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Natural Pedagogy

The role of communicative cues in the transmission of cultural knowledge in human infants

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Introduction

1: There are ***species-characteristic forms of human cultural knowledge*** whose social transmission exploits specialized mechanisms that are absent in non-human (primate) cultures.

=> Transmission of ***cognitively 'opaque'*** cultural forms (Part 1)

=> Transmission of ***generic knowledge*** **about** ***kinds*** (Part 2)

2: Humans evolved a ***species-unique cultural learning mechanism***

'Natural Pedagogy'

a dedicated social communicative learning system of mutual design specialized for the transmission of

a) cognitively opaque cultural forms (Part 1)

b) generic knowledge about kinds (Part 2)

Some of the differential features of

- **HUMAN CULTURES** **vs.**
- **PRIMATE CULTURES**
  Population-specific traditions
  (e.g., nut cracking, termite fishing)

- **Early and Fast-learning**
- **Wide range of cultural forms**
- **In a variety of domains**
- **Arbitrariness, Conventionality, Symbolism**

- **Slow acquisition**
- **Few cultural skills**
- **Restricted domains**
- **No Arbitrariness, No Conventionality, No Symbolism**

Do we share the same cultural transmission mechanisms with our primate ancestors?

a) ‘TEACHING’ in apes

Widely shared popular belief :
Apes ‘teach’ their offsprings (kind of “just-like-us”)
(C. Boesch, 2009, clip)

a) 'TEACHING'? NO!

Scientific consensus:
No evidence of pedagogical guidance
of on-looking juvenile learner by expert parent

There is no:

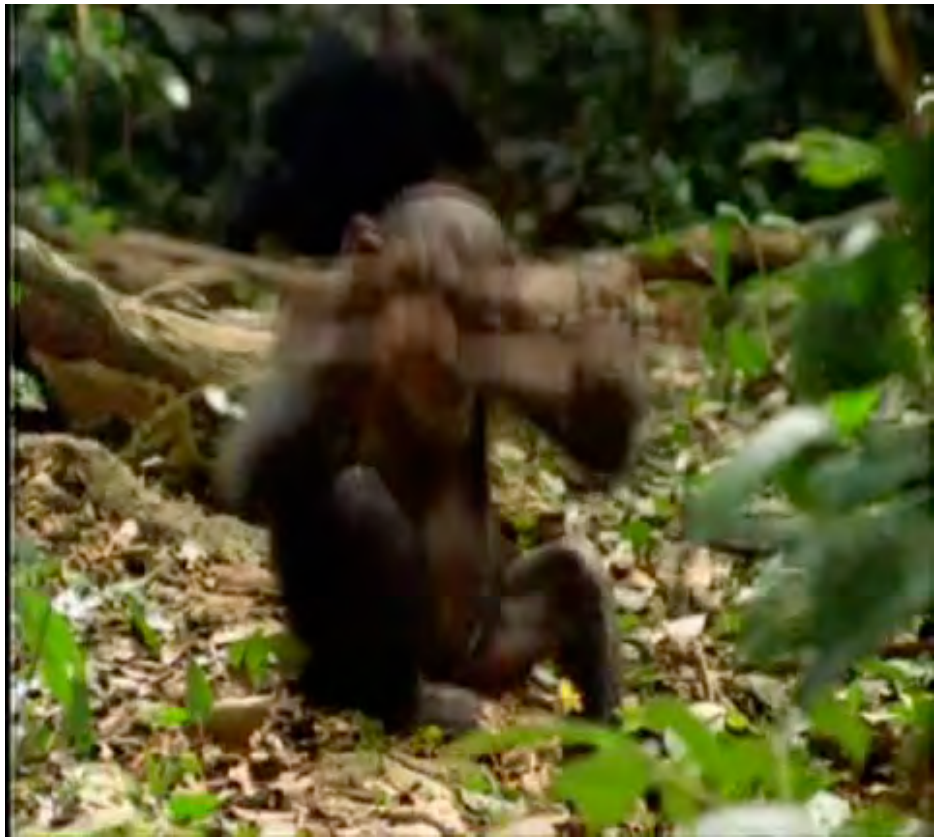
- demonstration
- selective direction to relevant info
- correction
- negative or positive feedback
- no communicative eye-contact with learner or referential gaze-direction

- 'Model's action: purely functional motor performance of skill
- ***No modification of action*** due to presence of learner

- **It takes several years to master nut-cracking for juvenile chimps**

b) IMITATION? NO!

- Primate learner focuses only on outcome: visible result of action
- No attention paid to the choice of means action or or manner of tool use
- Means actions are NOT copied
- Repeated attempts to reproduce interesting outcome through trying out own motor repertoire
- **It takes several years to master nut-cracking for juvenile chimps**



c) 'EMULATION' YES

- **Emulation learning:**
- Slow observational learning process through ***individual re-discovery*** of observed new skill
- Through **repeated "trial-and-error" attempts to achieve observed outcome**
- By applying a variety of different actions from own motor action repertoire
-
- eventually 'hitting upon' an efficient solution (means action) that is retained
- **Fidelity of transmission is relatively low** ('rediscovered' means is not always the same as the observed means)
- IndividualvVariants are often generated

Two central distinguishing features of

- **HUMAN CULTURES** vs. **PRIMATE CULTURES**

Population-specific traditions
(e.g., nut cracking, termite fishing)

a) Cognitive 'opacity'
of cultural forms

a) Cognitive 'transparency'
of cultural forms

b) Multiple types of input:

b) Single type of input:

(i) Non-communicative Observation Context:

Non-communicative Observation Context only:

Primary functional use of skill

Primary functional use of skill

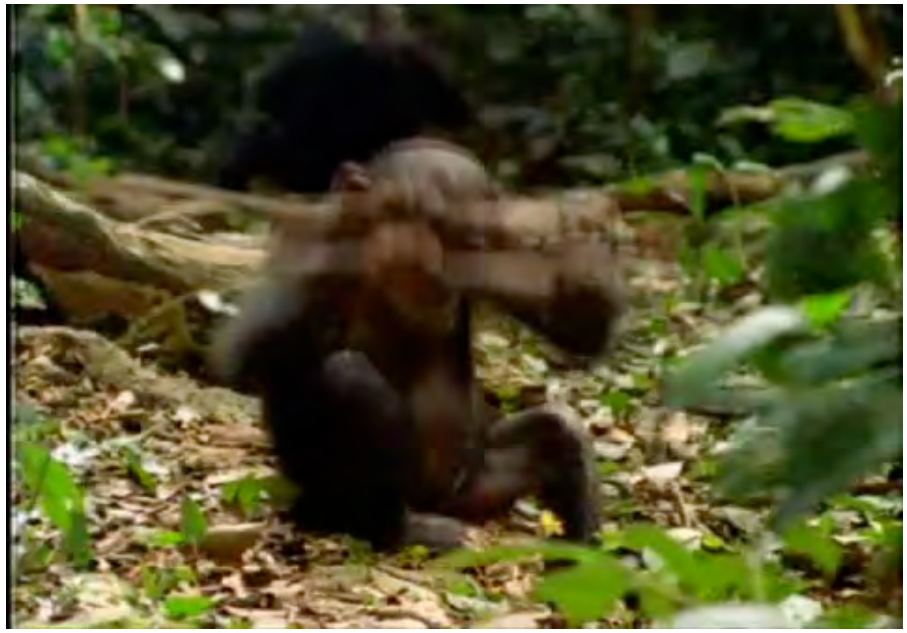
(ii) Communicative Demonstration Context:
Ostensive-referential knowledge manifestation

Primate cultural skills are *Cognitively 'Transparent'*

Restricted domain of cultural skills:

- To achieve *directly visible goals*
- That *afford direct reinforcement* (e.g., food)
- **Their teleological (*means-end) and causal* (contact physics) *structure* is *fully transparent***

(sub-goal => final-goal sequence is directly visible)



=> Primary Mechamism of Cultural Transmission:

GOAL EMULATION

is a sufficiently adequate observational learning mechanism to ensure intergenerational transmission of - cognitively transparent - cultural skills

The challenge of human CULTURAL LEARNING:

(Gergely & Csibra, 2006)

COGNITIVE OPACITY

of cultural forms

- Human infants fast-learn a large amount of ***cultural knowledge and skills*** in numerous domains

- Even when these cultural forms are - at least, partially - ***cognitively opaque*** to them

Cognitive 'opacity'
of human cultural forms

When the user or learner of a cultural form has no cognitive understanding or 'insight' into some significant aspect of how and why the cultural entity works or used: e.g., in relation to its

a) causal mechanism

b) teleo-functional and/or intentional structure

c) adaptive value (or lack of it)

d) mechanism of symbolic reference

Sylvia's recipe
(a true story of cognitive opacity)

Sylvia is an excellent cook. She has a special way of doing a ham roast. One aspect of her preparation is quite unique. She begins by cutting a section off both ends of the ham. One day, when her elderly mother was visiting, she set out to make her special ham for dinner. As her mother watched her remove the end sections, she exclaimed "Why are you doing that?!" Sylvia looked puzzled: "Well, I really don't know... Come to think of it: that's the way you always began with a ham."

- Her mother replied:"But that is because I did not have a wide enough pan!"

Babyjumping: Salto del Colacho, Spain 2009.

Ancient tradition practiced at least since the 16th century in order to get ***Satan 'take the Evil off' the babies*** born in the given year

Csecsemőátugrás A babák átugrásának úrnapi hagyománya az 1600-as évekig nyúlik vissza, és a célja, hogy az elmúlt egy esztendőben megszületett csecsemőkről a sátán levegye a gonoszt. A felvétel a Salto Del Colacho, azaz az Ördög Ugrása fesztiválon készült a spanyolországi Castrillo de Murcia faluban.
Fotó: MTI/AP –Israel L. Murillo

Despite decades of active research in Natural Pedagogy
it is still cognitively ‘opaque’ to us what specific function
The MOBILE PHONES may serve in this cultural tradition…

Example of fast learning and long-term retention of a
cognitively opaque novel means action
by 14-month-old preverbal human infants

Meltzoff, 1988; Gergely et al., 2002, *Nature*

Modeled Action

Re-enactment

The choice of means action remains *cognitively opaque*:
Why did she use her head when she could have used her (free) hands?
(Violation of the efficiency principle)

The puzzle of transmission of cognitively opaque cultural forms

(Apes do not learn unnecessary, inefficient aspects
of modeled behavioral skills)
(e. g., Whiten; Tomasello)

Why did the 14-month-olds re-enact the new 'head-action',
when they could have simply touched the box
with their hands?

(I. e., they could have ***emulated*** *the goal by applying a*
more familiar and efficient means action available to them)

=> the cognitive 'opacity' of the 'head-action'
(it's not the most efficient means available to the actor!)

How do humans learn cognitively opaque cultural forms?

A favorite candidate mechanism for human cultural learning:

IMITATION or (BLIND) MOTOR 'COPYING'

- **Memetics** (Dawkins, Blackmore, Dennett)
- **Theories of cultural evolution** (Boyd & Richerson, Donald)
- **Cultural Anthropology** (Fiske, LeVine, Mead)
- **Developmental psychology** (Baldwin, Bandura, Meltzoff, Tomasello)
- **Comparative Psychology and Cultural Primatology**
  (Whiten, Byrne, Russon)
- **Neuroscience (Mirror Neuron System)**
  (Rizzolatti, Iacoboni, Jeannerod)

Simulation-based Approaches

(e.g. Meltzoff; Tomasello et al.; Craighero & Rizzollati (MNS))

Meltzoff's version:

IMITATIVE LEARNING

as a human-specific - simulation-based- cultural learning mechanism

1. IDENTIFICATION:

Human infants have an innate predisposition to *identify with* others perceived as „like-them";

2. IMITATION: Drive for automatic imitative copying

a) Infants „have an inbuilt drive to „act like" their conspecifics" (Meltzoff, 1996);

b) Identification activates an *automatic tendency to imitate* the other's behaviors.

Simulation-based approaches cannot solve the
'Relevance-Blindness' problem raised by Cognitive Opacity

'Copy or not to copy?'

Meltzoff's model: COPY! (If it is done by a human „like-me")

Sperber's Problem (Relevance Selection):

'WHAT to copy and WHAT NOT to copy?'

'Blind' imitation is 'relevance-blind'

(***No selection mechanism*** to differentiate ***relevant*** aspects of behavior to be imitated and retained from ***non-relevant*** aspects to be omitted)

An alternative approach

Natural Pedagogy:

Learning through Communicative 'Teaching'

(Gergely et al., 2007; Csibra & Gergely, 2006; 2009, *Trends in Cogn. Sci.*)

- A human-specific, **cue-driven social cognitive adaptation of mutual design** dedicated to ensure efficient learning of relevant cultural knowledge.

- Humans are **predisposed to 'teach' and 'learn' new and relevant cultural information** from each other.

- Ignorant conspecifics are naturally motivated to acquire such knowledge by preferentially **seeking out and attending to ostensive, referential, and manifestative cues** of others

- That trigger a **receptive fast-learning mode** in them.

