Preverbal infants can recognise ostensive communication and infer communicative transfer of relevant information

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A Historical (Episodic) Introduction:
The difficult birth of Natural Pedagogy Theory

Early difficulties in studying the influence of
ostensive communicative cues
on inferring intended reference

No Native English-speaking Female Person
Can be found in the whole CBCD
To display the Ostensive communicative cue of Motherese!!! (around 2004)

Solution: Roberta the Hungarian substitute...
The Pragmatic Sense:

Humans’ evolved species-unique inferential capacity to express and recognise intentions via communicative actions

Evolved capacity for Recognising Ostensive Actions and Communicative Intentions

1. Relevance Theory of Ostensive Communication (Sperber & Wilson, 1986, 2002)

both claim that human infants evolved special sensitivity

a) recognise that certain actions are intended as communicative

b) infer what relevant information the Communicator intends to convey about the intended referent by his communicative action manifestations in the given context

c) can do so even without and before Language Acquisition!
Human Ostensive Communication:

A mixed communicative system relying on two kinds of evolved mechanisms to ensure efficient information transfer:

a) **Code-based Conventional Symbols** - linguistic mapping devices:
   - *Spoken Words* and *semantic combinatorial mechanisms* (syntax)

   = These code-based signals encode (and can be used to automatically decode)

   the **LITERAL** or **SENTENCE MEANING** of a Verbal Utterance

b) **Pragmatic Inferential mechanisms** to reconstruct

   the Communicator’s **INTENDED MEANING (the Speaker’s Meaning)**

   conveyed by the Verbal Utterance in the given communicative context
3 Arguments for the
Primacy of Pragmatic Inferential mechanisms
in the cognitive adaptation for Ostensive Communication

ARGUMENT 1: The Under-determination Argument

The Pragmatic approach to human verbal communication

Basic distinction between:

Literal or Sentence Meaning vs. (Speaker’s) Intended Meaning

1. Code-based linguistic mechanisms (e.g. automatic lexical access)
   can only decode the Literal Meaning of a verbal utterance

= INSUFFICIENT account of Verbal Comprehension as in most contexts of use
   the Literal Meaning vastly under-determines the Speaker’s Intended Meaning
   that his utterance conveys in the given pragmatic context

==> Context-based Pragmatic Inferences are necessary for the Recipient
   • to recover the Speaker’s Intended Meaning
**ARGUMENT 2: The apparent paradox of word learning:**
How does the young learner acquire the conventional meanings encoded by unfamiliar words in the first place?

A bootstrapping problem in language acquisition

Arguably,

- one needs a code in order to understand communication
- one needs to understand communication in order to acquire a code

In particular,

- children acquire the meaning of a word by understanding what the speaker intends to refer to
- But how can they understand what the speaker intends to refer to without knowing what the word means?
ARGUMENT 2: The apparent paradox of word learning

A Cognitive Solution:

Evolved capacity for Recognising Ostensive Actions and Communicative Intentions


both claim that human infants can

a) *recognise* that certain actions are *intended as communicative*

b) *infer* what *relevant information* the Communicator intends to convey
   by his communicative action manifestations in the given context

c) *can do so even without and before Language Acquisition!*

In fact, it is argued that young language learners

**must rely on context-based pragmatic inferences in the first place**

to identify and acquire the *conventional meanings encoded by novel words*

from the way competent speakers’ use them in various communicative contexts

(e.g., Bloom, 2000, Vouloumanos & Onishi, 2013).
Human adaptedness for Non-Verbal Ostensive Communication

Humans possess a sophisticated ability to **ostensively communicate** their **Referential and Informative Intentions** by relying on **purely non-verbal means of ostensive communicative action manifestations** *(Sperber & Wilson, 2002, Gergely & Csibra, 2005, 2006)*

(i. e., **without** the necessity to employ **code-based linguistic mapping devises** to encode their intended meaning).
Natural Pedagogy theory:

Young infants show specialised sensitivity to

Ostensive and Referential signals of communication:

Csibra & Gergely (2009, 2011)

Ostensive Behavioral signals:

1. Eye-contact
2. Motherese
3. Turn-taking contingent reactivity

Induce recognition of

- ‘being addressed’ by a Communicative Agent
- with the Communicative Intention to manifest
- his Referential and Informative Intention ‘for’ the Addressee to infer
Recognising Ostensive Communication invites two kinds of Pragmatic Inferences:

**Type A**) to reconstruct the Communicator’s Referential Intention:

- Pragmatic Inferences to identify the *Intended Referent* manifested by the Communicator’s ostensive referential signals used in the given context

**Type B**) to reconstruct the Communicator’s Informative Intention:

- Pragmatic Inferences to figure out the *New and Relevant Information about the Intended Referent* that the Communicator intends to convey by his action manifestations in the given context
Type A): Identification of the intended referent

Natural Pedagogy theory:

1. Ostensive Signals induce inferences for REFERENT IDENTIFICATION in infants

   a) Ostensive signals (Eye-contact, Motherese, Turn-taking contingent reactivity)

   When followed by

   b) Referential Signals (Gaze-shift, Pointing)

=> will induce gaze-following by infants to identify the intended referent of the Communicator
Referential Gaze Following is Dependent on the Presence of Ostensive Signals in Infants

Senju and Csibra, (2008)

Ostensive Signals:
1. Eye-contact
2. Infant-directed speech (Motherese)

No Ostensive Signals:
1. No eye contact
2. Adult directed speech
Ostensive signal precedes object-directed gaze-response:
2. Infant-directed speech (Motherese)

Senju and Csibra, (2008)
No Ostensive signal precedes object-directed gaze-response:

2. Adult-directed speech (ADS)

Senju and Csibra, (2008)
Motherese induces gaze-following to referent at 6 months (Senju & Csibra, 2008) [and so does eye-contact]
M. Hernik & T. Broesch (2019, Dev. Sci.)

A recent cross-cultural replication of Senju & Csibra, 2008:

**An eye-tracking study of 5-to-7-month-olds in Vanuatu**

**Ostensive Cuing Context: Being addressed in Motherese (IDS)**

After an indigenous adult model *addressed the infant in Motherese (IDS)* - but not when she did so in ADS - young Ni-Vanouatu infants significantly *gaze-followed the model’s subsequent gaze-shift to the target object*

*Tanna island in Vanuatu*

is an indigenous Melanesian small-scale society where face-to-face parent-infant interactions are reportedly less prevalent than in Western populations.
Natural Pedagogy Theory:
**Turn-Taking Contingent Reactivity at a distance**
as a hypothesised cue of Ostensive Communication

**Turn-Taking Contingent distal Reactivity**
can induce **BOTH** kinds of Pragmatic Inferences:

**Type A): Referent Identification**

Exp. 1-3:

(A) to identify (or disambiguate) the **Intended Referent**

that the communicative agent intends to convey **Relevant information about**

**Ostensive Signals** + followed by + **Referential signals**

(like gaze-shift towards the intended referent)

**Prediction** => will induce in infants Gaze-following to the intended Referent

**Type B): to infer the relevant and new information**

Exp 4-5:

(B) to infer (**the Informative intention**) **the relevant and new information** that the Agent intends
to convey **about the intended referent**
CONTINGENCY DETECTION & ORIENTATION FOLLOWING IN INFANTS

Infant-induced - high, but imperfect - contingent reactivity by an unfamiliar robot

the first such study by Movellan & Watson, 1996: 10-month-old infants


=> Infant-induced Contingent Reactivity induces attribution of Social Intentional Agency to the robot
10-month-old discovers an unfamiliar non-human robot’s Contingent Reactivity at a distance (Movellan & Watson, 1996)

Watson, (1972, 1994) Detection of contingent reactivity induces SOCIAL RESPONSES: Smiling and Cooing at the object!

