On the Origins of Understanding: From early intentions in utero to shared social projects of common purpose

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Overview – 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
Overview –
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.

"Every mental phenomena is characterised by what the Scholastics of the Middle Ages called the intentional (or mental) inexistence of an object, and what we might call... reference to a content, direction toward an object... or immanent objectivity." (Franz Brentano, 1874, p. 88).
Standard Model of Motor Intentionality as Means-Ends Relation

• Bower, Broughton, and Moore (1970) demonstrated that when a newborn infant’s reach-to-grab was thwarted, by a visual illusion, distress ensued
• Infants adjust the pattern of their kick to elicit action in an overhead mobile, if the conditions are manipulated so that minimal response is given, distress ensues (Angulo-Kinzler, 2001; Fagen and Rovee, 1976; Rovee-Collier et al., 1978; Rovee-Collier and Gekoski, 1979; reviewed in Zeedyk, 1996)
• Even neonates move their arms to achieve particular sensory effects (van der Meer, 1997; van der Meer and van der Weel, 2011; van der Meer et al., 1995)

Standard Motor Intentionality Development:

1. First, any spontaneous action generates sensory effect
2. Then, a particular intentional action generates a particular sensory effect
Standard Model of Motor Intentionality as Means-Ends Relation

Standard Motor Intentionality Development:

1. First, any spontaneous action generates sensory effect
2. Then, a particular intentional action generates a particular sensory effect
   – if intentional act is successful, joy or satisfaction ensues
   – if intentional act fails, distress or frustration ensues

But these experiments look at external sensory effects produced by objects...
Toward a Primary Sensorimotor Intentionality

**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)

Brentano makes it clear that “every mental phenomena includes something as object within itself” (1874, p. 88).

That ‘something as object’ is the 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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Primary Sensorimotor Intentionality

Pre-reflexive, pre-conceptual.

Future-oriented.

Simple.


Neonatal Movement Analysis

Neonatal Unit Studio

Parent-infant motion, video, and audio capture:

- 500Hz Qualisys
- Double digital video
- Double digital audio
Testing for $\tau$ in Limb Displacements

![Image](image1.png)

$$\tau_A = k \frac{0.5(t-T^2)}{t}$$

![Image](image2.png)
\( \tau \)-coupling in Limb Displacements

8 Normal Term Birth Babies; 480 movements
75% of arm movements prospectively controlled

Primary Sensorimotor Intentionality:

A pre-reflexive, pre-conceptual motor intentionality, perceptually prospectively controlled.
Intentional Agency Evident at Start of 2\textsuperscript{nd} Trimester

\begin{itemize}
  \item first tentative signs at \textbf{8-10 weeks} in the first spontaneous, coordinated limb movements (de Vries, Visser, & Prechtl, 1982; Prechtl, 1986)
  \item discrimination in action patterns of limbs in \textbf{14 week} GA twins between twin-object-, and self-directed movements (Casteillo et al., 2010)
  \item action-planning evident in kinematics by \textbf{18-22 weeks} GA (Zoia \textit{et al.}, 2007)
  \item behavioural evidence of ‘bicycling’, reaching, grasping, exploring, etc. (Piontelli, 2010)
\end{itemize}


Primary Sensorimotor Intentionality

\begin{itemize}
  \item motor intentionality of
    \begin{itemize}
      \item a pre-conceptual, pre-reflexive, perceptually prospective kind
    \end{itemize}
  \item that enables
    \begin{itemize}
      \item development from a primary anoetic (not knowing/without intelligence) consciousness to
      \item a secondary noetic (knowing/intelligence) consciousness (cf. Vandekerckhove & Panksep 2010; Panksep, 2011)
    \end{itemize}
  \item perceptually aware:
    \begin{itemize}
      \item (i) a viseroceptive awareness of vital, somatic need;
      \item (ii) a proprioceptive awareness of the body-in-action;
      \item (iii) an exteroceptive awareness of the world of objects and other animals
    \end{itemize}
\end{itemize}
Primary Sensorimotor Intentionality

- enables development of ‘sensorimotor intelligence’ (Piaget, 1953; 1954)
- through repetition of successful intentional action
  - this is what Baldwin (1895) called the ‘circular reaction’

“The self-repeating or ‘circular’ reaction... is seen to be fundamental and to remain the same, as far as structure is concerned, for all motor activity whatever: the only difference between higher and lower function being, that in the higher, certain accumulated adaptations have in time so come to overlie the original reaction, that the conscious state which accompanies it seems to differ per se from the crude imitative consciousness in which it had its beginning.”

