Invited Plenary Talk at the CBCD 21st Anniversary workshop, Birkbeck College, London, November 15-16, 2019

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

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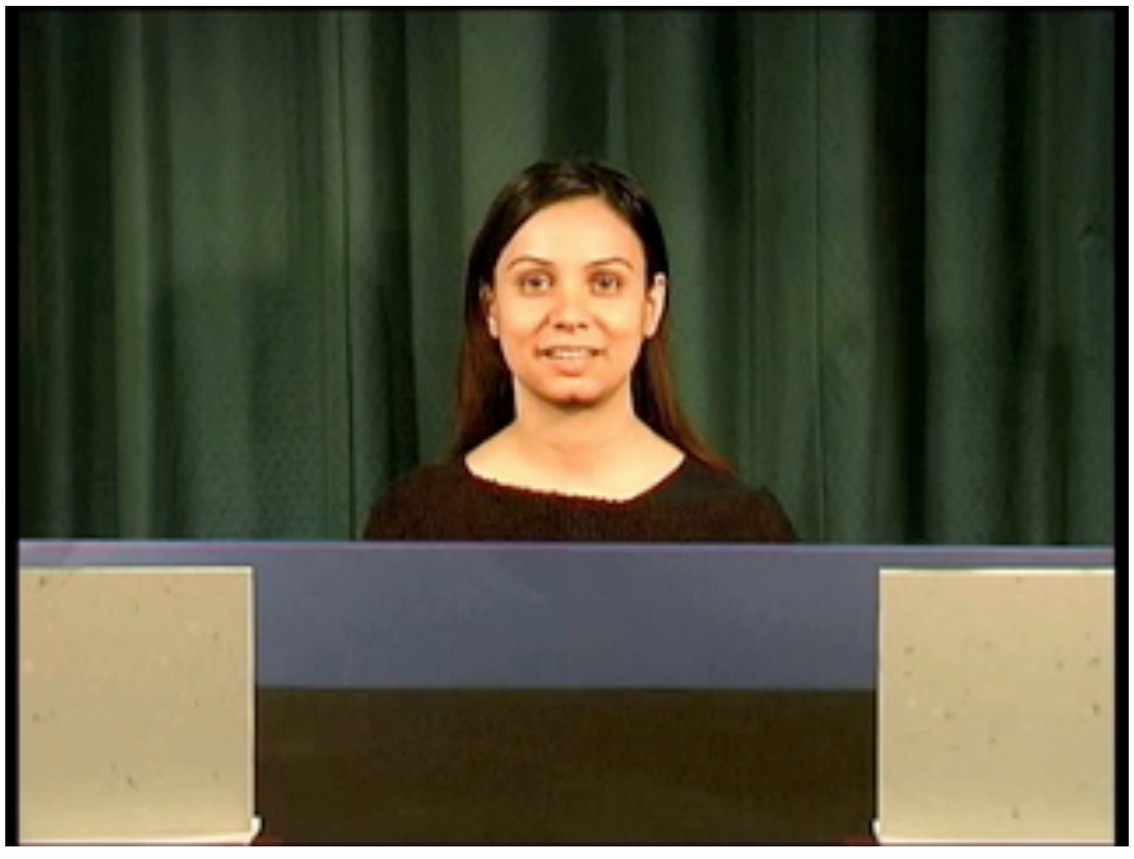
A Historical (Episodic) Introduction:
The difficult birth of Natural Pedagogy Theory

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)
2. ***Natural Pedagogy Theory*** (Csibra & Gergely, 2006, 2009, 2011)

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

(Grice, 1957, 1989, Sperber and Wilson's Relevance Theory, 1986, 2012)

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

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

<u>Ostensive Behavioral signals</u>:

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***

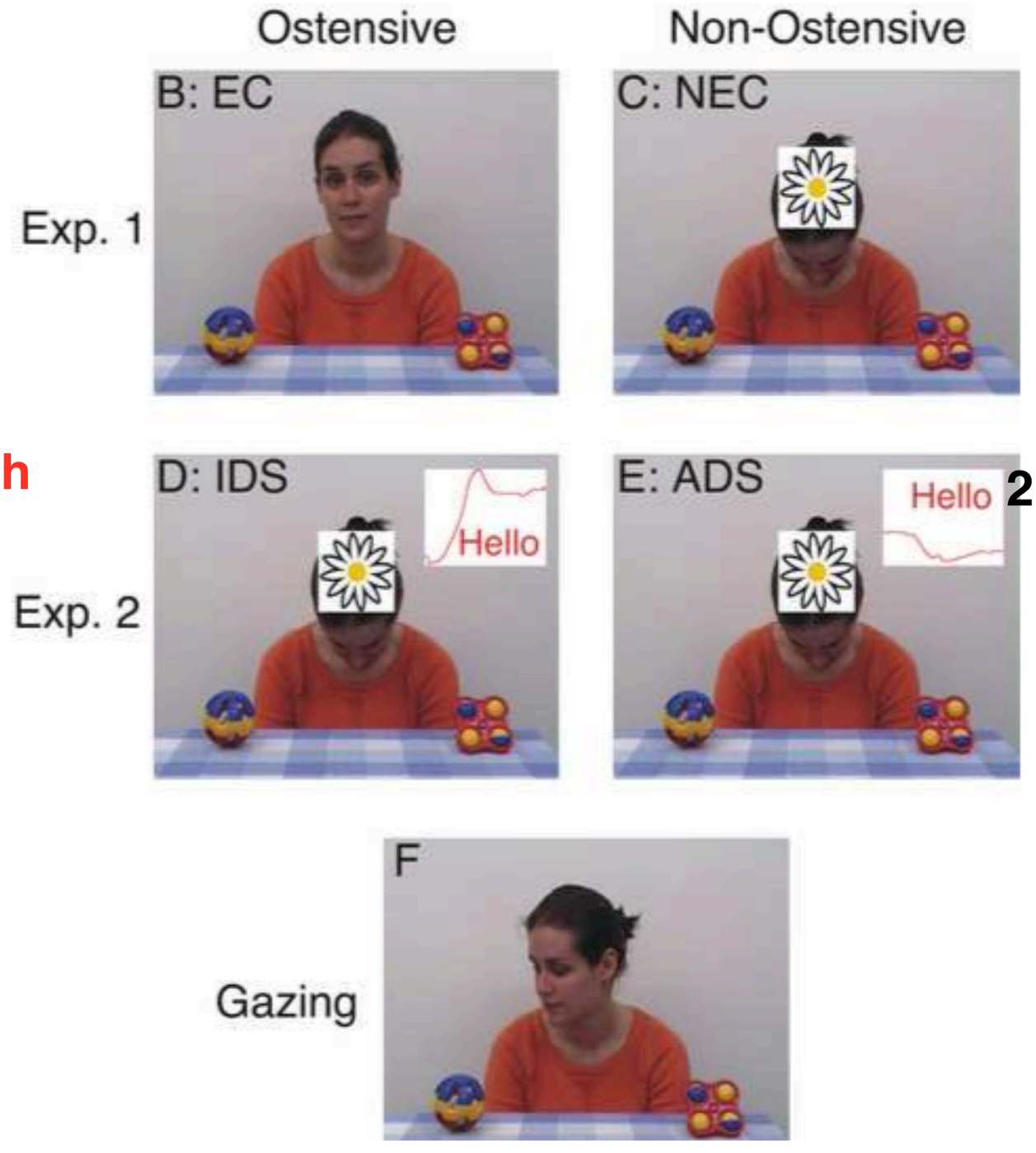
Referential Gaze Following is Dependent on the Presence of Ostensive Signals in Infants

Senju and Csibra, (2008)

Ostensive Signals:

1. Eye-contact

2. Infant-directed speech (Motherese)

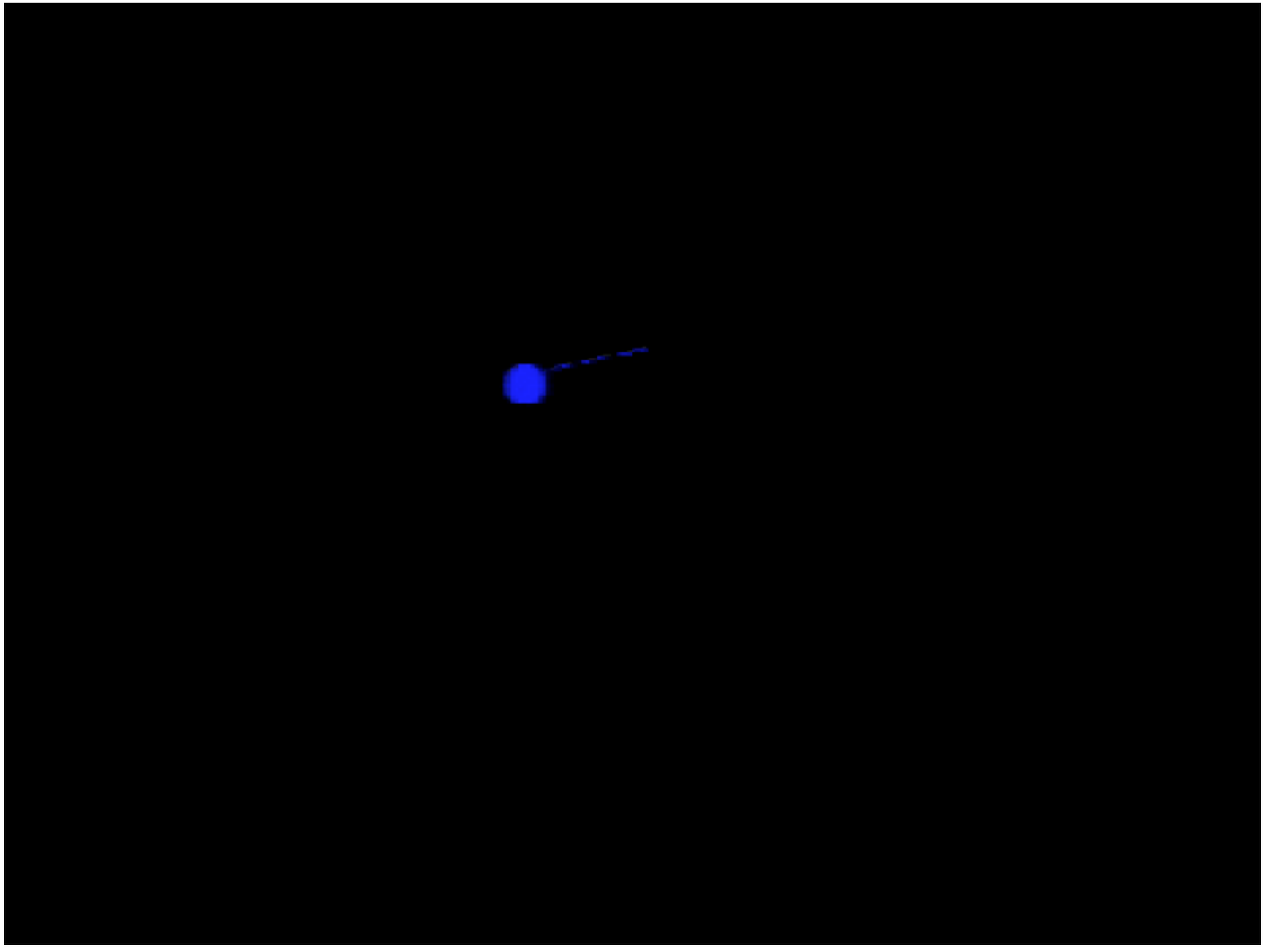


No Ostensive Signals:

1. No eye contact

2. Adult directed speech

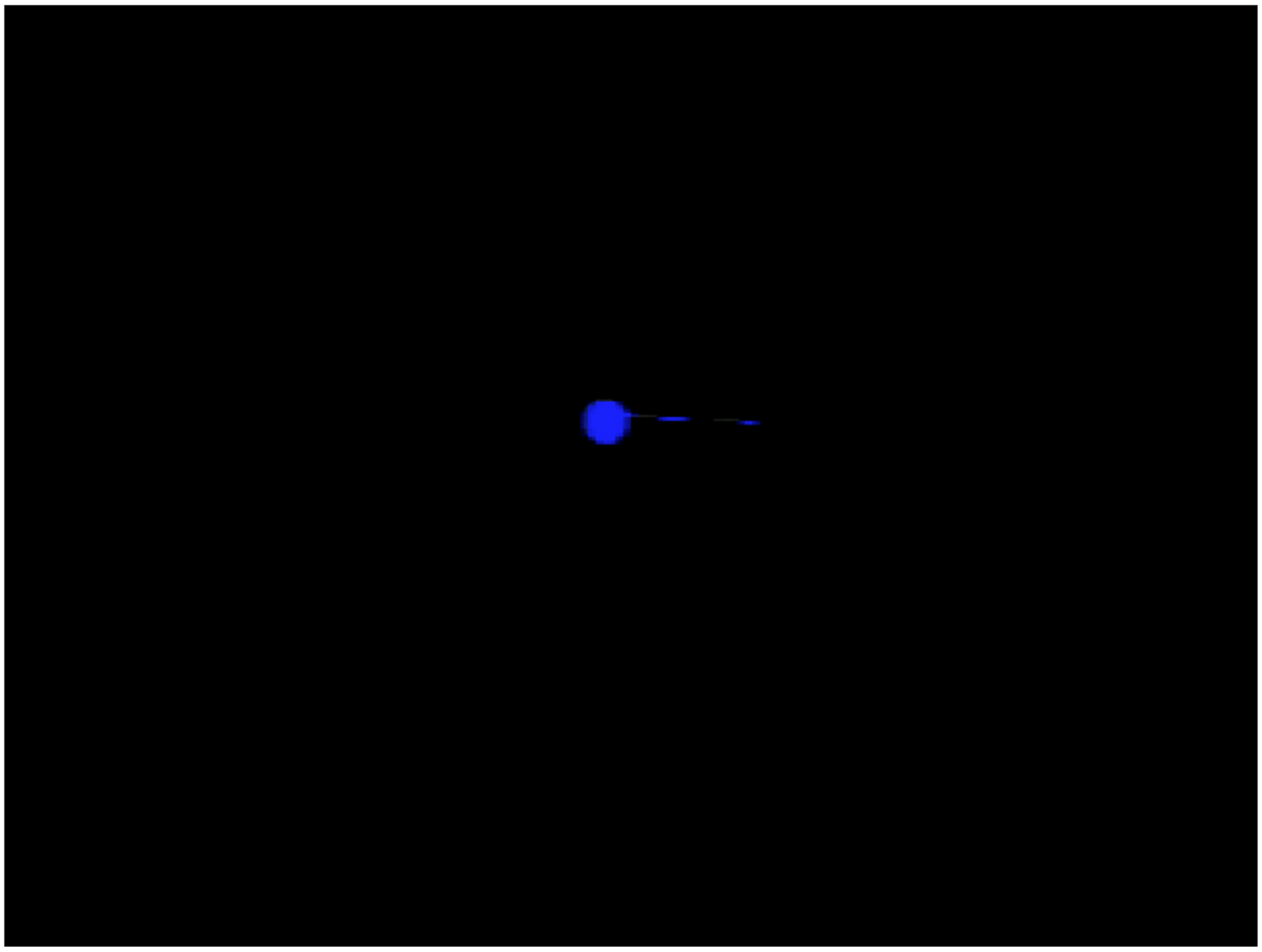
Ostensive signal precedes object-directed gaze-response:
2. Infant-directed speech (Motherese)



