Cognition, emotion and the cerebellum

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Jeremy D. Schmahmann, M.D.
Ataxia Unit, Cognitive/Behavioral Neurology Unit
Laboratory for Neuroanatomy and Cerebellar Neurobiology
Department of Neurology
Massachusetts General Hospital, Harvard Medical School
jschmahmann@partners.org
The neural basis of romantic love. Bartels and Zeki, Neuroreport, 2000
Motor deficit following cerebellar stroke

**SCA** infarction
ANTERIOR LOBE
MICARS = 20

**PICA** infarction
POSTERIOR LOBE
MICARS = 1
23-yr woman following removal of a cerebellar tumor
Cerebellar cognitive-affective syndrome

• Executive Function
  Planning, set-shifting, verbal fluency, abstract reasoning, working memory

• Spatial Cognition
  Visual spatial organization and memory

• Language Deficits
  Agrammatism and aprosodia

• Personality Change
  Blunting of affect or disinhibited and inappropriate behavior

Schmahmann and Sherman, 1998
Cerebellar tumor resection in children

5-yr-old boy. Medulloblastoma

Rey figure.
6-yr-old boy.
Left cerebellar
cystic astrocytoma
Cerebellar cognitive affective syndrome in children after tumor resection

- **Problem-solving**
  - Failure to organize verbal or visual-spatial material

- **Visual-spatial**
  - Impaired planning and organization

- **Expressive language**
  - Long latencies, poor initiation, brief responses, lack of elaboration, word finding, confrontation naming

- **Memory**
  - Impaired for stories; better with multiple-choice

- **Regulation of affect (vermis lesions)**
  - Irritable, impulsive, disinhibited, labile affect

Levisohn, Cronin-Golomb, Schmahmann, 2000
Neuropsychiatric findings in patients with cerebellar degeneration (n=31)

Non-cognitive psychiatric disorders 77%
Mood disorders 68%
Personality change 26%
DSM-IV criteria for dementia 19%

Leroi et al., Am. J. Psychiatry 2002
Other conditions with cerebellar abnormalities

- Autism
- Schizophrenia
- Attention Deficit Hyperactivity Disorder
- Dyslexia
- Cognitive deficits in infants born very pre-term
Neuropsychiatry of the Cerebellum

- Attentional Control
- Emotional Control
- Autism Spectrum Disorders
- Psychosis Spectrum Disorders
- Social Skill Set

Positive (exaggerated) symptoms
Negative (diminished) symptoms
in each category
reflecting cognitive / emotional dysmetria

Schmahmann, Weilburg, Sherman, 2007
<table>
<thead>
<tr>
<th><strong>Attentional Control</strong></th>
<th><strong>Positive (exaggerated) symptoms</strong></th>
<th><strong>Negative (diminished) symptoms</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inattentiveness, Distractibility, Hyperactivity, Compulsive and ritualistic behaviors</td>
<td>Ruminativeness, Perseveration, Difficulty shifting focus of attention, Obsessional thoughts</td>
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<tr>
<th><strong>Emotional control</strong></th>
<th><strong>Positive (exaggerated) symptoms</strong></th>
<th><strong>Negative (diminished) symptoms</strong></th>
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<tbody>
<tr>
<td></td>
<td>Impulsiveness, disinhibition, Lability, unpredictability, Incongruous feelings, pathological laughing / crying, Anxiety, agitation, panic</td>
<td>Anergy, anhedonia, Sadness, hopelessness, Dysphoria, Depression</td>
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<thead>
<tr>
<th><strong>Autism spectrum</strong></th>
<th><strong>Positive (exaggerated) symptoms</strong></th>
<th><strong>Negative (diminished) symptoms</strong></th>
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</thead>
<tbody>
<tr>
<td>Stereotypical behaviors, Self stimulation behaviors</td>
<td>Aviodant behaviors, tactile defensiveness, Easy sensory overload</td>
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<tr>
<th><strong>Psychosis spectrum</strong></th>
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<th><strong>Negative (diminished) symptoms</strong></th>
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<tbody>
<tr>
<td>Illogical thought, Paranoia</td>
<td>Lack of empathy, Muted affect, emotional blunting, Apathy</td>
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<th><strong>Social skill set</strong></th>
<th><strong>Positive (exaggerated) symptoms</strong></th>
<th><strong>Negative (diminished) symptoms</strong></th>
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<tr>
<td>Anger, aggression, Irritability, Overly territorial, Oppositional behavior</td>
<td>Passivity, immaturity, childishness, Difficulty with social cues and interactions, Unawareness of social boundaries, Overly gullible and trusting</td>
<td></td>
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These findings indicate that:

• The cerebellum is involved not only in movement, but also intellect and emotion

• Different parts of cerebellum regulate different functions

• Damage to the anterior lobe results in dysmetria of movement, causing **ataxia**

• Damage to the posterior lobe results in dysmetria of thought and emotion, causing **the cerebellar cognitive affective syndrome**

*(the dysmetria of thought theory)*
Dysmetria of Thought Theory

In the same way that the cerebellum regulates the rate, rhythm, force, and accuracy of movements, so does it regulate the speed, consistency, capacity, and appropriateness of mental or cognitive processes.

Schmahmann 1991, 2004
Implications for therapy

• Recognize and treat neuropsychiatric symptoms in patients with cerebellar diseases:
  – Depression, anxiety and panic disorder
  – Executive dysfunction
  – Memory impairment
  – REM sleep behavior disorders
  – Pathological laughing and crying
  – Children - developmental and language delay, psychological and emotional distress
  – Psychosis following cerebellar tumor resection
  – Autism spectrum behavioral disorders in cerebellar agenesis, malformations, hypoplasia, post-tumor resection
Treatment approaches

• Recognize that there is a problem, counsel
  – The “need to know” imperative
• Apply cognitive/behavioral therapies
  – Bring actions to conscious awareness
  – Focus on one task at a time
• Use medications appropriate to relieve each of the symptoms
• Consider physical rehabilitation strategies that may influence motor control as well as mood and cognition
Center for Morphometric Analysis
Matthew Albaugh
Verne Caviness
Anders Dale
Gordon Harris
Christian Haselgrove
Steve Hodge
Jeremy Jackson
Dave Kennedy
Nikos Makris
John Schlerf
Larry Seidman

Martinos Center - DSI
Tom Benner
George Dai
Alex DeCrespigny
Helen D’Arceuill
Bruce Fischl
Patrick Hagmann
Bruce Rosen
Ruopeng Wang
Van Wedeen

MRI Atlas
Julien Doyon
Alan Evans
Colin Holmes
Amy Hurwitz
Noor Kabani
Karyne Lavoie
David McDonald
Michael Petrides
Arthur Toga

Cerebellar cognition
Milan Chheda
Alice Cronin-Golomb
Lisi Levisohn
Josef Parvizi
Janet Sherman
Jeffrey Weilburg

Rhesus tract tracing
Deepak Pandya
Charlene DeMong
Jason MacMore

Rhesus behavior
Ron Killiany
Tara Moore
Mark Moss
Doug Rosene

Photo by Jinny Sagorin

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