired visual brain.

• Are differences are due to type of test?

• Do different test type activate different areas of the brain?

• Perhaps these different areas results in differences but not a delay or absence of ToM.

• Perhaps Vision supramodality is responsible for positive results? Who knows?
ToM and Cerebral Visual Impairment

• Very limited literature

• Clearly a difficult and neglected field

• But let’s explore CVI in a bit more detail
But first a quick Recap

Vision Involves More Than The Eyes, and.....

Vision is Processed in Many Parts of the Brain

FROM SECRET LIFE OF THE BRAIN: PBS
Analysing the visual scene and giving attention

• Cooperation of three areas of brain

1 Posterior parietal lobes: appraise overall visual scene
2 Temporal lobes: recognise
3 Frontal lobes: mediate choice
## Visual Features of CVI

<table>
<thead>
<tr>
<th>Area of Damage Seen on MRI Scan</th>
<th>Visual Features to Look For</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Occipital Lobes</strong></td>
<td></td>
</tr>
<tr>
<td>Left occipital lobe</td>
<td>Lack of visual field on the right side for both eyes</td>
</tr>
<tr>
<td>Right occipital lobe</td>
<td>Lack of visual field on the left side for both eyes</td>
</tr>
<tr>
<td>Both occipital lobes</td>
<td>Impaired central visual functions of acuity, contrast, and color</td>
</tr>
<tr>
<td></td>
<td>Lack of visual field on both sides (often manifesting as visual field constriction)</td>
</tr>
<tr>
<td></td>
<td>Severe damage causes profound visual impairment</td>
</tr>
</tbody>
</table>

## Posterior Parietal Lobes

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<tr>
<th>Left posterior parietal lobe</th>
<th>Right posterior parietal lobe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intermittent lack of attention on the right side</td>
<td>Significant lack of attention on the left side and intermittent lack of attention on the right side (Ting et al., 2011)</td>
</tr>
<tr>
<td>A tendency to miss people and events on the right side</td>
<td>People and events on the left side are frequently missed</td>
</tr>
<tr>
<td>A tendency to bump into people and objects on the right side, especially when upset or tired</td>
<td>People and objects on the left side are frequently bumped in to</td>
</tr>
<tr>
<td>Reduced accuracy of visual guidance of movement of the right side of the body</td>
<td>A tendency to be right-handed</td>
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<tr>
<td>A tendency to bump into people and objects on the right side, especially when upset or tired</td>
<td>Weakness of the left side of the body (as a result of damage further forward in the brain)</td>
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<td>A tendency to bump into people and objects on the right side, especially when upset or tired</td>
<td>Difficulties with spoken or written language (because the left parietal lobe serves language)</td>
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<td>Reduced accuracy of visual guidance of movement of the right side of the body</td>
<td>When drawing, the right side of the picture can be distorted</td>
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- Difficulties with spoken or written language (because the left parietal lobe serves language)
- When drawing, the right side of the picture can be distorted

- A tendency to be right-handed
- Weakness of the left side of the body (as a result of damage further forward in the brain)
| Both posterior parietal lobes (Severe damage affecting the cortex, white matter, or both) | Inability to see more than one or two items in a visual scene at once (simultanagnosia), despite the requisite visual field. Inability to use vision to guide movement, accurately despite sometimes having clear three-dimensional vision. Inability to give attention to more than one or two things at once. Noise or conversation can make the child lose visual attention. Inability to move the eyes from one target to another at will, despite ability to move the eyes. Profound lack of ability to see moving targets is common. Lack of lower visual field below the horizontal midline. |
## Temporal Lobes

<table>
<thead>
<tr>
<th>Left temporal lobe</th>
<th>Impaired object recognition (object agnosia); color recognition may be used to compensate.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Impaired shape recognition (shape agnosia).</td>
</tr>
<tr>
<td></td>
<td>Difficulty learning the shapes of letters (alexia).</td>
</tr>
<tr>
<td>Right temporal lobe</td>
<td>Impaired face recognition (prosopagnosia).</td>
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<tr>
<td></td>
<td>Impaired ability to see meaning in facial expressions.</td>
</tr>
<tr>
<td></td>
<td>Difficulty being orientated (may be profound) and navigating known environments (topographic agnosia).</td>
</tr>
</tbody>
</table>
Both Temporal Lobes

<table>
<thead>
<tr>
<th>Both temporal lobes</th>
<th>Combination of the impaired abilities described for the left and right temporal lobes (integrative agnosia). Difficulty knowing the length and orientation of lines, or size of objects. Impaired visual memory (often with reliance on auditory memory and language ability).</th>
</tr>
</thead>
</table>
As Dutton, Chokron, Little and McDowell (2017) say

“The posterior parietal lobes thus reconfigure visual information received via the dorsal stream from the occipital lobes and from the middle temporal lobes that process moving imagery. They create the nonconscious virtual, dynamic three-dimensional pictorial and auditory mental emulation of the structure of our surroundings that enables us to move accurately without collision and injury”
We also know from Pre-term Children......