The *Pedagogical Stance* is triggered by Ostensive-Communicative cues:

- ***eye-contact, eye-brow flashing,***
- ***turn-taking contingent reactivity,***
- ***motherese,***
- ***being addressed by own name***

[for review of evidence of early sensitivity to ostensive cues, see Csibra & Gergely, 2009]

Ostensive cues function:

- ***to signal that the other has a Communicative Intention*** **addressed to the infant**
- ***to Manifest New and Relevant information about a Referent (Referential Intention)***
- ***'for' the infant to fast learn***

The Mutual Design Structure of Human Pegagogical Knowledge Transfer:

Cues of *Ostensive Communication* and *Manifestation of Relevance*

1) OSTENSION: „He intends to 'teach' me something *new* and culturally *relevant*!"
Special sensitivity to *Ostensive-Communicative cues:*
(eye-contact, eye-brow flash, turn-taking contingency, motherese, own name)

***Function*: Conveying Communicative Intention to Manifest New and Relevant information 'for' the addressee to learn**

2) REFERENCE: „*What* am I going to be 'taught' about?"
Special sensitivity to *Referential cues*
(shifting eye-gaze to, head turn to, pointing at the referent object)

Function: Identifying the Referent about which New and Relevant information is going to be Manifested

3) RELEVANCE: „*What is it* that I should learn about the about the referent?"
Special sensitivity to *Knowledge Manifestation* (in contrast to functional Use)

Function: Manifesting (foregrounding) the New and Relevant information in a manner that makes it identifiable (inferable) by the learner.

Meltzoff's (1988) "Head-on-Box" study
involved an ostensive-communicative cuing context

Example of fast learning and long-term retention of a

cognitively opaque (partially understood)

novel means action by 14-month-old human infants

An alternative account for the re-enactment
of the cognitively opaque means action in terms of Natural Pedagogy:

Hypothesis:

(a) Imitative re-enactment of the (cognitively opaque) 'head-action' was

selective*, *inferential*, and *relevance-guided

(b) It was induced and guided by the demonstrator's

ostensive communicative manifestation of the relevant content

to be acquired (=> "touch box *with the head*")

The natural pedagogy hypothesis:

Infants may have noticed that

***even though the model's hands were free*,**
***she did not use them*,**

but *ostensively demonstrated* instead 'for' the infant the – apparently less efficient – novel 'head action' as culturally *relevant*

and (as such) to be learned inspite of it's cognitive opacity.

Gergely, Bekkering, & Király, 2002, *Nature;* Gergely et al., (in prep.)

- Group 1: **'Hands-occupied' condition**
  (Different Constraints for model and infant):

  The model's hands were visibly occupied

- Group 2: **'Hands-free' condition**
  (Identical Constraints for model and infant):

  The model's hands were visibly free

(A) Action observation in Communicative Context

‘Hands-free’ condition

Ostensive Communicative demonstration

(A) Action observation in Communicative Context

‘Hands-occupied’ condition

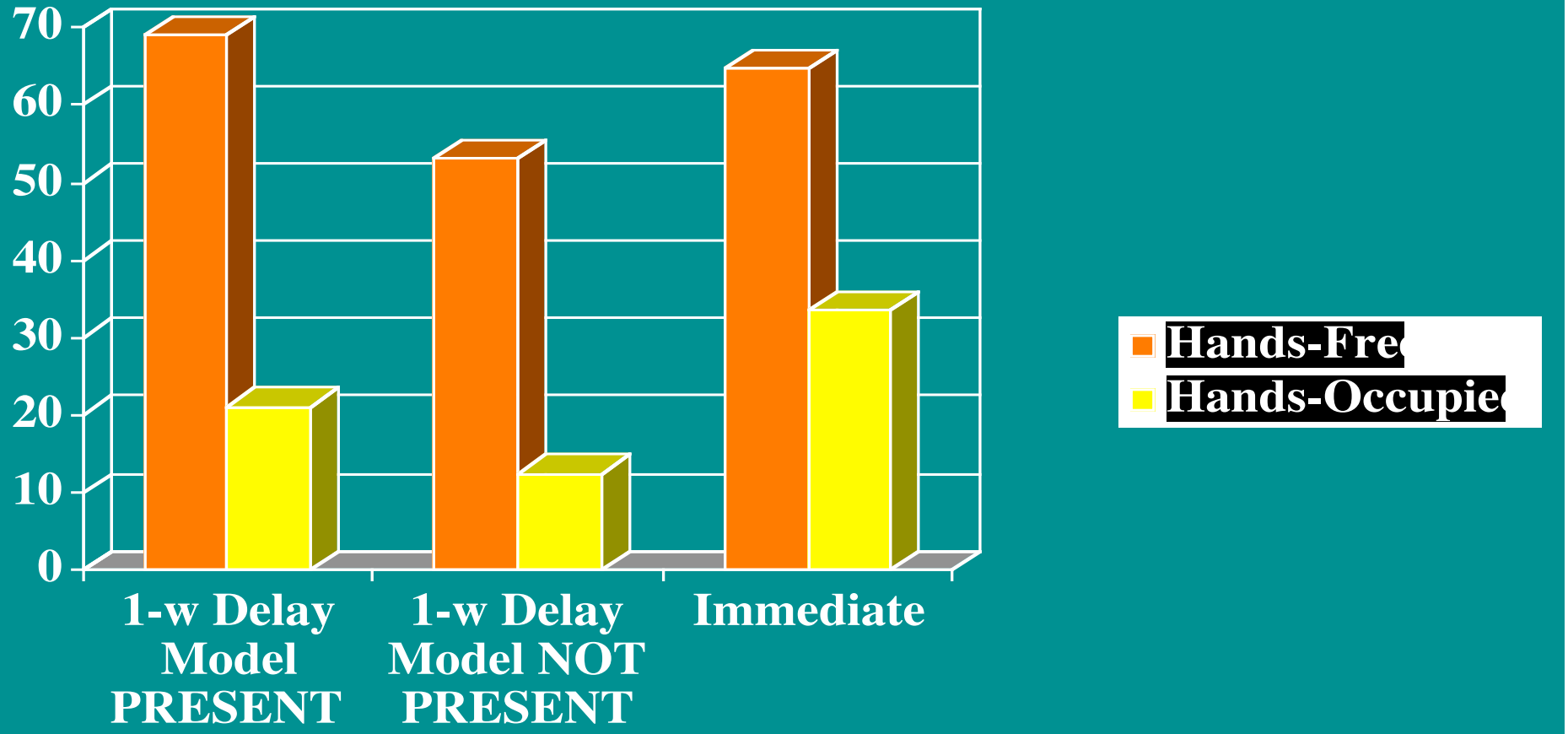
Ostensive Communicative demonstration

Test phase: 1-week delay or Immediate

COMMUNICATIVE DEMONSTRATION CONTEXT

Percentage of imitation of the 'head-action' in the Hands-free vs. Hands-occupied conditions

p=.021 p=.030 p=.018



<u>The Natural Pedagogy account</u>:
Ostensive cues trigger relevance-guided inferences as to

What is 'New' and 'Relevant'
in the demonstrated action?

A) <u>'Hands-Occupied' Condition</u>:

<u>Goal</u> ? (illuminability of box by touch): YES

<u>Means</u> ? (Head-Action): NO! Why?

(Because it seems justifiable – and so expectable –
given the actor's situational constraints)

Therefore: the Head-Action is Not imitated!
the Goal is achieved by emulation (hand-action).

<u>The Natural Pedagogy account</u>:
Ostensive cues trigger relevance-guided inferences as to

What is 'New' and 'Relevant'
in the demonstrated action?

B) <u>'Hands-Free' Condition:</u>

<u>Goal</u> ? (illuminability of magic box): YES

<u>Means?</u> (Head-Action): <u>YES!</u> Why?

Because **the model's** ostensively cued **COMMUNICATIVE MANIFESTATION of** the - cognitively *opaque* - 'head-action' is interpreted as a 'pedagogical' instruction that the demonstrated novel means is culturally **RELEVANT** and should be learned.

Hence: *Both the Goal AND the Means* are imitated!

Some conclusions

1. **Selective Imitation** of the novel means is ***not automatically triggered by identification*** (which would have predicted equal imitation in the two conditions);

2. Imitative learning is ***selective, inferential,*** and ***relevance-guided***

3. It is triggered by ***ostensive - social communicative - cues*** of the demonstrator

A central hypothesis of the theory of natural pedagogy:

(Csibra & Gergely, 2006; Gergely & Csibra, 2005, 2006)

Ostensive-communicative cues

play a vital role

in triggering inferences as to what is

Novel and Relevant **in the manifested content**

Human-specific input conditions for cultural learning:

Intentional Actions of Other Humans

observed in two types of context

(A) Ostensive Communicative Demonstration Context

(Communicative Action Manifestation 'for' the observer:

Ostensive and Referential Cues accompany the agent's action)

(B) Non-communicative Observation Context

Observing other agent's intentional action (Over-seeing, over-hearing, incidental observation etc.)

Testing the role of 'Ostensive Cues' in triggering relevance-guided selective imitative learning

Imitation of Head-Action in

'Ostensive-Communicative'

vs.

'Non-communicative Observation'

demonstration conditions

(Gergely et al., in prep.; Gergely & Csibra, 2005; Gergely, 2007)

(B) Non-communicative observation Context

Observing other agent's intentional action:

Person Acts on Object

Hands Occupied Condition

Imitation of Novel Actions

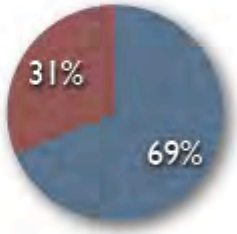
Hands Free

Hands Occupied

Context

Ostensive Pedagogy

Communicative



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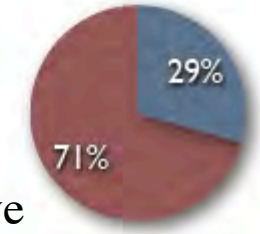
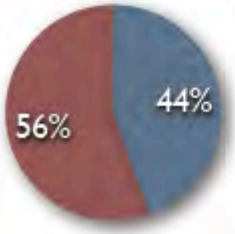
Imitation
No imitation

*

Incidental Observation

Non-communicative





Gergely et al., in prep.

Evidence for emulation

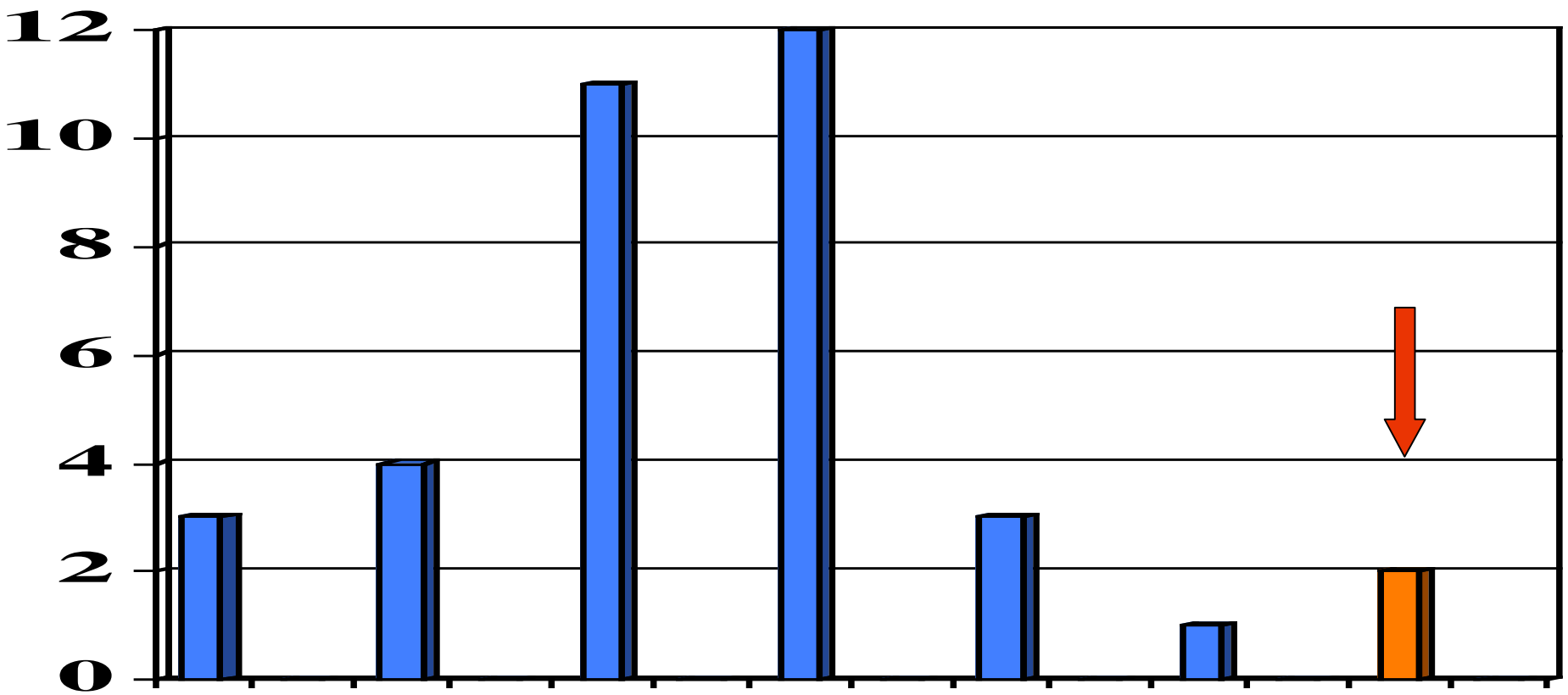
1. Each and every infant performed the ***Hand-Action at least once*** (and often many times) irrespective of condition;

2. 75% of those who imitated the Head-Action **performed the emulative *Hand-Action first*** (nearly always succeeding to illuminate the light-box by hand)!

3. In fact, only 10% of the ‘head-actions’ coded as true ‘imitative’ responses (using Meltzoff’s criterion) involved faithful ‘motor copies’ of the model’s head-action!

Imitative Learning as ***Relevance-guided Emulation!***

Variability of types of head-responses coded as "head-action imitation" in 14-month-olds



Beyond Imitative Learning:

Pedagogical cultural knowledge transfer as

relevance-guided emulation

The relevant new information identified for the infant

What ***specific sub-goal*** needs to be achieved:

'Make physical contact with light-box ***with your head'***

⇒ Infants reproduce the specified sub-goal, but they do so

not by faithful imitative motor copying of the model's head-action,
but by (playfully) ***emulating the new sub-goal*** they have acquired.

