# Brainstem Disruptions to the Core Self in Autism

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# Two Types of Cognition (Bruner, 1990)

**(1) Narrative**

- 'line mode' (Donaldson, 1992)
- proceeds through time
- necessarily embodied
- built on the structure of experience
  - Situation, motivation, perception, action, and its result
- always coloured with vital affectivity

**(2) Logico-scientific**

- conceptual
- static, timeless
- becomes disembodied
- built on knowledge from experience
  - accumulation of the result of action
- abstract, generalised facts
  - not necessarily situated, affective, motivated, etc.

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# Early Origins of Shared Meaning:

## Emotion and Embodiment in a New Life

“Motor coordination is the sole product of brain function”

- *Roger Sperry (1952), Nobel Laureate*

# Two Fundamental Psychological Principles

- **Principle 1: I like to move it.**
  - Satisfaction in movement in acquiring 'goals'.

- **Principle 2: I like to move it with you!**
  - Satisfaction in coordinated interpersonal sensorimotor acts, *e.g*. dancing

- **Together: This gives meaning-making** and social understanding in intersubjective engagement

# Two Fundamental Psychological Principles

- **Principle 1: Movements are self-generated, affect-driven, prospective, intentional acts.**
  - Satisfaction in movement in acquiring 'goals'.

- **Principle 2: Movements are made in concert with social others, sharing intentions.**
  - Satisfaction in coordinated interpersonal sensorimotor acts, *e.g*. dancing

- **Together: This gives meaning-making** and social understanding in intersubjective engagement

# Mind in Movement

## Actions are Prospective by Necessity

- biomechanical inertial forces necessitate prospective control (Bernstein, 1967; von Hofsten, 1993; 2004)
- actions are expensive; to act economically and with adaptive effect they must be guided by prospective perception (von Hofsten 1993; 2004; Lee, 1998; 2009)
- all units of action must be 'goal'-directed (Lee 1998; 2009)

Delafield-Butt, J. T., & Gangopadhyay, N. (2013). Sensorimotor intentionality: The origins of intentionality in prospective agent action. *Developmental Review,* 33(4), 399-425.

# A Primary Sensorimotor Intentionality

Brentano makes it clear that

"**every mental phenomena includes something as object within itself**" (1874, p. 88).

That 'something as object' is born of the necessity of prospective control.

Every action anticipates a 'goal', *ie. an object* or its consequent effect

Every action presumes a motor-sensory contingency

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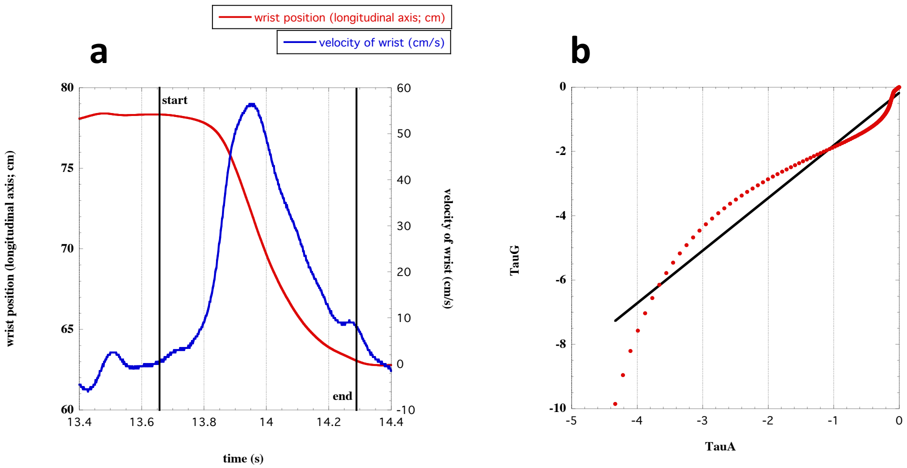
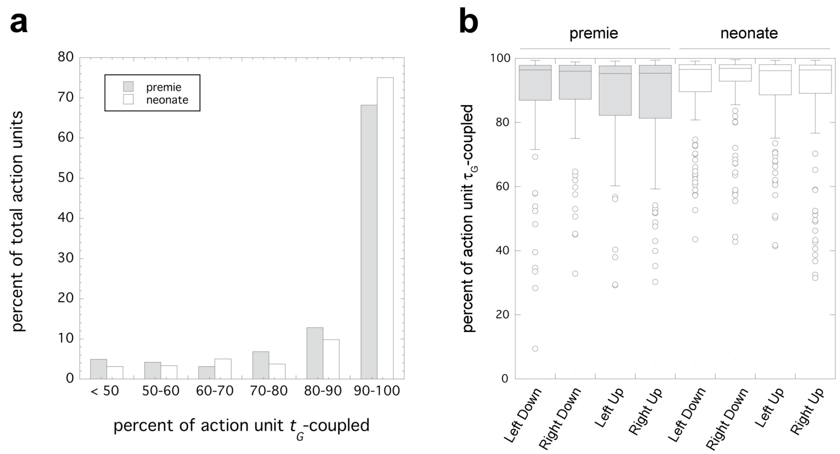
# Prospective Control in Limb Movements




$$\tau_A = k\,\tau_G$$

$$\tau_G = 0.5(t - T^2/t)$$

$$\tau_A = k\,0.5(t - T^2/t)$$

Delafield-Butt, J. T., Freer, Y., Perkins, J., Skulina, D., Schögler, B., & Lee, D. N. (2018). Prospective organization of neonatal arm movements: A motor foundation of embodied agency, disrupted in premature birth. *Developmental Science, 21*(6), e12693. doi:doi:10.1111/desc.12693

# Primary Sensorimotor Intentionality

Pre-reflective, pre-conceptual.

Future-oriented.

Simple.

Delafield-Butt, J. T., & Gangopadhyay, N. (2013). Sensorimotor intentionality: The origins of intentionality in prospective agent action. *Developmental Review,* 33(4), 399-425.

# Intentional Agency Evident at Start of 2nd Trimester

• first tentative signs **at 8-10 weeks** in the first spontaneous, coordinated limb movements (de Vries, Visser, & Prechtl, 1982; Prechtl, 1986)

• discrimination in action patterns of limbs in **14 week** GA twins between twin-object-, and self-directed movements (Casteillo *et al.*, 2010)

• action-planning evident in kinematics by **18-22 weeks** GA (Zoia *et al.*, 2007)

• anticipation of self-directed actions (Myowa-Yamakoshi & Takeshita, 2006)

•behavioural evidence of 'bicycling', reaching, grasping, exploring, etc. (Piontelli, 2010)

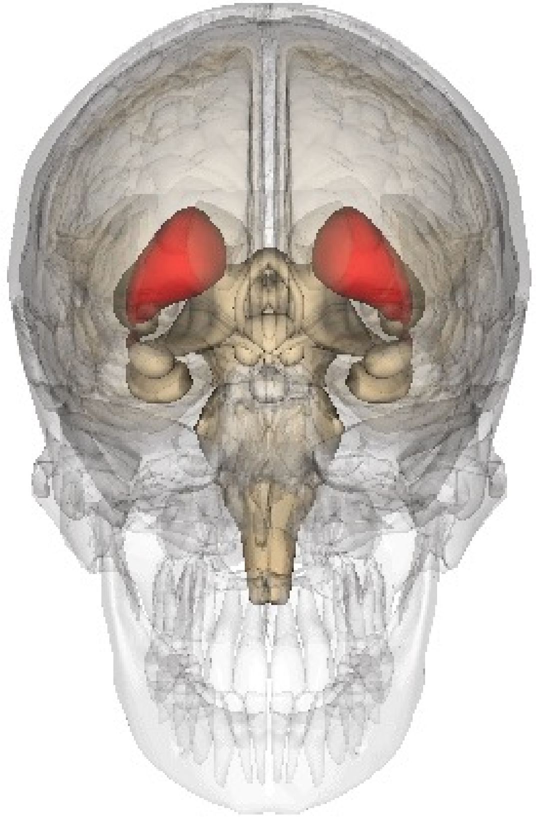
Delafield-Butt, J. T., & Gangopadhyay, N. (2013). Sensorimotor intentionality: The origins of intentionality in prospective agent action. *Developmental Review,* 33(4), 399-425.