Senju and Csibra, (2008)

No Ostensive signal precedes object-directed gaze-response:

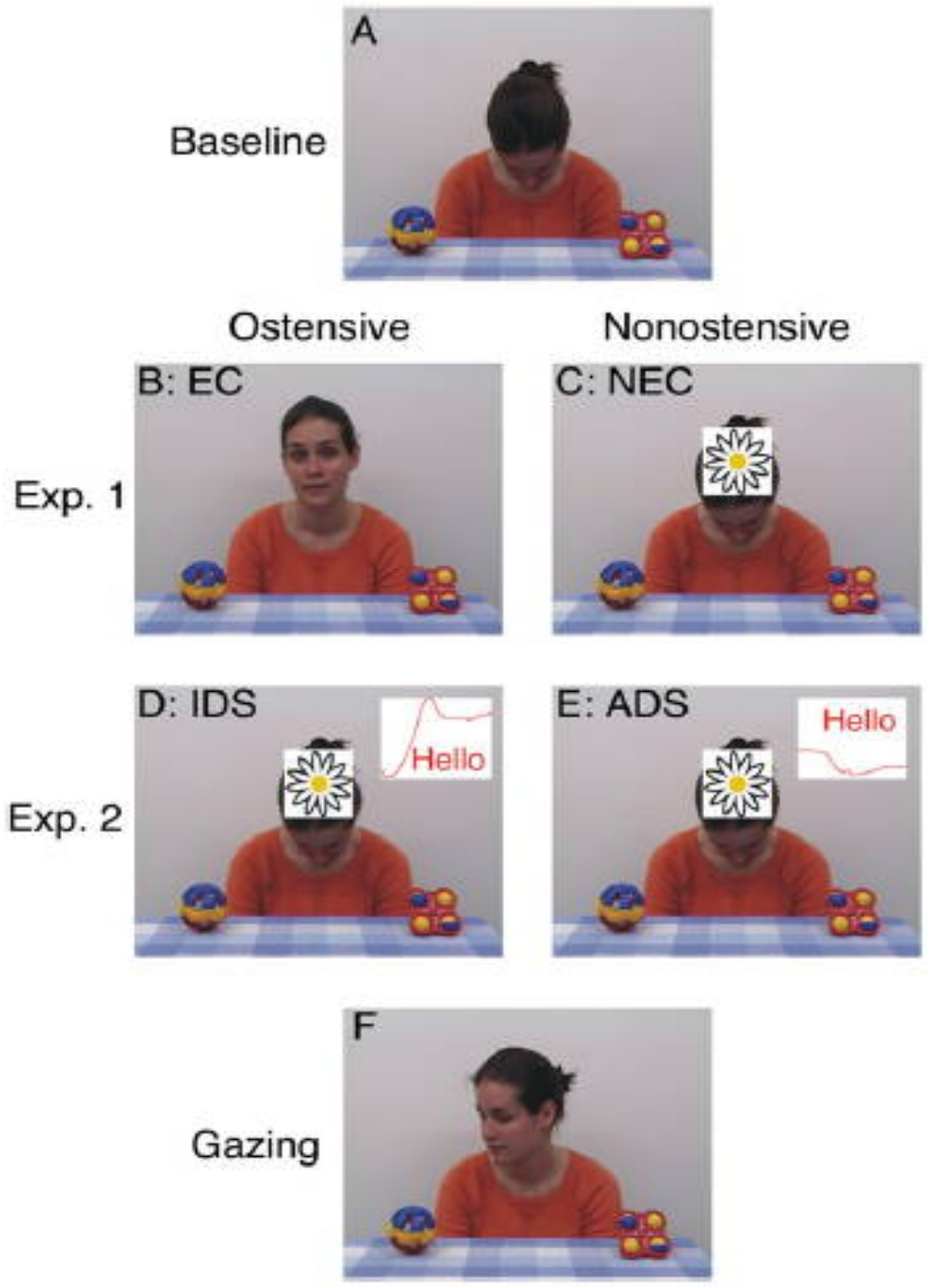
2. Adult-directed speech (ADS)

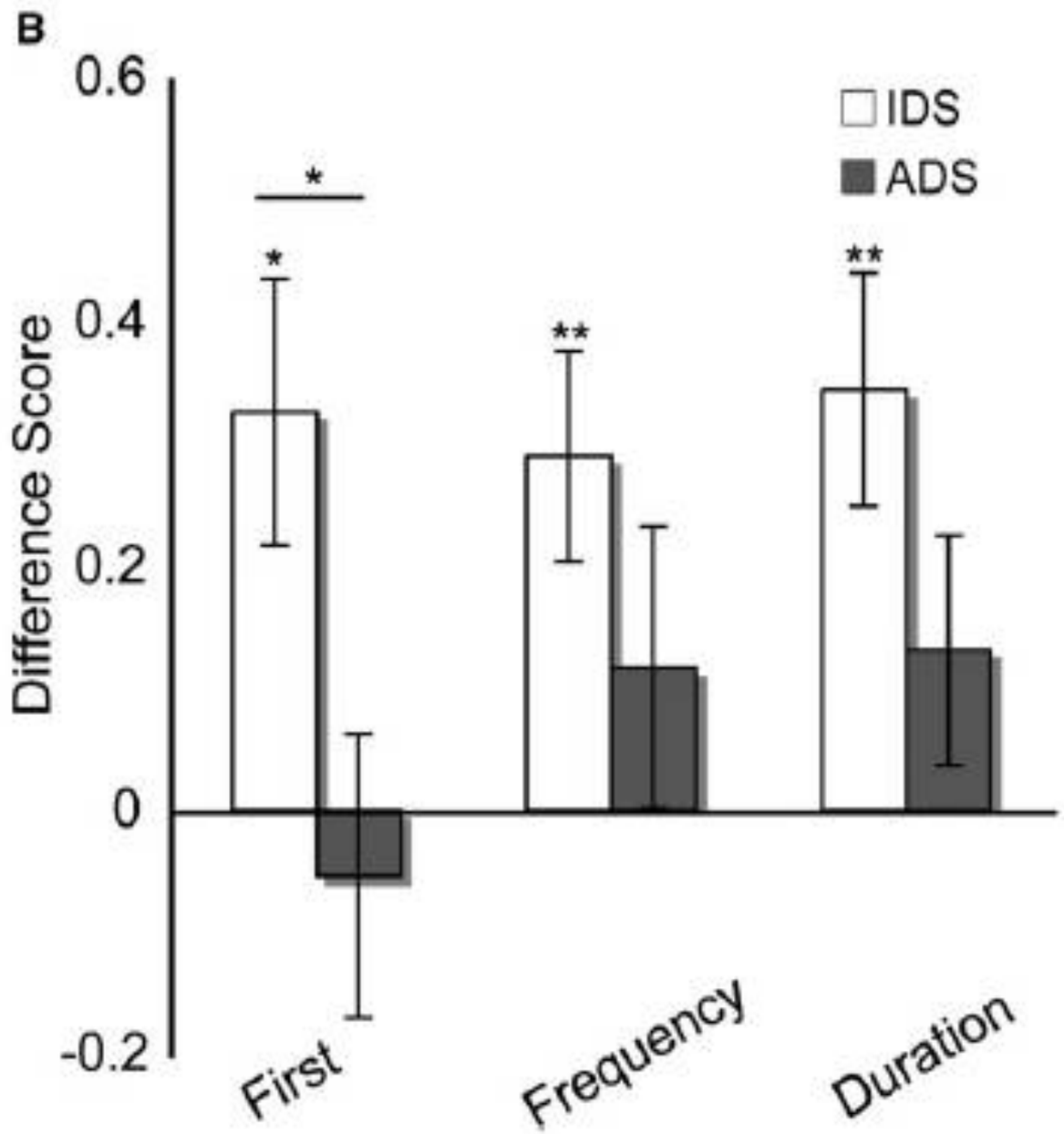


Senju and Csibra, (2008)

Motherese induces gaze-following to referent at 6 months

(Senju & Csibra, 2008) [and so does eye-contact]





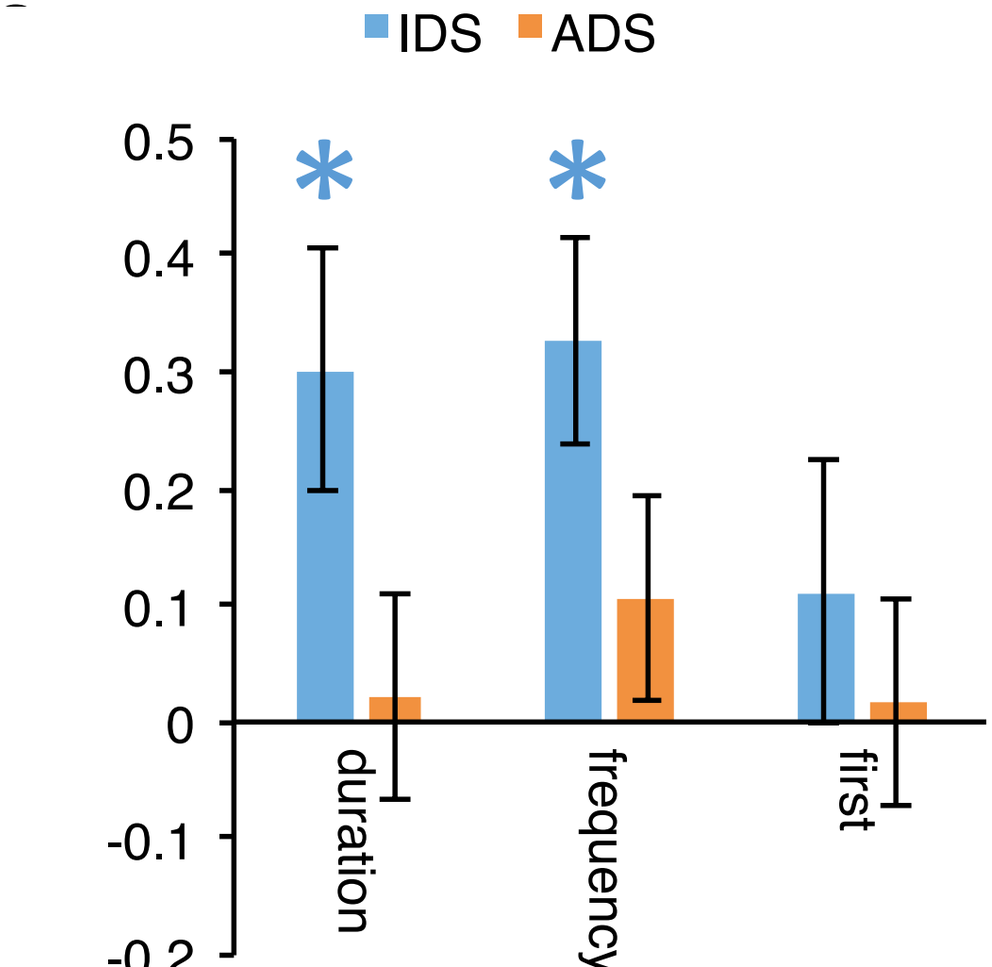
M. Hernik & T. Broesch (2019, Dev. Sci.)

A recent <u>cross-cultural replication</u> of Senju & Csibra, 2008:

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

<u>Ostensive Cuing Context</u>: Being addressed in Motherese (IDS)

After an indigenous adult model *a<u>ddressed the infant in Motherese (IDS)</u>* -
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



<u>Tanna island in Vanuatu</u>

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

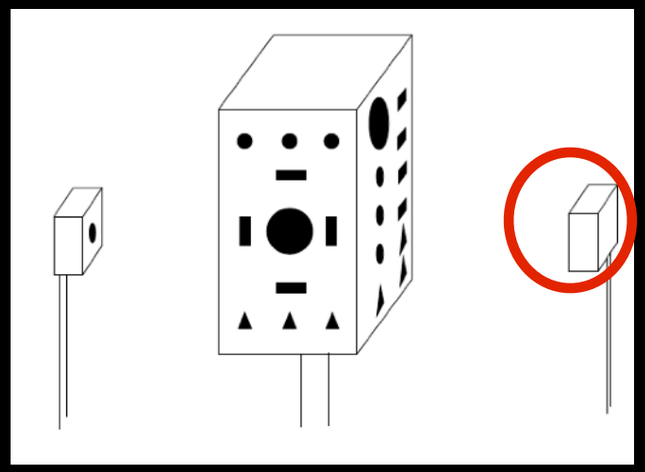
Exp 4-5:

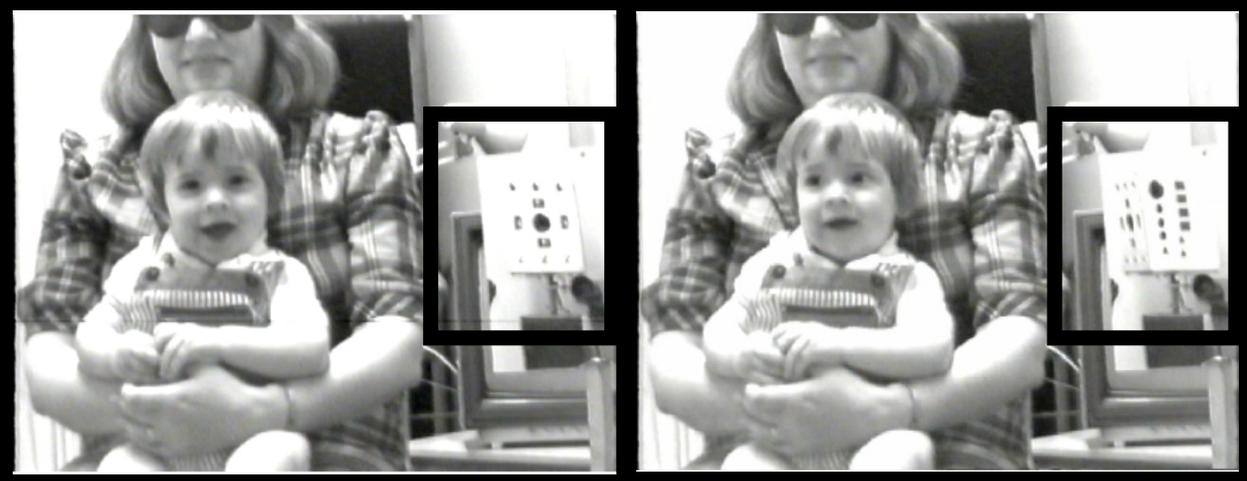
(B) to infer *(the* ***Informative intention****)* ***the relevant and new information*** *that the Agent intends to convey about the intended referent*

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





(Movellan & Watson, 1996, 2002; Johnson, Slaughter, & Carey 1998)

=> 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

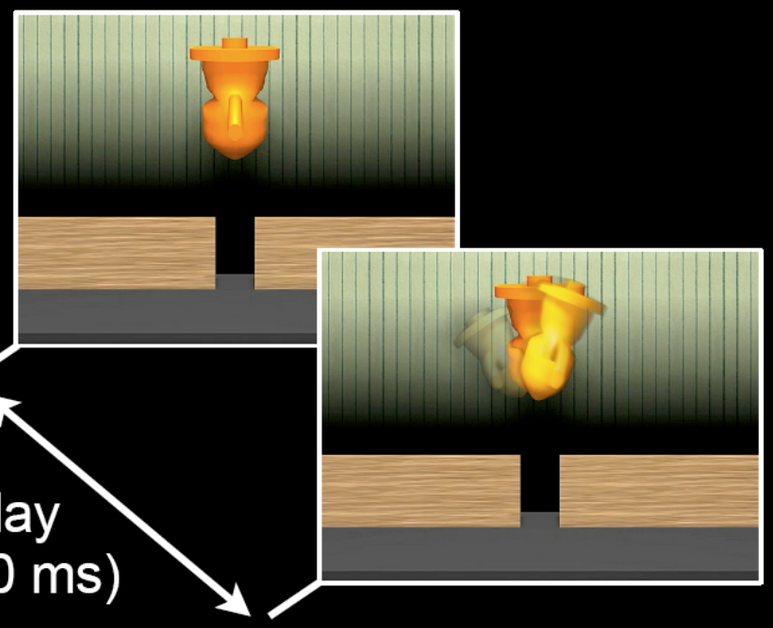
Téglás, Csibra, & Gergely, (in prep.)