Limitations of Imitation

<u>Part 2</u>:
Natural Pedagogy as a mechanism
To facilitate the transmission of generic knowledge about kinds

Human communication is a species-unique system of
Epistemic Cooperation

dedicated to the efficient transfer of
<u>two main types of information about referents:</u>

A) *EPISODIC information* *vs.* ***B) GENERIC/SEMANTIC information***

about ***<u>non-generalizable</u>***
properties of
PARTICULAR REFERENTS
whose relevance is restricted
to the 'here-and-now' situation

about ***GENERIC kind-specific referent properties*** that are ***<u>generalizable</u>***
beyond the 'here-and'now'
to the ***REFERENT KIND*** the referent belongs to

The problem of referential disambiguation:

- To identify the *intended referential scope* (particular vs. generic) of a communicative act requires *pragmatic inferences* by the addressee.

  (Sperber and Wilson, 1986; Csibra & Gergely, 2009).

- Deictic reference: Picks out ***particular referents*** only

  (e.g.,gaze-direction or pointing)

How can we convey *generic information* about
sortal referent kinds
through communicating about particular referents?

Natural Pedagogy as Mother Nature's solution to the Induction Problem

An innate design feature of Natural Pedagogy:

The 'Genericity Bias' Hypothesis

(Csibra & Gergely, 2009)

- The *'Genericity Bias'* is a built-in 'default' setting for interpreting the Intended Referential Scope

  of *Ostensive Communicative Acts* as conveying

  Kind-relevant knowledge generalizable to the referent kind

- The Genericity Bias is triggered by *specific Ostensive Communicative Signals*

- To which human infants show innate sensitivity to

This adaptation has several evolutionarily useful consequences:

Natural Pedagogy allows for the fast and efficient *transfer of generic and culturally shared knowledge about kinds*

- even in early *non-verbal ostensive communicative referential acts* that rely solely on *deictic referential devises only*

  (that are restricted to pick out particular referents)

2. even when young infants may yet be *unable to compute the pragmatic* inferences necessary to disambiguate the intended referent, and

3. even if they *cannot yet rely on their mindreading ability to* infer the representational contents of the other agent's beliefs to help them *referentially disambiguate the communicative act*.

Evidence for the 'Genericity Bias'

Hypothesis: **Ostensive cues** induce

a) The Genericity assumption

(i) *a* ***'genericity bias'*** in referential interpretation:

=> Expectation that the communicative manifestation about the referent conveys knowledge ***generalizable to the referent kind*** (i. e. it conveys ***generic/semantic*** rather than episodic knowledge).

b) The Universality assumption

=> Expectation that the manifested information conveys ***universally shared cultural knowledge available to all others*** (not only to the communicator)

Demonstration 1:

Social Referencing

Interpretation of ***object-referential emotion displays***
of others by 18-month-olds
Egyed, Kiraly, & Gergely (submitted)

Note: Standard accounts of Social Referencing assume:

Agent-centered *person-specific and episodic* interpretation
of the referential emotion expressions of others
(e.g., Tomasello, 1999; Mumme & Fernard, 2003, but see Gergely et al., 2007)

Infants attribute a person-specific subjective dispositional attitude to the agent towards the particular referent ('preference' *vs*. 'dislike'):

"Allison *likes* broccoli"

The problem of under-determination of the input

Object-directed emotion expressions ('liking' *vs*. 'disgust') are **inherently ambiguous**: they can convey information either about

a) ***person-specific mental dispositional attitude of the agent towards the referent*** ('preference' *vs*. 'dislike'):

"Allison *likes* broccoli"

or about

b) ***Valence-related dispositional properties of the referent kind*** ('likeability' *vs*. 'dislikability')

"Broccoli is *good*"

Subjects : 4 groups of 18-month-olds

Stimuli: Two unfamiliar objects

1: Baseline – control group
No object-directed attitude demonstration

Simple Object Request by Experimenter A

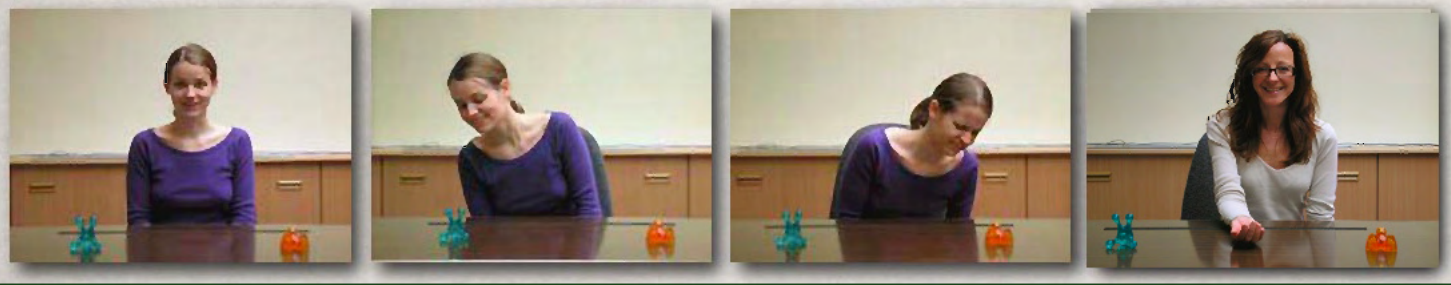
Subjects: n= 20 Age: 18-month-olds

Ostensive Communicative Demonstration
Requester: OTHER person (Condition 1)

Learning from Attitude Expressions

18-month-olds

Ostensive Expression - Generalization



Percent Giving Positive Object

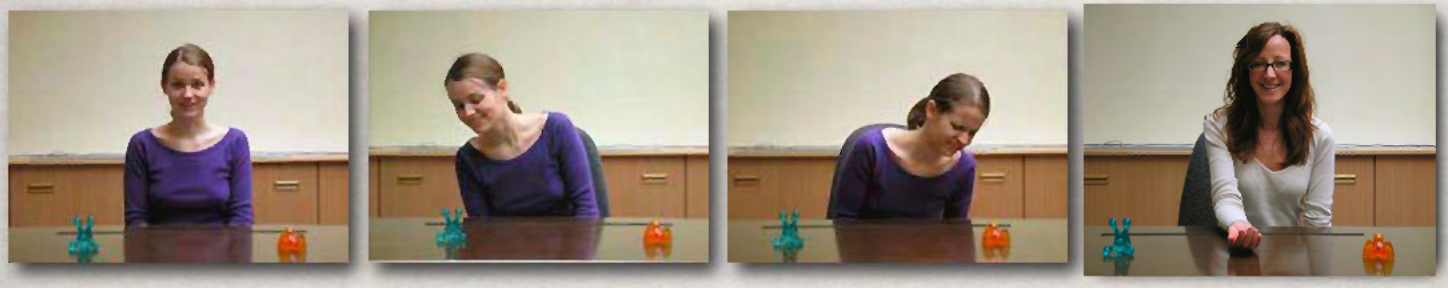
71

Non-Ostensive (Non-Communicative) Demonstration
Requester: OTHER person (Condition 2)

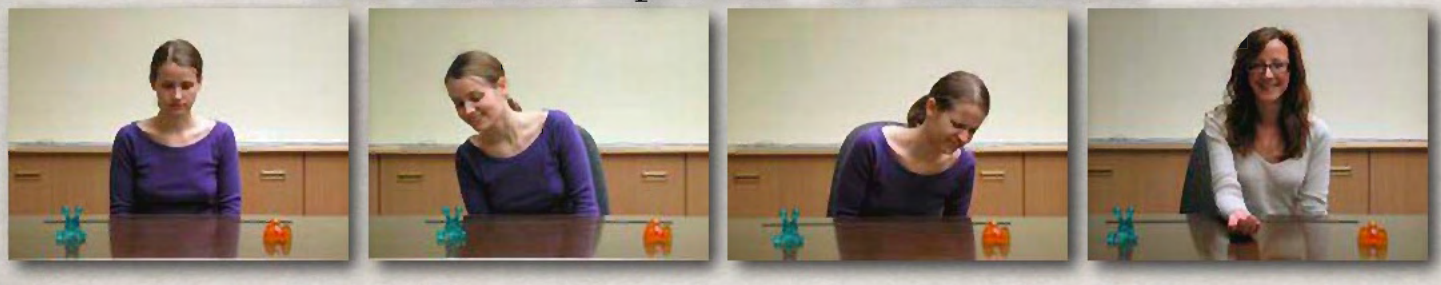
Learning from Attitude Expressions

18-month-olds

Ostensive Expression - Generalization



Non-Ostensive Expression - No Generalization



Condition 4: Non-Ostensive (Non-Communicative) Demonstration Requester: SAME person

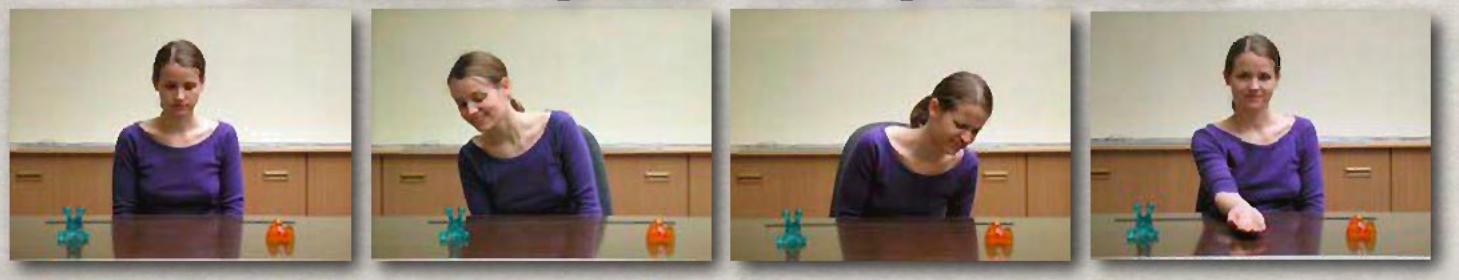
Learning from Attitude Expressions

18-month-olds

Ostensive Expression - Generalization

Non-Ostensive Expression - No Generalization

Non-Ostensive Expression - Person-Specific Attribution



Egyed et al., in prep.

Conclusions

Evidence for the interpretation-modulating role of
Ostensive Communicative Signals

- **18-month-olds differentially interpret the same object-directed emotion expressive displays of others in a**

NON-COMMUNICATIVE
versus
OSTENSIVE COMMUNICATIVE CUING CONTEXT

- ***The ostensive-communicative cues induce a Genericity Bias of referential interpretation***

Demonstration 2:

Testing the **GENERICITY BIAS HYPOTHESIS**

The role of Ostensive Communicative Cuing Context
in inducing the

AnotB perseverative search error phenomenon

"The illusion of being taught"

(Topál, Gergely, Miklósi, Erdöhegyi, & Csibra, 2008, *Science*)

The AnotB perseverative search error phenomenon

- Classical Piagetian paradigm:

  Stage IV task (8-12 months) of Piaget's studies on the development of the object concept ("object permanence")

- An *episodic* object hiding-and-searching game

Ostensive-Communicative Condition

Example of A trials (presented 3 times)

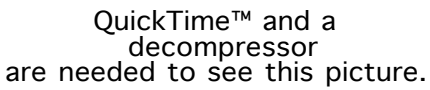
Hiding target object under the first (A) container

QuickTime™ and a
decompressor
are needed to see this picture.

Ostensive-Communicative Condition

Example of B trials

Hiding target object under the second (B) container



A standard explanation for the AnotB error phenomenon:

The Prepotent Response Inhibition Account

(e. g., Adele Diamond):

- perseverative search error due to a developmentally transient
failure to inhibit the primedand prepotent motor response (search at A):

- whose priming is due to previous *repeated motor execution*
of the reinforced 'Search-under-A' response

- This is attributed to the as yet incomplete neuronal maturation of frontal brain areas responsible for executive function motor control mechanisms

The AnotB demonstration phase typically involves
Ostensive communicative cues by the demonstrator!

