Invited Talk at the Symposium *"From implicit to explicit cognition. The cognitive development in childhood"*, 26th September 2014, Krakow, Instytut Psychologii, Uniwersytet Jagielloński

Perception of 'Pure' Communication in preverbal Infants:

Detecting Information Transfer and Communicative Agency in Turn-taking Contingent Interactions

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'Kinds of Agents'

Gergely, 2010

Two specialized cognitive adaptations in humans for understanding

(A) Instrumental Agency and Actions

Instrumental Action Goals: *To change the physical world*

The infant's naïve theory of Rational Action:
The Teleological Stance and Implicit Theory of Mind

Gergely & Csibra, 2003, *Trends in Cog Sci*

(B) Communicative Agency and Actions

Epistemic Action Goals: *To change the other's mind*

Core Cognitive Adaptations for Cultural Learning in humans

THE GATES OF KNOWLEDGE

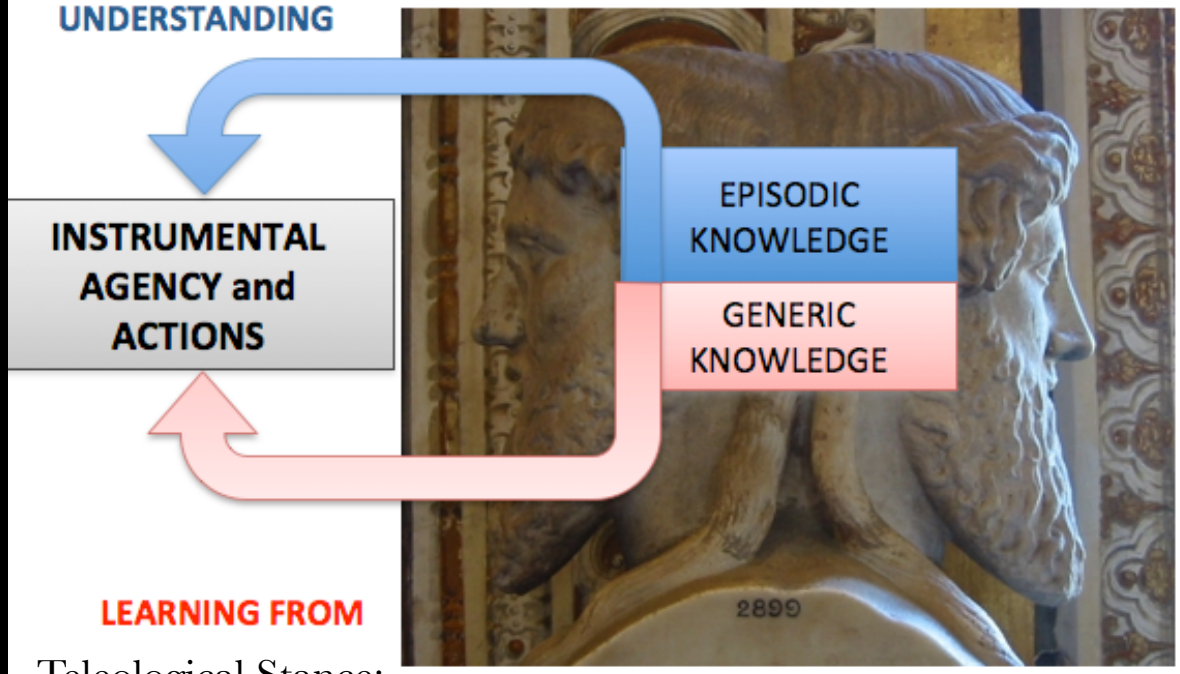
Arch of Janus in the Foro Boario in Rome

Core Cognitive Adaptations
Enabling the Inter-generational Transfer of Shared Cultural Knowledge in human social groups

Basic Cognitive Systems selected as specialized adaptive mechanisms for different epistemic domains

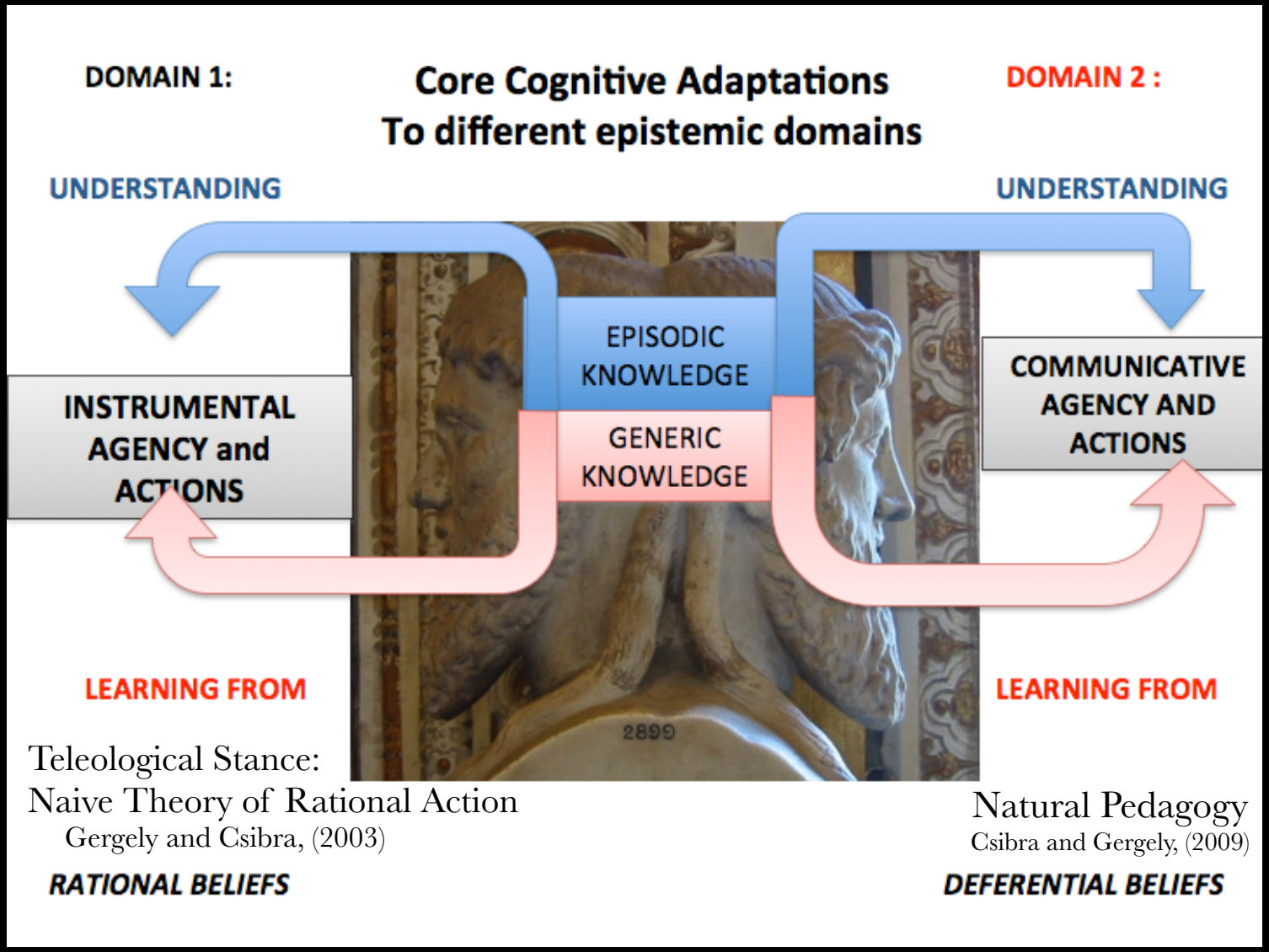
DOMAIN 1:

UNDERSTANDING



Teleological Stance:
Naive Theory of Rational Action
Gergely and Csibra, (2003)

RATIONAL BELIEFS

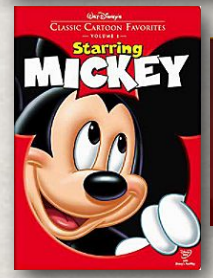

DOMAIN 1:
Core Cognitive Adaptations
To different epistemic domains
DOMAIN 2 :
UNDERSTANDING
UNDERSTANDING
EPISODIC KNOWLEDGE
GENERIC KNOWLEDGE
INSTRUMENTAL AGENCY and ACTIONS
COMMUNICATIVE AGENCY AND ACTIONS
LEARNING FROM
LEARNING FROM
Teleological Stance:
Naive Theory of Rational Action
Gergely and Csibra, (2003)
RATIONAL BELIEFS
Natural Pedagogy
Csibra and Gergely, (2009)
DEFERENTIAL BELIEFS

Ostensive Communicative signals and The Unique Morphology of the Human Eye

Orangutan

Human

- Human eyes differ in morphology from that of other primates. They are
  - wider horizontally,
  - expose higher proportion of the sclera, and
  - the sclera is white



- This morphological difference is complemented by special sensitivity to high contrast elements of eyes in humans

The Bogart Illusion

Evolved sensitivity to Signals of Communication in human infants

Ostensive and Referential Cues

Orangutan

Human

- Cues function to engage and direct other's attention to new and relevant information

Addressing Cues => ***Communicative Intention***

(eye-contact, motherese, turn-taking)

⬇

Referential Cues => ***Intended Referent***

(gaze-shift; pointing)

⬇

Demonstrative Cues => ***Informative Intention***

('motionese' gestural displays)

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 (Informative Intention)***

Ostensive Cues Trigger Referential Expectation

OSTENSION => REFERENCE

Ostensive Cues => Signal ***Communicative Intention***

to convey

New and Relevant Information about a Referent =

Informative or Referential Intention

followed by

=> Trigger Expectation of **Referent Identification**

Referential Cues (Gaze-shift, Pointing) => to **Identify the Referent**

=> Trigger **Gaze-following to the Referent**

OSTENSIVE SIGNALS

that human infants evolved innate sensitivity and preparedness for:

1. ***Eye-contact***

=> followed by Referential cues => induces Gaze-following to Referent

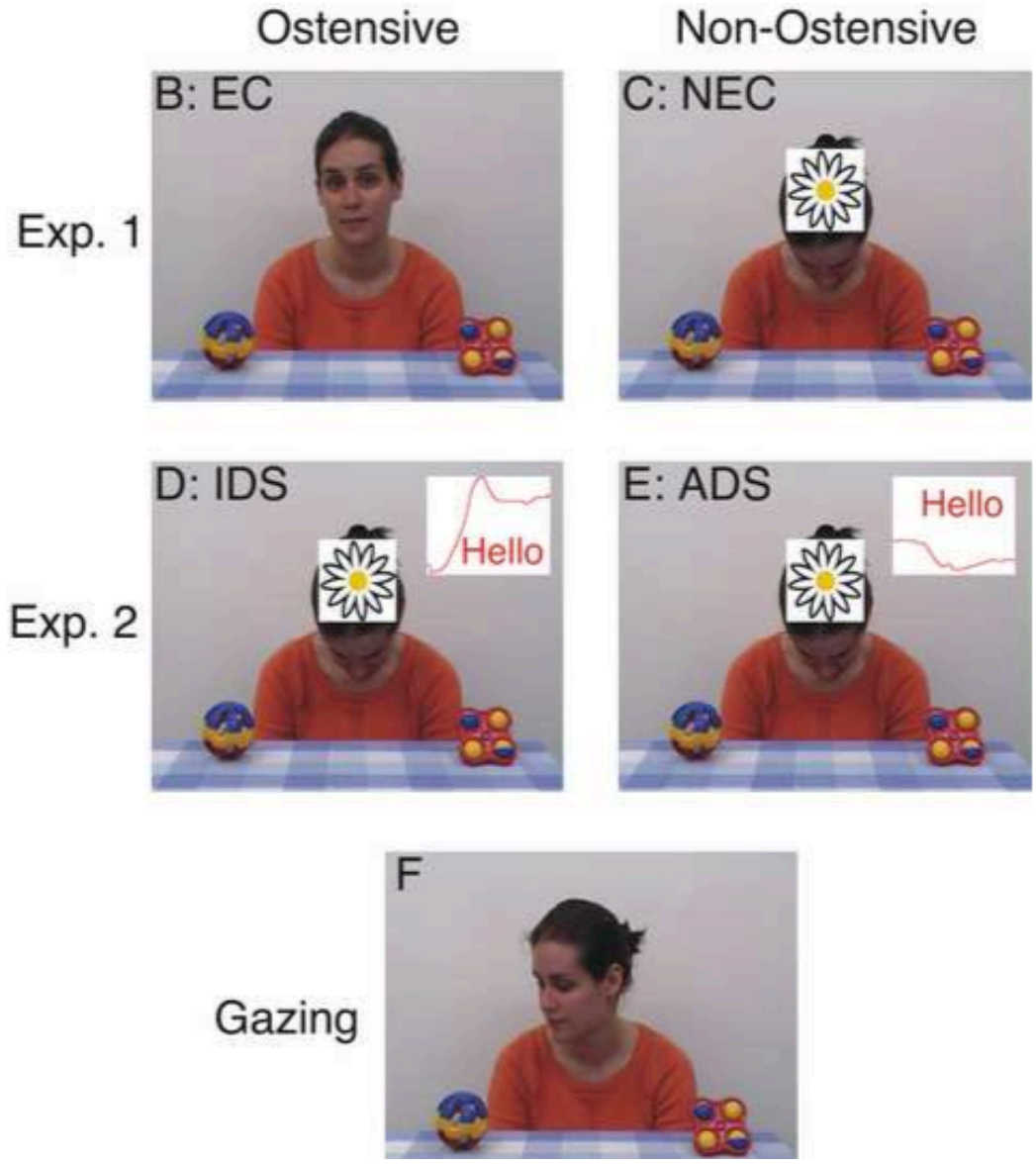
2. ***Motherese***

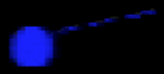
=> followed by Referential cues => induces Gaze-following to Referent

3. ***Turn-taking contingent reactivity***

=> followed by Referential cues => induces Gaze-following to Referent

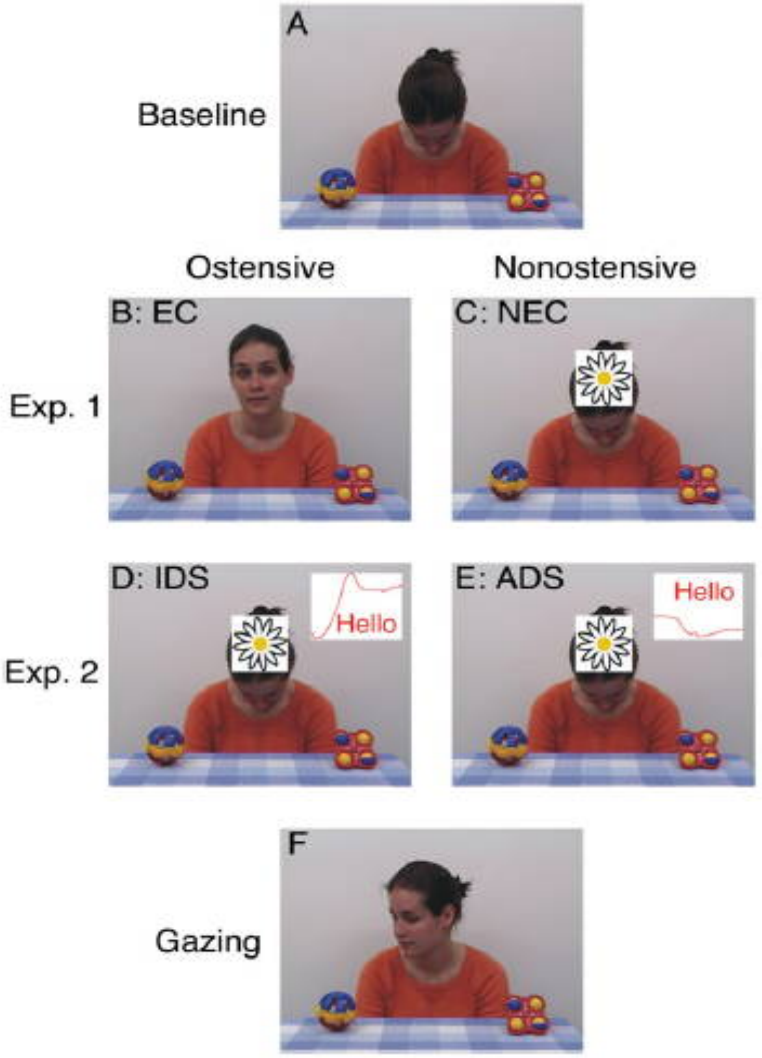
Referential Gaze Following is Dependent on the Presence of Ostensive Signals in Infants