OSTENSIVE CUING
Triggers Referential Expectation

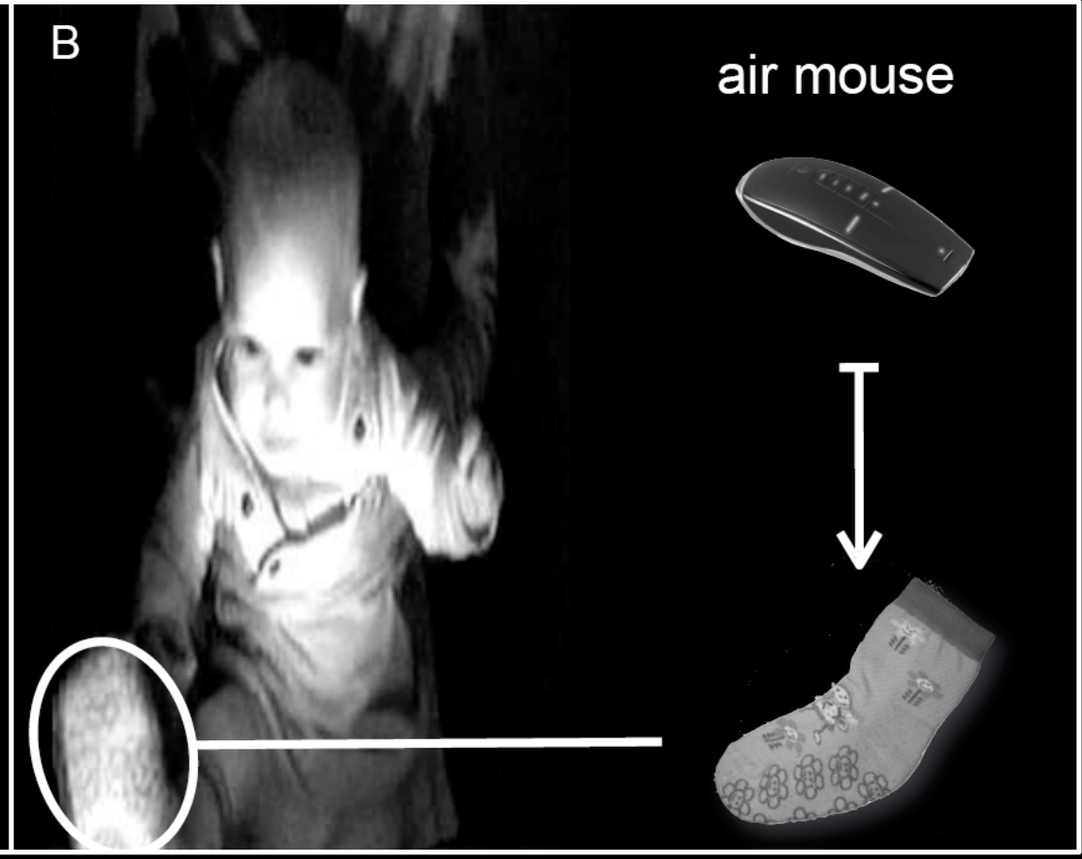
Do 12-month-olds follow the object's orientational cue to target referent as a function of infant-induced highly contingent distal reactivity?

EXPERIMENTAL PROCEDURE

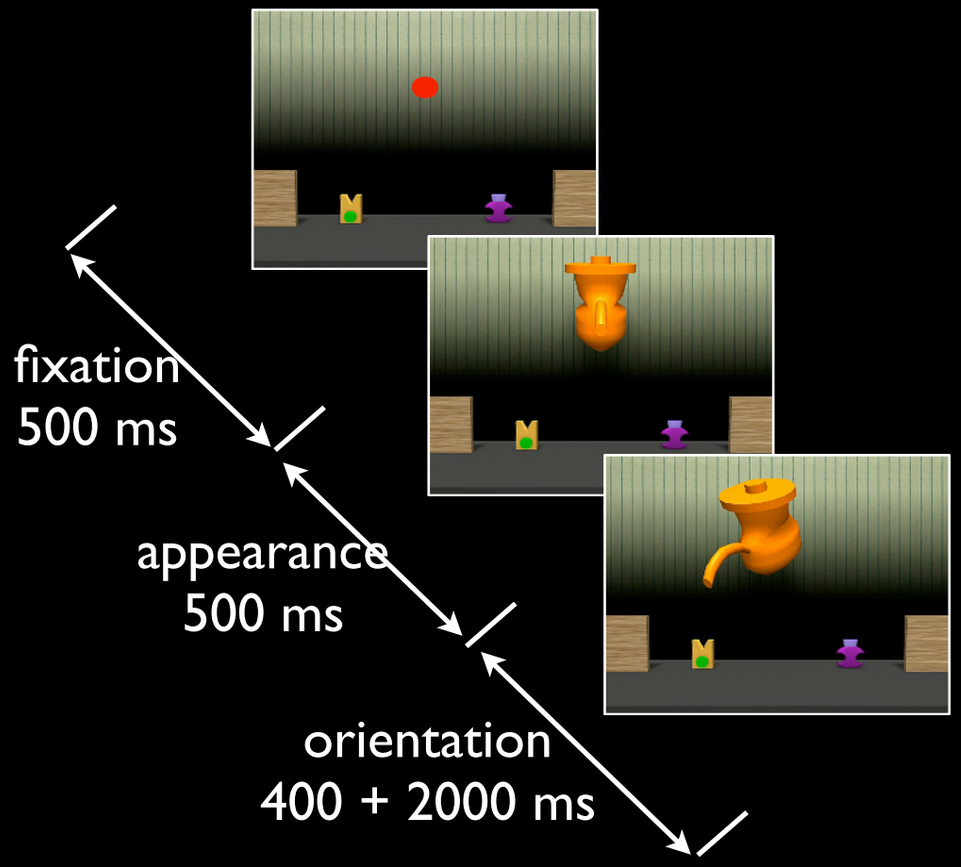
A

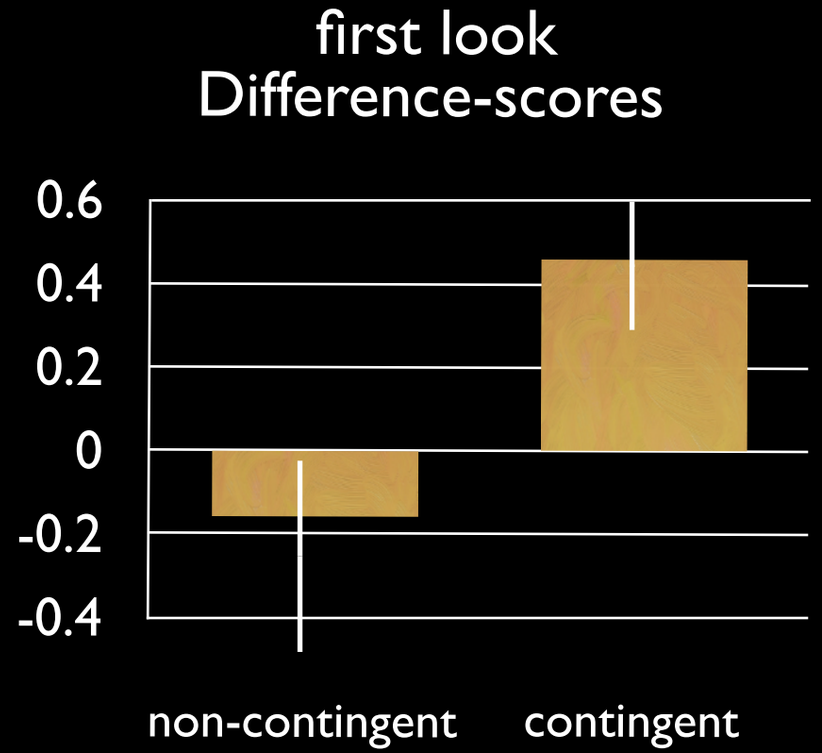


B



EXPERIMENT 1 - ORIENTATION FOLLOWING to the INDICATED REFERENT





N=16 N=18

12-month-olds

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:

Deligianni, Senju, Gergely & Csibra, 2011, *Dev. Psych.*

8-month-olds

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

Contingent response:
Target object moves

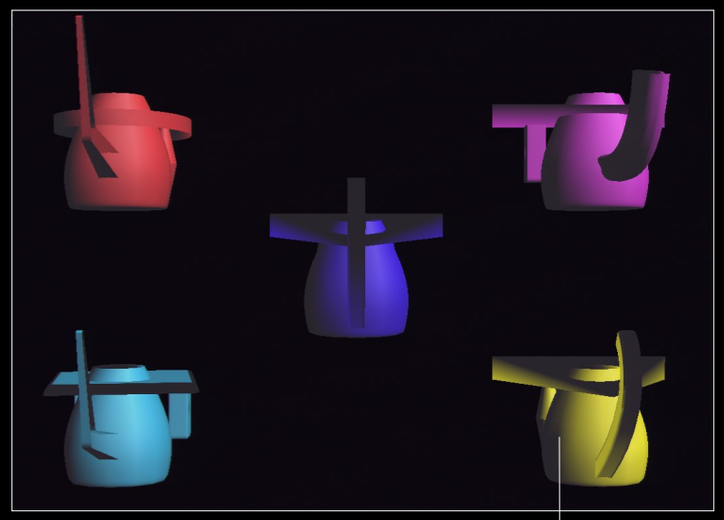
(i) Infant-induced Contingent Reactivity

versus

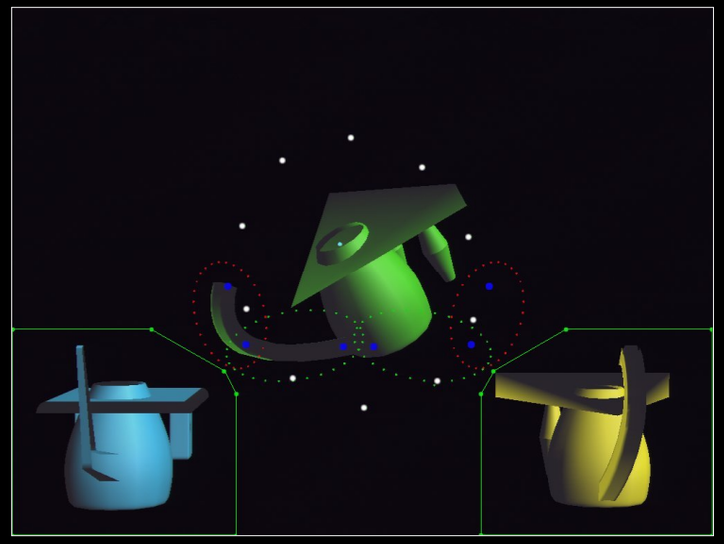
(ii) Non-Contingent Random Activity (yoked control)

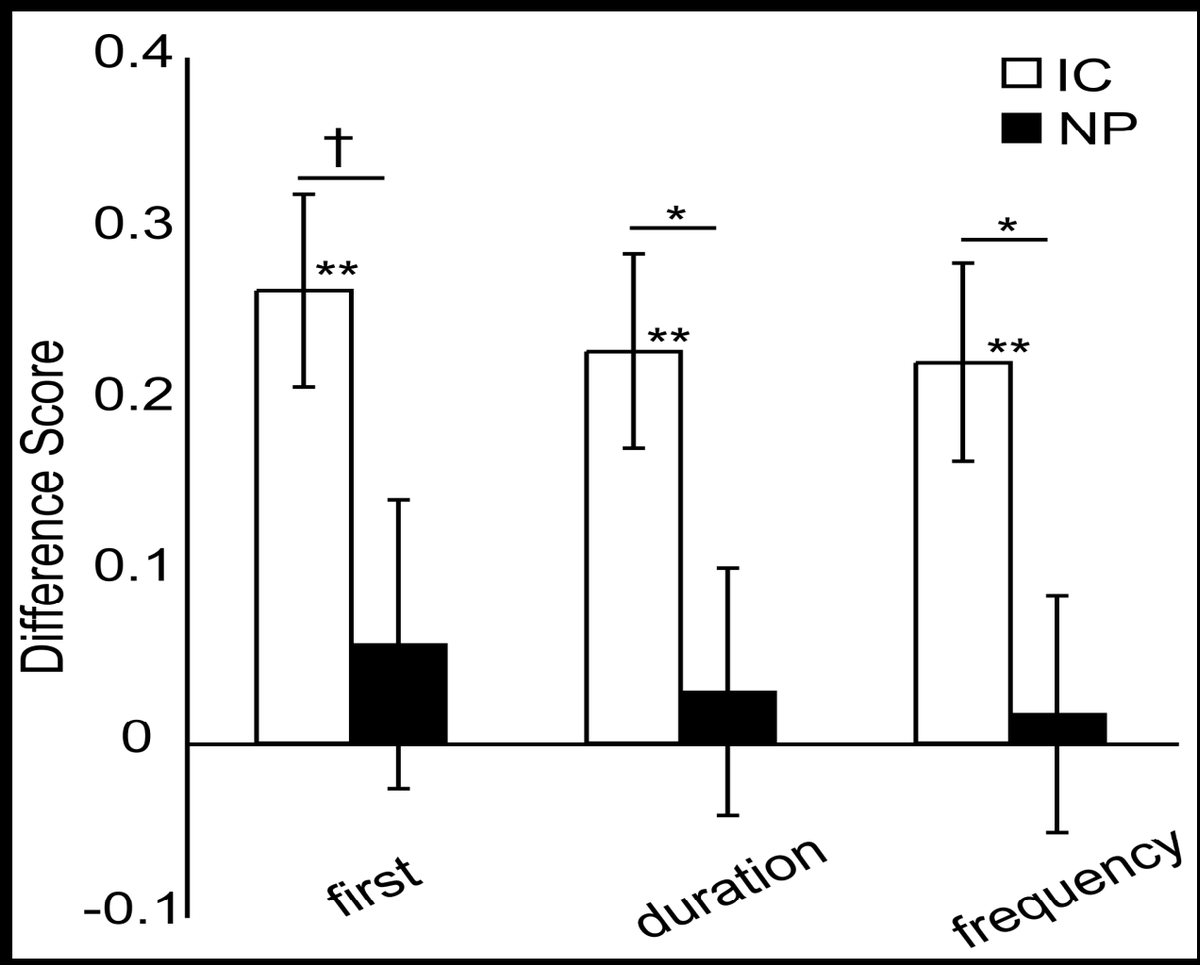
Infant's gaze-following to target referent
In the Contingent (IC) vs Non-contingent (NP) condition