Natural Pedagogy theory:

The GENERICITY ENCODING BIAS Hypothesis

- **Ostensive-Communicative cues => kind-generalizable (semantic) properties are encoded more strongly than only episodically relevant information**

Generic interpretation: Container A is 'for' (hiding/keeping) objects of this kind

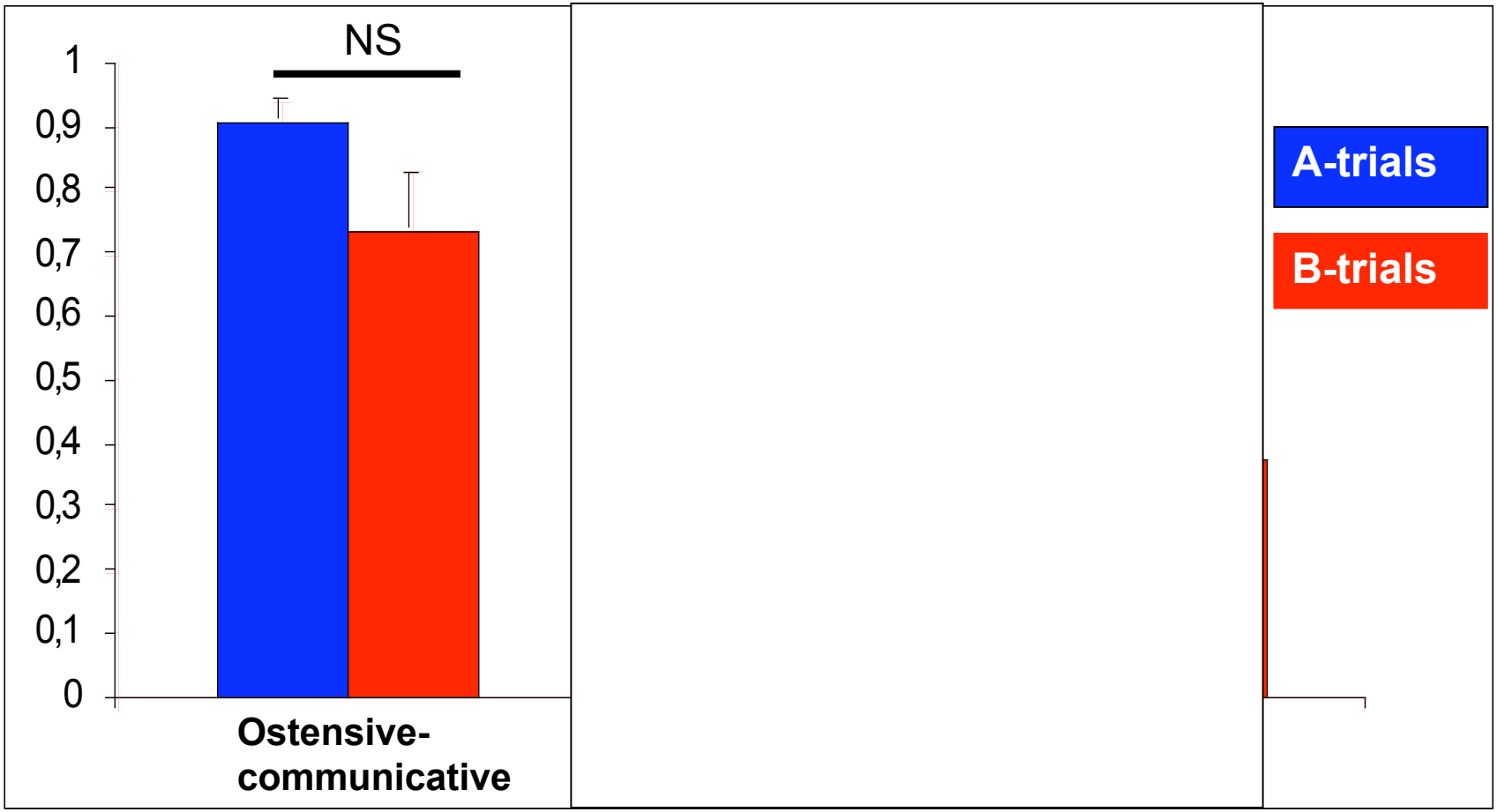
versus

Episodic interpretation: The object is now in Container A (or B)

10-month-old infants (N=14 in each condition)

The Perseverative Error:

Ratio of the number of reaches to location-A in the 1st (A1-4) and 2nd (B1-3) phases of the experiment



Demonstration Conditions

Wilcoxon matched pairs tests

No-Person ‘Ghost’ Demonstration Condition

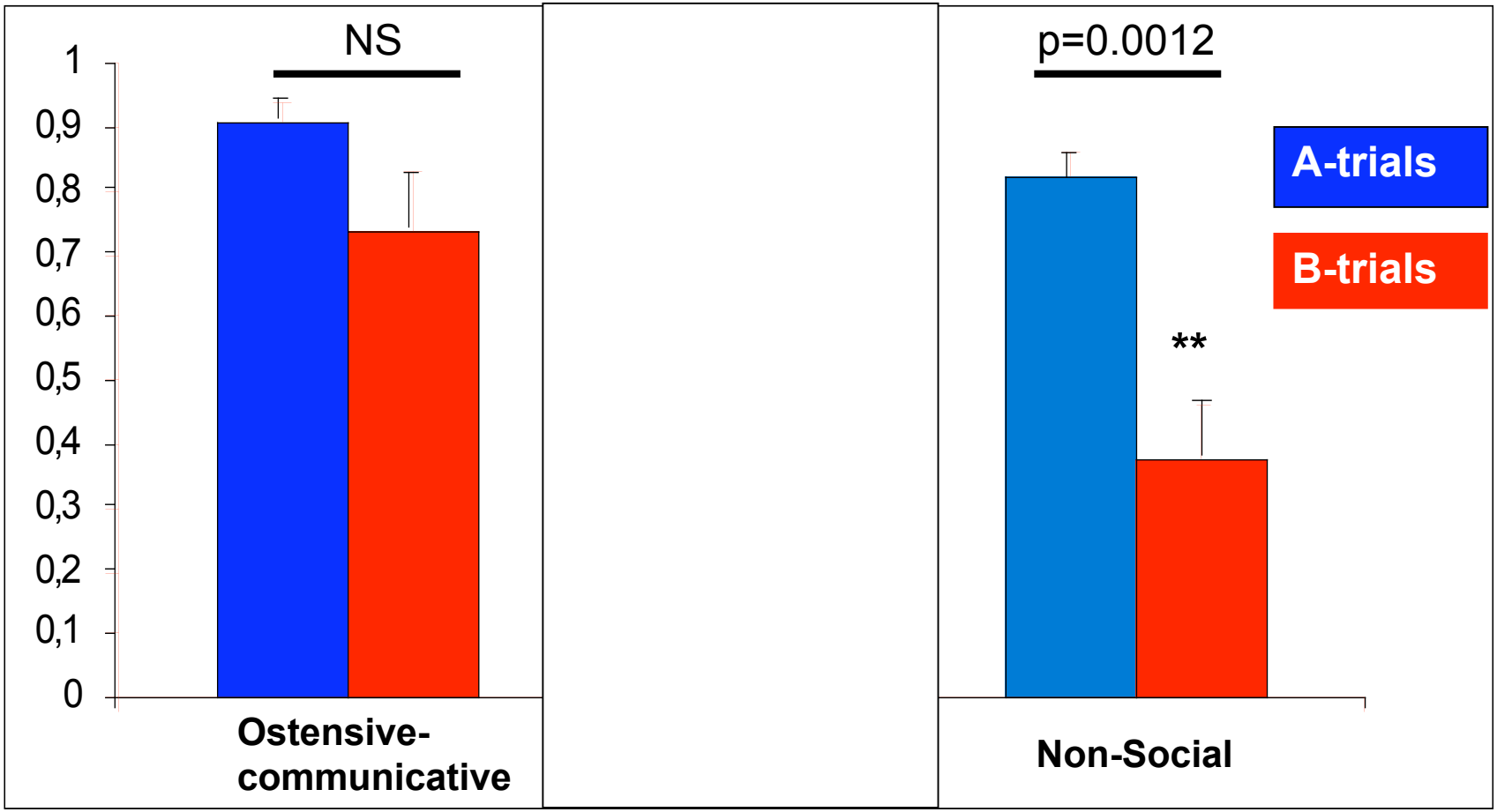
Example of B trials

Hiding target object under the second (B) container

QuickTime™ and a
decompressor
are needed to see this picture.

10-month-old infants (n=14 in each condition)

Ratio of the number of reaches to location-A in the
1st (A1-4) and 2nd (B1-3) phases of the experiment

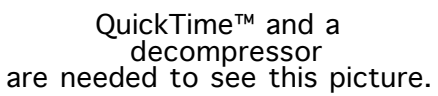


Demonstration Conditions

Wilcoxon matched pairs tests

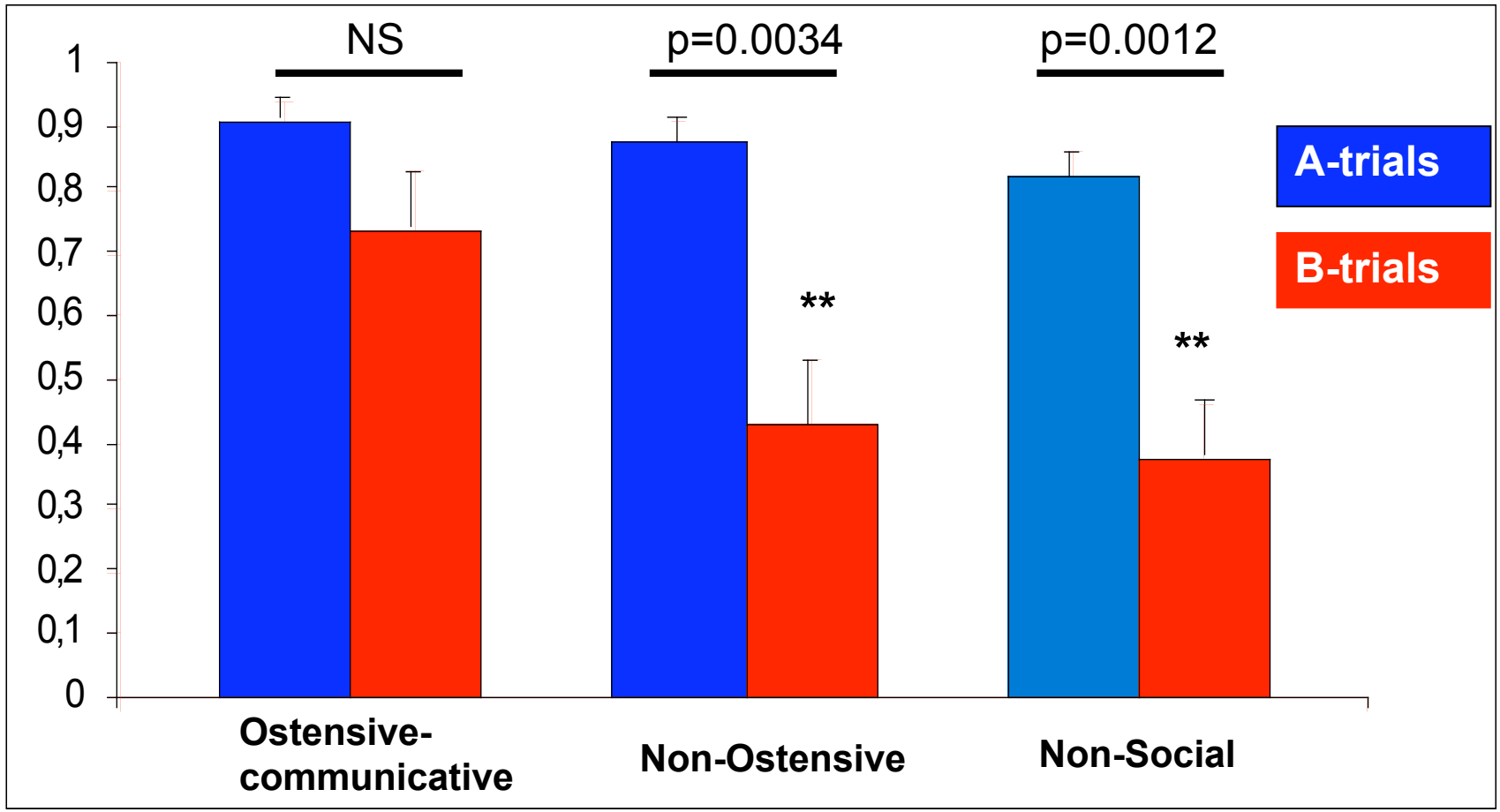
Non-Ostensive (Non-Communicative) Condition

Hiding target object under the second (B) container



10-month-old infants (n=14 in each)

Ratio of the number of reaches to location-A in the 1st (A1-4) and 2nd (B1-3) phases of the experiment



Demonstration Conditions

Wilcoxon matched pairs tests

Conclusions

1. The Prepotent Response Inhibition Account

- error due to developmentally transient
failure to inhibit the over-primed prepotent motor response (A):

- due to as yet incomplete neuronal maturation of brain areas responsible for executive function motor control mechanisms

is *not supported* by these findings

2. The ostensive communicative cuing context induced the 'generic interpretation bias' in infants

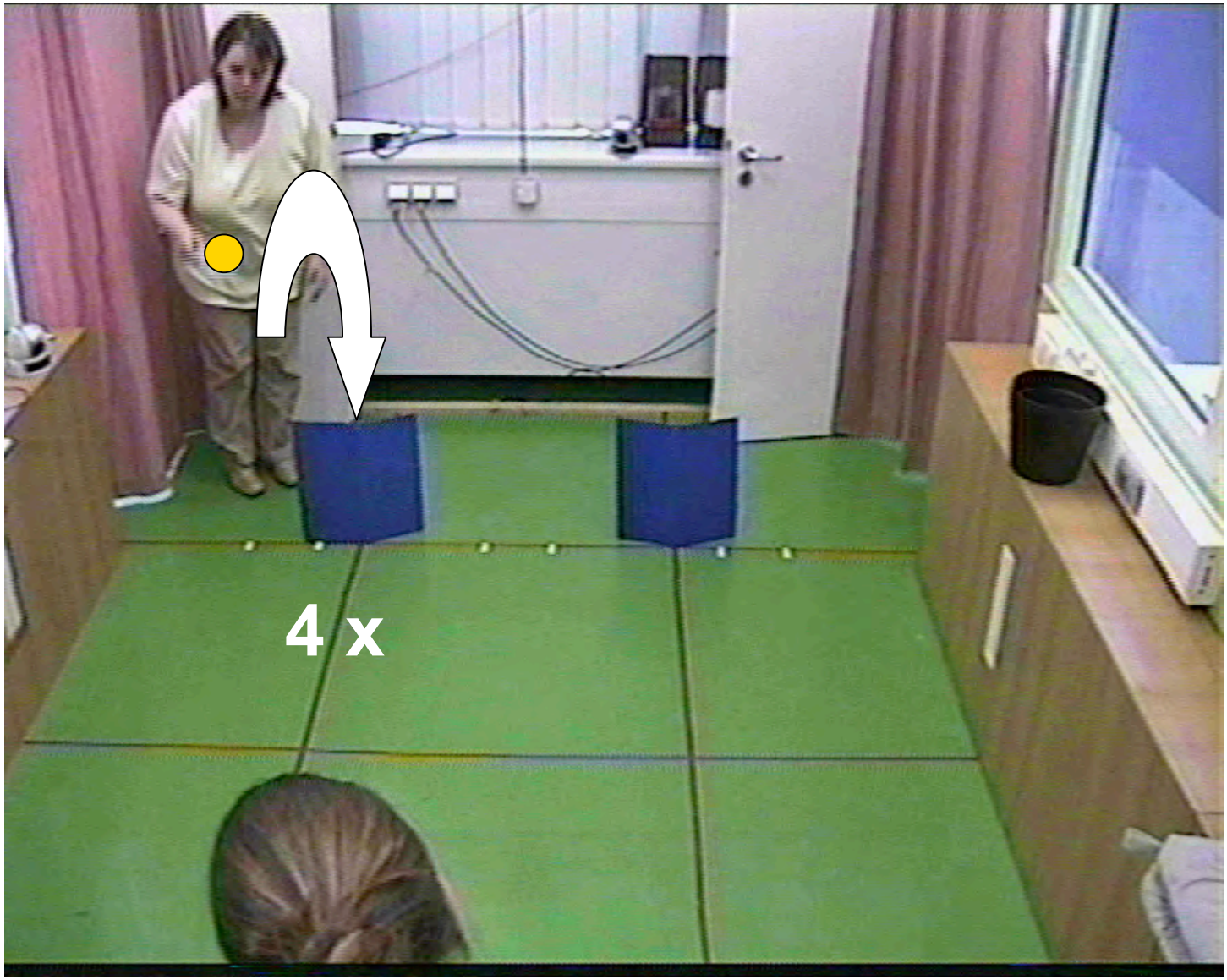
leading them to misinterpret the episodic hide-and-search game as a 'serious' pedagogical teaching event about generic object properties