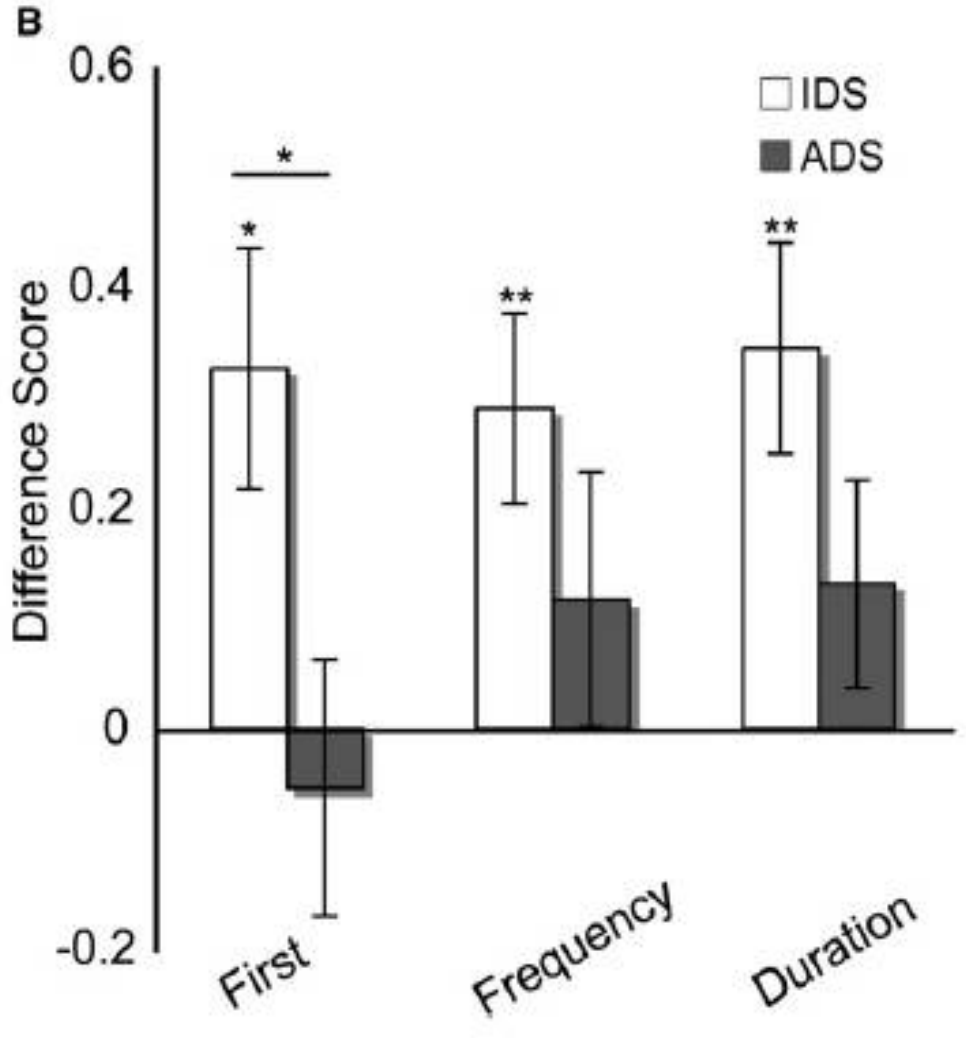




Motherese induces gaze-following to referent at 6 months

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





Brain Responses to Ostensive Signals

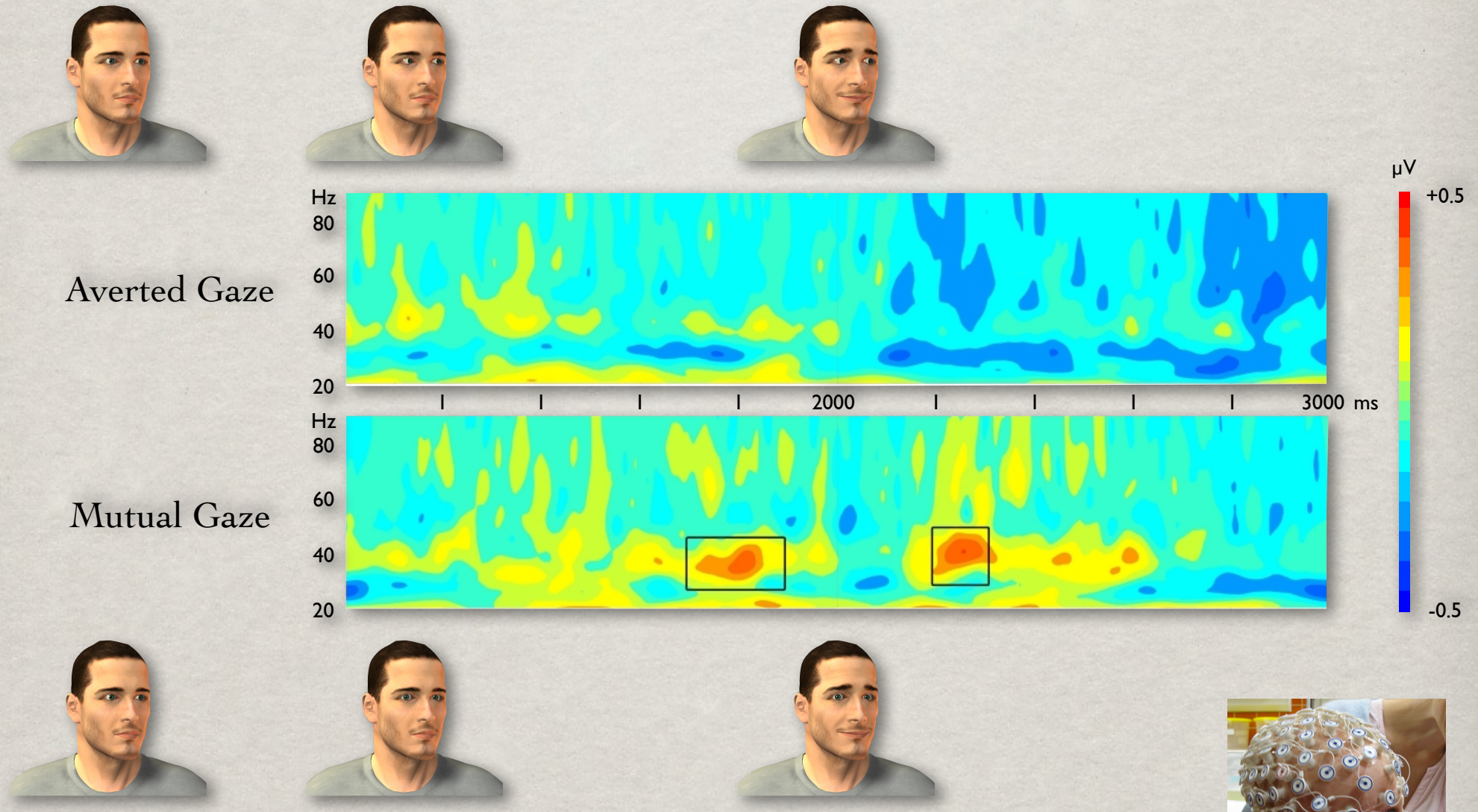
in 4-month-old infants

Mutual Gaze

Averted Gaze

Grossmann et al., 2008

Brain Responses to Ostensive Signals



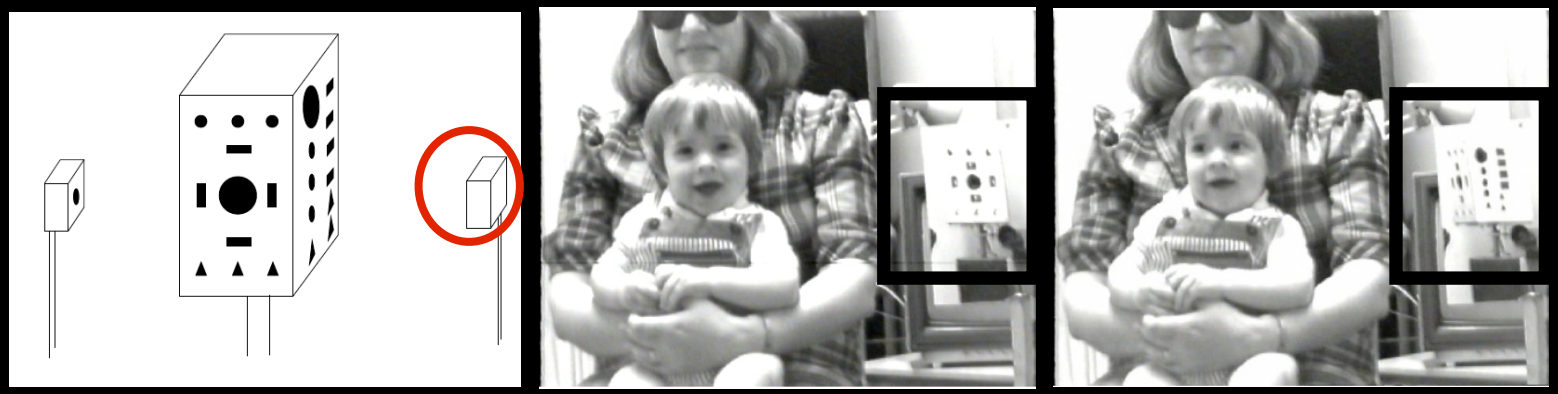
Frontal Gamma-band EEG Oscillations in 4-month-olds

Grossmann et al., 2008

CONTINGENCY DETECTION & ORIENTATION FOLLOWING IN INFANTS

Infant-induced (R-S) - 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)

=> R-S Contingent Reactivity induces attribution of *Social Intentional Agency* to the robot

John S. Watson's classical demonstration of Contingency Seeking:
10-month-old discovers an unfamiliar non-human robot's
Contingent Reactivity at a distance (Movellan & Watson, 1996)

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

Hypothesis> High-but-Imperfect Contingent Reactivity is a cue of
SOCIAL INTENTIONAL AGENCY - implying *Perception*, *Attention*, and *Voluntary Control*

Motion sensors

gyroscopes/
accelerometers

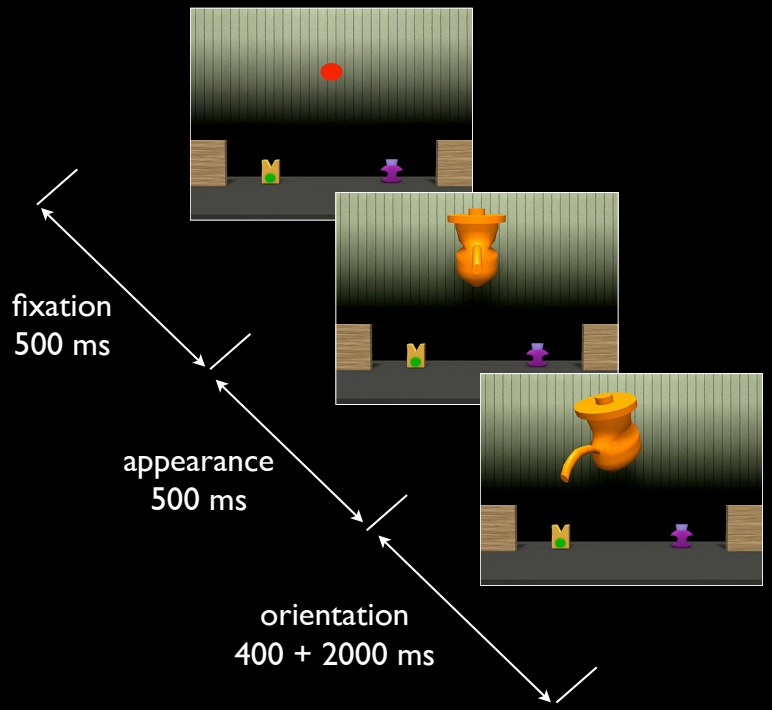
space shuttles

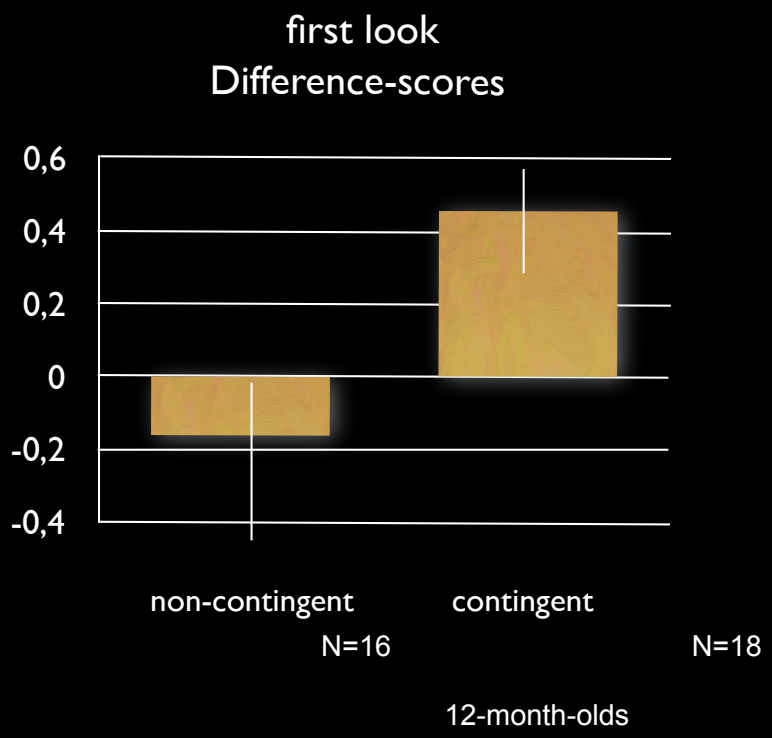
video game controllers, photo cameras, phones

mouse

EXPERIMENT 1 - ORIENTATION FOLLOWING

EXPERIMENT 1 - ORIENTATION FOLLOWING





Results:

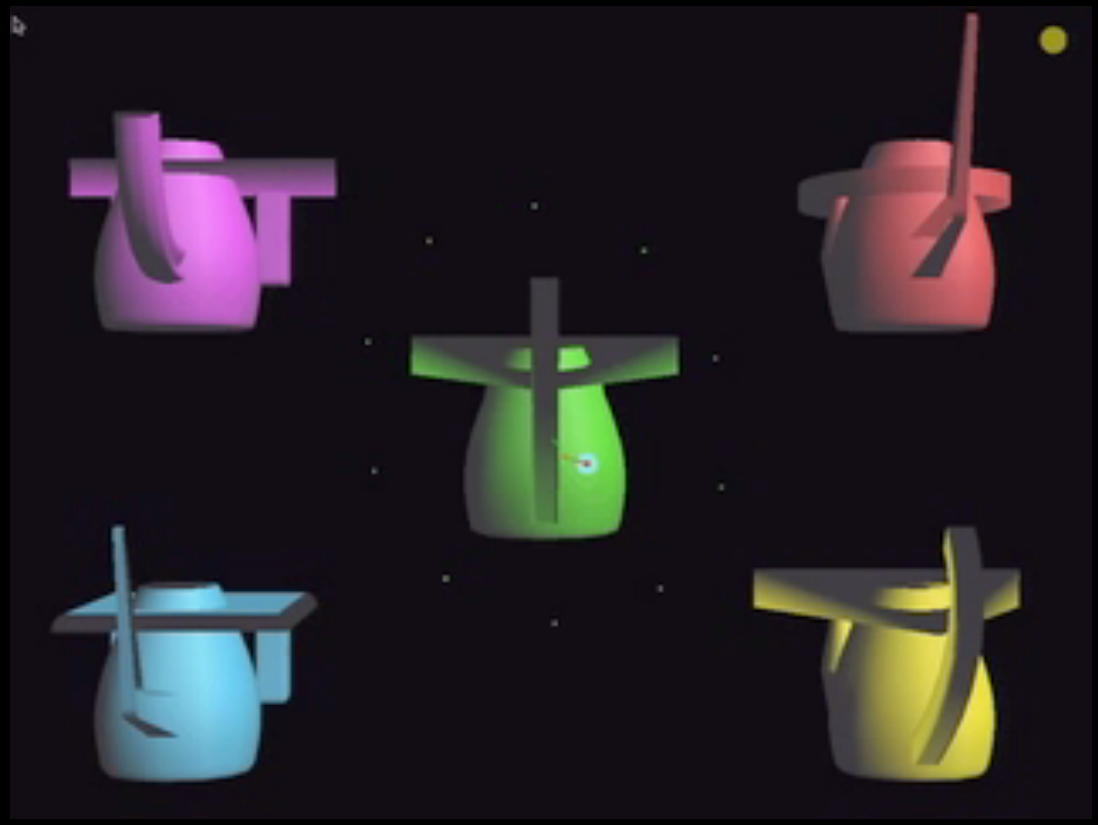
=> 12-month-olds whose leg-kicking induced contingent reactivity of the target object followed the object's orientational movement cue to the target

=> Infant-induced *turn-taking contingent reactivity functions* as an *ostensive referential cue* resulting in the *attribution of Communicative Agency*

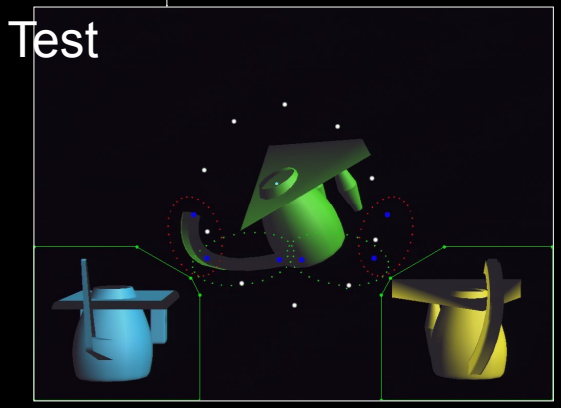
=> This induces in 12-month-olds ***referential expectation*** and consequent ***gaze-following*** of the agent's orientational movement cue to identify the referential target object

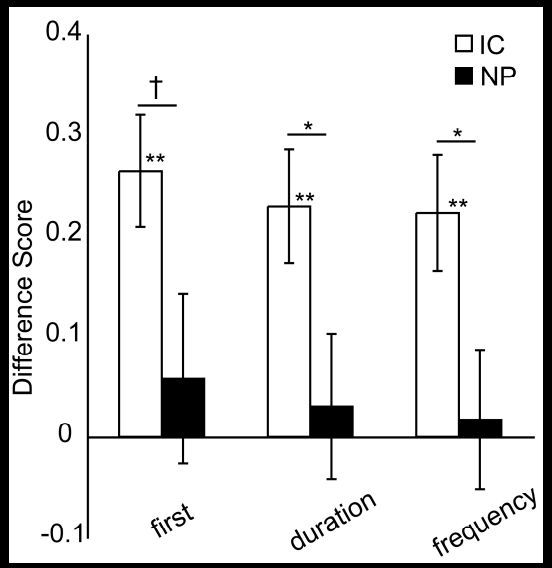
=> Results of Experiment 1 are in line with earlier findings (Movellan and Watson, 1998, 2002; Johnson, Slaughter & Carey, 1998)

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



8-month-olds: Two groups
(A) Infant-induced Contingent Reactivity versus
(B) Non-Contingent Random Activity





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

Questions yet to be answered:

1. 2nd-Person vs. 3rd Person Perspective

- Do infants attribute Communicative Agency when observing turn-taking contingent interactions from a 3rd-Person perspective?