Familiarization:



Test:





Deligianni, Senju, Gergely & Csibra, 2011, *Dev. Psych.*

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*** or *attending* vs. as evidence for ***showing*** 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

<u>Pragmatic Inferences to recover the Communicative agent's Informative Intentions</u>

<u>Hypothesis</u>: 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****)*

<u>Cue of Ostensive Communication</u>:

Turn-taking exchange of Variable Signal Sequences

The "Flat-Fish Conversation" Studies:

Tauzin and Gergely (2018, Sci. Rep., 2019 PNAS)

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

Tauzin and Gergely (2019, *PNAS*)

10-month-olds observing from a 3rd-person perspective

Agent-to-Agent Turn-Taking Contingent Interactions

Two levels of Contingencies studied:

Condition 1:		Condition 2:
(a) Partial variability	vs.	(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

AGENT-1		*AGENT-2*
ABC	-	ADE
AFG	-	AKH
…		
GRJ	-	GOK
GUL	-	GAP
…		
DBO	-	DTJ
DKY	-	DJR

AGENT-1		*AGENT-2*
ABC	-	ABC
AFG	-	AFG
…		
GRJ	-	GRJ
GUL	-	GUL
…		
DBO	-	DBO
DKY	-	DKY

Turn-Taking Exchange of Contingent Signal Sequences

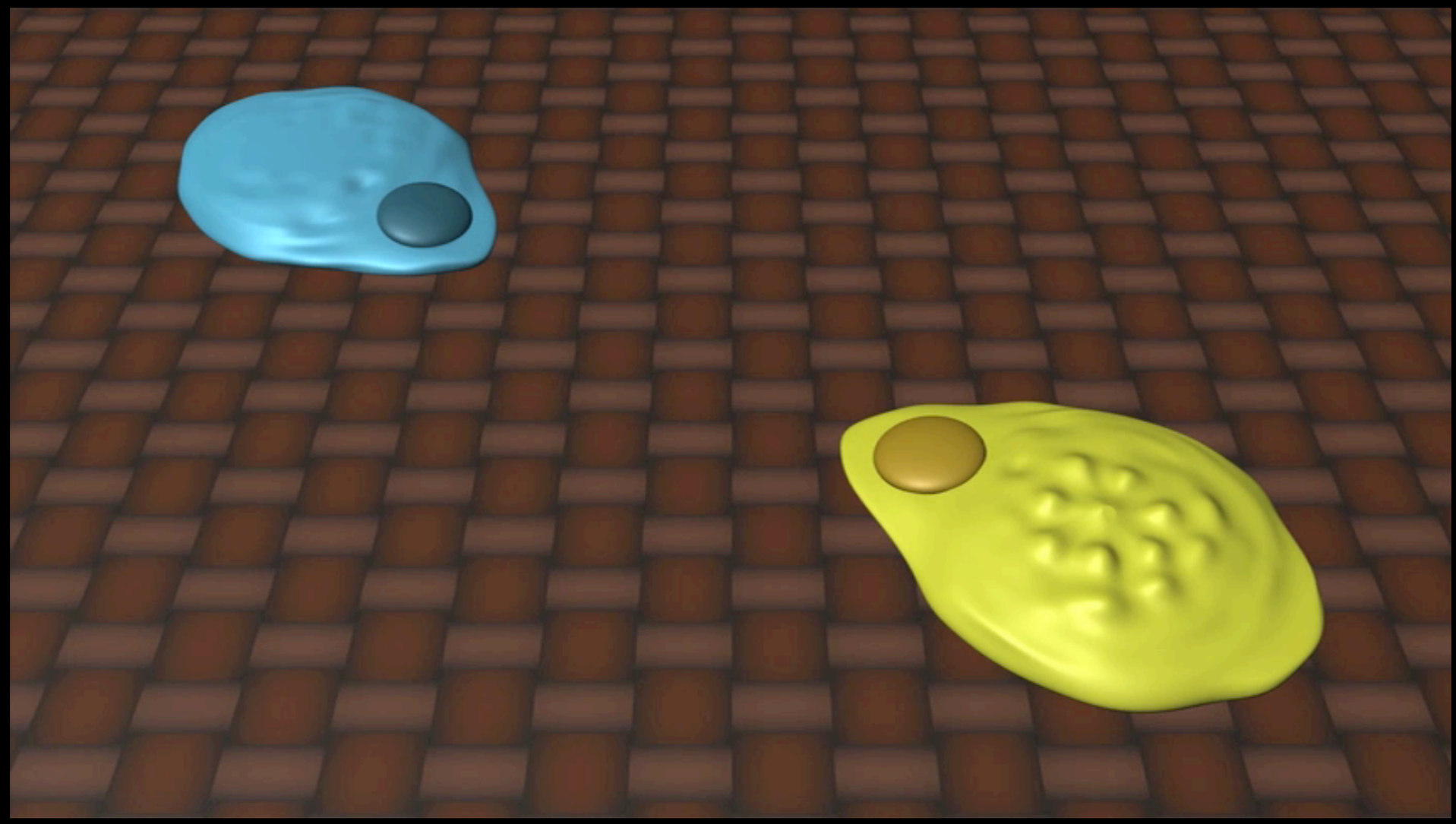
Hign-but-Imperfect Contingency: **Unpredictability Present!**

(a) The "Conversation"
Partial signal variability condition

Sound Signal Sequences: **Melodic Tone Triplets**

AGENT-1 *AGENT-2*

ABC - ADE
AFG - AKH
...
GRJ - GOK
GUL - GAP
...
DBO - DTJ
DKY - DJR



Turn-Taking Exchange of Contingent Signal Sequences

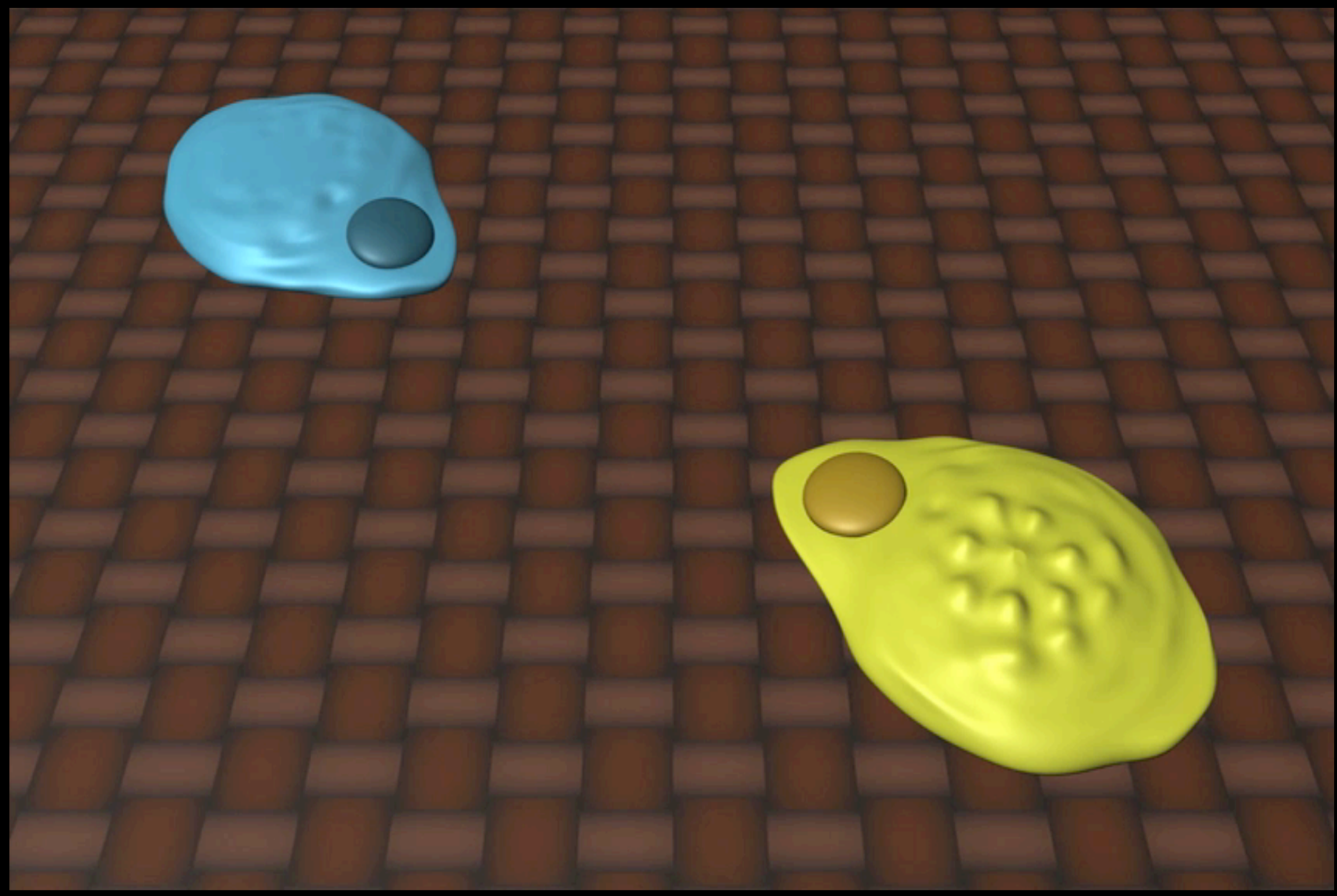
Perfect Contingency: **No Unpredictability!**

(b) **The "Echo"**

Identical Content Repetition condition

Sound Signal Sequences: **Melodic ToneTriplets**

AGENT-1		*AGENT-2*
ABC	-	ABC
AFG	-	AFG
...		
GRJ	-	GRJ
GUL	-	GUL
...		
DBO	-	DBO
DKY	-	DKY



(i) **Lower-than-perfect contingency**

Unpredictability: YES!