Testing sensitivity to ostensive cues in
human infants, dogs and (human-raised) wolves
in the AnotB task

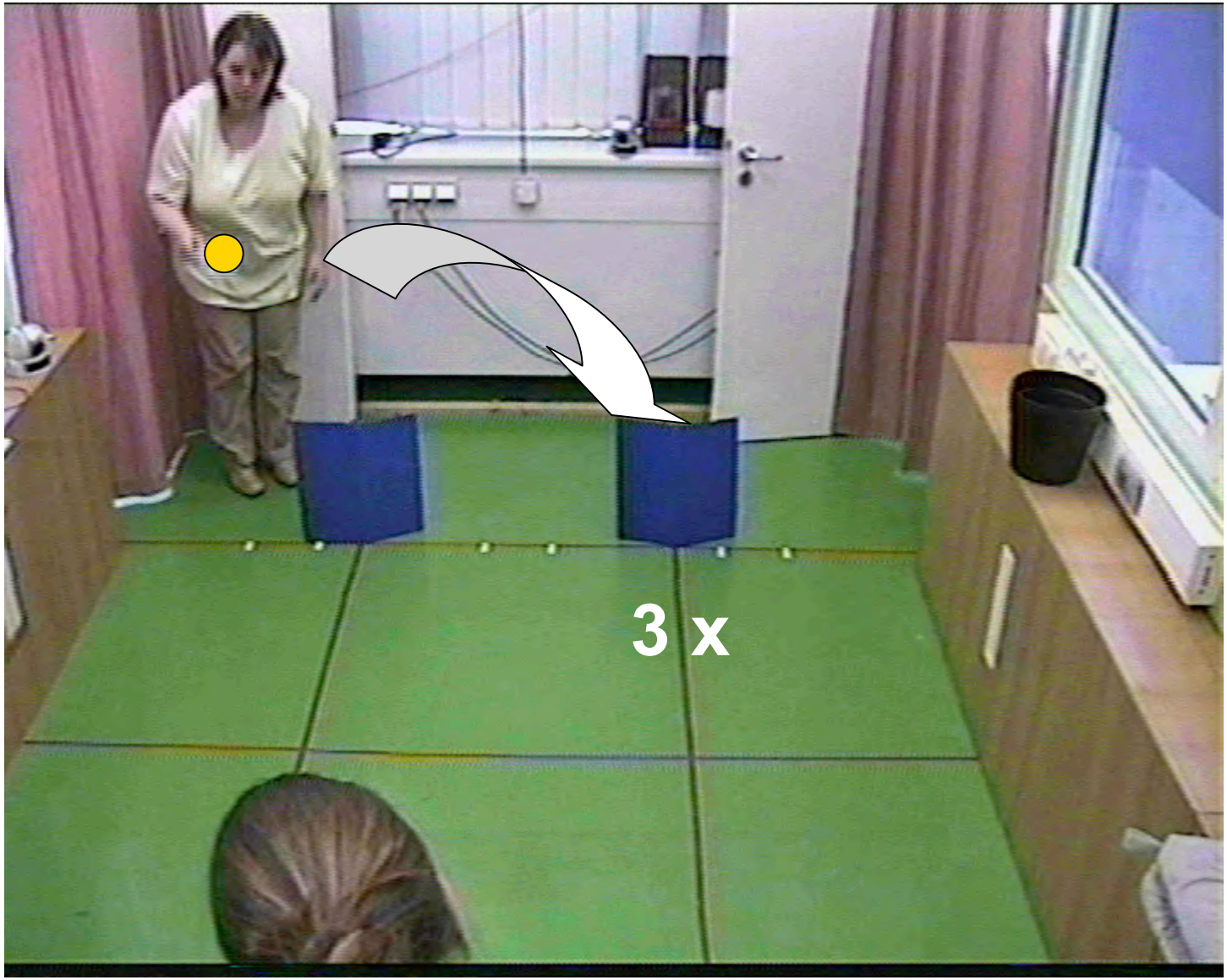
Topál, Gergely, Erdöhegyi, Csibra, & Miklósi, *Science*, (2009)

- Dogs have been selected (by humans) to be **specially sensitive and responsive to human ostensive-communicative cues**