2. Necessary and Sufficient Cues

- Do turn-taking contingencies provide *sufficient* informative cues to induce attribution of communicative agency on their own?

or

- Are additional *cues of intentional and/or social agency* also necessary?

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

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

- Why do infants gaze/follow to fixate the referent?

> *Alternative Interpretations of Referential Actions:*
> ***Seeing*** *vs.* ***Showing***

- 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) ?

The 'Flat-Fish' studies:

Tibor Tauzin & Gergely (in prep.)

10-month-olds observing
Agent-to-Agent Turn-Taking Contingent Interactions
from a 3rd-person perspective

Two levels of Contingencies studied:

High-but-Imperfect Contingencies Perfect Contingencies

Condition 1:
(a) Partial variability vs. Condition 2:
(b) Identical repetition

According to the information processing approach to communication (Channon, 1948)

- The function of communication is to ***transmit information***.
- ***Information*** is related to the ***unpredictability*** in a message.
- Hypothesis:
- Human infants' evolved *special sensitivity* to detect

the ***relative unpredictability*** *of contingent behavioral sequences* in turn-taking interactive exchanges

as cues of potential ***information transfer***
that sanction the attribution of ***communicative agency***

Taking an information processing approach to communication (Channon, 1948)

> A new hypothesis:

Perceived Unpredictability functions as a cue to potential

Information Exchange

This can account for why turn-taking exchanges of

lower-than-perfectly contingent behavioural signals

(i) Lower-than-perfect contingency >

=> *indicates relative Unpredictability*
of the Behavioral Signal Sequences Exchanged

=> *cues potential Information Transfer*

(ii) Perfect Contingency >

=> *indicates full Predictability*

=> *no Information Transfer is possible*

Prediction:

Only turn-taking interactions that *involve relative unpredictability* of the contingent behaviour sequences will induce attribution of

> Communicative Agency and Referential Intention

> Hence Referential Gaze-following by the infant

i.e.

Imperfect contingencies > Referential Gaze-following

Perfect Contingencies > NO Referential Gaze-following

Observing Third-Party (S-S) Contingent Interactions
Turn-Taking Exchange of Contingent Signal Sequences

Familiarization Stimuli:

Two stationary unfamiliar entities who exchange contingent **series of sound signals** alternating in a turn-taking manner

The serial structure of the melodic tone triplets exchanged:

(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	-	GOK
GUL	-	GAP
...		
DBO	-	DTJ
DKY	-	DJR

Turn-Taking Exchange of Contingent Signal Sequences

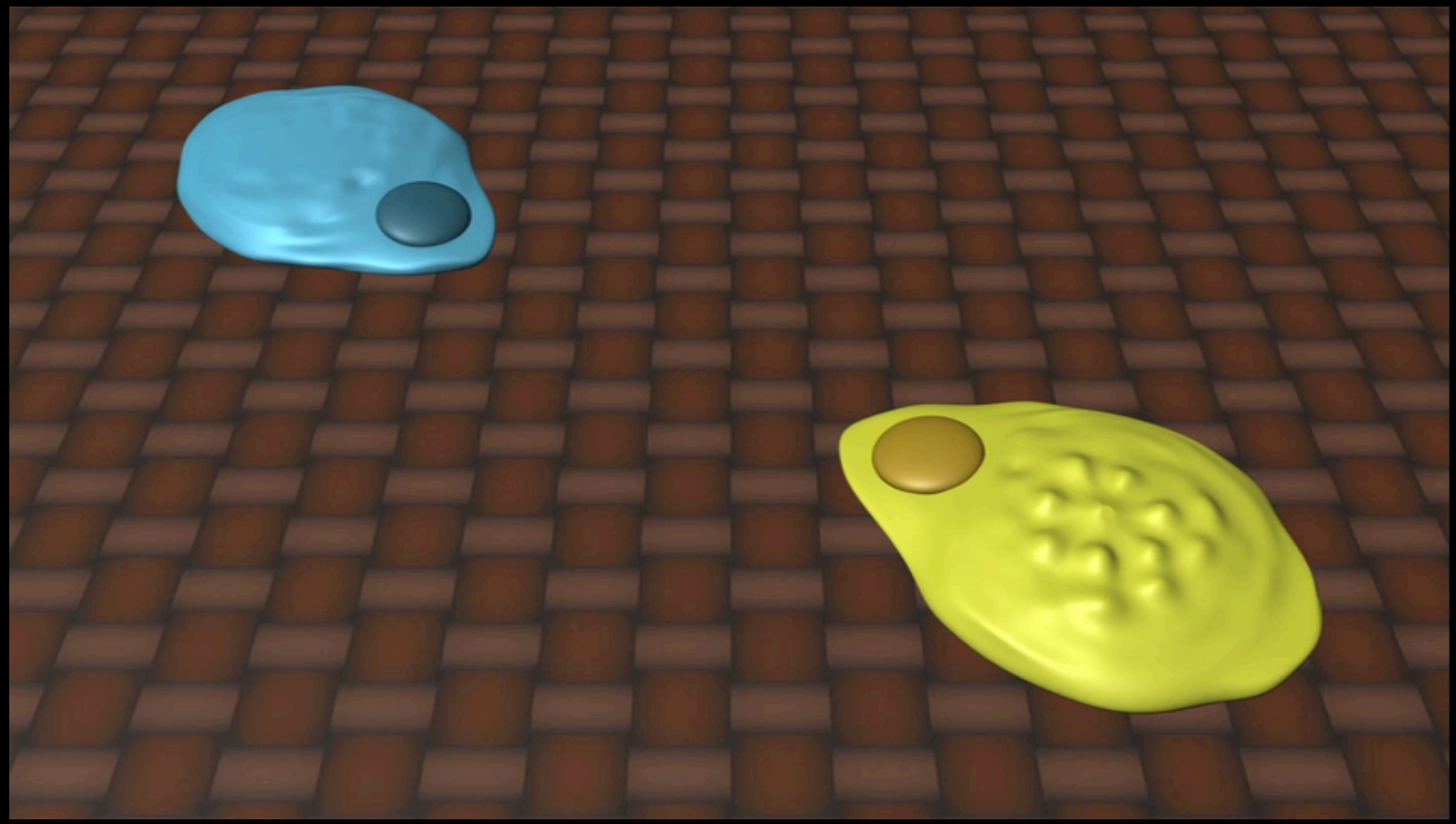
Hign-but-Imperfect Contingency (Unpredictability Present)

(1a) 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



Turn-Taking Exchange of Contingent Signal Sequences

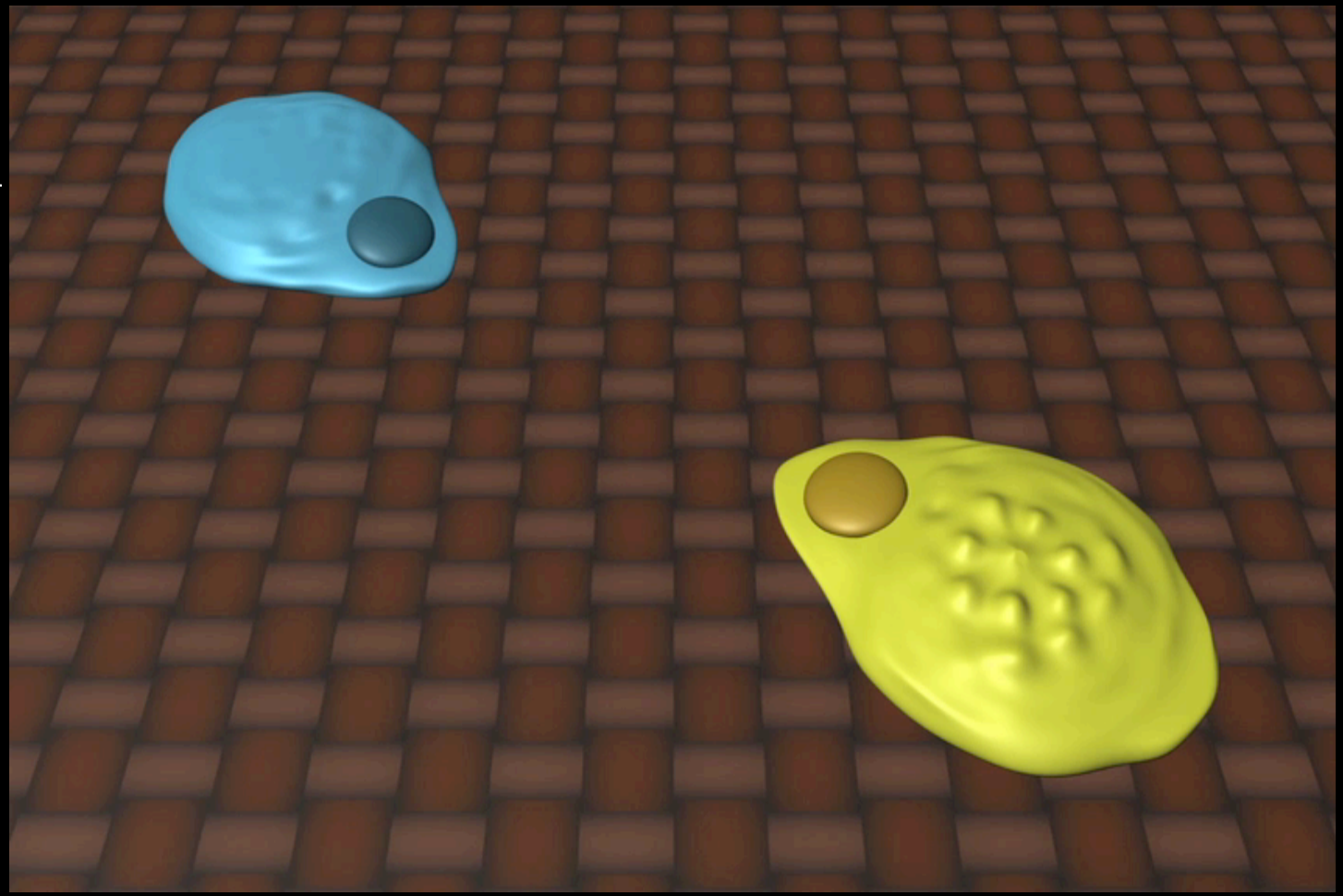
Perfect Contingency (No Unpredictability)

(1b) The "Echo"