# Primary Consciousness, the Centrencephalic Me, (Foundation of Core Self)

- upper brain stem and midbrain region is seat of the integrative 'core self' (Merker, 2007; Northoff & Panksepp, 2008; Panksepp & Northoff, 2009; Panksepp, 2011)
- the Core SELF at the midbrain and upper brain stem is

  ***anatomically subcortical***, but

  ***functionally supracortical***. (Penfield & Jasper, 1954)
- connected to skeletomusculature by *ca.* 14 weeks G.A.
- controls primary prospective action
- conscious and acts with felt appraisal (Penfield & Jasper, 1954)
- site of affective learning and memory (Winn, 2012; Panksepp 1998)
- evidenced in anencepaphalic children
- and foetal prospective motor control before cortical lamination



# The Centrencephalic (Core) Me

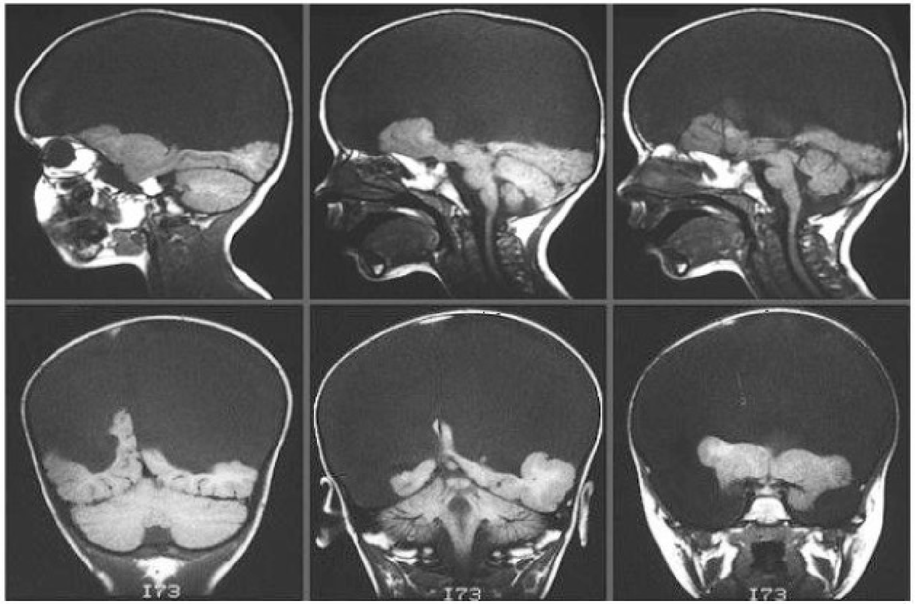


**Figure 8.** Saggittal and frontal magnetic resonance images of the head of a child with hydranencephaly. Spared ventromedial occipital and some midline cortical matter overlies an intact cerebellum and brainstem, while the rest of the cranium is filled with cerebrospinal fluid. Reprinted with the kind permission of the American College of Radiology (ACR Learning File, Neuroradiology, Edition 2, 2004).

Figure 9. The reaction of a three-year-old girl with hydranencephaly in a social situation in which her baby brother has been placed in her arms by her parents, who face her attentively and help support the baby while photographing.

Merker, B. (2007). Consciousness without a cerebral cortex: A challenge for neuroscience and medicine. *Behavioral and Brain Sciences, 30*(1), 63-134.

# The Centrencephalic (Core) Me

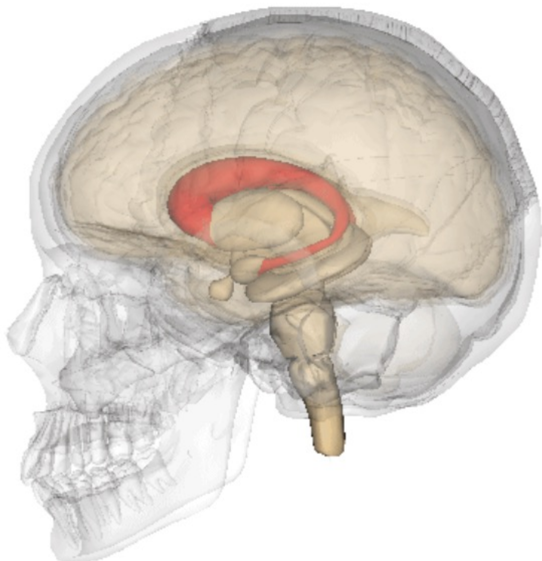
- a cortex is not necessary to
  - be conscious,
  - have feelings,
  - act with intentions,
  - perceive and appraise the environment,
  - engage socially and purposefully,
  - learn

- *c.f.* surgically decerebrate cats and rats (Wood, 1964)

Trevarthen, C., & Delafield-Butt, J. T. (2017). Development of Consciousness. In B. Hopkins, E. Geangu & S. Linkenauger (Eds.), Cambridge Encyclopedia of Child Development (pp. 821-835). Cambridge: Cambridge University Press.
Low, P. (2012). The Cambridge Declaration on Consciousness. J. Panksepp, D. Reiss, D. Edelman, B. Van Swinderen, P. Low & C. Koch (Eds.), *Francis Crick Memorial Conference on Consciousness in Human and non-Human Animals*. Churchill College, Cambridge.

# Making Sense of the World – Brainstem-Mediated Primary Consciousness “Foundation of the Core Self”

- A pre-reflective, pre-conceptual conscious experience
- Prospective, anticipatory awareness.
- Affective,  evaluative.
- Brainstem mediated.
- ‘Phenomenal-Consciousness’, not yet ‘Access-Consciousness’ (Block, 1995)
- Direct neural access to
    - Exteroception,
    - Interoception,
    - Proprioception.



- Autism is a disturbance to Primary Conscious Experience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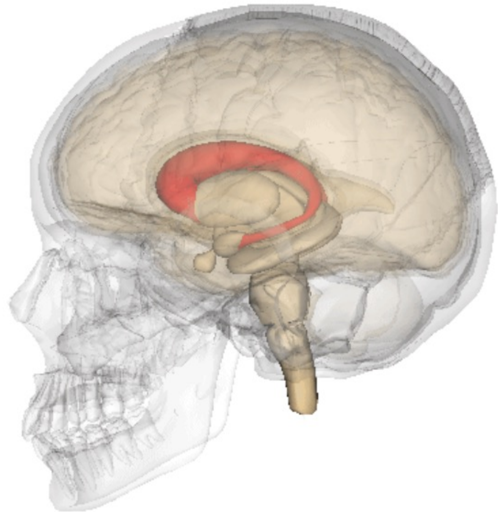
# Making Sense of the World –
# Limbic-Mediated <u>Secondary</u> Consciousness
# Memories and Simple Plans

- Learning mediated by basal ganglia
- Classical conditioning (e.g. FEAR basolateral and central amygdala)
- Instrumental and Operant Conditioning (SEEKING via Nucleus Accumbens)
- Behavioural and Emotional habits, or rituals of practice

- Preconceptual awareness, primary conscious access to sub-neocortical memories that inform agent choice.