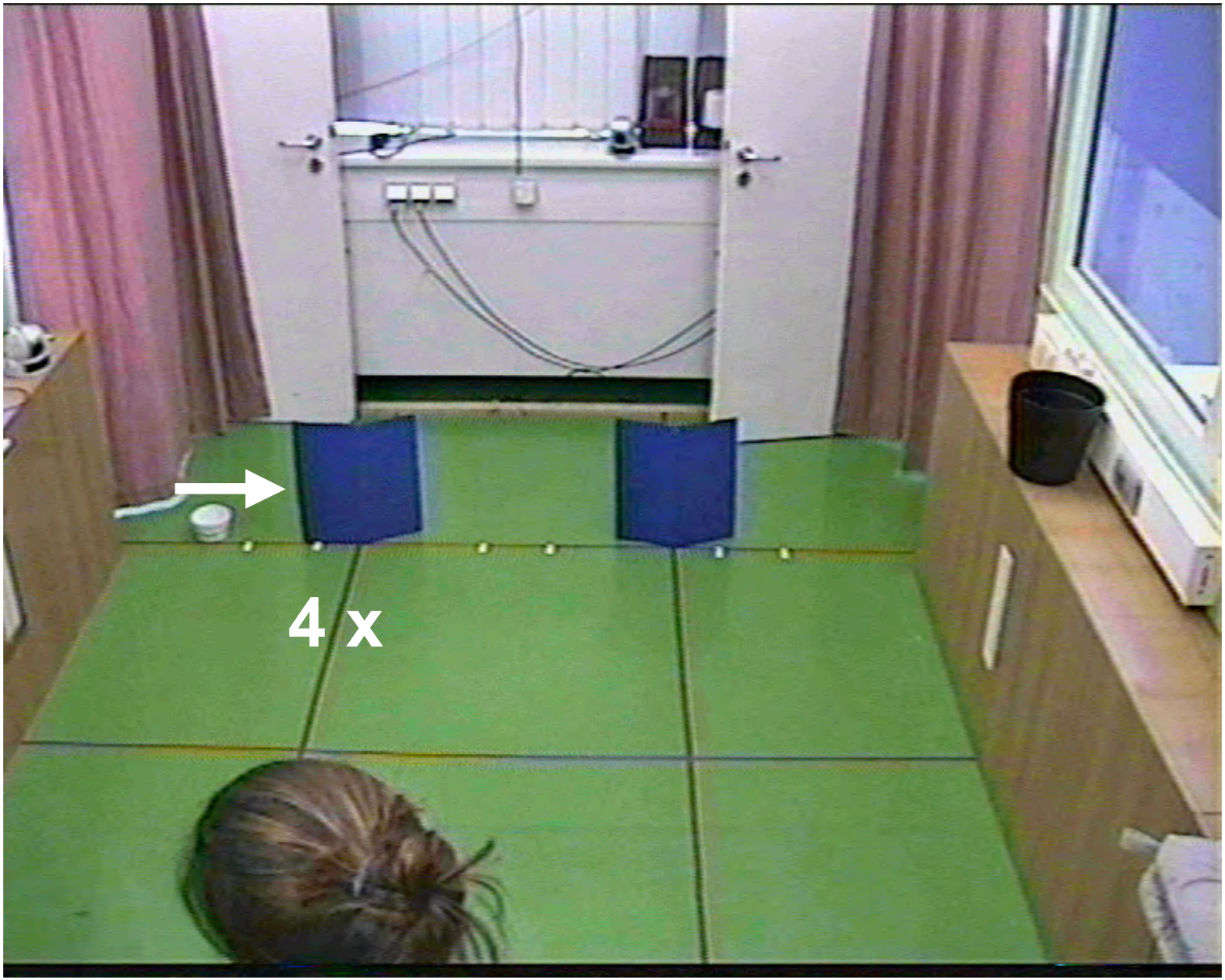
. SOCIAL HIDING CONDITION: A trials



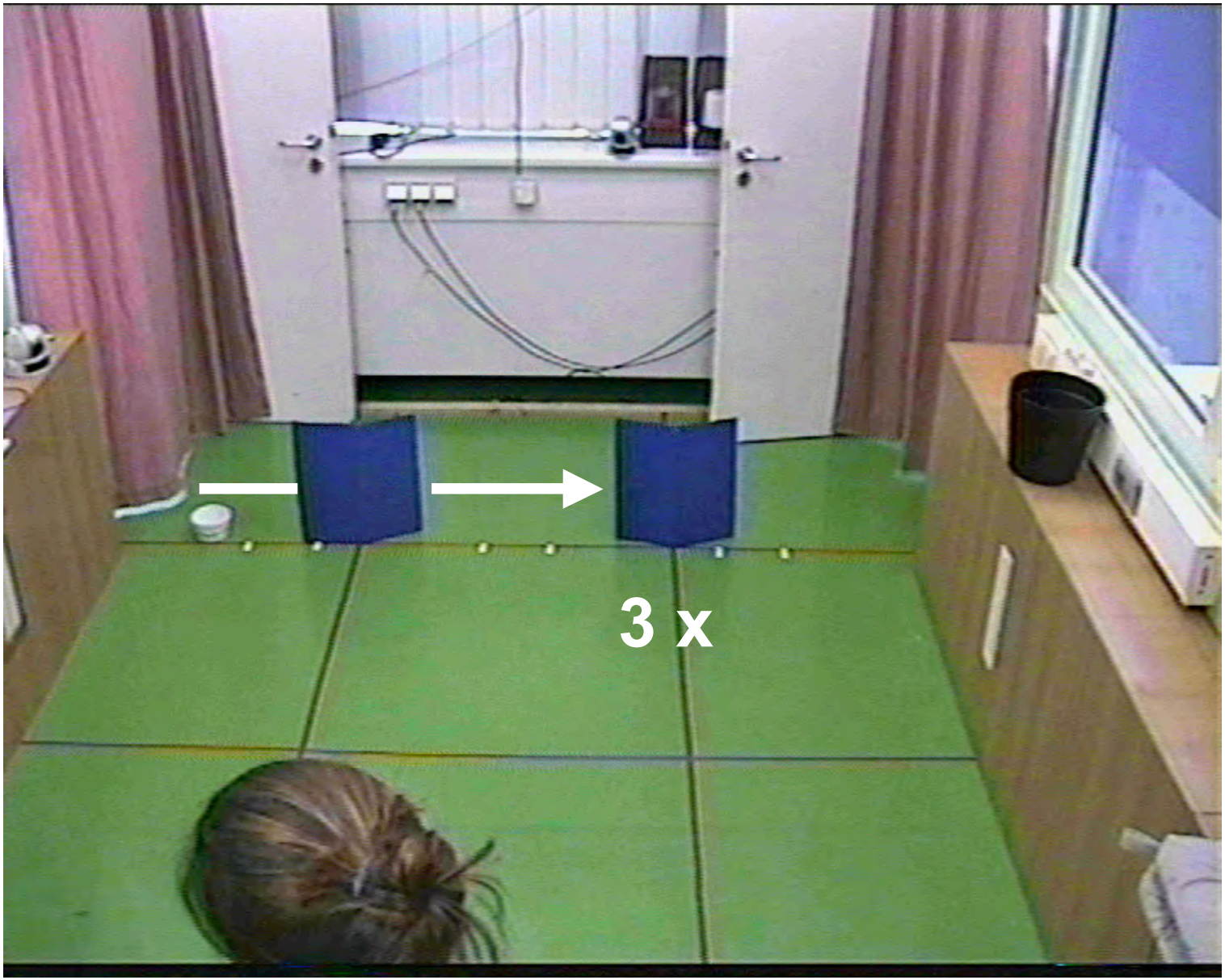
SOCIAL HIDING CONDITION: B trials



NON-SOCIAL HIDING CONDITION: A trials

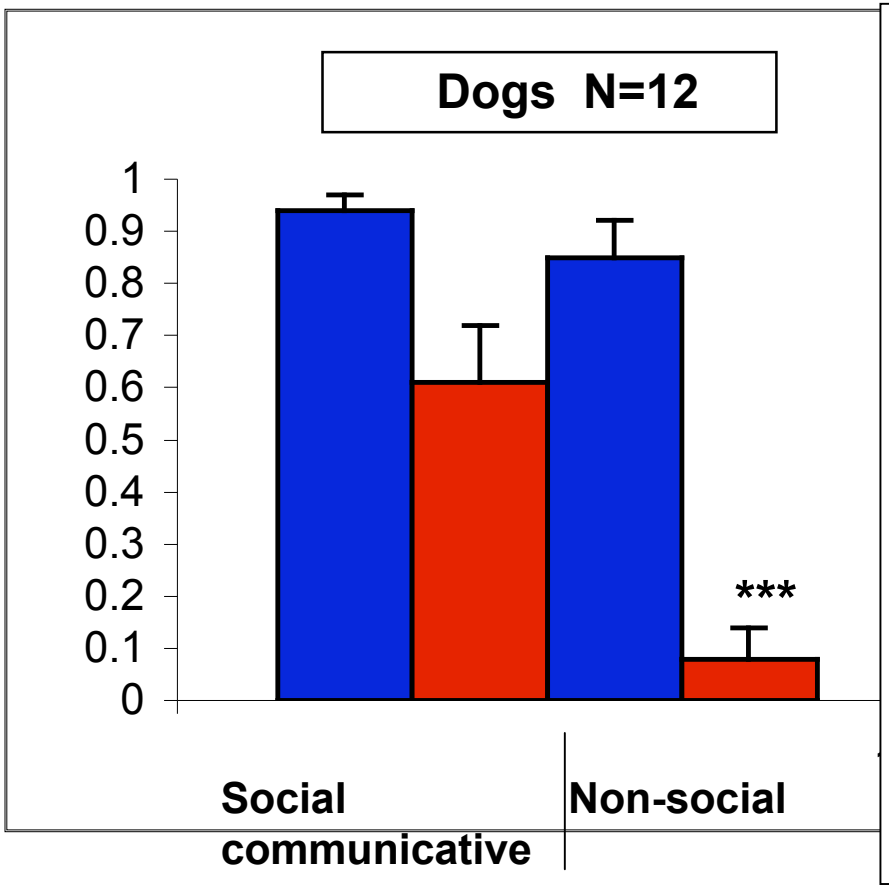


NON-SOCIAL HIDING CONDITION: B trials



Dogs in the A-not-B error task

Ratio of searches at location A in the first (A1-4) and second (B1-3) parts of the A-not-B error task



Similarly to human infants:

1. **Dogs show the perseverative error In the Communicative Demo condition**

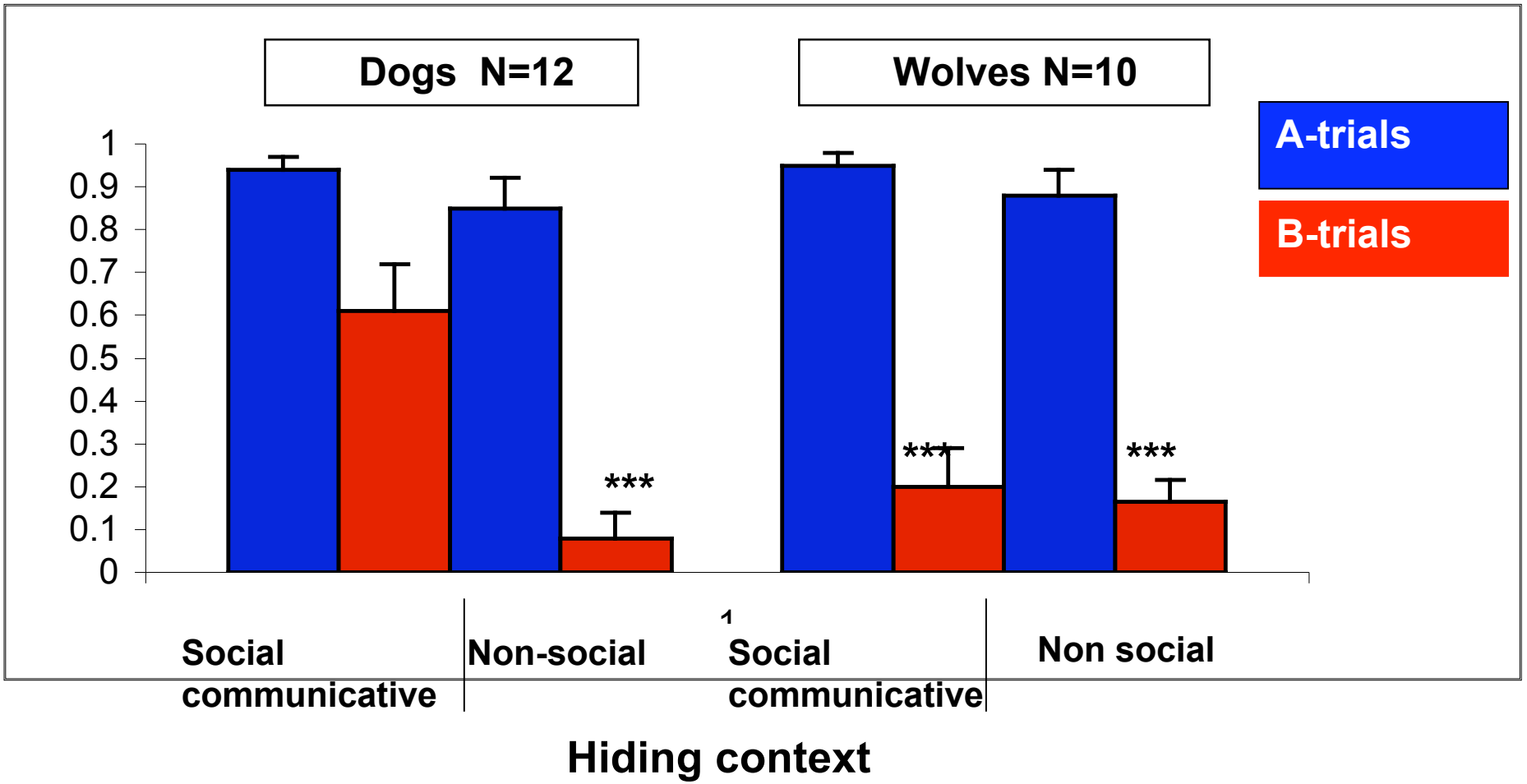
2. **The perseverative error disappears In the Non-Social Demo condition**

Hiding context

Kruskall Wallis tests with Dunn's post test

Dogs & wolves in the A-not-B error task

Ratio of searches at location A in the first (A1-4) and second (B1-3) parts of the A-not-B error task



Kruskall Wallis tests with Dunn's post test

What is the evolved communicative function of dogs' sensitivity to human ostensive-referential cues?

Hypothesis 1: Natural Pedagogy in Dogs…?

(generic knowledge transfer about kinds?…)

OR

Hypothesis 2: Dogs have been selected to expect humans who address them by ostensive signals to communicate ***episodic imperative orders*** to them to perform in the 'here-and-now'

Episodic imperatives **= commands to perform a specific action at a specific location** identified by the referential signals of the communicator.

Control condition:

Demonstrator Change during B-trials (in SocCom Context)

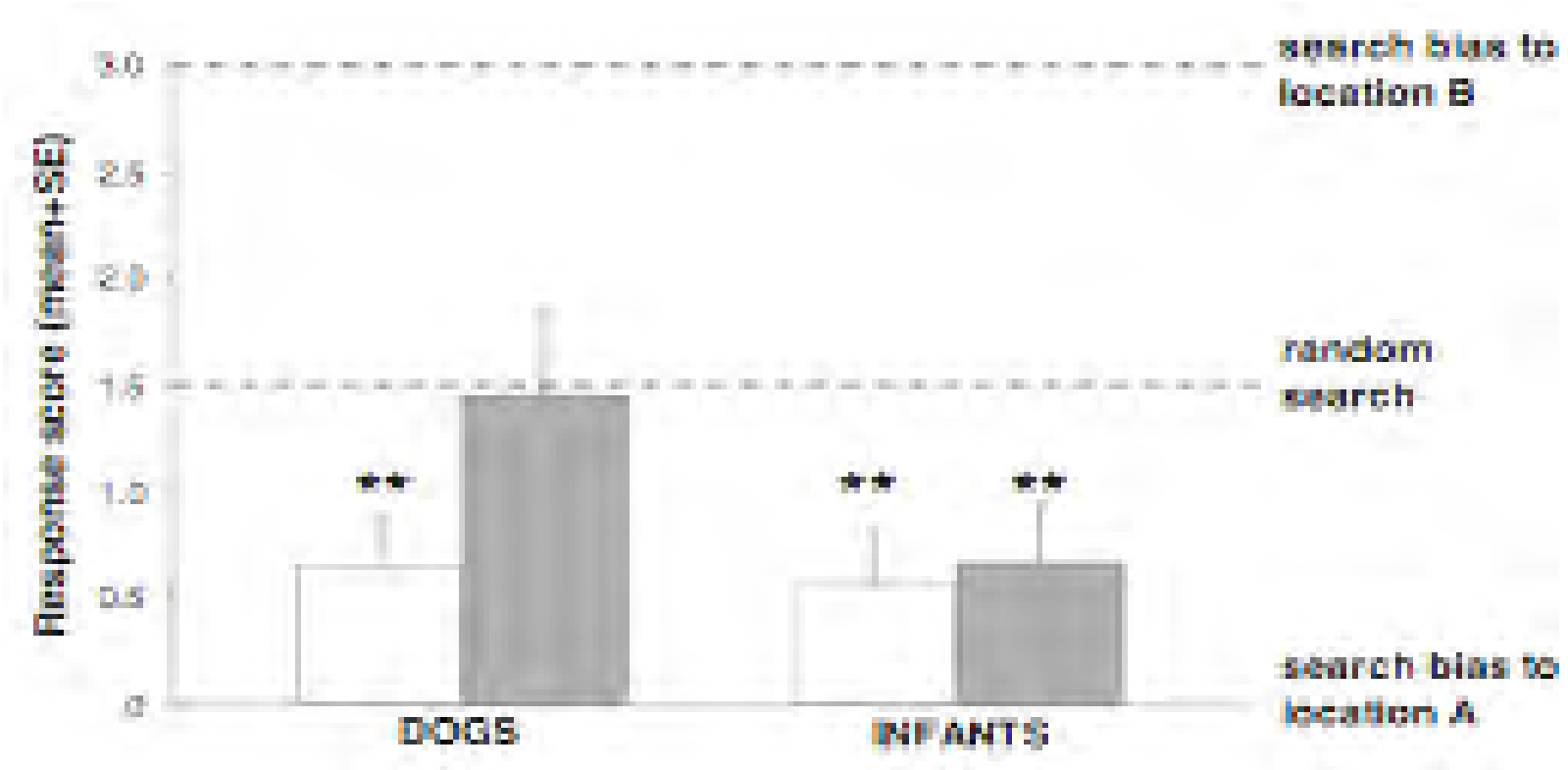
In dogs *versus* 10-month-old human infants

4 A-trials: Demonstrated by ***Experimenter 1***

3 B-trials: Demonstrated by ***Experimenter 2***

Hypothesis 1: **predicts generalizability of effect across contexts**

Hypothesis 2: **predicts NO GENERALIZATION of effect across demonstrators**



= Same Demonstrator during A and B trials

= Different Demonstrators during A versus B trials

Context-generalization Control Condition:

Demonstrator Change during B-trials (in SocCom Context)

In dogs *versus* 10-month-old human infants

10-month-old infants: *Perseverative error remains unchanged!!!*

What has been learned is kind-relevant generic knowledge that is generalizable across contexts

Dogs: *Perseverative error disappears!!!* (Context-specificity effect)

What has been communicated is an episodic imperative command restricted to the 'here-and-now' episodic context

Demonstration 4:

The role of Natural Pedagogy and the generic interpretation bias

In the early development of the representation of

Artifact kind concepts

The developmental origins of representing sortal kind categories

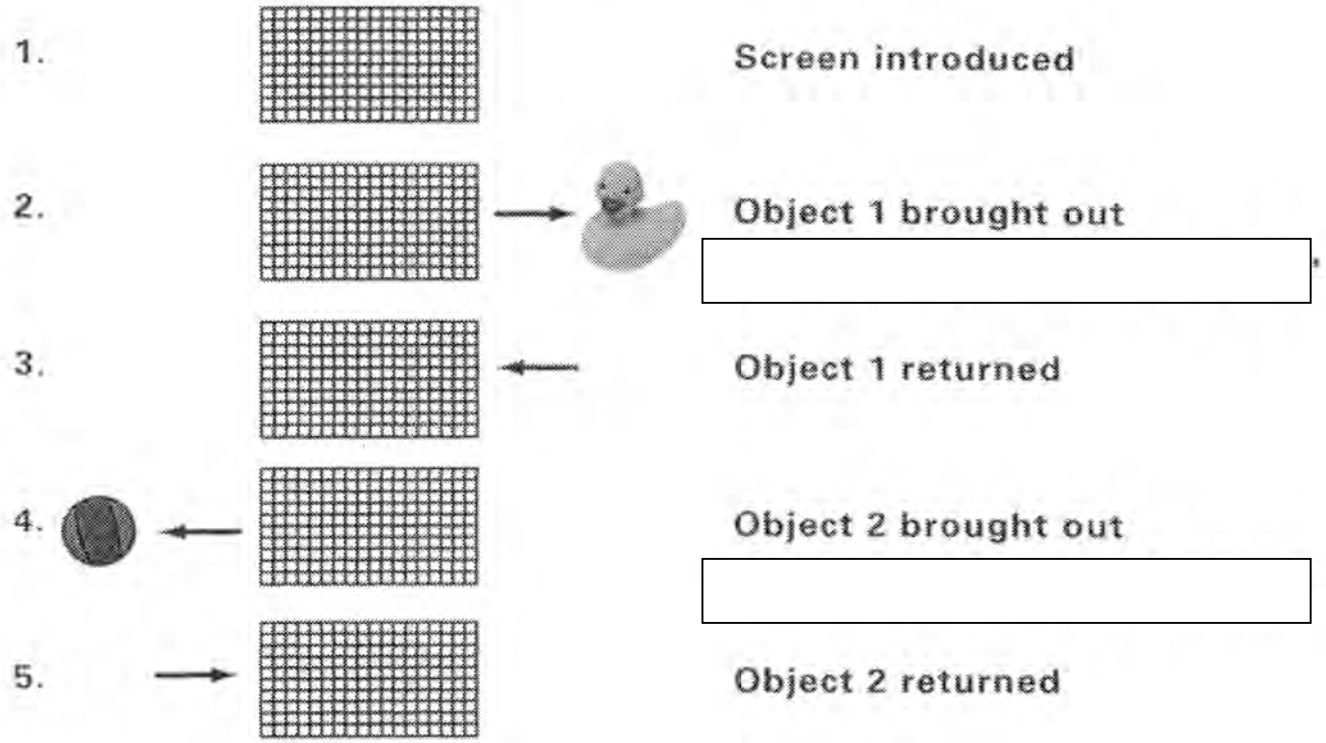
(Objects, Persons, Animates, Artifacts, Dogs, Balls, Chairs)

- *Two types of criteria* used to individuate objects belonging to "*sortal kind categories*" (by 12-months)

a) spatial-temporal criteria (Spelke-objects):
(such as solidity, continuity)

b) feature-based criteria
(e.g., shape, texture, color)

Xu & Carey paradigm



- Xu & Carey (1996):

1. 12-months-olds expect two objects:

(Longer looking - violation of expectation - when seeing one object rather than two)

= Evidence for **Feature-based Object Individuation** ('feature binding')

2. 10-month-olds do *not* yet have expectation for two objects!

= no evidence for using *feature-based criteria* for OI at 10 months.

Early Object Individuation is based based on ***spatial-temporal criteria*** *only*,

General conclusion
(Xu & Carey, 1998, 2004; Xu, 2002, 2004, 2007):

Before 12 months

1. Though *features can be used for Categorization*,

2. *Features do not yet support Object Individuation*
(due to lack of feature-binding)

The language-based hypothesis

of the development of the representations of Sortal Kind Concepts:

(Xu & Carey, 2004; Xu, 2002; 2007)

- Hypothesized causal role of a language-specific mechanism :

a) Linguistic labeling of objects ("a dog!") triggers the concept of "SORTAL KIND" category.

b) Linguistic labeling leads to Object Individuation by representing the labeled object as "a particular member of a specific 'SORTAL KIND' category".

-

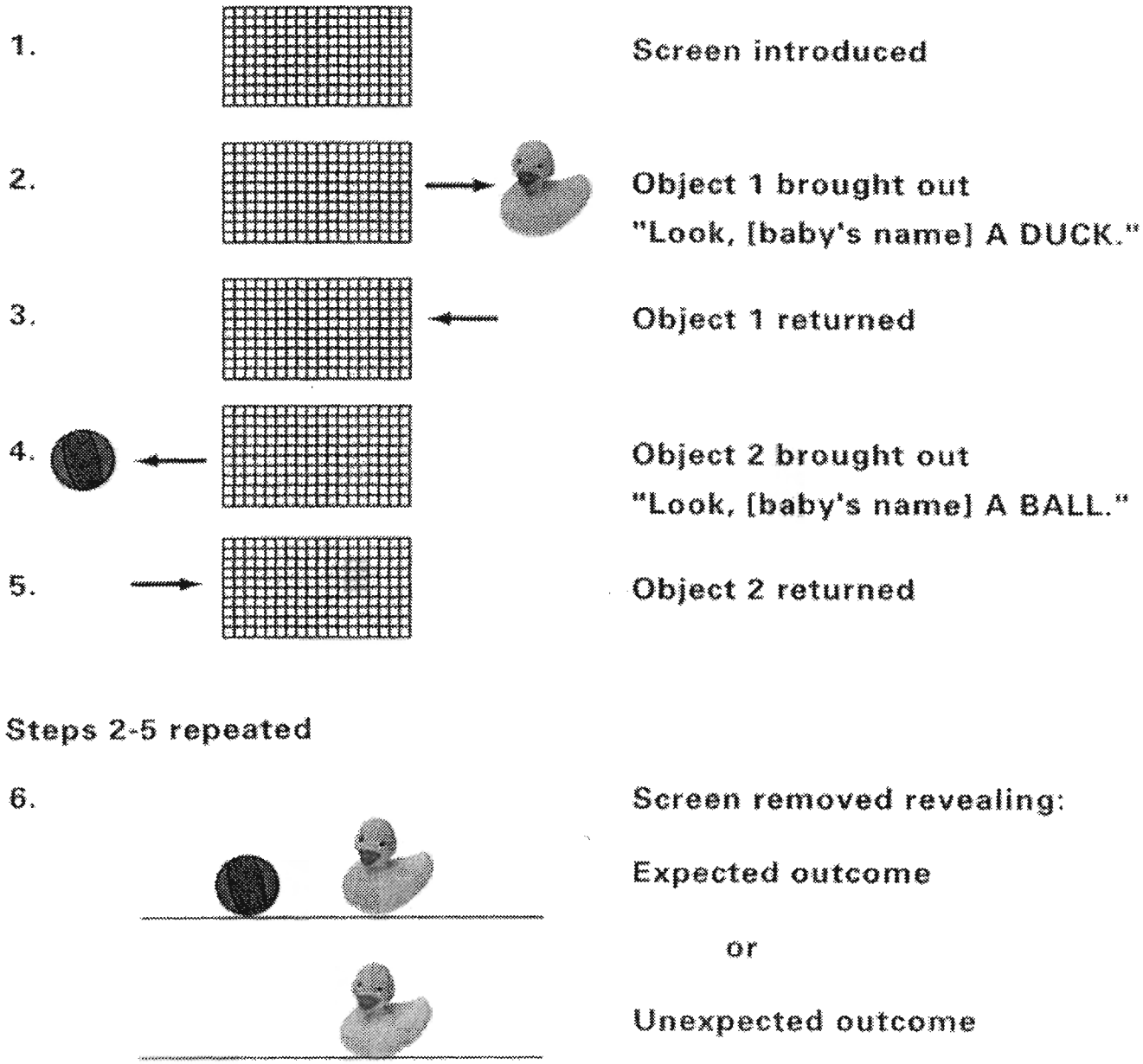


Fig. 1. Schematic representation of the events in Experiment 1: Two-word Condition.

- Evidence for the linguistic labeling hypothesis
  (Xu, 2002, 2004)

a) Hearing ***two different verbal labels*** when the two objects appear *facilitates early Object Individuation:*

=> already 9-month-olds expect TWO OBJECTS!

=> Linguistic labeling triggers the assignment of
SORTAL KIND Category membership

- Evidence for the *language-specificity* of the OI facilitation effect by verbal labeling:

When using two different, but *non-linguistic* 'labeling' stimuli:

positive vs. negative *emotive sounds*

9-month-olds do NOT expect TWO objects

- Conclusion (Xu, 2007):

The facilitation of Object Individuation is ***specific to the causal effect of linguistic labeling*** that induces the ***setting up of kind representations***

Questions:

1. Are there other, *non-linguistic* input conditions that may trigger representing a referent as a member of a Sortal Kind Category?

Hypothesis:

Ostensive Manifestation of Artefact Function?

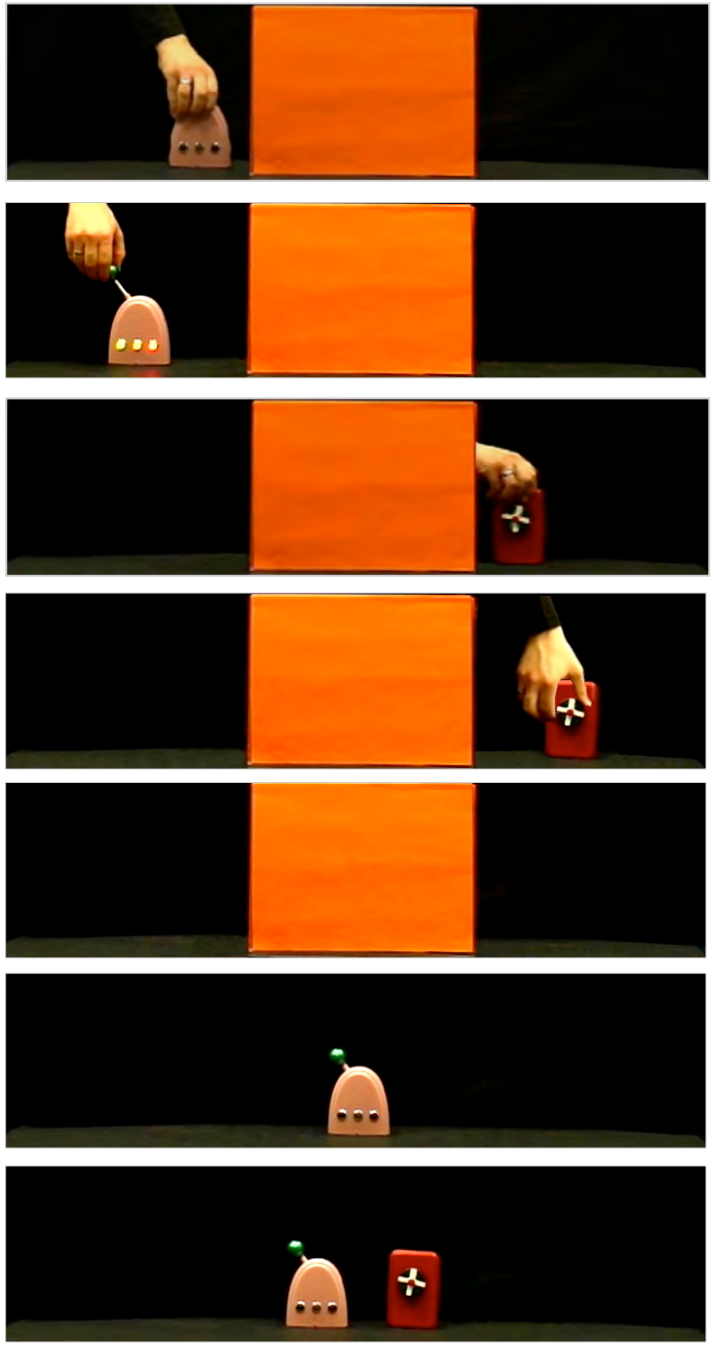
Causal Intervention => Effect

= Manifestation of hidden dispositional property (artifact function)

Hypothesis from the perspective of Natural Pedagogy:

2. Potential Causal Role of Infant-Directed Speech
   (as an Ostensive-Communicative Referential Cue inducing a *semantic encoding bias*)

Note: The Xu-Carey studies *always* involved addressing and attention-orienting cues produced in motherese!