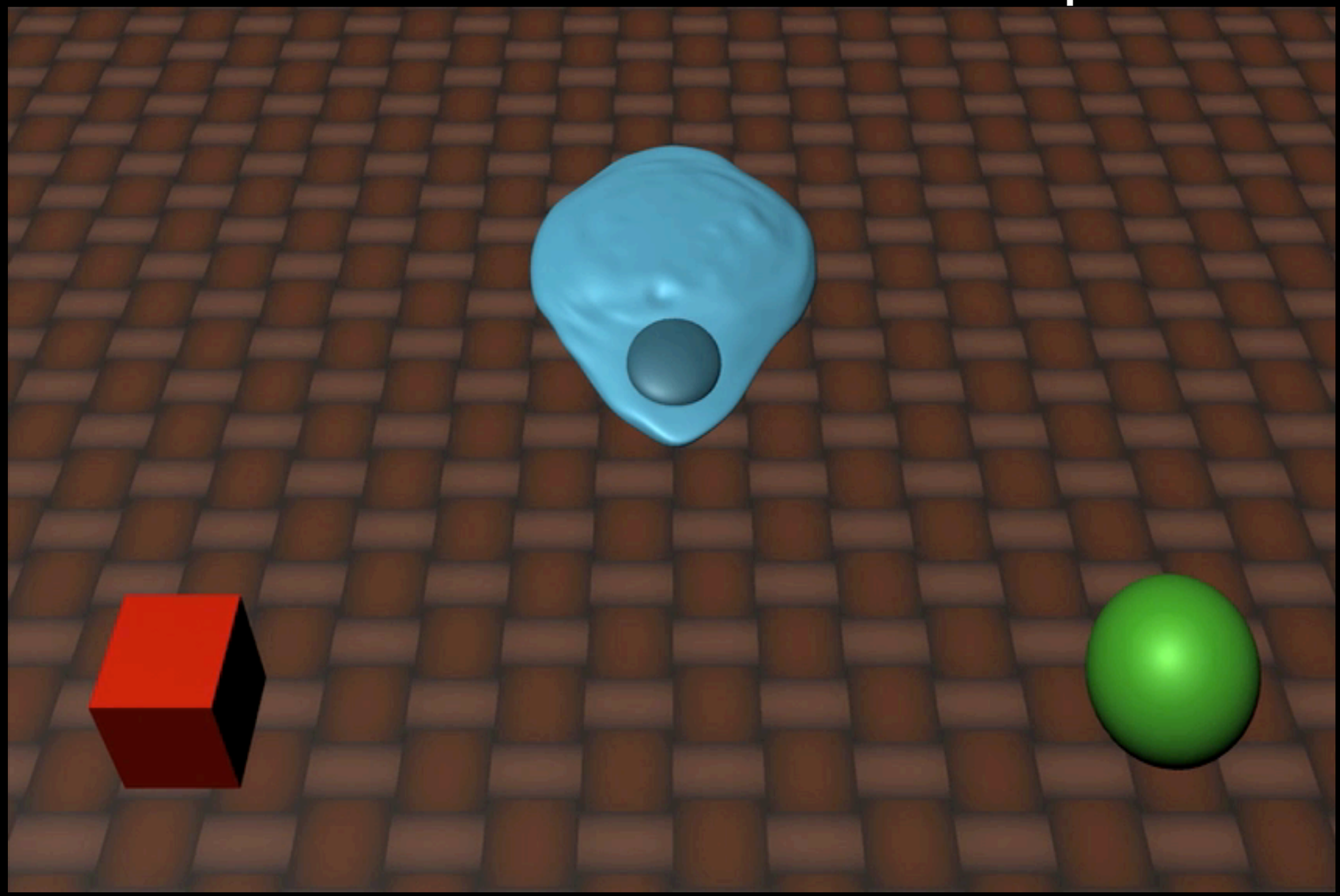
=> compatible with Information Transfer

(ii) **Perfect Contingency**

Fully Predictable

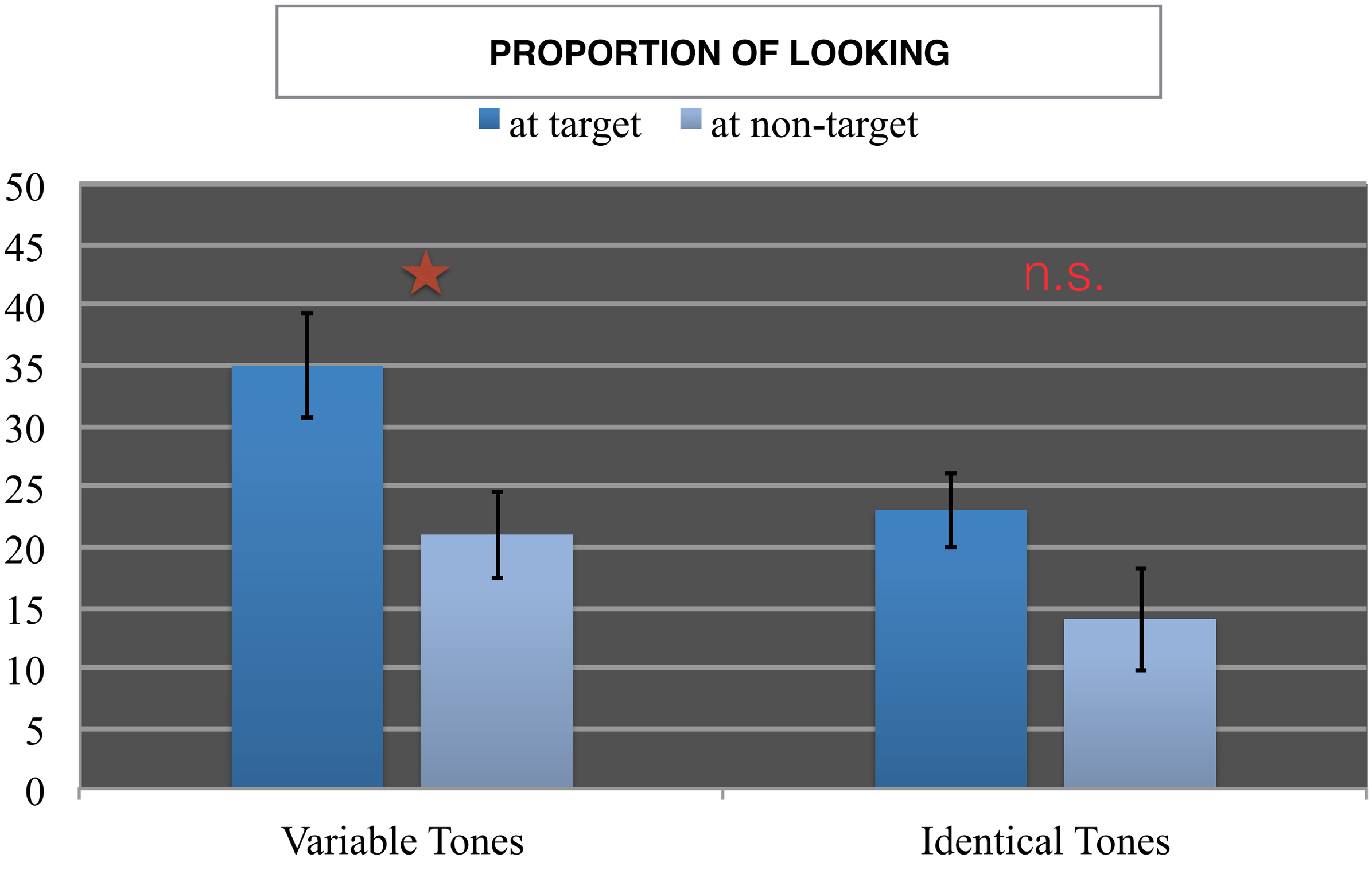
=> No Information Transfer is possible

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



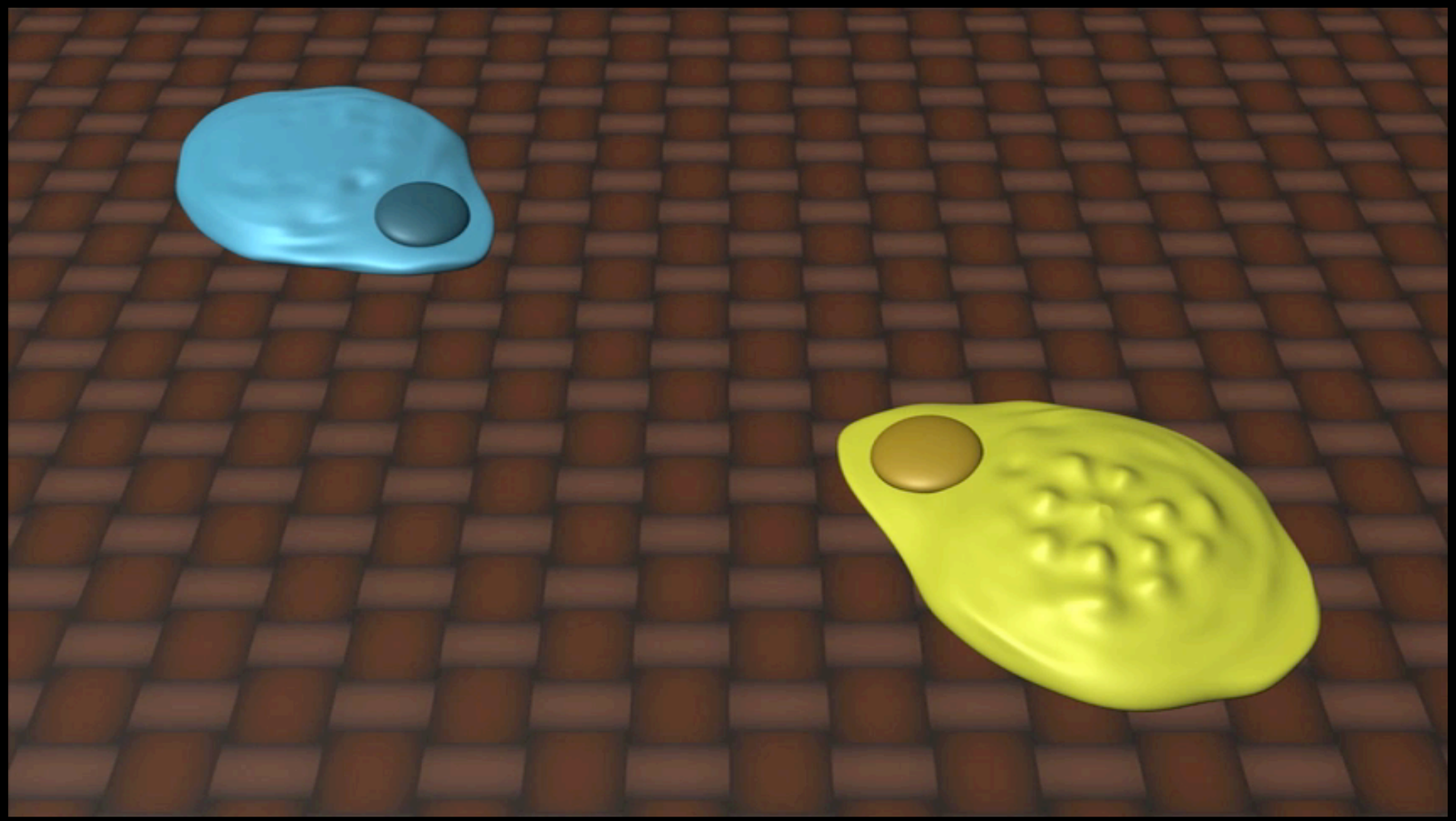
Turn-Taking Exchange of Contingent Signal Sequences

Hign-but-Imperfect Contingency: **Unpredictability Present!**

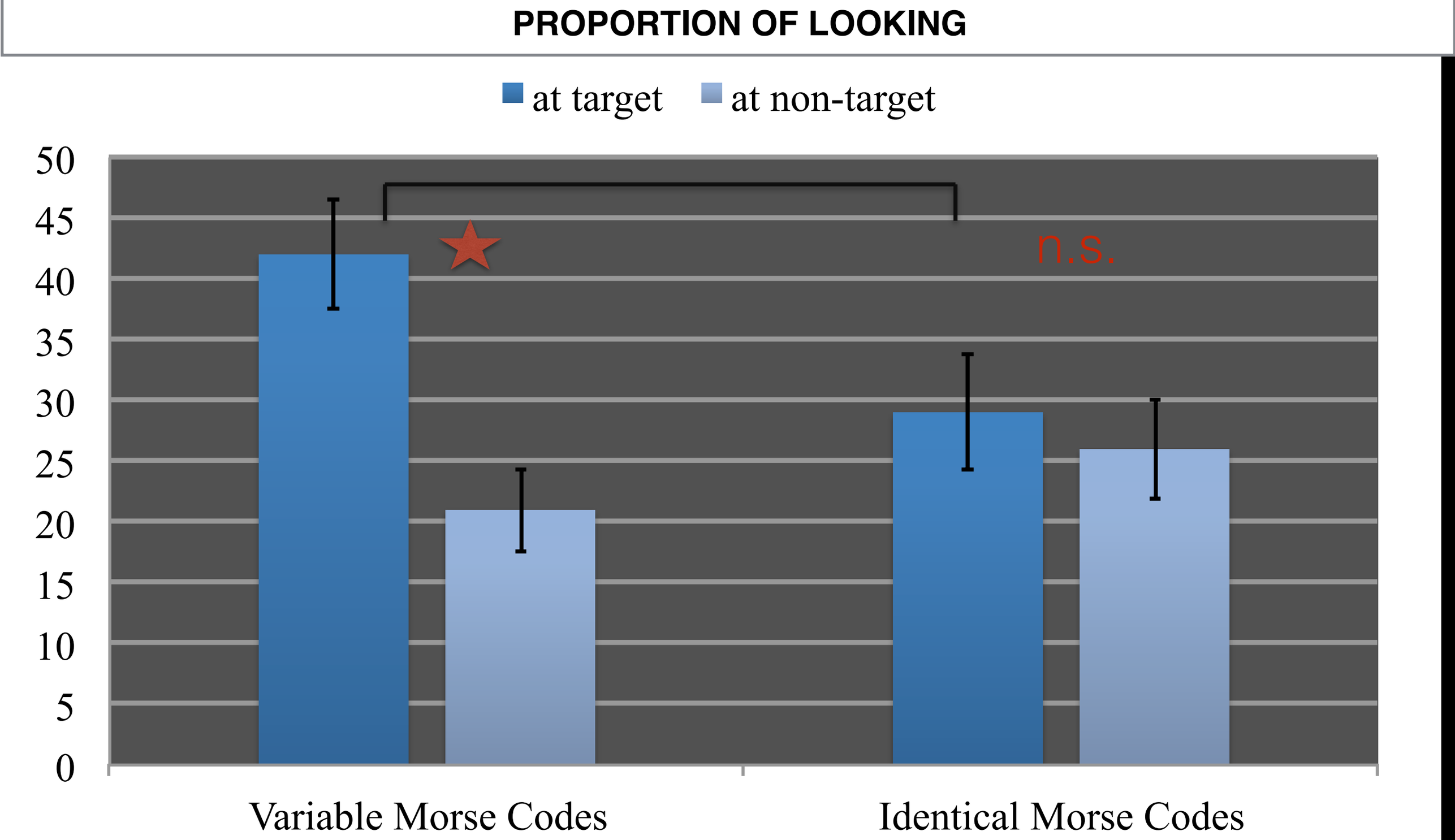
(a) The "Conversation"
Partial content variability condition

Sound Signal Sequences: **Morse Code Beeps**

AGENT-1		*AGENT-2*
ABC	-	ADE
AFG	-	AKH
...		
GRJ	-	GOK
GUL	-	GAP
...		
DBO	-	DTJ
DKY	-	DJR



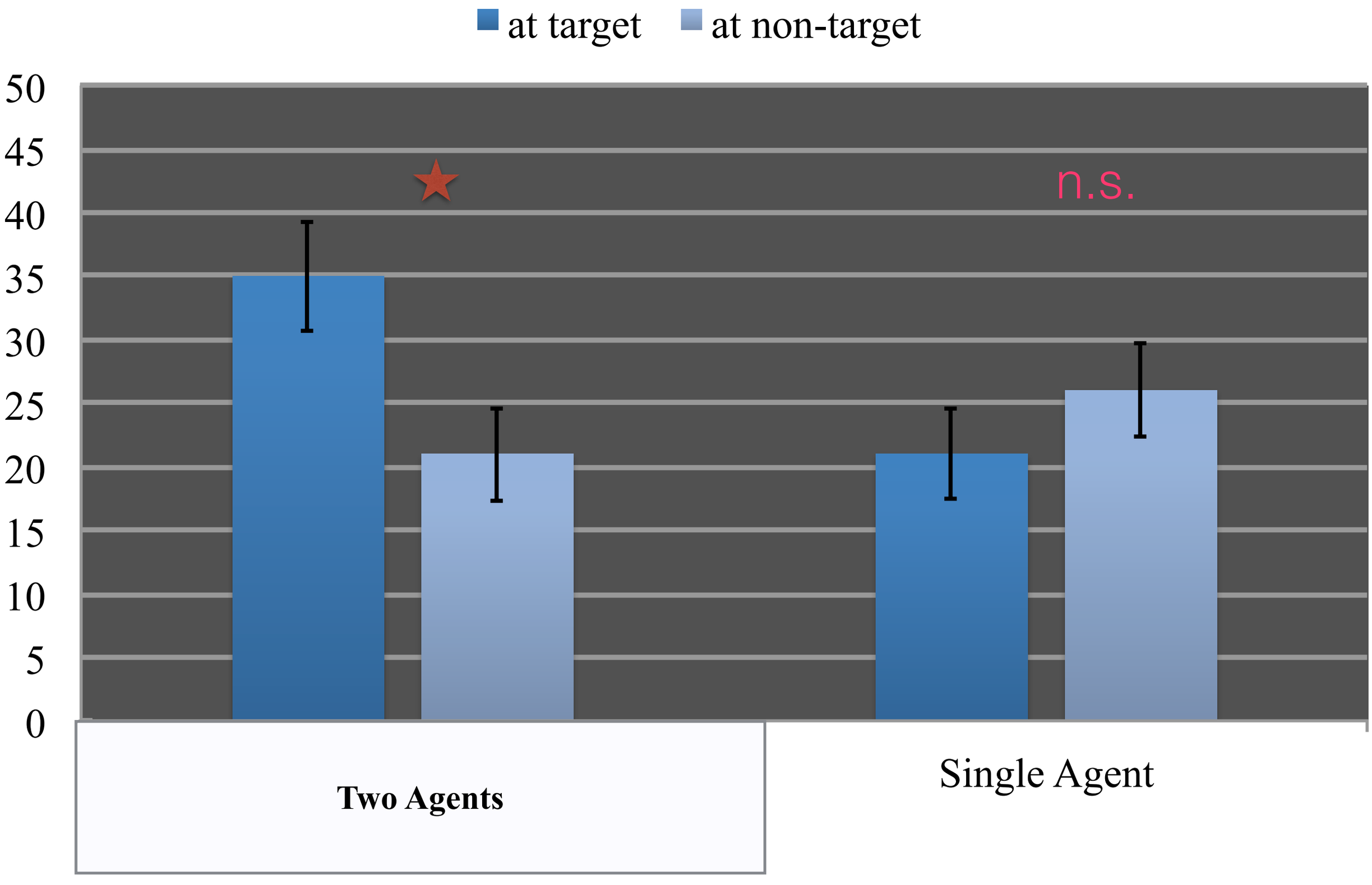
Morse Code Beep Sequences



Partial content variability condition

TWO AGENTS vs. SINGLE AGENT (CONTROL)

Experiment 3 - Looking proportion



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

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(Gergely & Jacob, 2012)

Seeing *vs.* ***Showing***

- Why do infants follow gaze to fixate the referent?