(Baldwin, 1895, p. 23).

The Centrencephalic Me

- 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.
- connected to skeletonmusculature 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)
- evidenced in anencephalic children
- and foetal prospective motor control before cortical lamination
The Centrencephalic Me

Figure 1. Saggital and frontal magnetic resonance images of the head of a child with hydranencephaly. Spaced 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, 2006).
The Centrencephalic Me

Figure 9. The reaction of a three-year-old girl with hydrancephaly 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, 2007)

The Centrencephalic 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)

Development of Understanding through a Hierarchy of Sensorimotor Organisation

- Cognitive development is a development from single action intentions (discrete actions) to projects of action units (serially ordered actions) (Pezzulo, 2011)

- Serially ordered action units organised from the beginning to produce distal goals (Jeannerod, 1999; Fogassi et al, 2005)
  - E.g. reach to grasp to place vs. reach to grasp to throw
  - N.B. Deficit in prospective control in autism

Hierarchical Organisation of Sensorimotor Intentionality

Hierarchical Organisation of Sensorimotor Intentionality

Table 1

<table>
<thead>
<tr>
<th>Level</th>
<th>Unit type</th>
<th>Description</th>
<th>Temporal range (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary</td>
<td>Action unit</td>
<td>A single continuous motion to a goal, e.g. arm movement to body-space or physical object goal</td>
<td>200–1200</td>
</tr>
<tr>
<td>Secondary</td>
<td>Proximal project</td>
<td>Coordination and serial organisation of multiple action units for a proximal goal, e.g. reach-to-grasp or reach-to-grasp-to-eat</td>
<td>1000–3000</td>
</tr>
<tr>
<td>Tertiary</td>
<td>Distal project</td>
<td>Coordination and serial organisation of proximal projects to achieve a higher, abstract, distal goal, e.g. cooking a dinner</td>
<td>&gt;3000</td>
</tr>
</tbody>
</table>

Sensorimotor Intentionality

- **Sensorimotor Intentionality develops:**
  - first intentionality in single ‘action units’ (primary)
  - then envelopes multiple action units to make (secondary) projects
  - then projects of projects of action units (tertiary)
  - and so on as the child develops further cognitive skills, enable sophisticated planning for prospectively controlling the present moment to achieve future goals

- **Tools of memory, planning, abstract reasoning and creative imagination enable more complex and abstract sensorimotor projects.**
Neonatal Sensorimotor Intentionality

• Tertiary Sensorimotor Intentionality – NOT YET PRESENT
  – very rudimentary, vague
  – requires memory, planning, abstract reasoning and imagination
  – enables distant goals to organise action in the present.
    • e.g. studying now for a degree or job in the future

• Secondary Sensorimotor Intentionality – RUDIMENTARY
  – establishing and developing
  – enables simple sensorimotor projects, e.g. walking or grasping
    • e.g. motility toward the breast, coordinated motor acts in social engagements

• Primary Sensorimotor Intentionality – EVIDENT
  – established and developing
  – developing precision with improved muscle tone and experience-dependent neuromotor maturation
  – simple intentional action
    • e.g. arm gesture, sucking control, gaze & head orientation
Toddler Sensorimotor Intentionality

- **Tertiary Sensorimotor Intentionality – ESTABLISHING**
  - rudimentary beginnings becoming substantiated
  - requires memory, planning, abstract reasoning and imagination
  - enables distant goals to organise action in the present.
    - e.g. studying now for a degree or job in the future

- **Secondary Sensorimotor Intentionality – EVIDENT**
  - established and developing
  - enables simple sensorimotor projects, e.g. walking or grasping
    - e.g. motility toward the breast, coordinated motor acts in social engagements

- **Primary Sensorimotor Intentionality – ESTABLISHED**
  - established and improving
  - developing precision with improved muscle tone and experience-dependent neuromotor maturation
  - simple intentional action
    - e.g. arm gesture, sucking control, gaze & head orientation

Child Sensorimotor Intentionality

- **Tertiary Sensorimotor Intentionality – ESTABLISHED**
  - rudimentary beginnings becoming substantiated
  - requires memory, planning, abstract reasoning and imagination
  - enables distant goals to organise action in the present.
    - e.g. studying now for a degree or job in the future

- **Secondary Sensorimotor Intentionality – ESTABLISHED**
  - established and developing
  - enables simple sensorimotor projects, e.g. walking or grasping
    - e.g. motility toward the breast, coordinated motor acts in social engagements

- **Primary Sensorimotor Intentionality – ESTABLISHED**
  - established and improving
  - developing precision with improved muscle tone and experience-dependent neuromotor maturation
  - simple intentional action
    - e.g. arm gesture, sucking control, gaze & head orientation
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.