Experimental set-up for Object Individuation Study:

The effect of Function Demonstration on Kind Assignment and Object Individuation in 10-month-olds

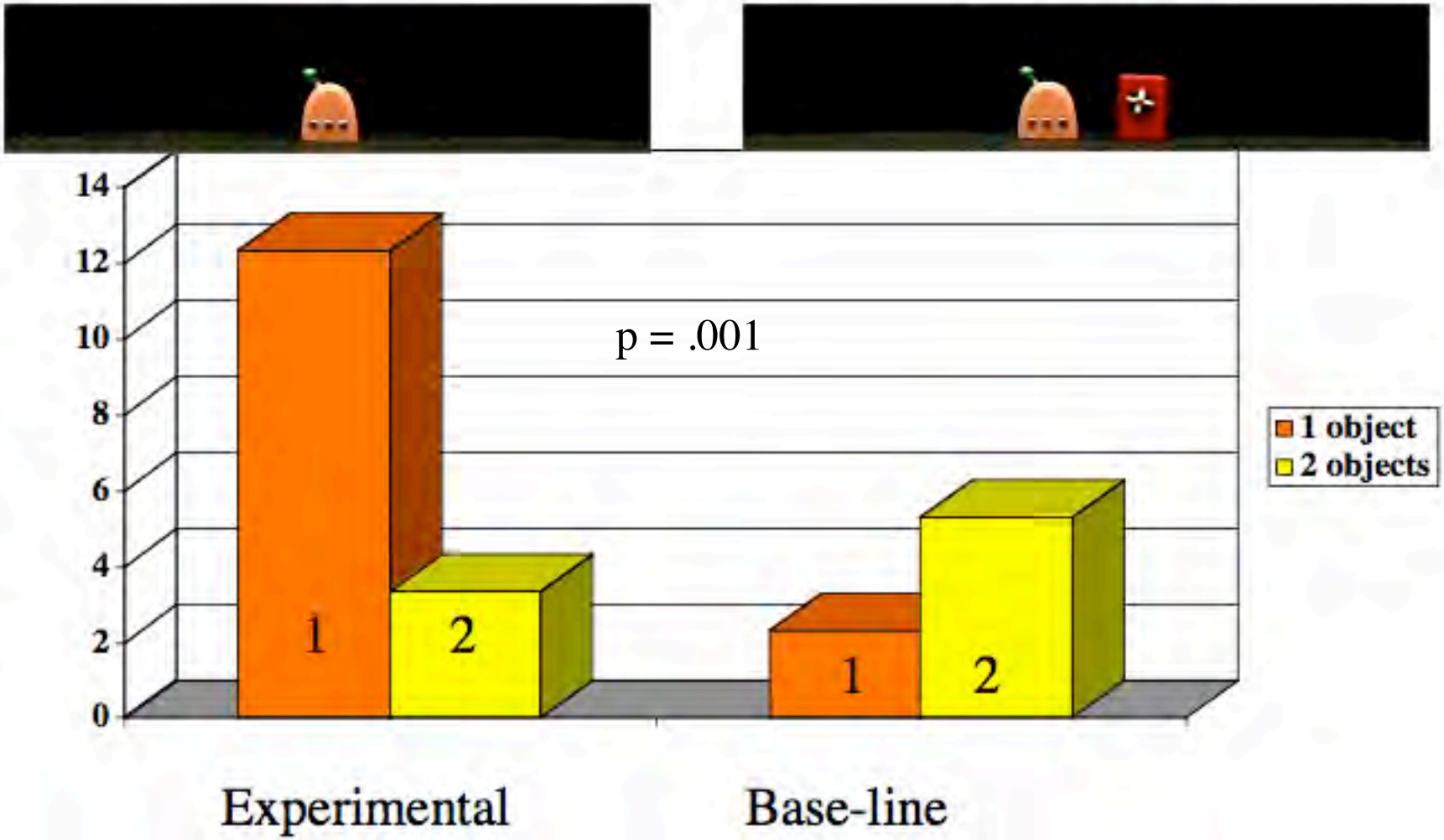
Futo, Csibra, Teglas & Gergely,(under review)

Exp. 1:

Function-based object individuation WITHOUT verbal labeling in an ostensive communicative demonstration context

Ostensive Cuing Context:Motherese

Non-verbal Function Manifestation in 10-month-olds



- **Two possible input sources** that may have *causally contributed to the object individuation effect*:

Q1: Is the ***full Means-end function demonstration necessary***?

Exp. 2A: No Manual Causal Intervention Condition

Q2: Is the ***Ostensive cuing (Motherese) necessary?***

Exp. 2B: No Ostensive Cuing Condition (No Motherese)

Exp. 2A: No manual causal intervention condition:

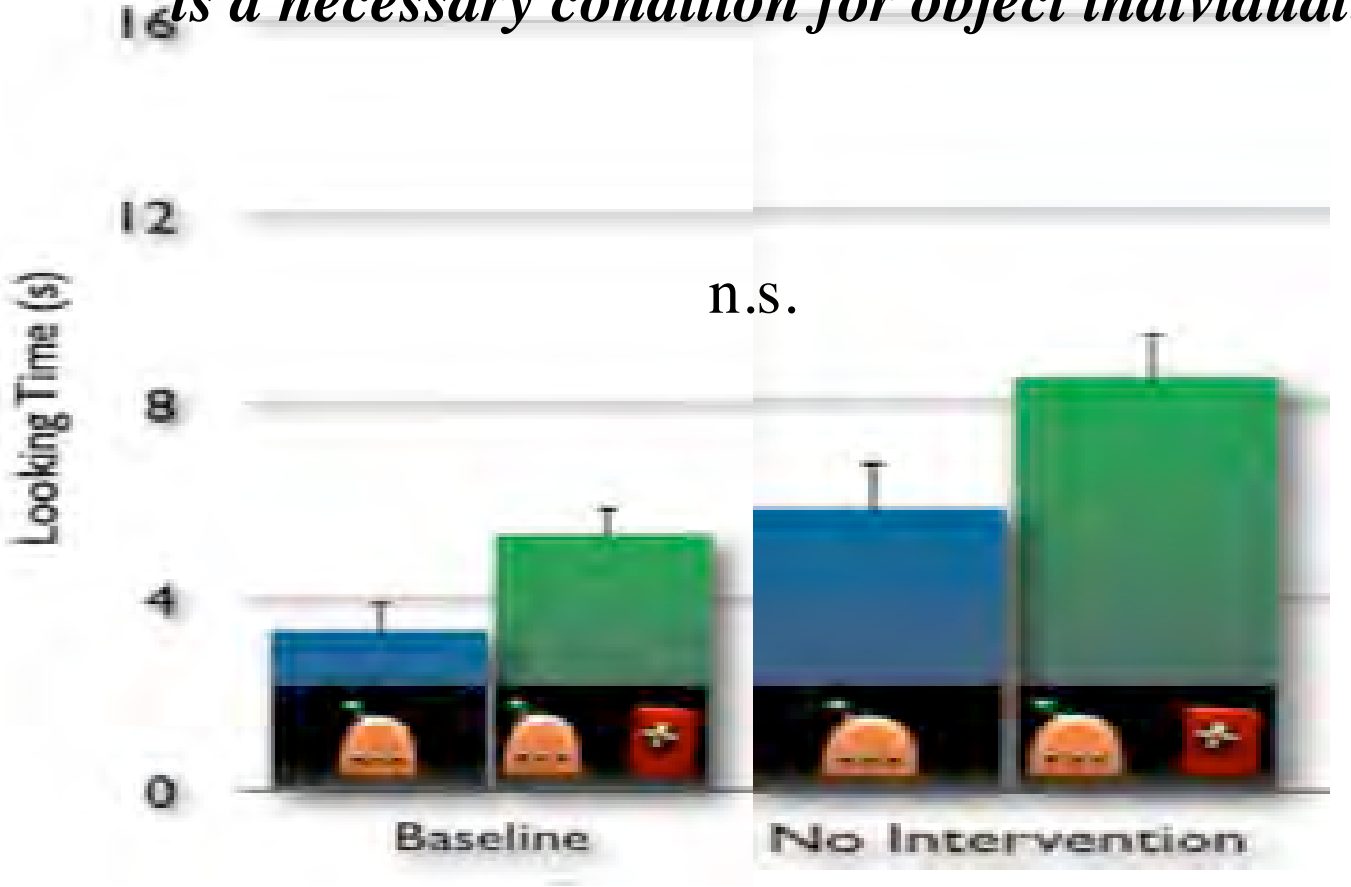
Ostensive demonstration of
Self-induced dynamic pattern of behavioral transformation
of object features

Ostensive cuing context: Motherese ('Hi, baby, hi! Look')

(Same as in Exp. 1)

Exp. 2A: No causal intervention condition

- ***The Causal Intervention*** (manually operating the part object) ***is a necessary condition for object individuation***



Ostensive Communicative cuing: Motherese

Exp. 2B:

No Ostensive Communicative Cueing Condition

(with causal manual intervention present)

a) Forward synthesized transformation ⇒ b) Backward synthesized transformation

Non-ostensive control

No Motherese

Exp. 2B:

No Ostensive Communicative Cueing Condition

(with causal manual intervention present)

Effect on object individuation disappears!

-> Assigning the observed functional use as a *kind-generalizable functional property of the artefact and its kind* is due to the semantic interpretation bias that is triggered by the ostensive communicative cue of motherese

Conclusions from Exp. 1 and 2.

- ***Observing a specific functional use of a referent object is <u>not sufficient</u>:***

- for interpreting it as the ***essential function*** that the referent is 'for'

- To activate an innate ***Sortal Arifact Kind Concept*** and assign the observed functional use as a ***Generic Property of the Artifact Kind***

- it is necessary that the functional use be ***"marked"*** *as a* ***generic kind-relevant property*** by the

- ***ostensive communicative cuing context***

Experiment 3:

One object with two different functions
or
Two objects with single functions?

The Ostensively induced

Illusion of seeing 2 artifacts

(when you see only 1!)

Ostensive Communicative Function Demonstration Phase

Experiment 3:
The Selective Feature Encoding Hypothesis

One object with Two Functions

Ostensive cuing context: Motherese

Demonstrating Function B

Demonstrating Function A

Experiment 3:
The Selective Feature Encoding Hypothesis

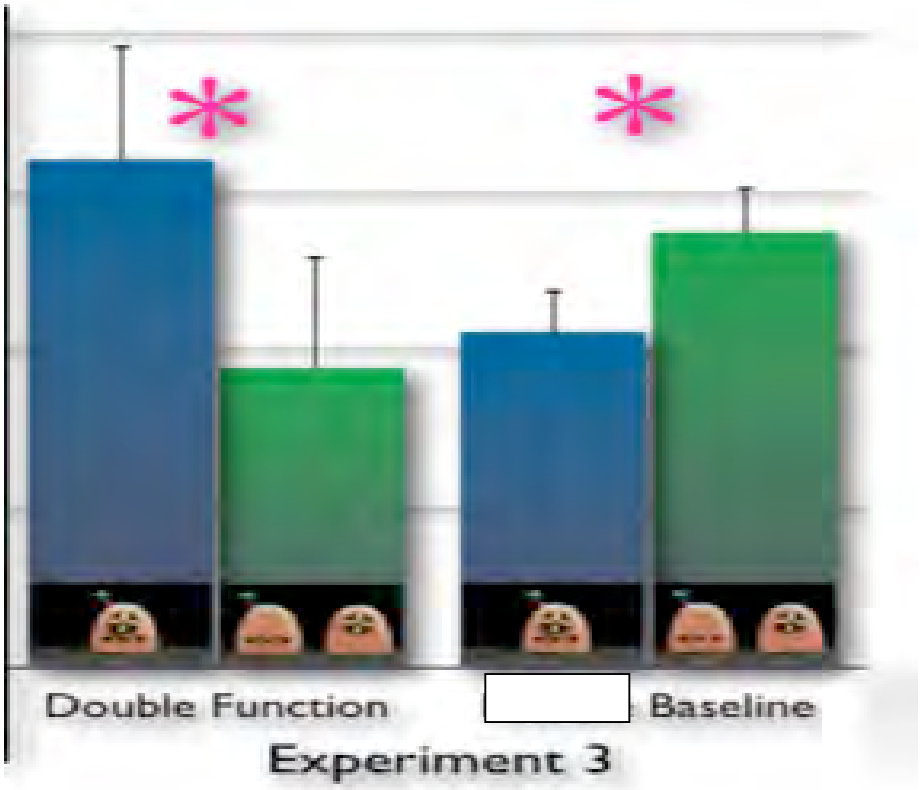
Ostensive cuing context: Motherese

Test Phase

Ostensively cued Function-based Kind-assignment

One Function => One Kind vs. Two Functions => Two Kinds

1. Each demonstrated function triggered a ***separate Artefact Kind Representation with a different essential function*** assigned to it



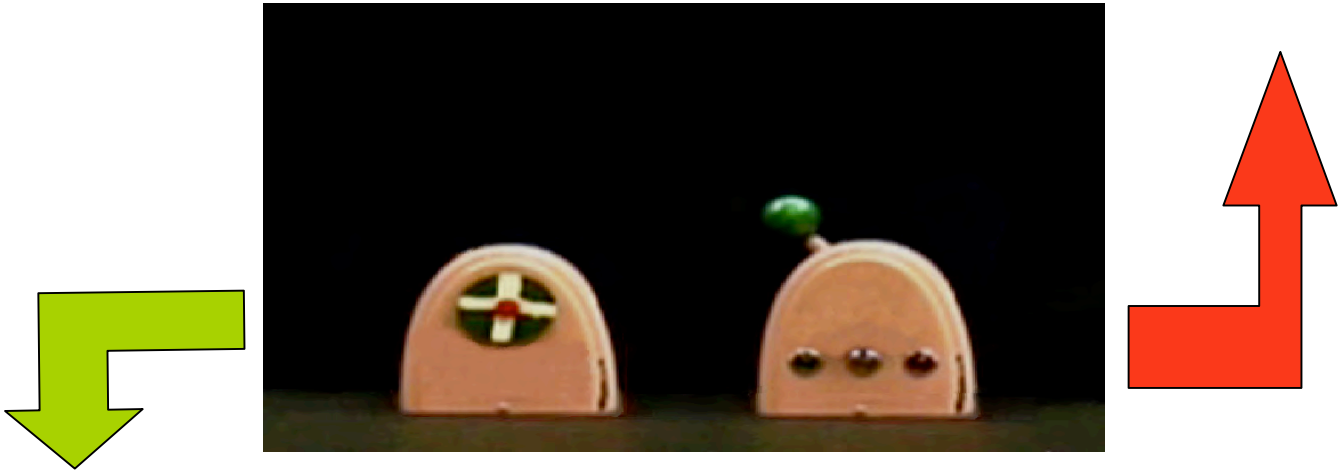
2. Setting up **Two Separate Kind Representations** resulted in the ***expectation of two individual artefacts*** (belonging to each respectively)

3. Hence the ***illusiory object individuation effect*** leading to expecting two artefacts with different functional properties

The Selective Feature Binding Hypothesis:

Each test object contains only the selectively bound function-related features represented by one of the Artifact Kinds only =>

a) ***Artefact Kind 1***: *represented in terms of features relevant for* the demonstrated **FUNCTION1: (Manipulandum1 => Effect1)**



b) ***Artefact Kind 2***: *represented in terms of features relevant for* the demonstrated **FUNCTION2: (Manipulandum2=> Effect2)**

The results of Experiment 3 support:

Artifact Kinds are among of the innate 'natural ontological kind categories' of the mind

Psychological Essentialism about Artifacts:

1 Artifact Kind => 1 Kind-specific Function

- THANKYOU!