• Children born extremely preterm are at risk of visual processing problems related to brain damage.

• Damage in visual pathways can remain undetected by conventional magnetic resonance imaging (MRI) and functional consequences cannot always be predicted.

• Delays in processing visual information can be identified in children born extremely preterm. The delays might be ascribed to deficits in neuronal connectivity in visual pathways at a microstructural level.

Dutton’s work tells us

• Children born preterm are at risk of disordered temporal processing of visual information.
• Whether it is the perception and interpretation of rapid changes in facial expression (contributing to acquisition of theory of mind);
• the ability to match one's movements to the moving visual scene to navigate in a crowd or to catch a ball;
• or the ability to find and follow someone in a moving group or recognize their movements – all may be impaired by deficient visuotemporal processing.
• Rapid sequential image capture and processing is needed to pick up the nuances of social interaction, while temporal image summation, which engages both cerebral and cerebellar function, is required to differentiate the flowing images of a running or walking person.
And we also know from work in Cerebral Palsy

• More work on this than on children with CVI

• Adegboye et al 2017. Higher social and emotional difficulties were found in the dystonic CP group compared to the control group. Nonverbal participants with dystonic CP were found to present with greater social impairment and lower ToM ability than their verbal counterparts. Emotional regulation and hyperactivity and attentional difficulties (HAD) significantly predicted ToM ability and social difficulties. Lower Gross Motor Function Classification System (GMFCS) level and IQ also contributed to differences in ToM ability.
• Caillies et al (2012) “Results clearly indicate that children with CP encounter problems with recursive ToM [second order false belief tasks] and irony comprehension”

• Dahlgren et al (2010) “CP children performed worse than matched non CP controls”

• Falkman et al (2005) “there are children with cerebral palsy who fail to solve theory of mind tasks irrespectively of the verbal loading of the tasks”

• Li et al (2014) “Impaired theory of mind in the children with cerebral palsy is reported”
This suggests

• If Children with CP in addition to those who are born pre-term (before 28 weeks gestation) appear to have difficulty with ToM development

• It just has to be the case that Children with CVI have difficulty with ToM – doesn’t it???

• (even though there is no [as yet] concrete research evidence for this)
Solutions

• So what does this mean for Practitioners

May be help can be found through Mirror Neurons (Gallese et al., 1996; Rizzolatti et al., 1996; Rizzolatti and Fadiga, 1998; Rizzolatti and Craighero, 2004).
Really Interesting Study


• Congenitally Blind Participants N = 8 Mean age 44 No recollection of any visual experience + congenital glaucoma (n = 5), retinopathy of prematurity (n = 1), and congenital optic nerve atrophy (n = 2).

• 14 Sighted Participants

• FMRI
• Presented 20 action and 10 environmental sounds
• Motor Pantomime task (participants to be virtually handed objects/tools)
• Presented also with Movies and Sound
• the mirror system can develop in the absence of sight and can process information about actions that is not visual.

• congenitally blind individuals showed activation in a premotor–temporoparietal cortical network in response to aurally presented actions, and this network overlapped with the mirror system brain areas found in sighted subjects.

• Studies have also revealed that individuals with no visual experience rely on supramodal brain areas within the ventral and dorsal extrastriate cortex,
And so if all of this is “true” / “Correct” ????

• If mirror neurons are activated by auditory (and there is some argument for tactile) information then we agree with van Dijk and others that using the Mirror Neuron System in a learning program for (young) children with developmental delay or sensory impairment(s) opens new perspectives for successful habilitation and development of a theory of mind.
What does this mean to the practitioner

(1) prolong facial expressions while facing the child, (Mirroring the face)
(2) complementing emotions through simple salient language; (activation of mirroring)
(3) speak clearly about the child's experiences,, prolonging explosive consonants (activation of mirroring)
(2) choose slow-moving uncluttered educational material; (activation of mirroring)
(3) minimize visual clutter, (what are you mirroring)
(5) identify and cater for any associated peripheral lower visual field impairment; (cannot mirror what you cannot see)
(6) keep background noise to a minimum, especially when talking; (What is being mirrored)

Dutton, 2016, Lueck and Dutton 2016 etc.............
Back to Representation

• Well I do not know “What it is like to be a bat” (Nagal, 1974)

• But we are beginning to understand what form, function and kind of mental representation children with cerebral visual impairment have

• And the evidence leads us to suggest that there is a deficit of a theory of mind but that deficit can perhaps be reduced and even overturned.

• But more research on this is definitely needed.
Thanks

• Thank you for indulging my ramblings

• If you would like to comment or enhance this talk in anyway let me know

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• BTW References are available I just haven’t added them to the powerpoint yet. Sorry.