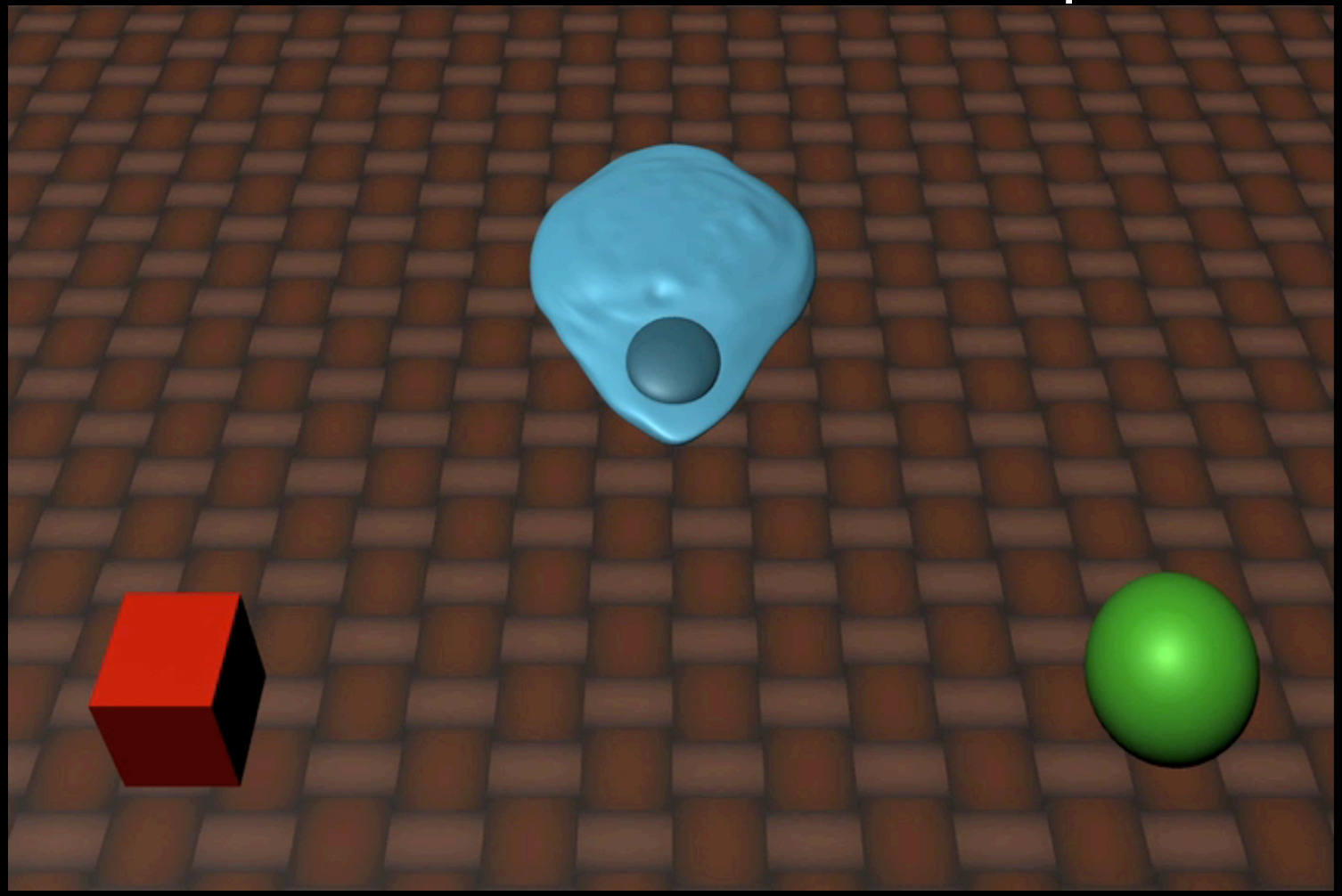
Identical Content Repetition condition

Sound Signal Sequences: **Morse Code Beeps**

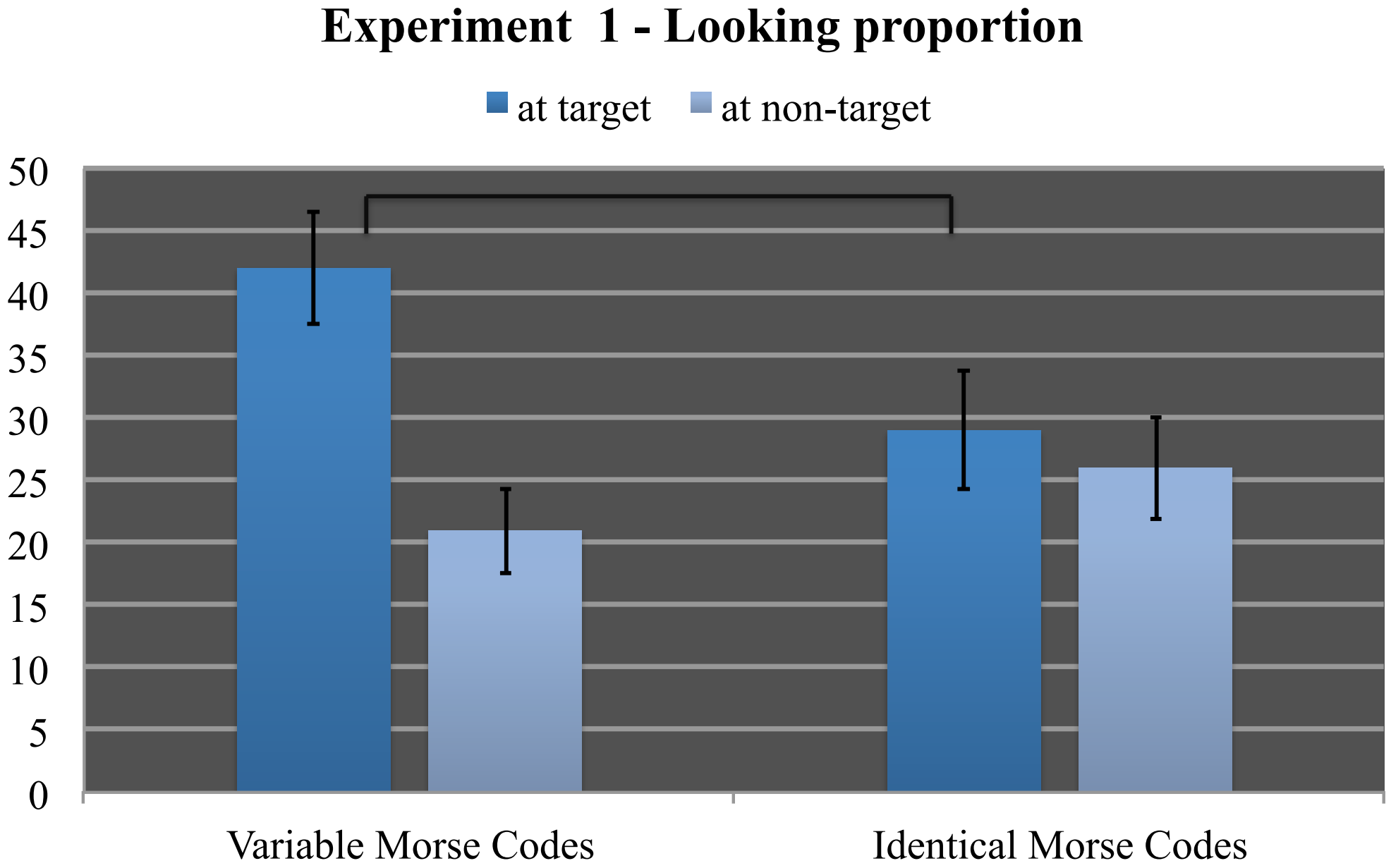
AGENT-1		*AGENT-2*
ABC	-	ABC
AFG	-	AFG
...		
GRJ	-	GRJ
GUL	-	GUL
...		
DBO	-	DBO
DKY	-	DKY



Test Phase
Orientational Cue => Referential Interpretation?



Do 12-month-olds gaze-follow the 'Blue Fish's orientation to target as a function of turn-taking contingent vocal reactivity?


Experiment 1 - Looking proportion
at target
at non-target
50
45
40
35
30
25
20
15
10
5
0
Variable Morse Codes
Identical Morse Codes

Turn-Taking Exchange of Contingent Signal Sequences

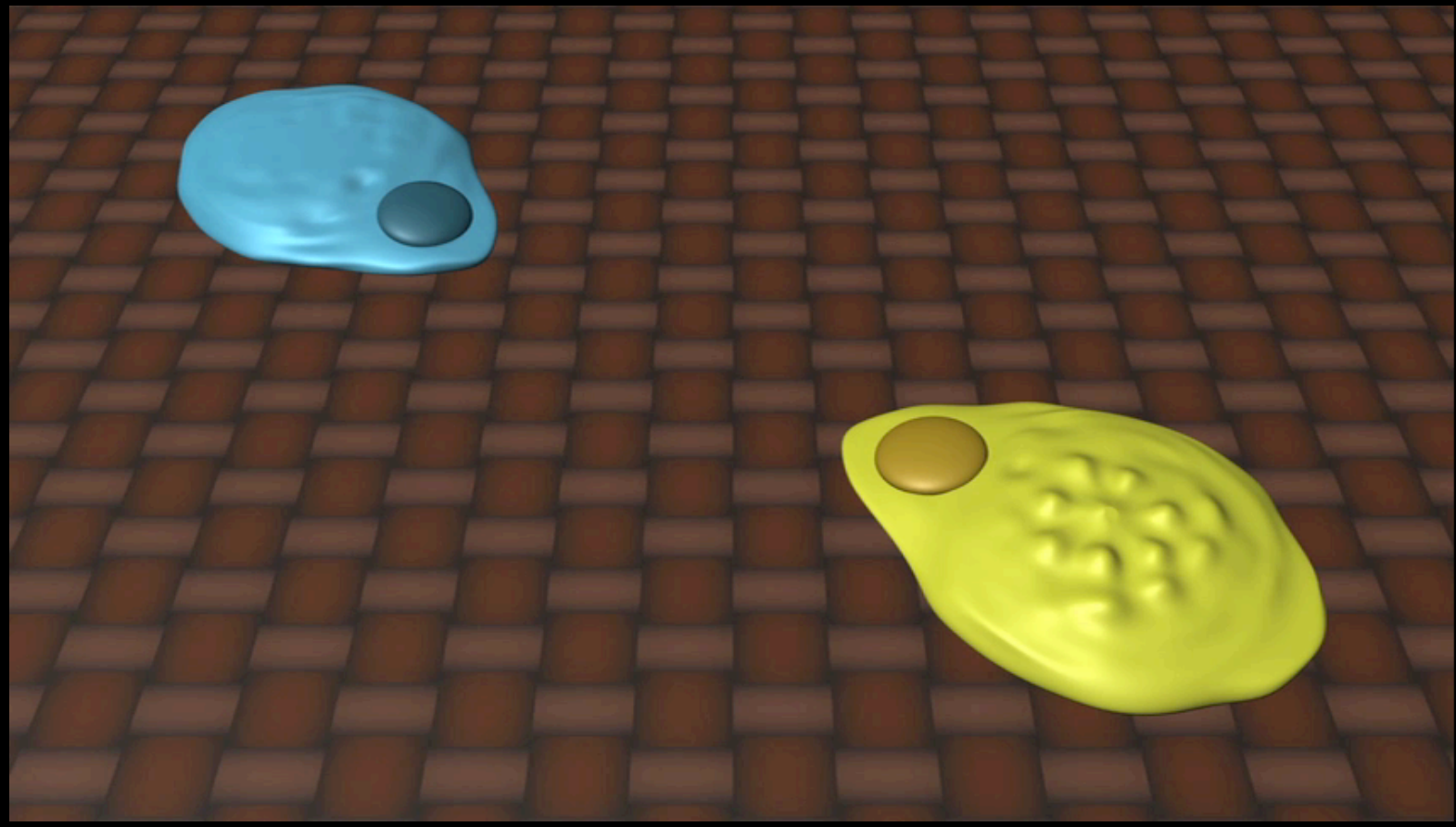
Hign-but-Imperfect Contingency (Unpredictability Present)