- <u>Autistic disturbance to Primary Experience affects Secondary Memory Stores and Conditioning – and *vice versa*</u>

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# Making Sense of the World – Cortex-Mediated Tertiary Consciousness Abstract, Conceptual Thought

- Tertiary affects and neo-cortical ‘awareness’ functions
- Cognitive and executive functions (abstract reflective thought, planning, and offline imagination)
- Emotional ruminations and regulations (medial frontal cortex)
- So-called ‘free will’
- ‘Intentions-to-Act’ (Searle)

- A Conceptually-backed, reflective consciousness.
- ‘Access Consciousness’ on top of ‘Phenomenal Consciousness’

- Autistic disturbance to Primary and Secondary Consciousness affects Tertiary Awareness – and *vice versa* – a disconnect arises

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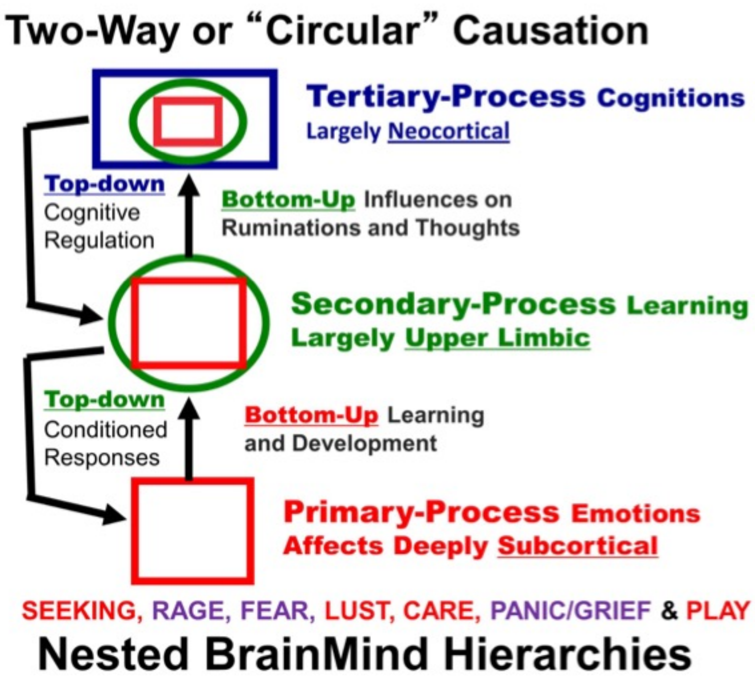
# Nested Mind-Brain Process

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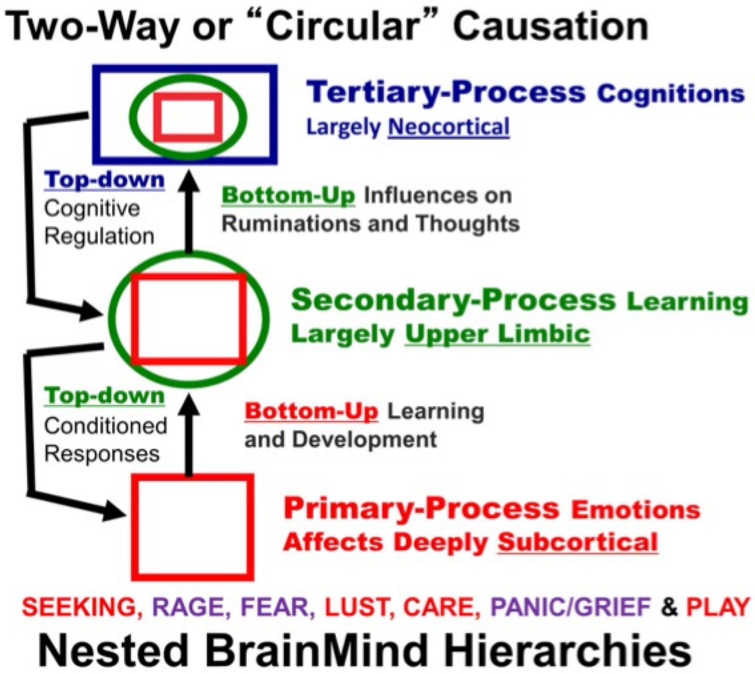


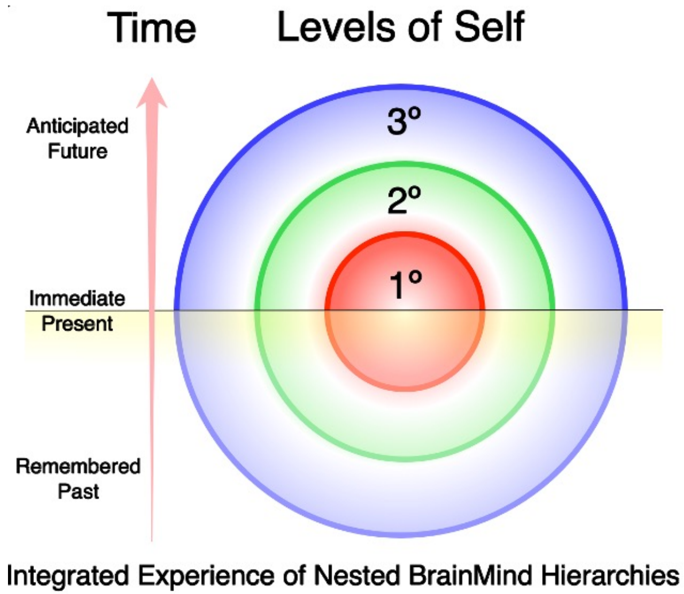


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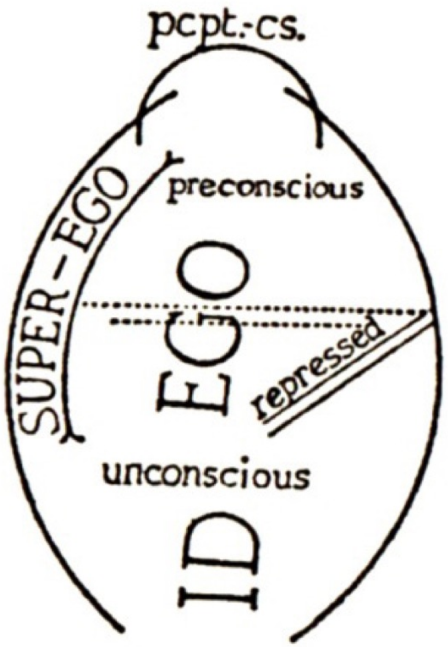