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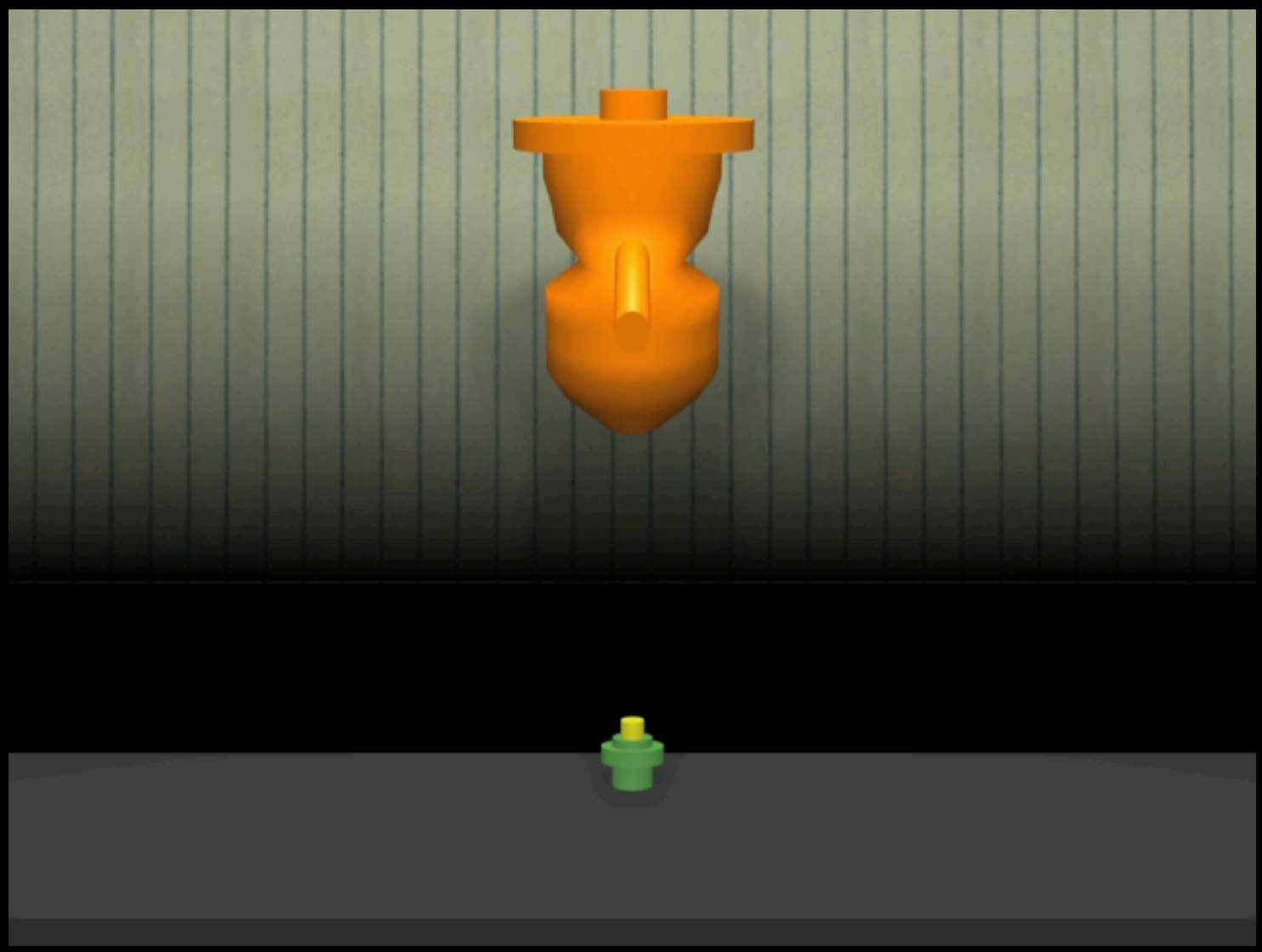
(ii) SHOW/DEMONSTRATE (x)?

Téglás and Gergely, (in prep.)

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

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 vs. **SHOWING**
(Intentional Agency) ***(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 o*nly predicted by the* *Communicative Agency account***

=> to be tested in Experiments 3-5:

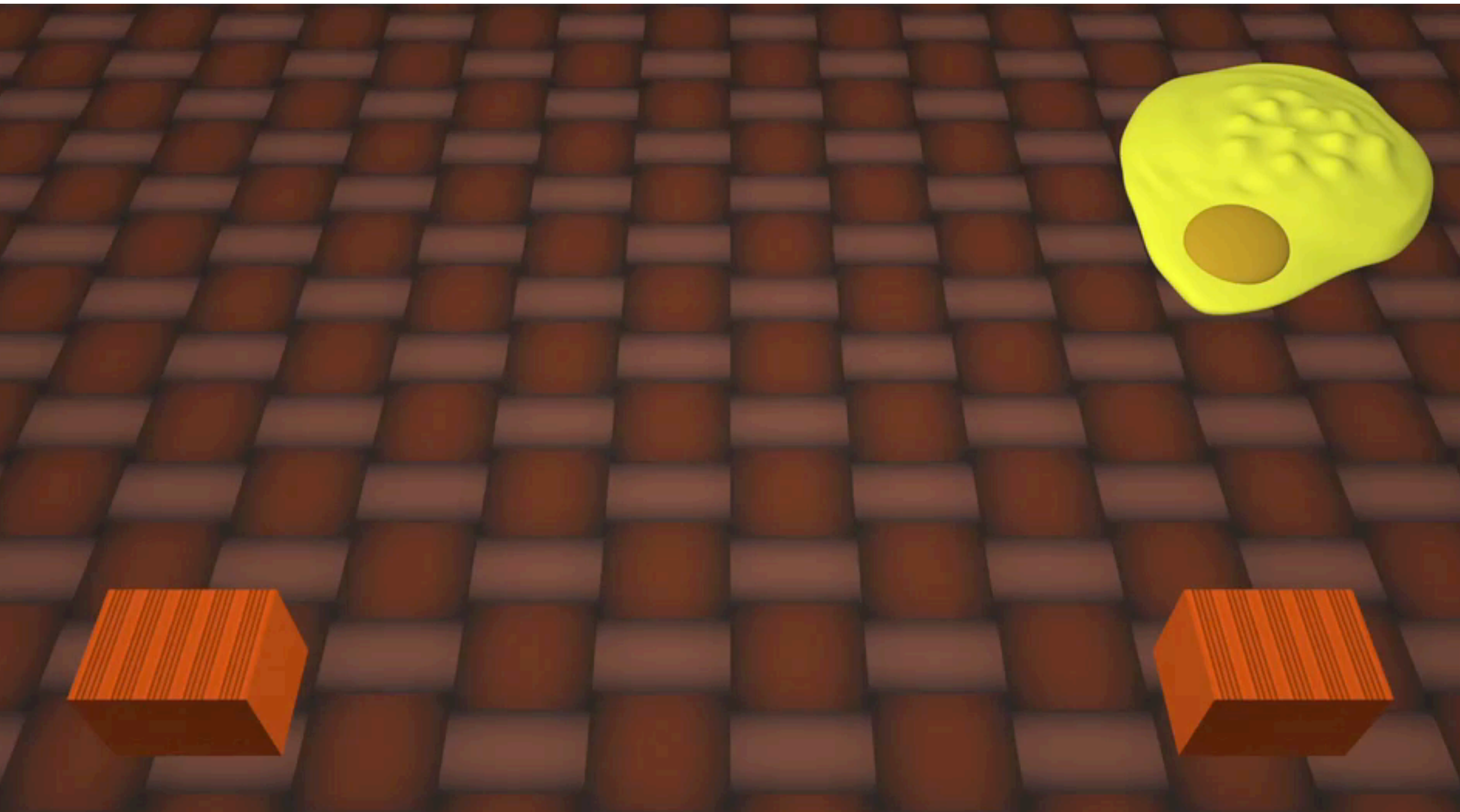
The INFORMING Study: Correcting the other's False Belief

13-month olds

Ostensive Cue:

Turn-taking Exchange of Variable Signal Sequences

Familiarization Phase:



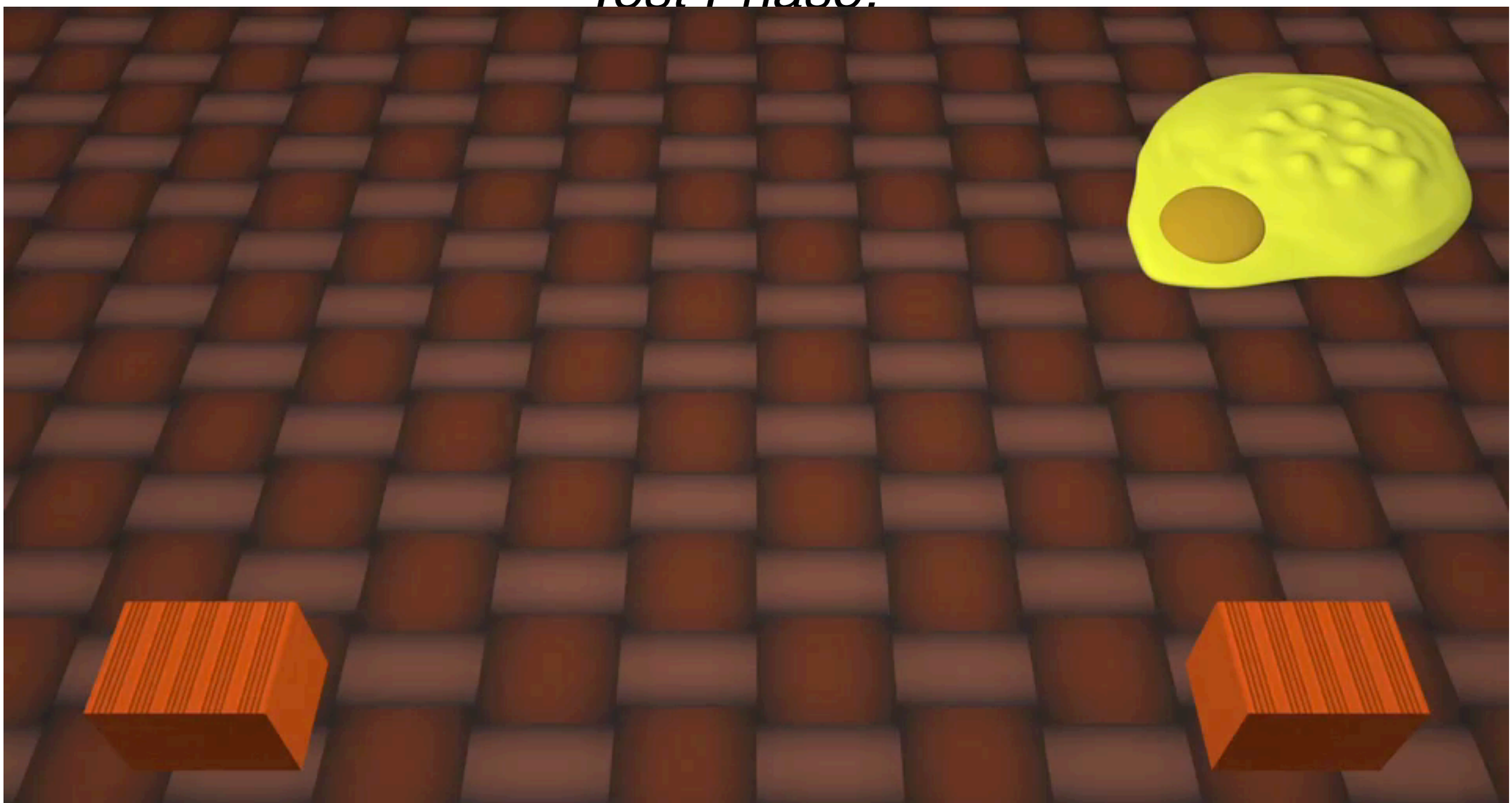
The INFORMING Study: Correcting the other's False Belief

Ostensive Cue:

Turn-taking Contingent Exchange of Variable Signal Sequences

13-month-olds

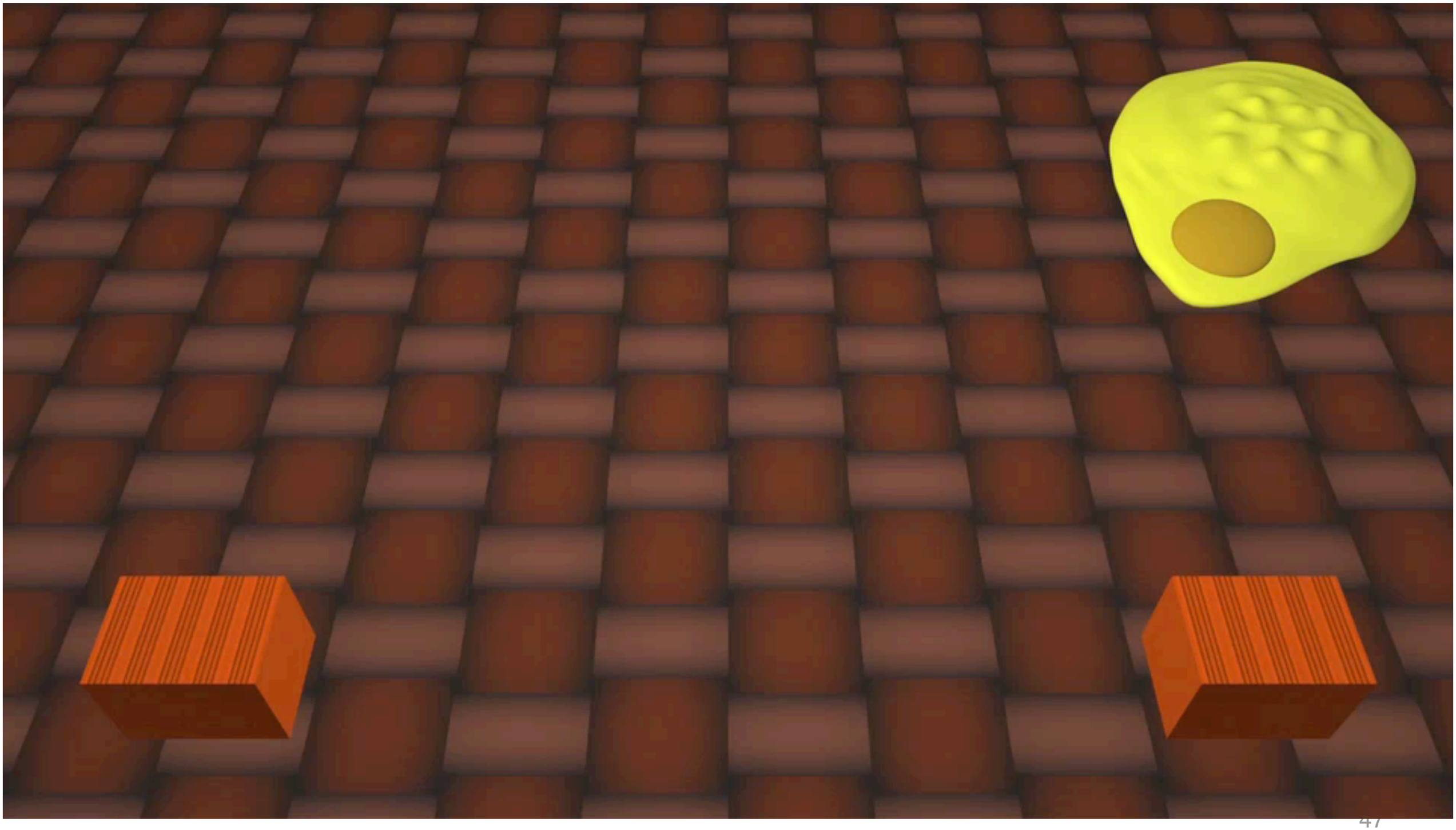
Test Phase:



Control: Turn-taking exchange with perfect signal predictability

13-month-olds

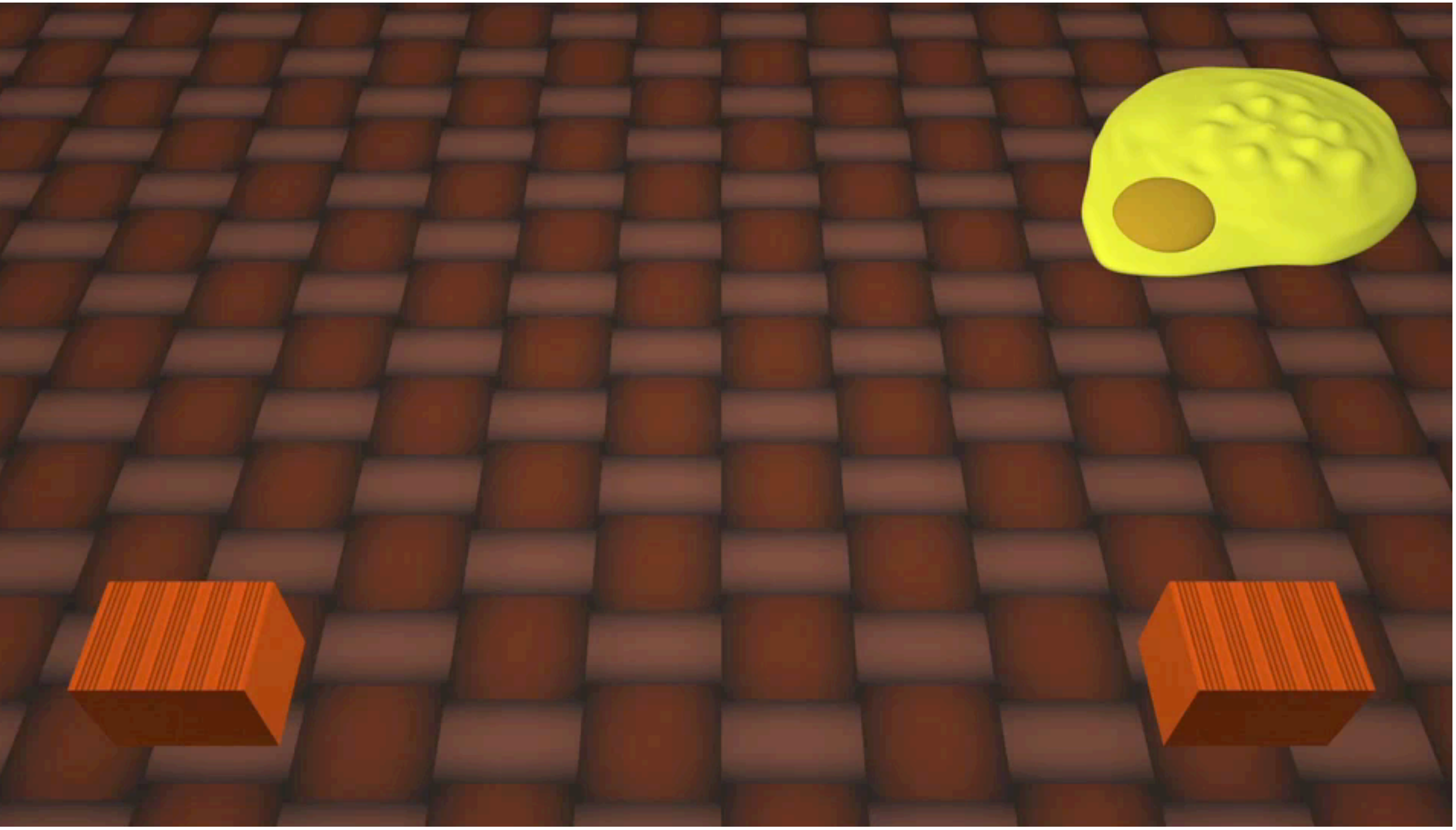
Familiarization: **Identical Content Repetition condition**



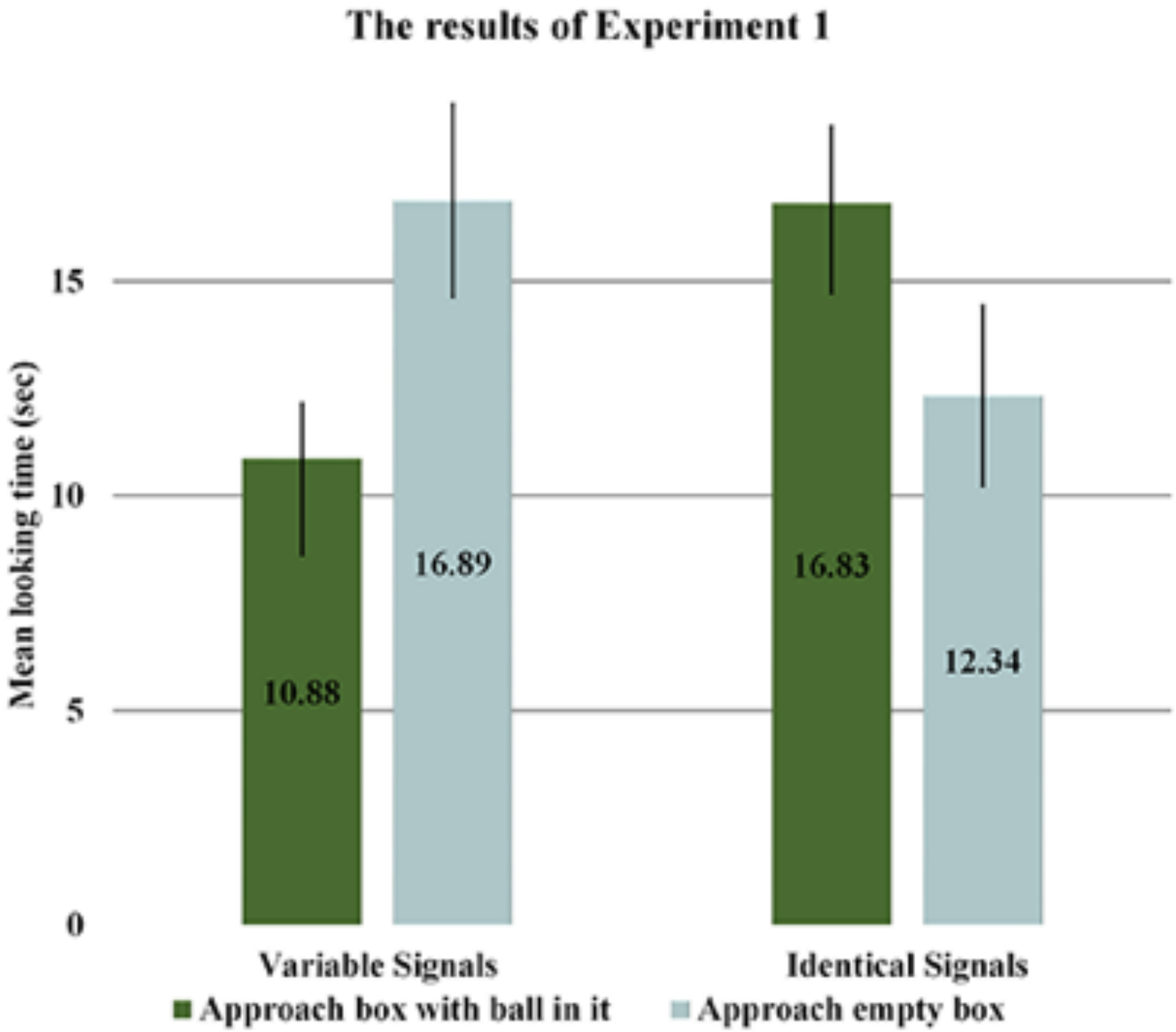
Control: Turn-taking with perfect predictability

TEST PHASE: **Identical Content Repetition condition**

13-month-olds



Looking Times in False Belief Experiment



True Belief Experiment

<u>Intervening Ball Event</u>:

"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:

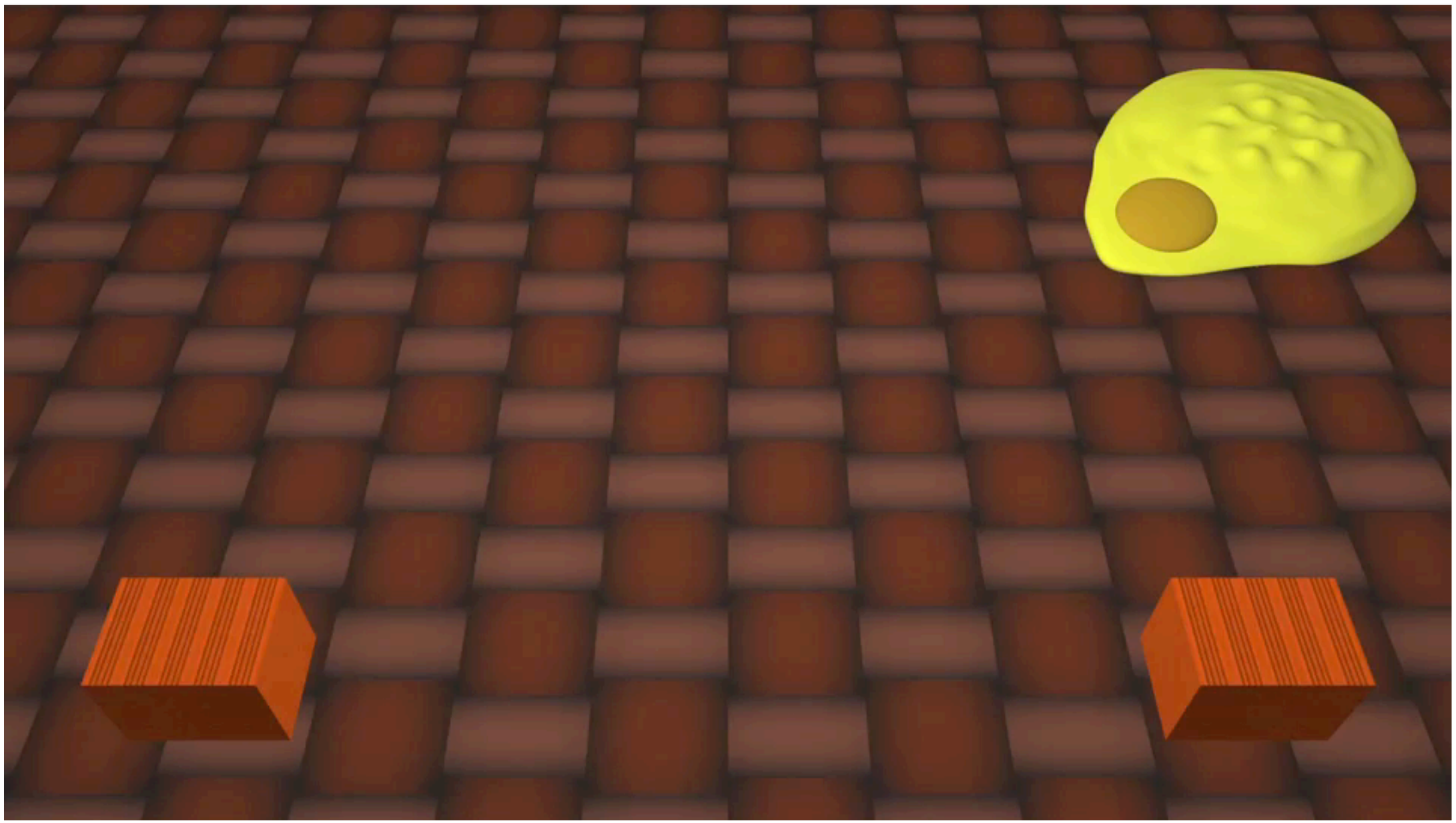
Ostensive Communication BEFORE Object Search

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

BEFORE Object Search:

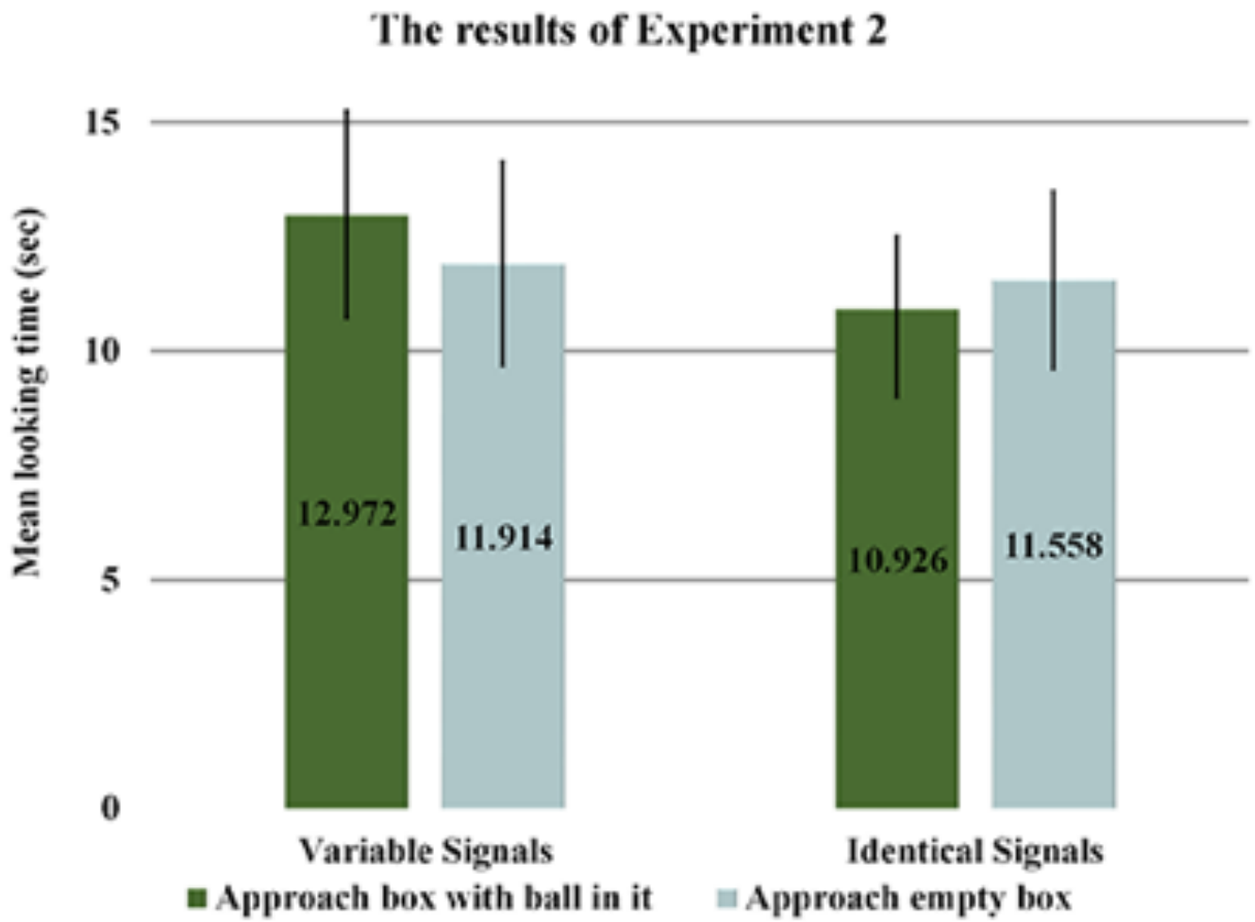
3. Agent 1 goes to search either Box(a) OR Box(b)

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

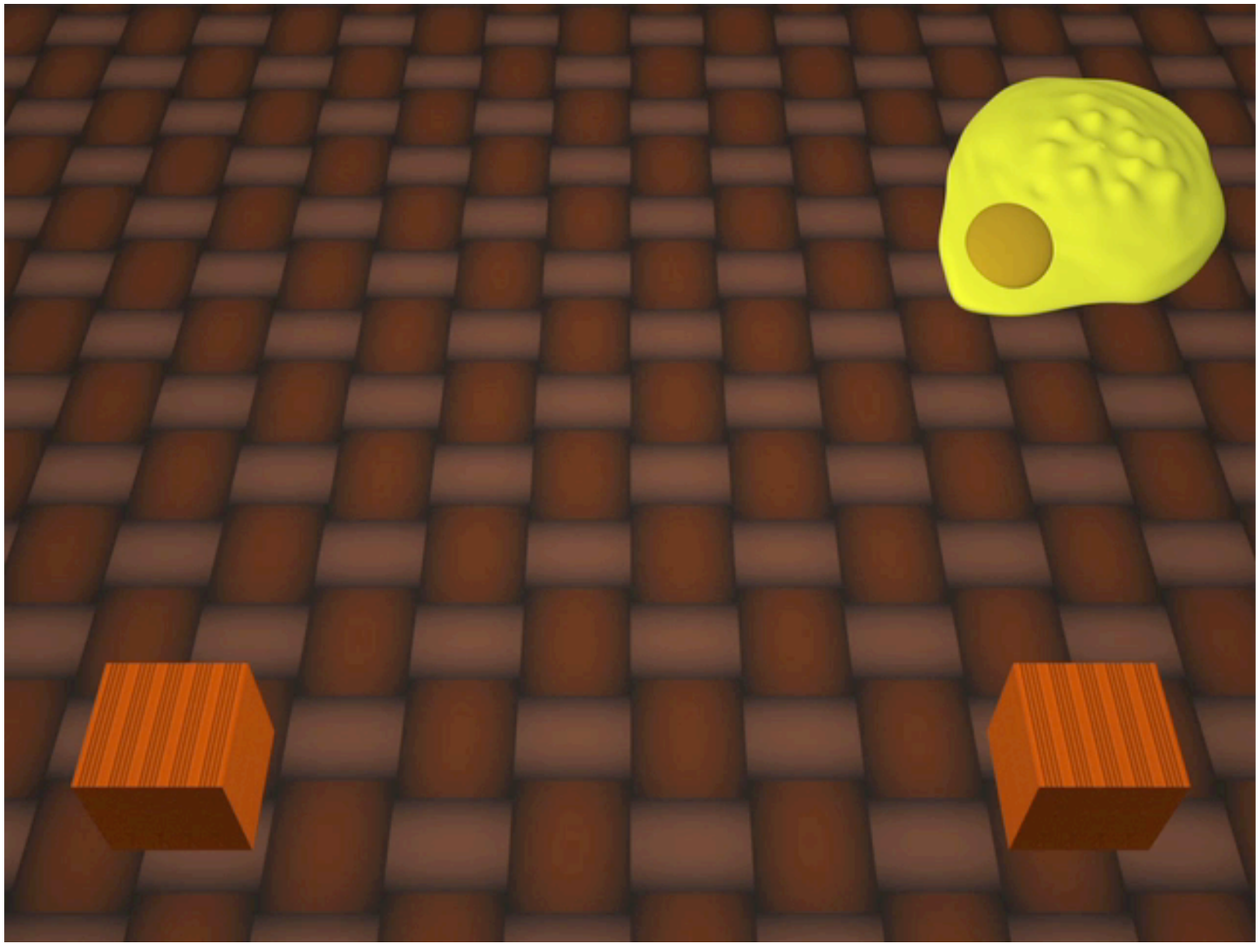


TRUE BELIEF:

No Relevant Information to convey to the Naive Agent!

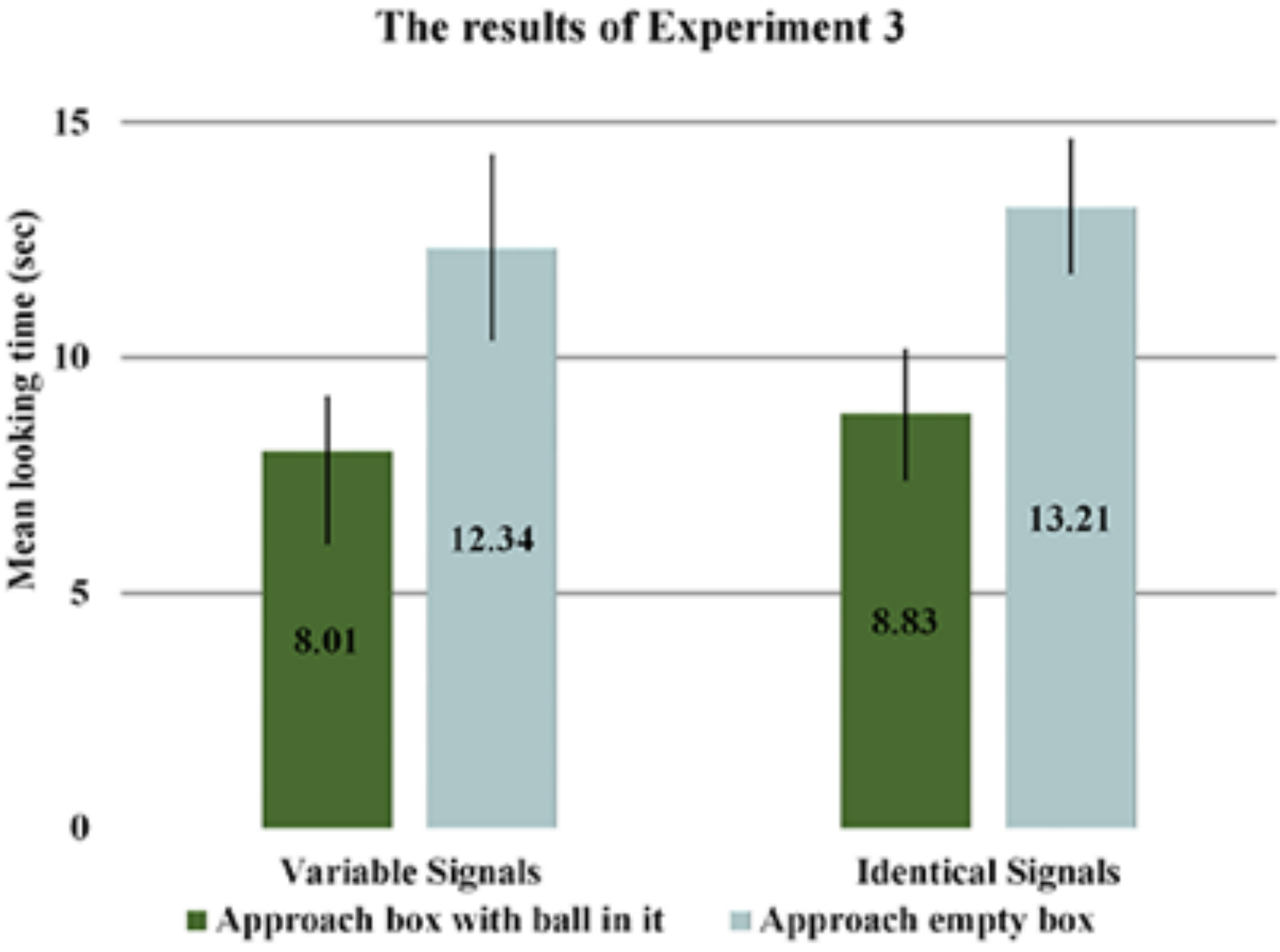
True Belief Control: Test Phase

No Ostensive Communication before Object Search



True Belief Control: Test Phase

No Ostensive Communication before Object Search



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

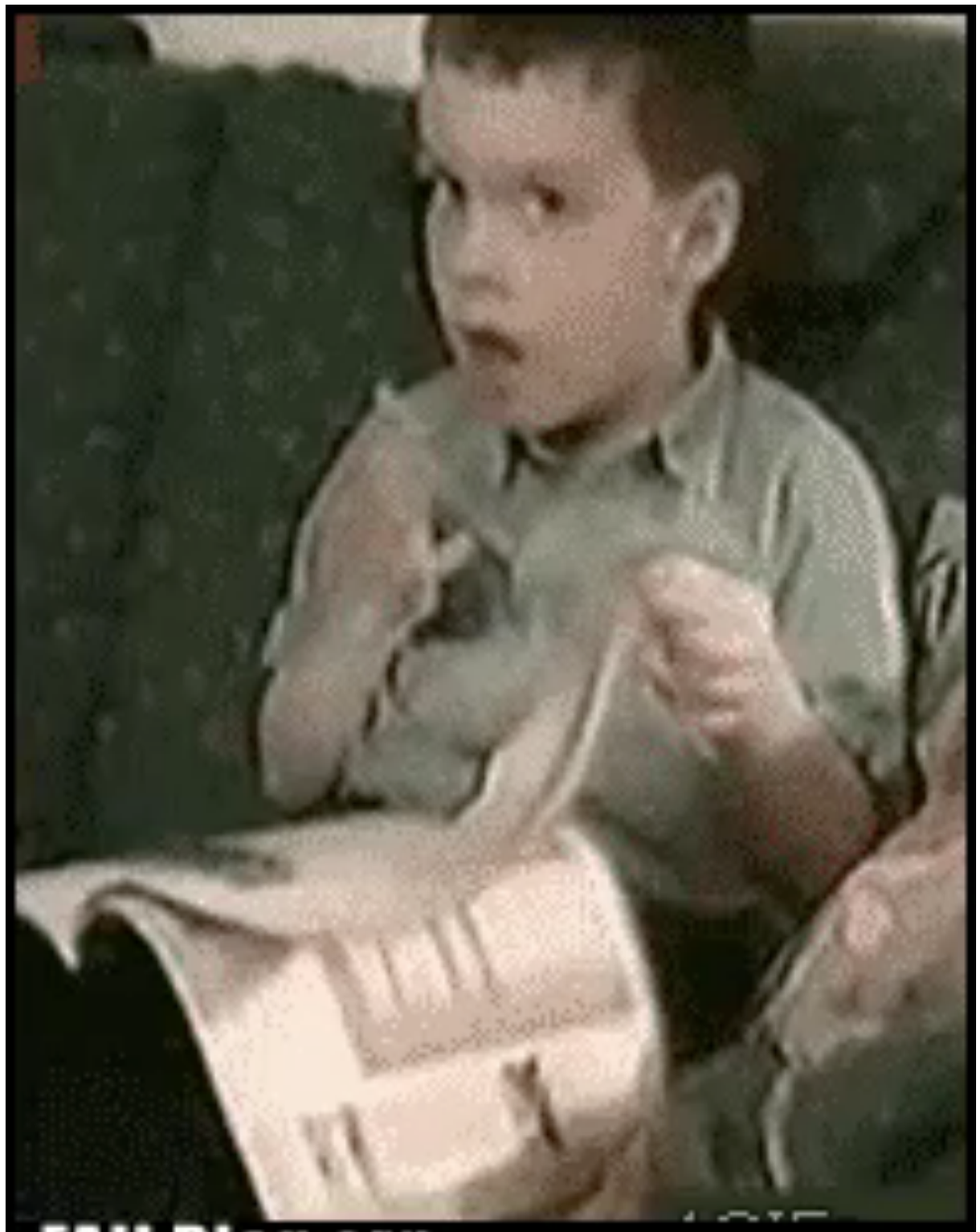
(i. e., **without** the necessity to employ **code-based linguistic mapping devises to encode their intended meaning).**

THANK YOU!

Thanks to

Tibor Tauzin
Erno Teglas

Gergo Csibra
Dan Sperber
Mikolaj Hernik
Ildiko Kiraly
Pierre Jacob



Thanks to

ERC Synergy Grant