Co-operation after birth to share meaning

These events are made in cycles and when completed successfully, satisfaction and joy emerge.
From solo sensorimotor projects to shared meaning-making

“There is a series of hierarchies of organization; the order of vocal movements in pronouncing the word, the order of words in the sentence, the order of sentences in the paragraph, the rational order of paragraphs in a discourse. Not only speech, but all skilled acts seem to involve the same problems of serial ordering, even down to the temporal coordination of muscular contractions in such a movement as reaching and grasping. Analysis of the nervous mechanisms underlying order in the more primitive acts may contribute ultimately to the solution even of the physiology of logic.”


Embodied, Non-verbal Narratives

• narratives have a discreet, finite nature like goal-directed sensorimotor projects
• they
  (i) initiate toward a shared, intersubjective ‘goal’
  (ii) build in intensity as the project proceeds
  (iii) reach a climactic point of maximal tension and release,
  (iv) conclude and appropriate the effect of their activity, giving something new.
• the intersubjective ‘goal’ is the ‘coming together’ of two agencies in common meaning, creating coherence of affect, intention, and action between them (Stern, 1985; Trevarthen & Delafield-Butt, 2013)
Co-created Sensorimotor Project

- shared projects of meaning-making
  - foundation of social learning
  - affective, sensorimotor, intentional
- initially the goal is not discreetly known
  - comparable to early prospectively guided sensorimotor intentionality
  - exploratory nature testing expectancies, c.f. foetal/newborn simple actions (anoetic)
- experience with individuals in contexts gives discreet goals, expectancies
  - enabling anticipation and prospective planning

NARRATIVE CYCLE

Neurobiology of Embodied Social Meaning-Making

1. Mind in action
   – generative, affective, intentional engagement

2. Mirror Neuron System
   – mind reading by ‘direct neural resonance’

3. Polyvagal System
   – direct social autonomic regulation
The Polyvagal System

Direct social regulation of autonomic systems through facial expression and gesture (Porges & Furman, 2011)

-- e.g. regulation of heart beat, arousal, anticipation to act, etc.

Altogether we feel the other’s feelings and intentions through direct social perception.

This is an affective and embodied social understanding.
Narrative Cycle

- common goal gives prospective structure
- participatory completion gives shared joy and social learning

Characters of a Narrative Sequence
(i) opening; ah, kiss, & engagement
(ii) build; regular 1.6/1.8 s bars and regular durations ca. 0.5 s
(iii) climax; baby joins in on beat with arm wiggle and coo
(iv) close; baby coo and mother coo w/ final lengthening

Non-verbal Autism-Therapist Narratives

- ‘Intensive Interaction’ therapist with an autistic teenager
- Non-verbal, violent, anti-social, and dangerous.
  - bite and scratch care-takers.
  - taken into a special home.
- This session is the first and only meeting with this therapist.

Autism: A Disorder in Intentional Movement and Affective Engagement

Autistic Disruption to Sensorimotor Intentionality

Primary disruption to primary motor intentions

**Autistic Disruption to Sensorimotor Intentionality**

Primary disruption to primary motor intentions leads to secondary, consequential disturbances and social isolation.

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**Mutual Joy in Intersubjective Contact**
Shared Understanding – Mind Reading

Emotions Exchanged at Synchronic ‘Frontier’


Making Sense of the World
Conclusions

- There exists an *invariant* Sensorimotor Intentionality
  - structures experience-dependent learning and development of cognition and social cognition.
  - 1° Level, single intention-actions (pre-conceptual)
  - 2° Level, projects of intention-actions (becoming conceptual)
  - 3° Level, projects of projects of intention-action (conceptual)

- Sharing sensorimotor projects generates social meaning
  - learning cultural expectations and patterns
  - structures attachment by companionship
  - creates shared joy and social understanding in embodied meaning-making
  - necessary for human life to thrive
References 1


References 2


See [https://strathclyde.academia.edu/JonathanDelafieldButt](https://strathclyde.academia.edu/JonathanDelafieldButt) for access to authored papers.
Sensorimotor Intentionality & Prospective Control

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Thank you.

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