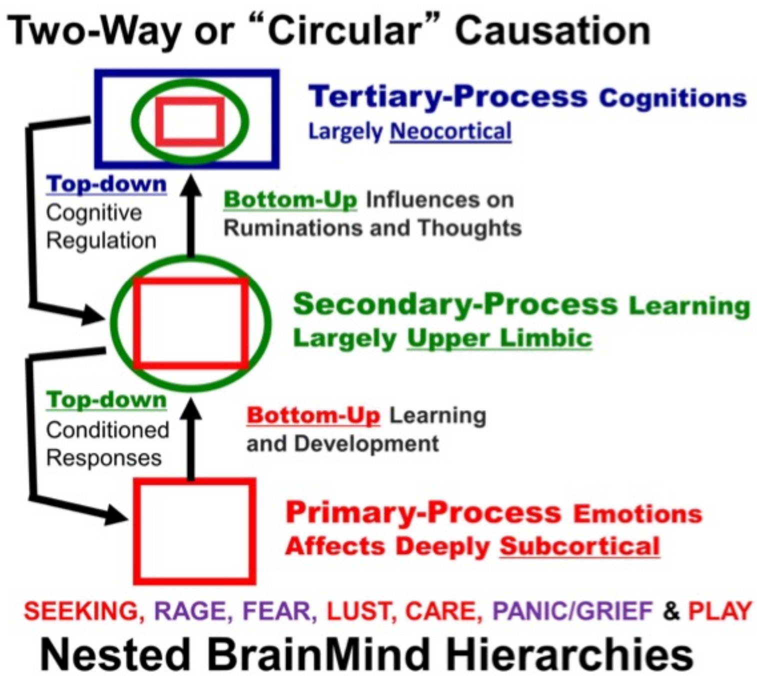


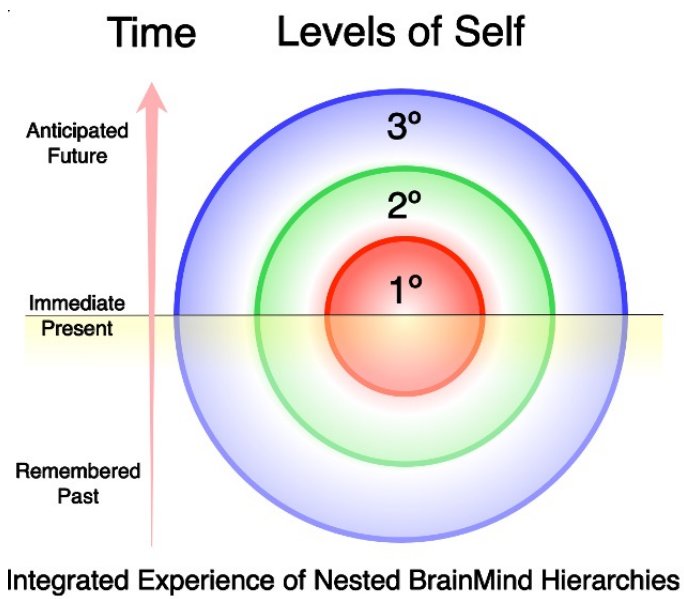



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# Nested Hierarchy of Sensorimotor Intentions

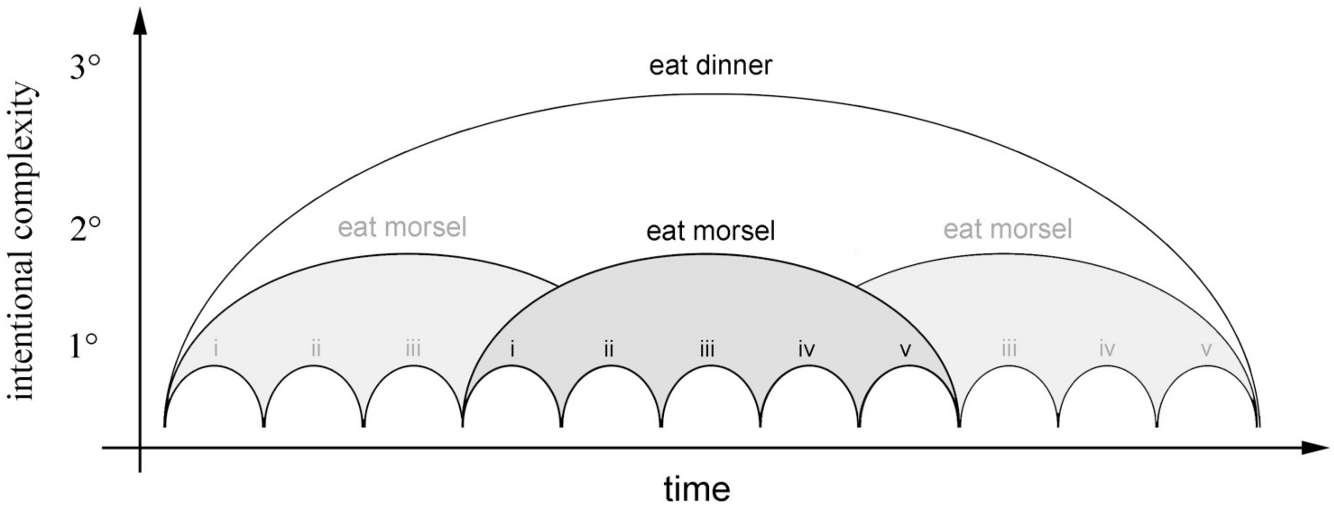


**Table 1**
Units of sensorimotor intentionality.

| Level | Unit type | Description | Temporal range (ms) |
|---|---|---|---|
| Primary | Action unit | A single continuous velocity to a goal, for e.g. an arm movement to a body-space or physical object goal | *ca.* 200–1200 |
| Secondary | Proximal project | Coordination and serial organisation of multiple action units for a proximal goal, for *e.g.* reach-to-grasp or reach-to-grasp-to-eat | *ca.* 1000–3000 |
| Tertiary | Distal project | Coordination and serial organisation of proximal projects to achieve a higher, abstract, distal goal, for e.g. cooking a dinner | >3000 |

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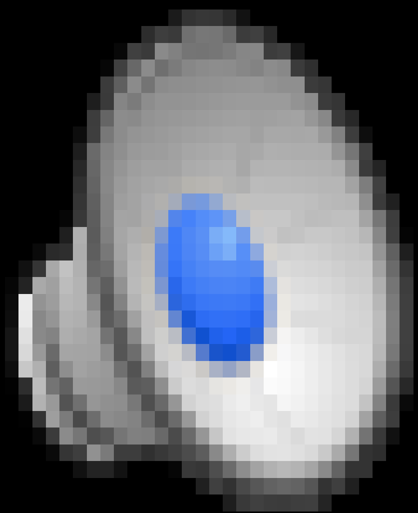
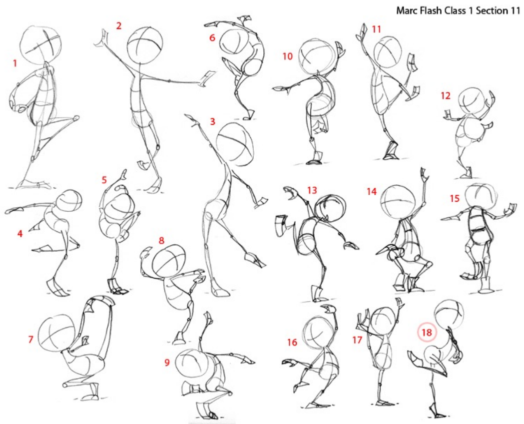
## Sensorimotor Satisfaction:

Joy in Successful Secondary Sensorimotor Intentionality



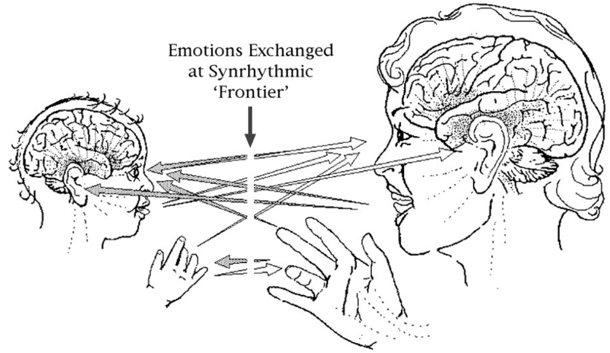
## Principle 1: I like to move it.




inherent satisfaction or joy in successful solo sensorimotor acts

(moving, grasping, walking, skiing, climbing, tight-rope walking)