(2a) **The "Conversation"**

Partial content variability condition

Sound Signal Sequences: **Melodic Tones**

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



Turn-Taking Exchange of Contingent Signal Sequences

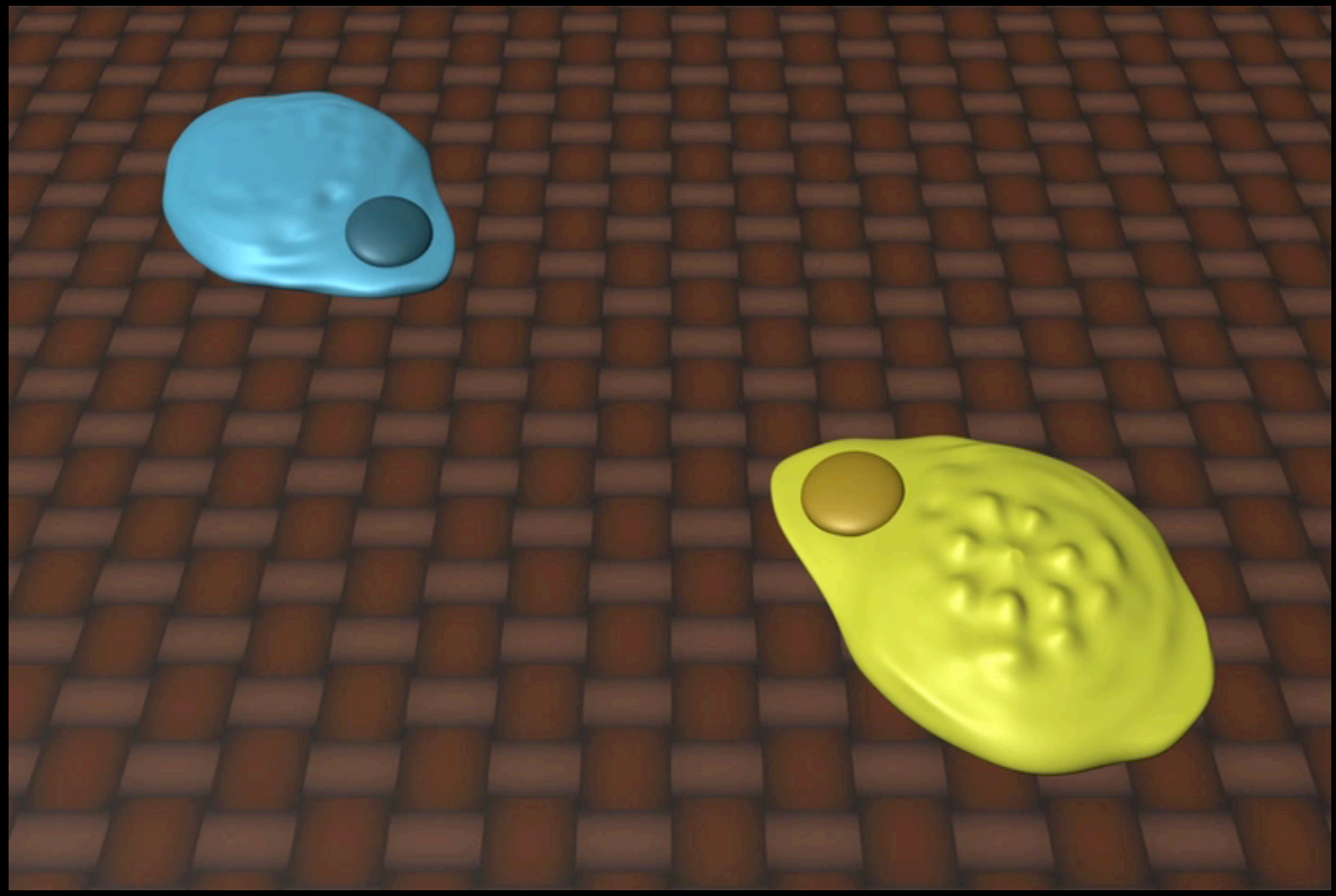
Perfect Contingency (No Unpredictability)

(2b) The "Echo"

Identical Content Repetition condition

Sound Signal Sequences: **Melodic Tones**

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



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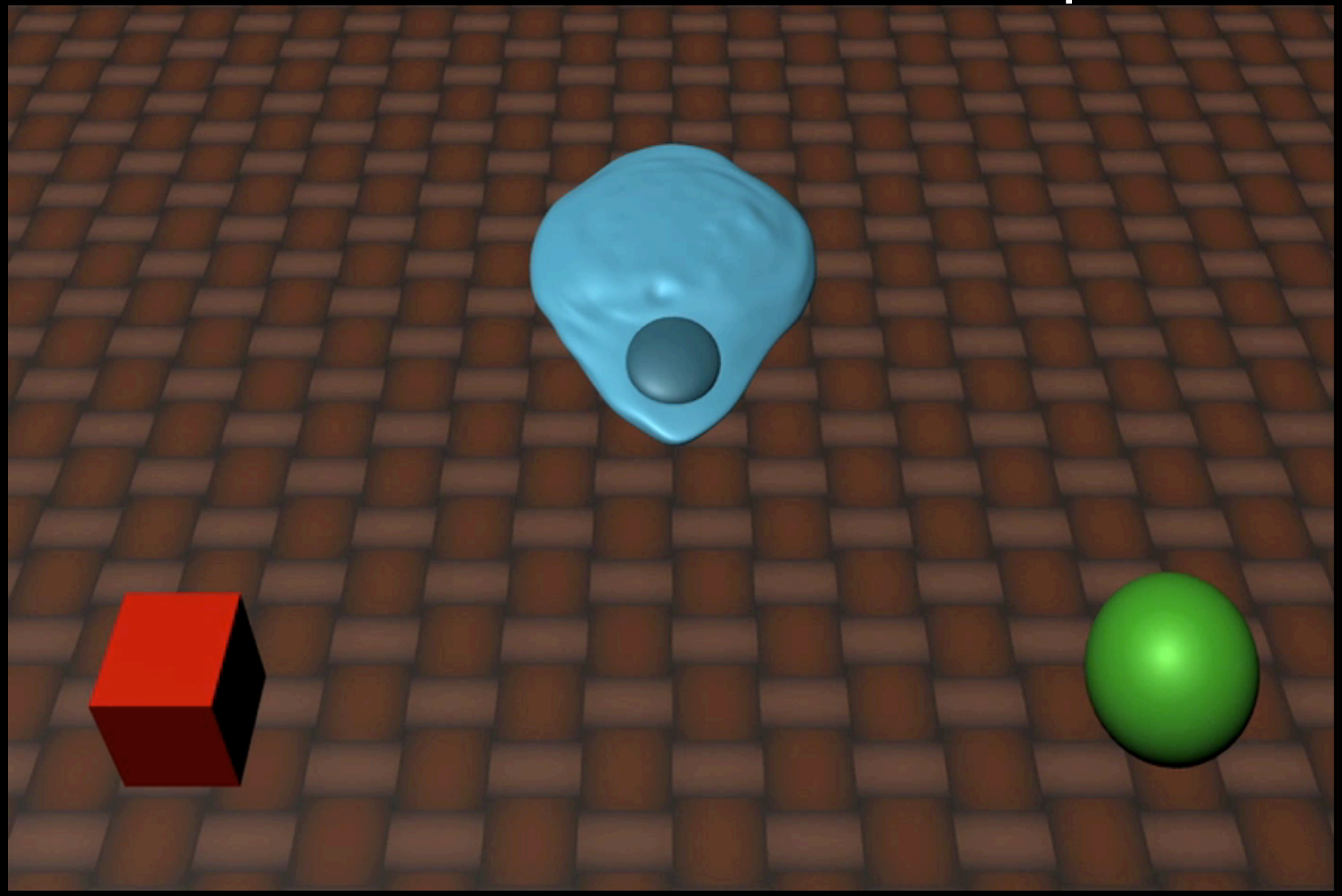
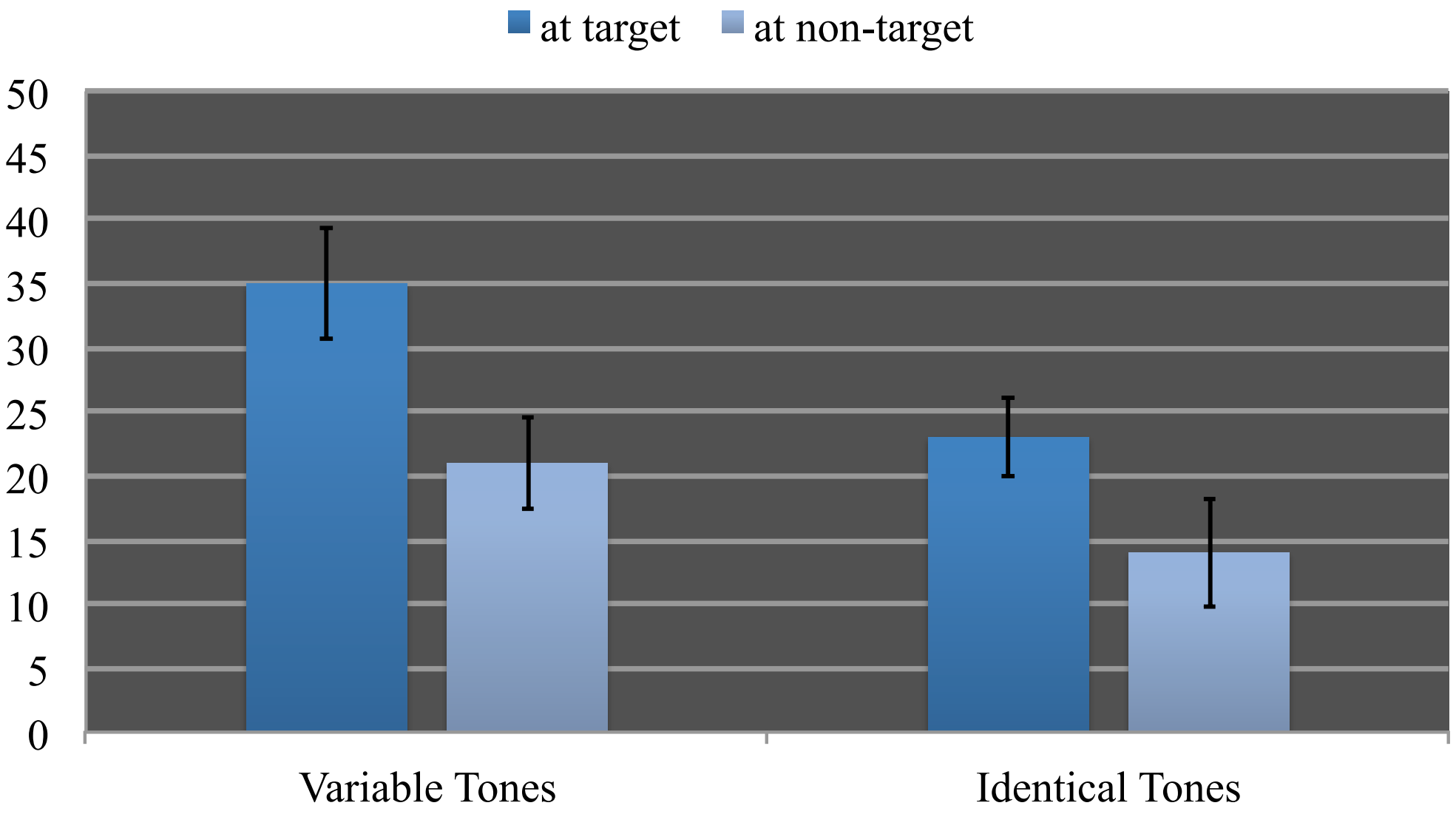
Orientational Cue => Referential Interpretation?



Do 12-month-olds gaze-follow the 'Blue Fish's orientation to target as a function of turn-taking contingent vocal reactivity?