Watson’s theory: High-but-Imperfect Contingent Reactivity is a cue for SOCIAL INTENTIONAL AGENCY

- warrants Referential Interpretation of distal Action
- implies Perception, Attention, and Voluntary Control
EXPERIMENT 1 - Infant-induced Contingent Reactivity triggers ORIENTATION FOLLOWING to Target Referent in 12-month-olds

Téglás, Csibra, & Gergely, (in prep.)

Do 12-month-olds follow the object’s orientational cue to target referent as a function of infant-induced highly contingent distal reactivity?
EXPERIMENTAL PROCEDURE

onset of leg-kick

variable delay (200, 400, 600 ms)
EXPERIMENT 1 - ORIENTATION FOLLOWING to the INDICATED REFERENT

- fixation 500 ms
- appearance 500 ms
- orientation 400 + 2000 ms

Difference-scores

- first look
  - non-contingent
  - contingent

12-month-olds

N=16  N=18
Results:

12-month-olds whose leg-kicking induced contingent reactivity of the target object followed the object’s subsequent orientational response towards the target.

Infant-induced *turn-taking contingent reactivity* functions as a cue of *ostensive referential communication*.

It induces 12-month-olds’ *referential expectation* and *referential interpretation* of the communicative agent’s object-directed orientational response.

Resulting in *gaze-following* to target to identify the *intended referent*.

These results are in line with earlier findings (Movellan and Watson, 1998, 2002; Johnson, Slaughter & Carey, 1998).
8-month-olds:

(i) Infant-induced Contingent Reactivity
(ii) Non-Contingent Random Activity (yoked control)

8-month-olds:

**Infant’s Response:**
Gaze-shift to focus the central target object

**Contingent response:**
Target object moves
Familiarization:
In the Contingent (IC) vs Non-contingent (NP) condition

Test:

Infant’s gaze-following to target referent

But:

Dual Interpretation of Gaze: SEEING vs. SHOWING

• HYPOTHESIS: during human evolution Gaze has become adapted for the communicative expression of

  • *demonstrative reference*

  *when used in ostensive contexts:*

• Humans can interpret another person’s object-directed gaze

  ⇒ as evidence for *seeing* vs. as evidence for *showing* or *attending* or communicatively referring
SEEING vs. SHOWING

In humans the other’s *object-directed gaze* can convey both it’s

- **natural meaning** (Grice, 1975):

  => The other *sees* or *attends to* the referent object,

- or it’s

  **non-natural meaning** (Grice, 1975):

  => the other’s *demonstrative reference* to the object.

Apprehending either of these meanings of a person’s gaze does not necessarily imply apprehending the other meaning as well.
Questions yet to be answered:

Contrasting theoretical accounts of referential gaze-following as involving attribution of:

(i) Intentional Agency vs. (ii) Communicative Agency

(Gergely & Jacob, 2012)

Seeing vs. Showing

- Why do infants follow gaze to fixate the referent?

- Do infants interpret the object-directed gazing/turning action by attributing the agent the referential intentional state of

  (i) SEEING and/or ATTENDING TO (x)

  or the communicative and referential intention to

  (ii) SHOW/DEMONSTRATE (x)?
Turn-Taking Contingent Reactivity
as a hypothesised cue of Ostensive Communication

However, evidence that Turn-Taking Contingent Reactivity induces
gaze-following of the Entity’s object-directed orienting response

is not sufficient to disambiguate whether the infant interprets the Entity’s orienting
response
towards the referent in terms of attributing

a) Intentional Agency:
as SEEING, LOOKING AT, or ATTENDING TO the distal referent
or in terms of attributing:

b) Communicative Agency:
as SHOWING or DEMONSTRATING the intended referent to the Addressee

PROBLEM:
How can we differentiate between these two interpretations?:

Note that in case of b), following referent identification the infant - due to the ostensively
activated presumption of Communicative Relevance - should further expect the Communicator
to manifest and convey New and Relevant information about the intended referent
(his Informative Intention), which should be pragmatically inferred by the infant in the given context
Ostensive signals induce

Pragmatic Inferences to recover the Communicative agent’s Informative Intentions

Hypothesis: Cues of Ostensive Communication - apart from an expectation of referent identification - will also trigger in infants a readiness to carry out further (Type B) context-based pragmatic Inferences to figure out the New and Relevant Information about the intended referent that the Agent intends to convey by his communicative action manifestations in the given context (i.e., to recover the Communicator’s Informative Intention)

Cue of Ostensive Communication:

Turn-taking exchange of Variable Signal Sequences

The “Flat-Fish Conversation” Studies:

According to Information Theory (Channon, 1948)

- The function of communication is to *transmit information*
- *Information* is related to the *unpredictability* in a message

Hypothesis: *Turn-Taking Contingent Interactions with Variability in the signal sequences exchanged*

*Is a Cue indicative of Ostensive Communication and exchange of relevant information*
10-month-olds observing from a 3rd-person perspective

Agent-to-Agent Turn-Taking Contingent Interactions

Two levels of Contingencies studied:

**Condition 1:**
(a) Partial variability

**Condition 2:**
(b) Identical repetition

**UNPREDICTABILITY PRESENT**

**FULL PREDICTABILITY**
Experiment 1 and 2:  
Turn-taking exchange of sequences of sound signals  
(non-speech sounds)

**MELODIC TONES** (Exp.1) or **MORSE CODE BEEPS** (Exp.2)

Serial structure of sound signal triplets

(a) **Partial Variability** vs.  (b) **Identical repetition**

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Turn-Taking Exchange of Contingent Signal Sequences
High-but-Imperfect Contingency: **Unpredictability Present!**

(a) The “Conversation”
Partial signal variability condition
Sound Signal Sequences: **Melodic Tone Triplets**

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Turn-Taking Exchange of Contingent Signal Sequences

Perfect Contingency: **No Unpredictability!**

(b) **The “Echo”**
Identical Content Repetition condition

Sound Signal Sequences: **Melodic Tone Triplets**

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(i) Lower-than-perfect contingency

*Unpredictability: YES!*

=> compatible with Information Transfer

(ii) Perfect Contingency

*Fully Predictable*

=> No Information Transfer is possible
Test Phase

Orientational Cue => Referential Interpretation?

Do 12-month-olds gaze-follow the Entity’s orientation to target as a function of turn-taking contingent vocal reactivity?
Melodic Tone Sequences

PROPORTION OF LOOKING

- at target
- at non-target

Variable Tones

Identical Tones

n.s.
(a) The “Conversation”
Partial content variability condition
Sound Signal Sequences: **Morse Code Beeps**

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</table>
We measured the proportion of cumulative looking time spent in the target ROI (in comparison with all ROIs) following the agent's turning to the Target Object:

\[
\frac{\text{Target ROI}}{\text{Agent ROI} + \text{Target ROI} + \text{Non-target ROI}}
\]
Partial content variability condition

**TWO AGENTS vs. SINGLE AGENT (CONTROL)**

Experiment 3 - Looking proportion

- **at target**
- **at non-target**

Two Agents

Single Agent

n.s.
Contrasting theoretical accounts of referential gaze-following as involving attribution of:

(i) Intentional Agency  vs.  (ii) Communicative Agency

(Gergely & Jacob, 2012)

Seeing  vs.  Showing

- Why do infants follow gaze to fixate the referent?

- Do infants interpret the object-directed gazing/turning action by attributing the agent the referential intentional state of

  (i) SEEING and/or ATTENDING TO (x)

  or the communicative and referential intention to

  (ii) SHOW/DEMOnSTRATE (x)?
Instrumental agency cues: CHASING
Goal-directed Intentional Action

Chaser is Intentional Agent

NOT Communicative Agent!