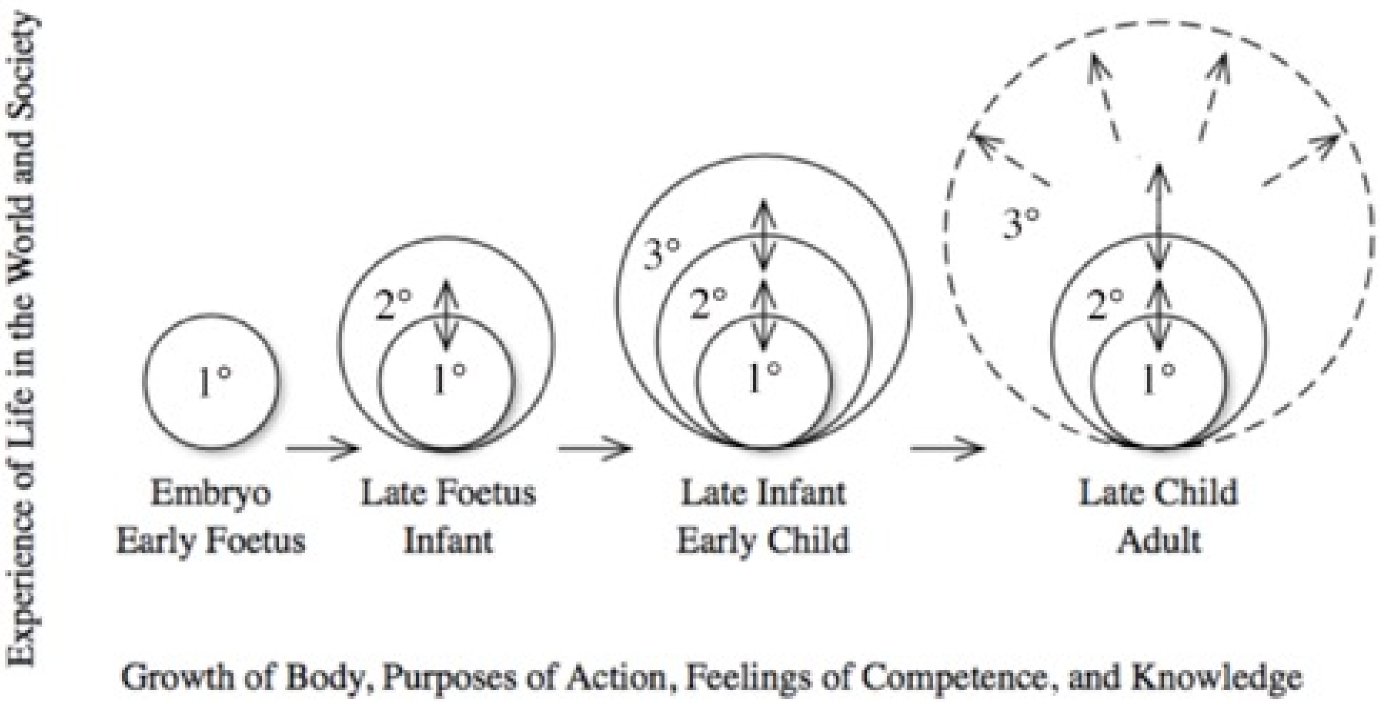
## Principle 2: I like to move it with you.




requires two sensorimotor systems with two timing systems to be **in step and in tune** with each other to generate shared meaning and joy.

Trevarthen, C., Aitken, K. J., Nagy, E., Delafield-Butt, J. T., & Vandekerckhove, M. (2006). Collaborative Regulations of Vitality in Early Childhood. In D. Cicchetti & D. J. Cohen (Eds.), *Developmental Psychopathology* (pp. 65-126). New York: John Wiley & Sons.

# Development of Human Consciousness in step with motor development

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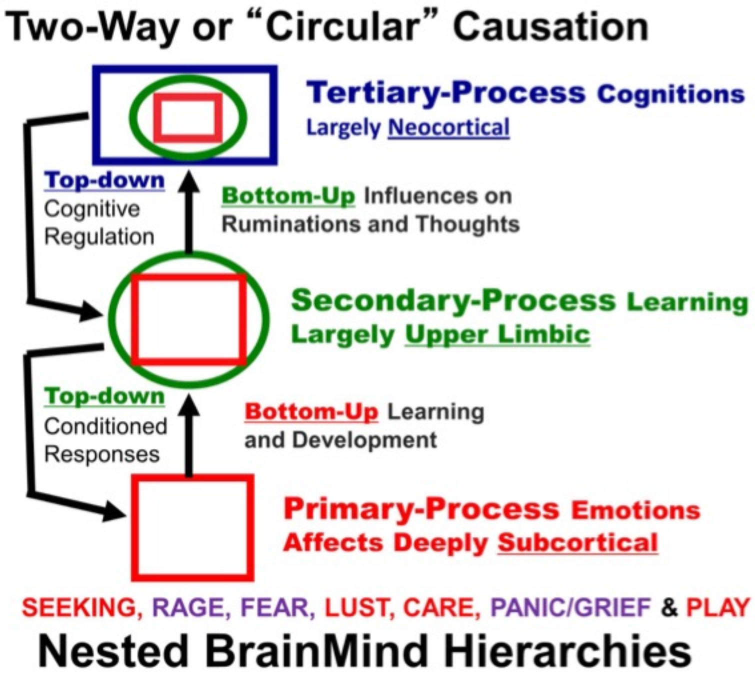
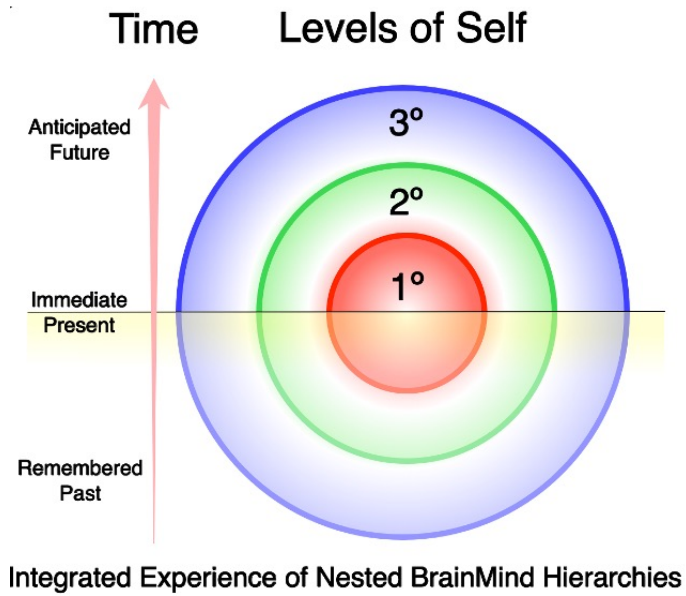
# Disruptions to the Primary, Core Self in Autism





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# Evidence for Brainstem Disturbance of the Core Self in Autism

1. First-person self report (Delafield-Butt, Dunbar, Trevarthen, 2022)
2. Motor control fundamentals (e.g. Trevarthen & Delafield-Butt, 2013; Anzulewicz et al, 2016).
3. Acoustic brainstem response latencies (e.g. Miron et al., 2018; Torres et al., 2023)
4. Neuroanatomical differences
    1. Postmortem tissue (Welsh et al., 2005)
    2. Brainstem volumetrics (Jou et al., 2013; Bosco et al, 2019)
    3. Brainstem morphometrics (Bosco et al., 2019)
    4. Brainstem tracts (Travers et al. 2015)

Dadalko, O. I., & Travers, B. G. (2018). Evidence for Brainstem Contributions to Autism Spectrum Disorders. *Frontiers in Integrative Neuroscience, 12*(47). doi:10.3389/fnint.2018.00047

Delafield-Butt, J., & Trevarthen, C. (2017). On the Brainstem Origin of Autism: Disruption to Movements of the Primary Self. In E. Torres & C. Whyatt (Eds.), Autism: The Movement Sensing Perspective: Taylor & Francis CRC Press.

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# Disruption to the Core Self in Autism, and Its Care

Jonathan Delafield-Butt, Ph.D., Penelope Dunbar, M.Res., and Colwyn Trevarthen, Ph.D.

### *1. Swimming as creative therapy*

Figure 3. Pum enjoying moving her body through the supportive medium of water, which offers routines of sensorimotor integration and progress in movement for psychological integration and health.

### *2. Collage as creative therapy*

Figure 4. An original collage artwork by pum that explores and expresses visually a growing understanding of the neurobiological basis of autism spectrum disorder. the fetus represents the core self, and the collage spatially positions images in correspondence to the brain locations of various structures to represent those functions (see box for description.).