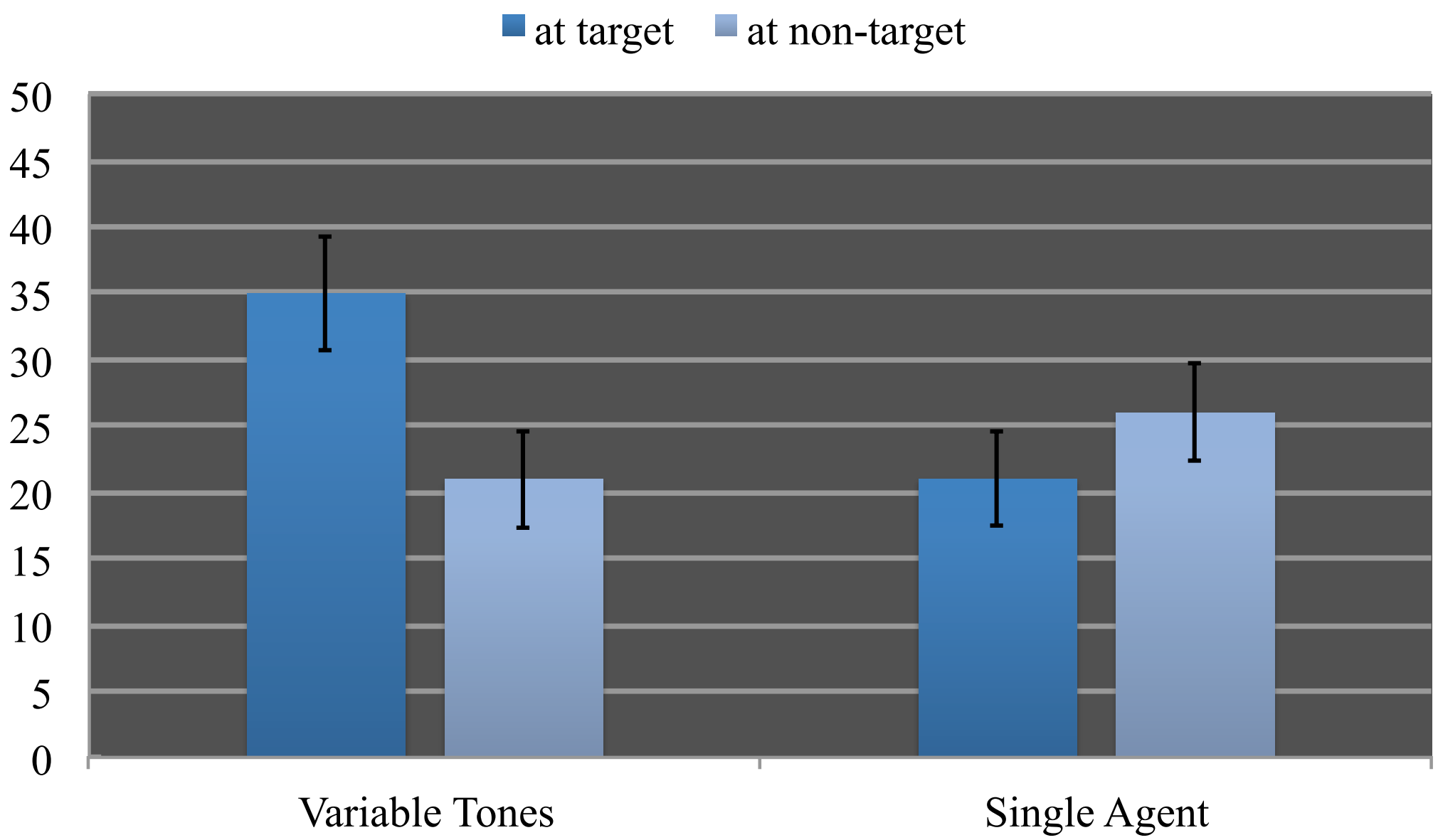
Melodic Tone Sequences

Experiment 2 - Looking proportion



Partial content variability condition

SINGLE AGENT CONTROL



The perception of 'pure' communication in preverbal infants

The "Conversation" Study:

1. Preverbal 10-month-olds (without knowing symbolic signals and/or their meanings):

—> <u>Detect Communication</u>:

<u>Cue</u>: *Unpredictability of Compositional Content* of the Contingent Signal Sequences Exchanged

The perception of 'pure' communication in preverbal infants

- Perceived Unpredictability allows preverbal infants to identify the type of behavioral interactions with the potential to transfer information between communicative agents

- even *before* understanding the symbolic content that the behavioral signals encode.

Question yet to be answered:

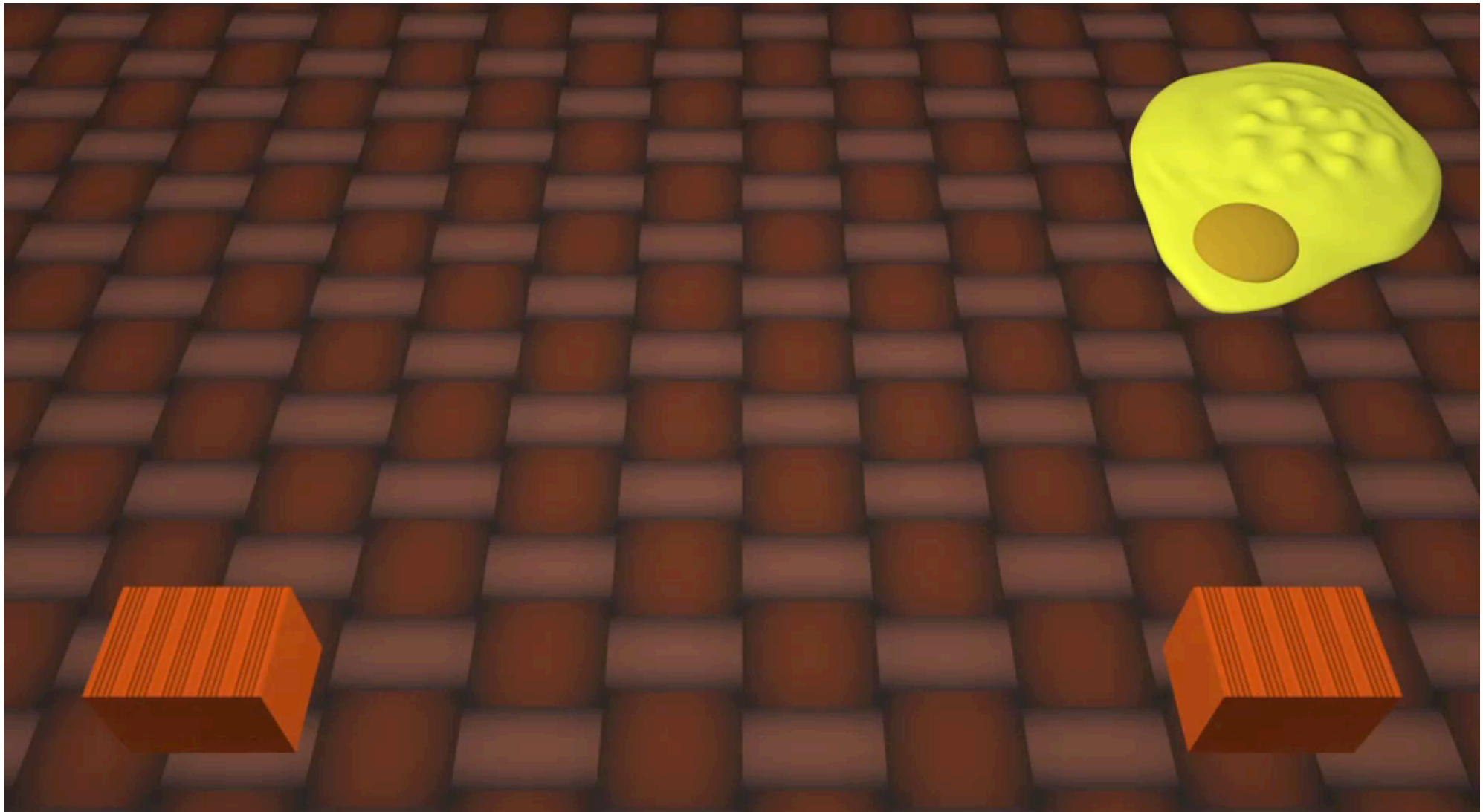
Inferring Communicative Content

- Can preverbal infants INFER the Relevant Information that the Communicative Agent intends to convey about the referent?

INFORMING:

To correct the other's False Belief

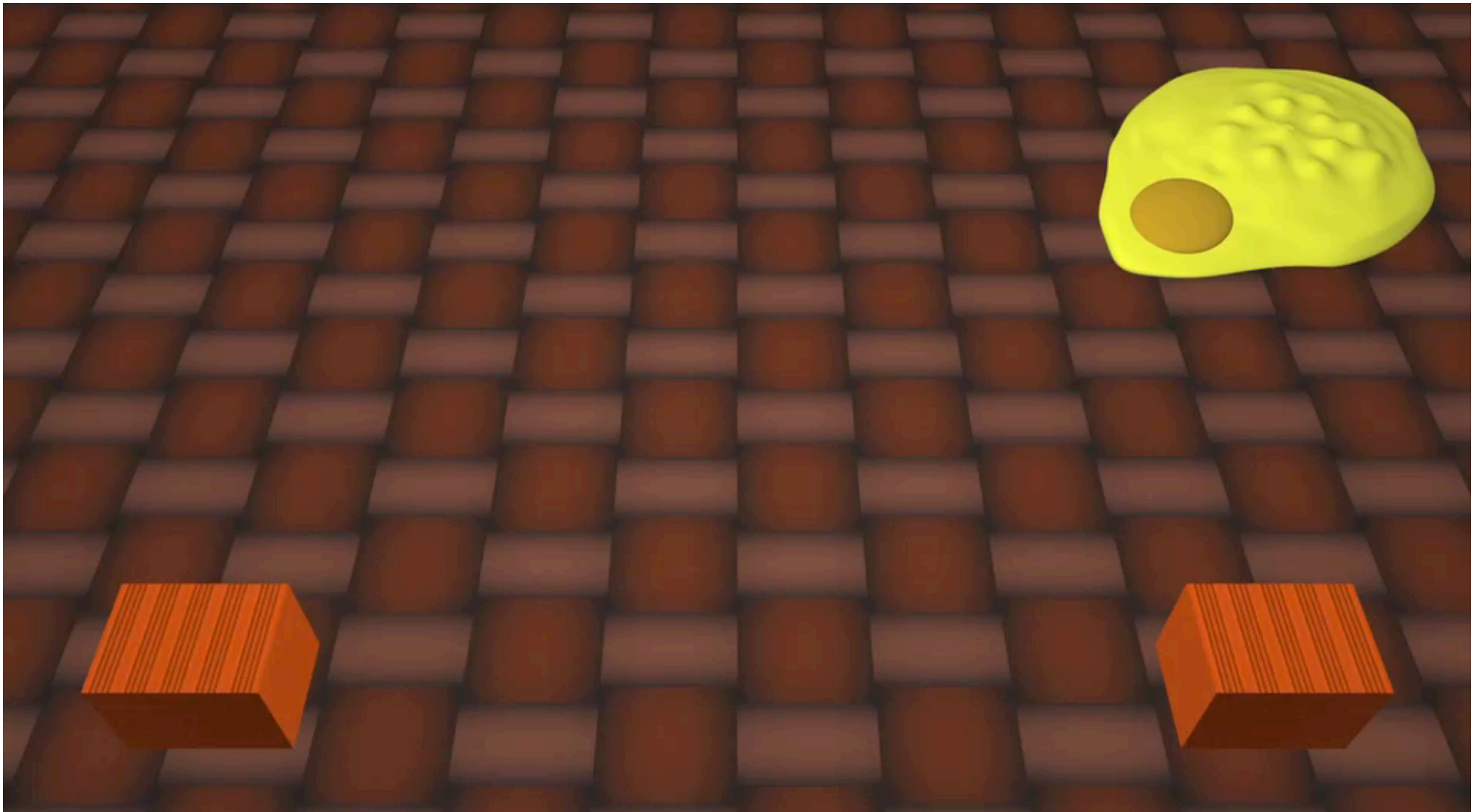
Familiarization: **Partial content variability condition**



INFORMING:

To correct the other's False Belief

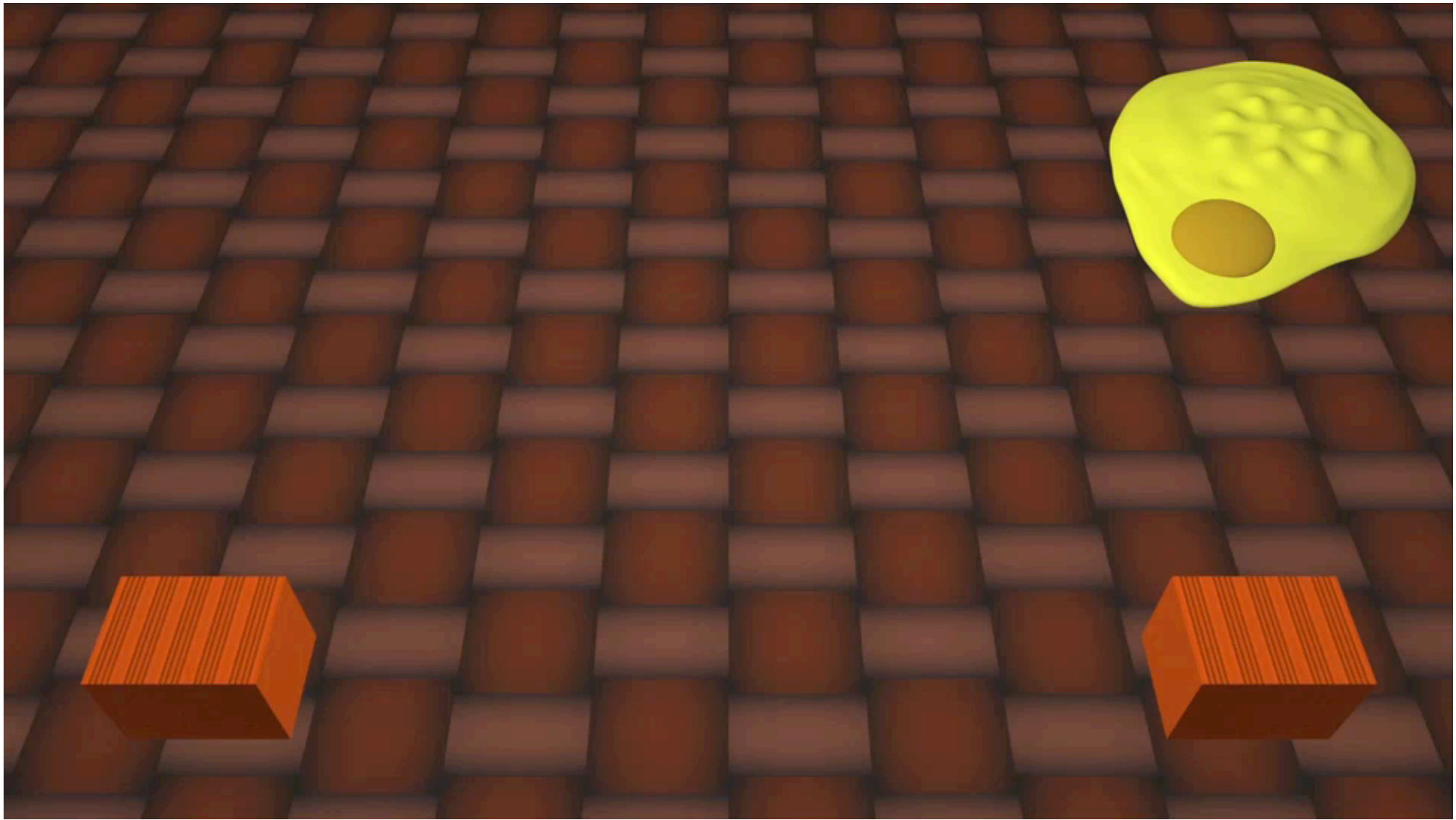
TEST PHASE: **Partial content variability condition**



INFORMING?:

No evidence for Communicative Information Transfer

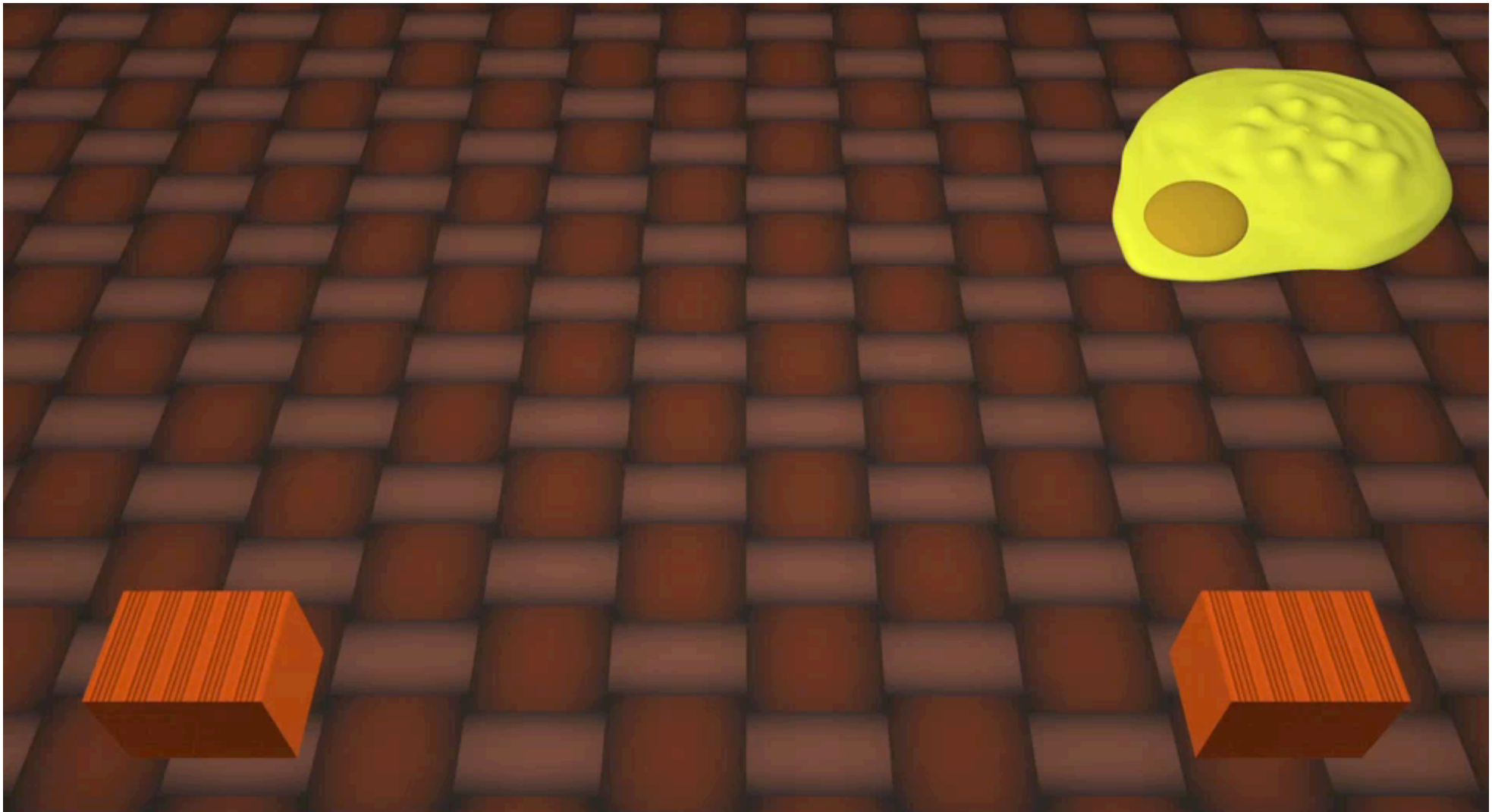
Familiarization: **Identical Content Repetition condition**



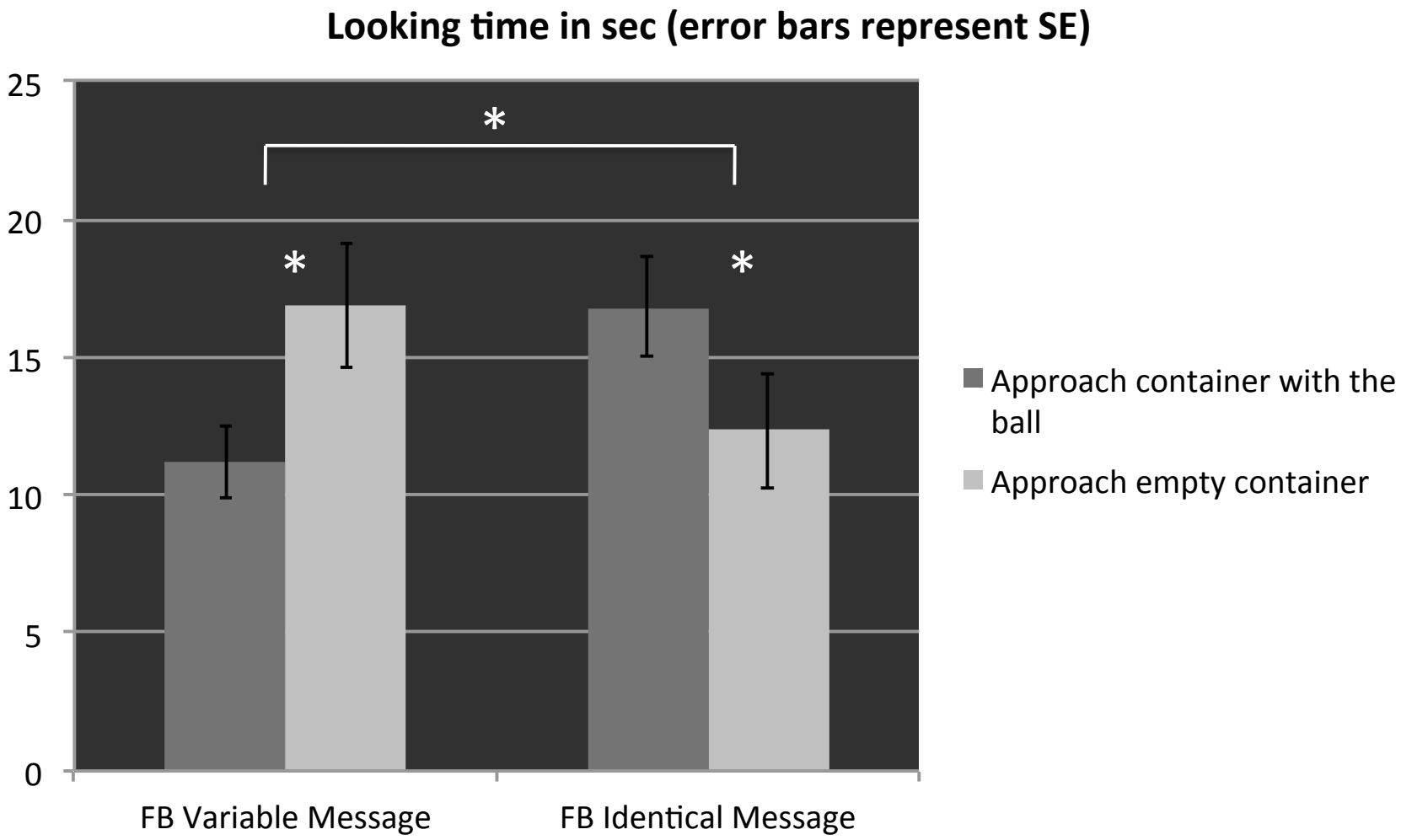
INFORMING? :

No evidence for Communicative Information Transfer

TEST PHASE: **Identical Content Repetition condition**



Looking times in false belief context



Question yet to be answered:

Inferring Communicative Content

- Can preverbal infants INFER the Relevant Information that the Communicative Agent intends to convey about the referent?

YES!!!

- But only if evidence of perceived *Unpredictability of Compositional Content* of the exchanged Contingent Signal Sequences is available:

(Partial content variability condition)

Question yet to be answered:

Note that Attribution of *Intentional Instrumental Agency* is NOT SUFFICIENT to induce Inferring Communicative Content!

Identical Content Repetition condition:

- Cues of Intentional Agency are present!

- Variability of behaviour - YES
- Reactivity at a distance - YES

- Relative Unpredictability of Compositional Content of the Contingent Signal Sequences Exchanged? NO!

THANK YOU!

in Collaboration with

Tibor Tauzin
Gergo Csibra
John S. Watson
Dan Sperber
Pierre Jacob
Erno Teglas
&
Mikolaj Hernik

Looking times in the TB conditions