Test: No Gaze-Following is induced!

Action Interpretation: Instrumental Agent chases/follows/attends to target object

Téglás and Gergely, (in prep.)
Recall that **Ostensive-Inferential Communication Proper**

Triggers **two kinds of Pragmatic Inferences**:

**Type A) pragmatic inference:** To identify the *Intended Referent* (*Referential Intention*) from demonstrative referential signals: - Exp. 1 (Evidence: gaze-following of referential signals in an ostensive context)

But: **Alternative Explanations in terms of**

SEEING/Attending *(Intentional Agency)*

**vs.**

SHOWING *(Communicative Agency)*

**Type B) pragmatic inference:** To infer the *new and relevant information* manifested **about the Intended Referent** that the Communicator intends to convey (*Informative Intention*)

- **Type B inference is only predicted by the Communicative Agency account**

  => to be tested in Experiments 3-5:
The INFORMING Study: Correcting the other’s False Belief

13-month olds

Ostensive Cue:

Turn-taking Exchange of Variable Signal Sequences

Familiarization Phase:
The INFORMING Study: Correcting the other’s False Belief

Ostensive Cue:
Turn-taking Contingent Exchange of Variable Signal Sequences

13-month-olds

Test Phase:
Control: Turn-taking exchange with perfect signal predictability

13-month-olds

Familiarization: Identical Content Repetition condition
Control: Turn-taking with perfect predictability

TEST PHASE: **Identical Content Repetition**

13-month-olds
Looking Times in False Belief Experiment

The results of Experiment 1

<table>
<thead>
<tr>
<th>Variable Signals</th>
<th>Mean looking time (sec)</th>
</tr>
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<tbody>
<tr>
<td>Approach box with ball in it</td>
<td>10.88</td>
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<tr>
<td>Approach empty box</td>
<td>16.89</td>
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<thead>
<tr>
<th>Identical Signals</th>
<th>Mean looking time (sec)</th>
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<tr>
<td>Approach box with ball in it</td>
<td>16.83</td>
</tr>
<tr>
<td>Approach empty box</td>
<td>12.34</td>
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</tbody>
</table>
True Belief Experiment

Intervening Ball Event:

“Ball jumps out of Box (a), Then Ball jumps back into Box (a)” involves

No Relevant New Information to convey to the Naive Agent (who is returning for the Ball)

BEFORE Event: Ball in Box(a) = AFTER Event: Ball in Box(a)
True Belief Experiment
Test Phase:

Ostensive Communication **BEFORE** Object Search

1. Agent1 (Naive) returns,
   2. Agent1 first initiates Turn-taking Exchange of Signals with Agent2 (Knowledgeable)

   **BEFORE** Object Search:

3. Agent 1 goes to search either Box(a) OR Box(b)
True Belief Experiment: Test Phase

Turn-taking Exchange of Variable Signals

BEFORE Object Search

No Relevant New Information ‘for’ Naive Agent
Looking times in the True Belief Experiment

The results of Experiment 2

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<tr>
<td>Identical Signals</td>
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TRUE BELIEF:
No Relevant Information to convey to the Naive Agent!
True Belief Control: Test Phase

No Ostensive Communication before Object Search
True Belief Control: Test Phase

No Ostensive Communication before Object Search

The results of Experiment 3

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CONCLUSIONS:

Recognising Signals of
Ostensive-Inferential Communication
Triggers two kinds of Pragmatic Inferences in infants:

Type A) To identify the Intended Referent

Type B) To infer the New and Relevant Information - the content of the Communicative Agent’s Informative Intention - that he intends to convey ‘for’ the Addressee about the Intended Referent in the given context

by relying on - purely non-verbal means of ostensive communicative action manifestations

(i.e., without the necessity to employ code-based linguistic mapping devises to encode their intended meaning).
THANK YOU!

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Ildiko Kiraly
Pierre Jacob

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