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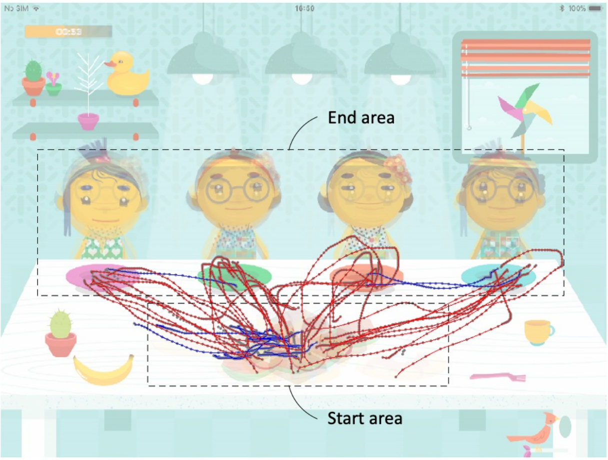
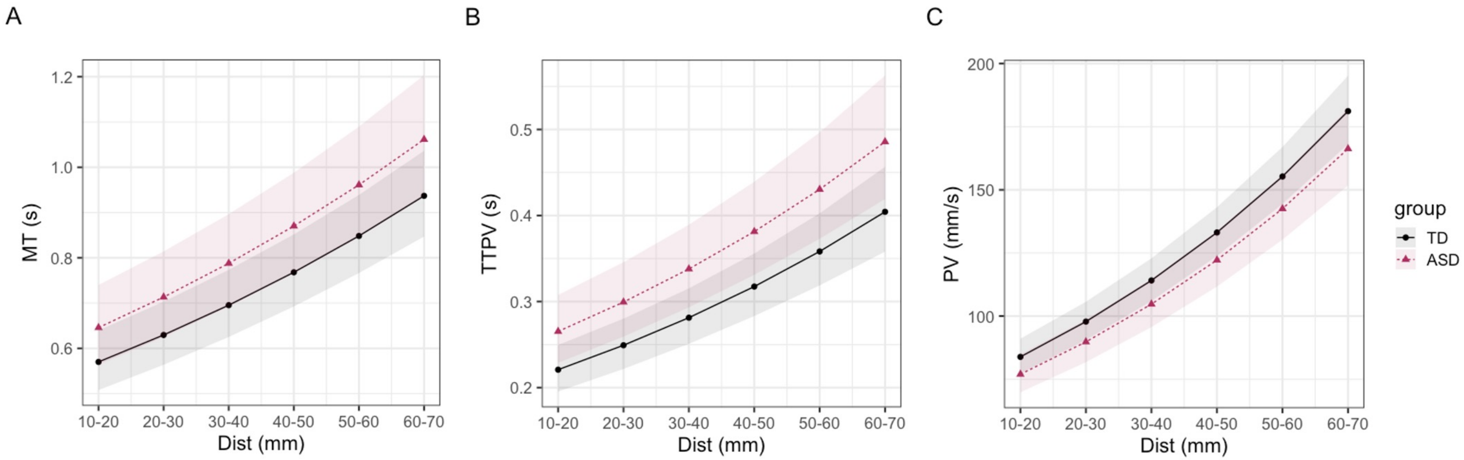
   (i) **Prospective control of movement** (Anzulewicz et al., 2016; Chua et al., 2022; Lu et al., 2022)



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## Toward the Autism Motor Signature: Gesture patterns during smart tablet gameplay identify children with autism

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Anna Anzulewicz[1,2], Krzysztof Sobota[2] & Jonathan T. Delafield-Butt[3]

Open access Protocol

BMJ Open

## Phase 3 diagnostic evaluation of a smart tablet serious game to identify autism in 760 children 3–5 years old in Sweden and the United Kingdom

Lindsay Millar,[1,2] Alex McConnachie,[3] Helen Minnis,[4] Philip Wilson,[5] Lucy Thompson,[5,6] Anna Anzulewicz,[7] Krzysztof Sobota,[7] Philip Rowe,[1,2] Christopher Gillberg,[4,6] Jonathan Delafield-Butt[1]


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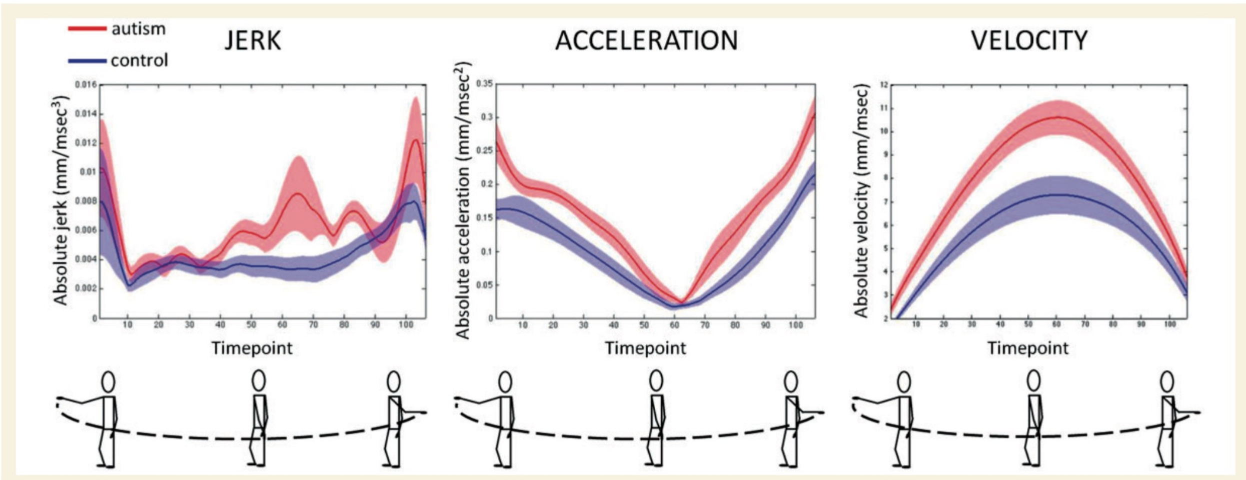
   **(ii) Fundamental motor kinematics (Cook et al., 2013; Torres et al., 2013; Fourie et al., in review)**



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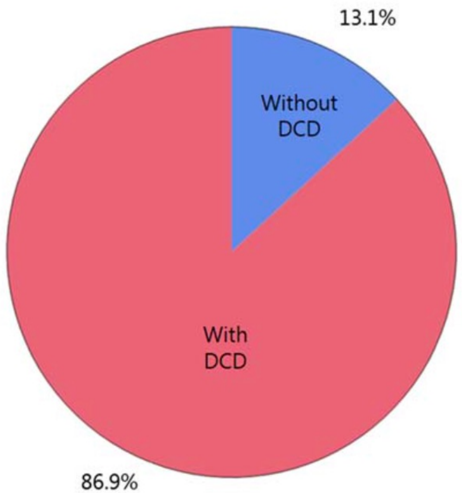
   (i) Prospective control of movement (Chua et al., 2022; Lu et al., 2022)
   (ii) Fundamental motor kinematics (Cook et al., 2013; Fourier et al., in review)
   **(iii) Developmental Coordination Disorder (Bhat, 2020; 2021)**

- **87% of ASD children also 'with' DCD**
- n = 11,814
- DCD measured by DCDQ proxy
- SPARK dataset.

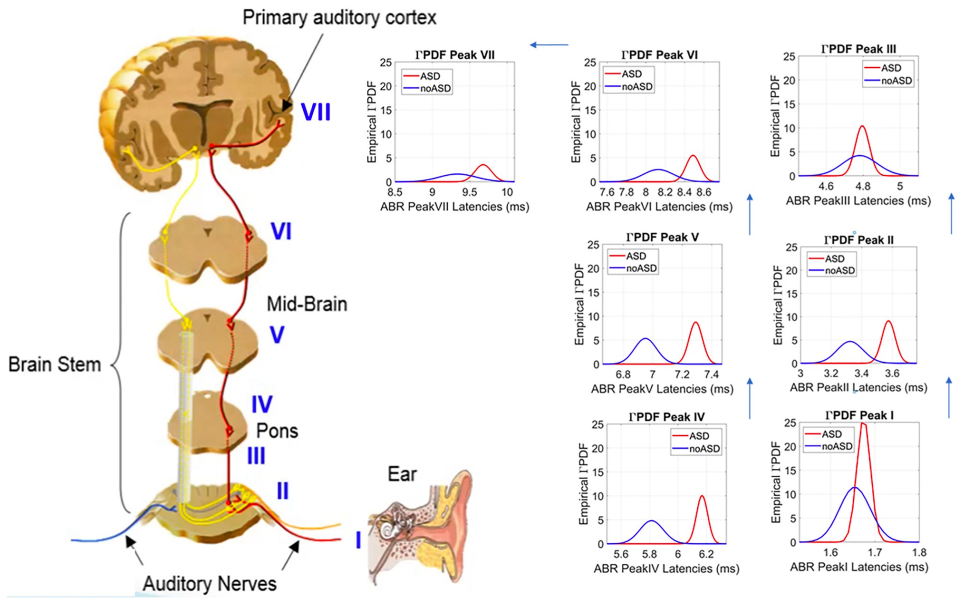



"cerebellum and basal ganglia [*via brainstem*] are unquestionably linked to DCD… both are involved in… neurodevelopmental disorders in general" (Biotteau et al., 2016 )

# Evidence for Brainstem Disturbance of the Core Self in Autism

1. First-person self report (Delafield-Butt, Dunbar, Trevarthen, 2022)
2. Motor control fundamentals (e.g. Trevarthen & Delafield-Butt, 2013; Anzulewicz et al, 2016).
3. Acoustic brainstem response latencies (e.g. Miron et al., 2018; Torres et al., 2023)

1. Increased and narrowed latencies at birth (Torres et al., 2023)
2. Increased latency in childhood (Miron et al., 2018)
3. Decreased latency in adulthood (Miron et al., 2018)




Miron, O., Beam, A. L., and Kohane, I. S. (2018). Autism Res. 11, 355–363. doi: 10.1002/aur.1886

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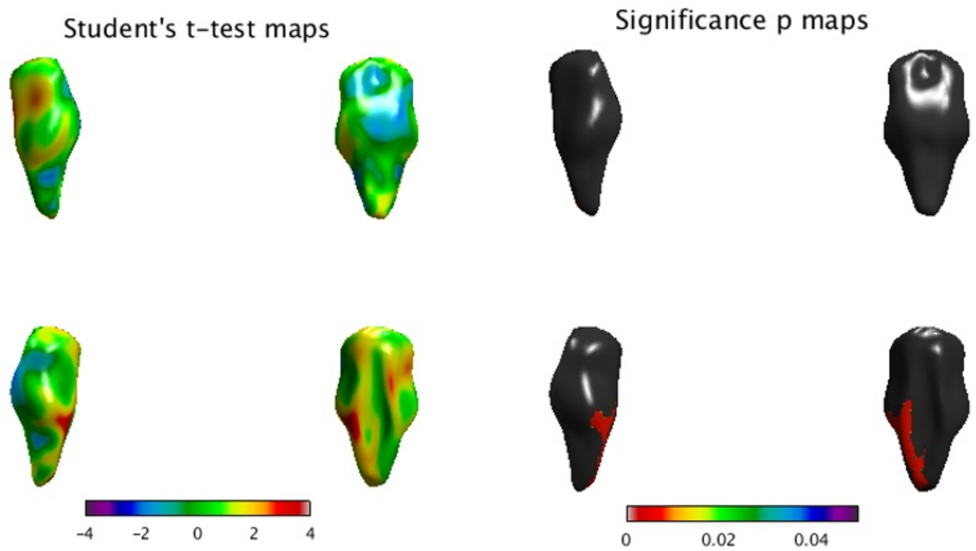
4. Neuroanatomical differences
    1. Postmortem tissue (Welsh et al., 2005)
    2. Brainstem volumetrics (Jou et al., 2013; Bosco et al, 2019)
    3. Brainstem morphometrics (Bosco et al., 2019)
    4. Brainstem tracts (Travers et al. 2015)

# Brainstem enlargement and morphometric differences in 3-6 year old children with autism (n=152)

- 76 preschool children with ASD
- 76 preschool children TD

- ASD brainstem volume greater
- ASD brainstem shape is different

- Increased significance in Males and Low IQ (ID) children




Bosco, P., Giuliano, A., Delafield-Butt, J., Muratori, F., Calderoni, S., & Retico, A. (2018). Brainstem enlargement in preschool children with autism: Results from an intermethod agreement study of segmentation algorithms. *Human Brain Mapping*. doi:10.1002/hbm.24351

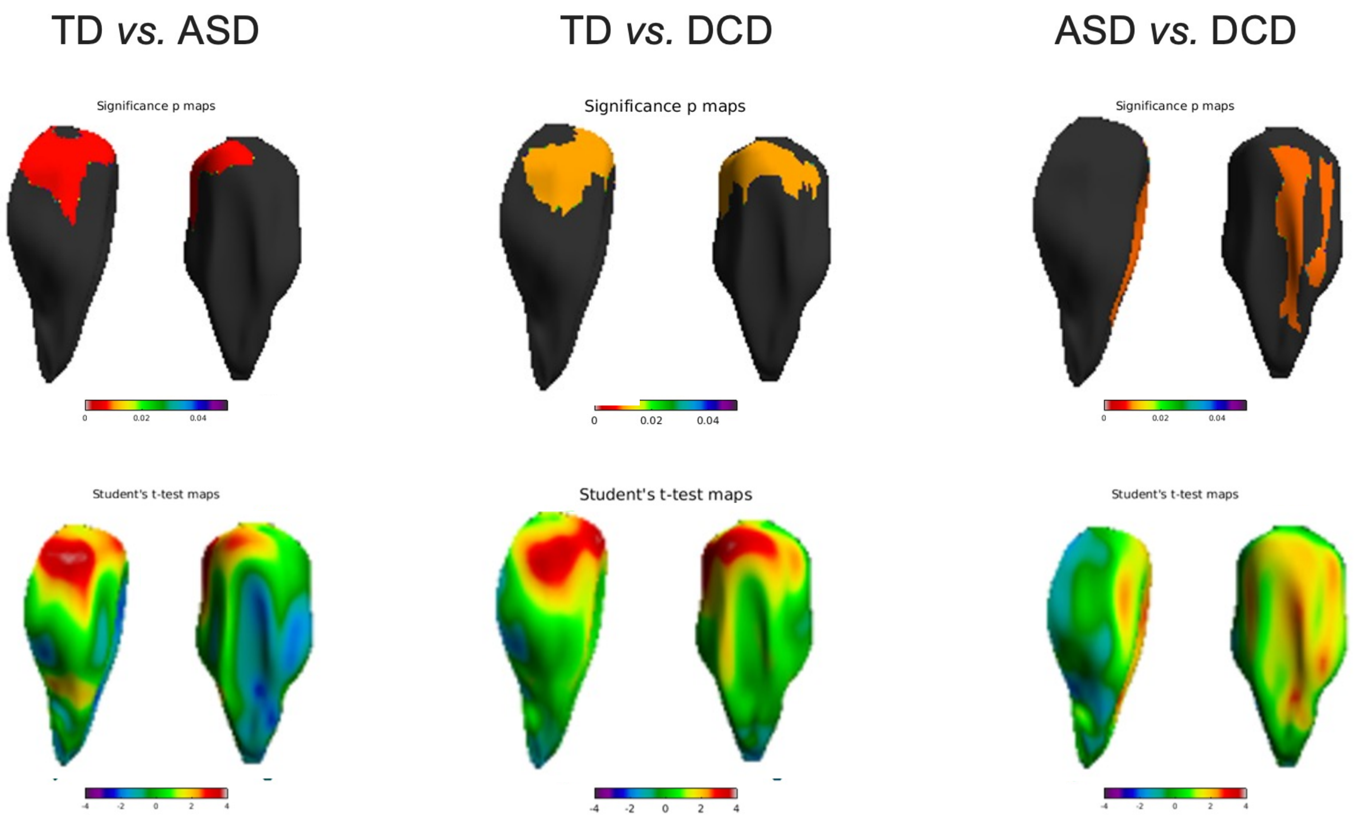
# Brainstem morphometric differences in children with autism and dyspraxia (n=87)

- 30 ASD
- 24 DCD
- 33 TD

- Morphometric differences

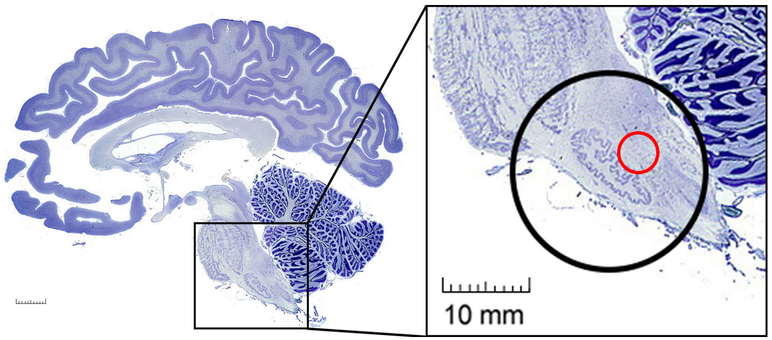
  ASD ≠ DCD ≠ TD

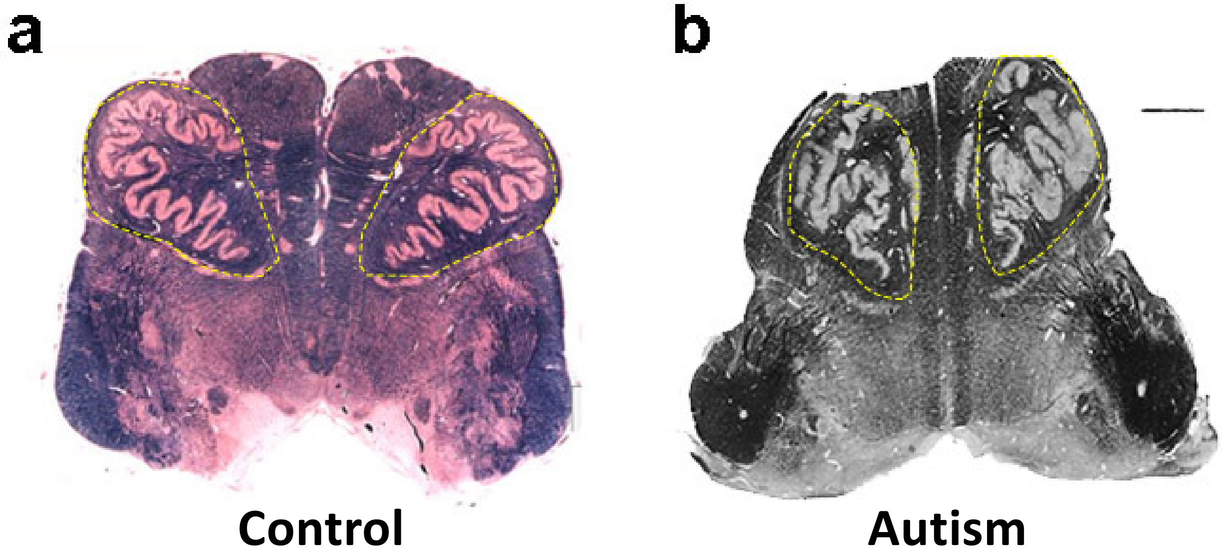
- Volumes comparable




Bosco, P., Harrison, L., Retico, A., Butera, C., Calderoni, S., Muratori, P., Aziz-Zadeh, L., & Delafield-Butt, J. (in prep) Brainstem morphometric differences in children with autism spectrum disorder, developmental coordination disorder, and those typically developing.

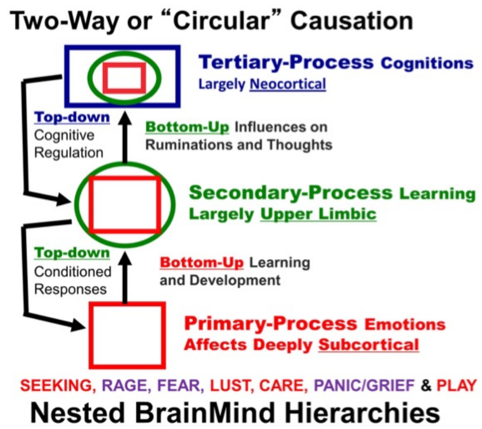
# Neural Growth Disruption in Brainstem Sensory-motor Nuclei




Delafield-Butt, J., & Trevarthen, C. (2017). On the Brainstem Origin of Autism: Disruption to Movements of the Primary Self. In E. Torres & C. Whyatt (Eds.), *The Movement Approach to Autism*: T&F.
Welsh, J. P., Ahn, E. S., & Placantonakis, D. G. (2005). Is autism due to brain desynchronization? *International Journal of Developmental Neuroscience*, 23, 253-263.

# Conclusions:
# Brainstem Disruption to the Primary, Core Self in Autism




Brainstem includes awareness, feelings, intentions

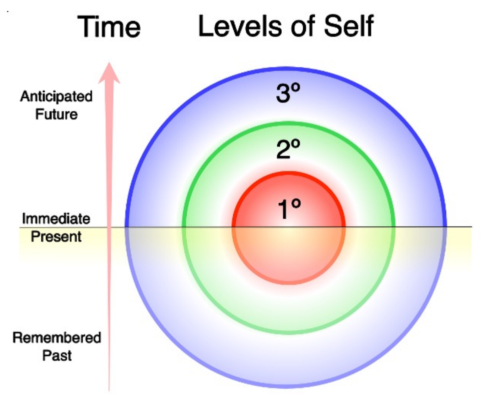
– core attributes of consciousness, primary consc.

Autism includes disruptions to brainstem

-- disruption to core experience, core self

Disruption of communication between 1° ←→ 3° levels,

- abstract, reflective awareness dissociated from an embodied, direct experience
- Arousal, attention, and sensorimotor regulation difficulties without coherent reflective awareness.




Delafield-Butt, J., Dunbar, P., & Trevarthen, C. (2021). Disruption to Embodiment in Autism, and Its Repair. In N. Papaneophytou & U. Das (Eds.), Emerging Programs for Autism Spectrum Disorder

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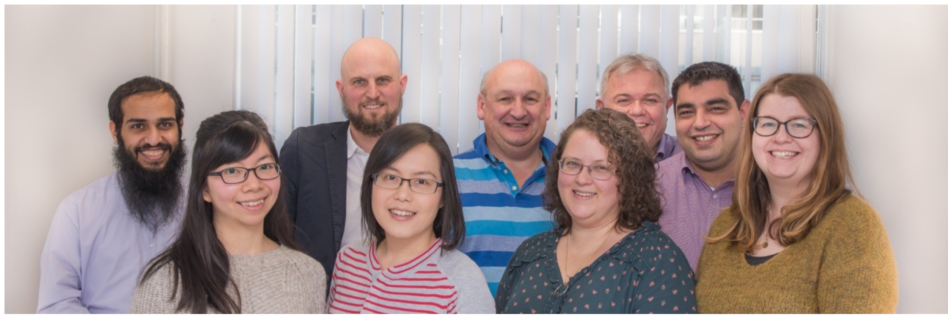
Funders
Hawthorne
European Commission
E·S·R·C Economic & Social Research Council
CAPITA
EPSRC Pioneering research and skills
Kingdom of Saudi Arabia
The Carnegie Trust for the Universities of Scotland
The Scottish Government Riaghaltas na h-Alba
RSE The Royal Society of Edinburgh Knowledge Made Useful
SINAPSE
The Robertson Trust

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# Thank you

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