Evaluating *each*- (but not *every*-) sentences encourages encoding individual properties

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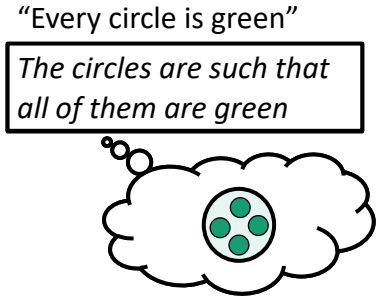
CUNY 2021 @ Penn

Big picture: meanings in mental grammar

How detailed are meaning representations?

How are they related to non-linguistic cognition?



How are universal quantifiers mentally represented?

Logical & psychological distinction

- ➥ First-order (individual-implicating) vs. Second-order (group-implicating)
- ➥ Object-files vs. Ensembles

Every-sentences trigger ensemble (group) representations

Each-sentences trigger object-file (individual) representations

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Many ways to describe “every circle is green”

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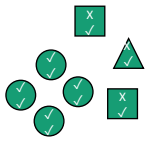
For each individual$_x$, if it$_x$ is a circle, it$_x$ is green

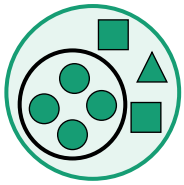
UNIVERSE: ∀x[Circle(x) → Green(x)]



Unrestricted First-order

The circles$_X$ are included in the green-things$_Y$

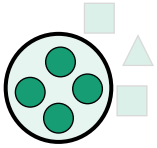
UNIVERSE: TheX:Circle(X) ⊆ TheY:Green(Y)



Unrestricted Second-order

The circles$_X$ are such that all of them$_X$ are green

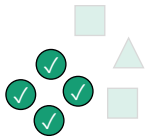
CIRCLES: ∀X[Green(X)]



Restricted Second-order

The individual circles$_x$ are s.t. each one$_x$ is green

CIRCLES: ∀x[Green(x)]



Restricted First-order

(Knowlton et al. *CUNY* 2020)

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"Each/Every circle is green"

The circles$_X$ are included in the green-things$_Y$

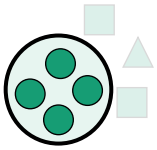
UNIVERSE: TheX:Circle(X) ⊆ TheY:Green(Y)

Unrestricted Second-order

The circles$_X$ are such that all of them$_X$ are green

CIRCLES: ∀X[Green(X)]

X can take on ≥1 value at a time

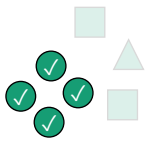


Restricted Second-order

The individual circles$_x$ are s.t. each one$_x$ is green

CIRCLES: ∀x[Green(x)]

x can take on only 1 value at a time



Restricted First-order

(Boolos 1984, 1985, 1998; Schein 1993; Pietroski 2018)

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Different underlying cogni

Second-order representations (*every*)

CIRCLES: ∀X[Green(X)] ≈The circles$_X$ are suc

take on ≥1 value at a time

First-order representations (*each*) rely on object-files

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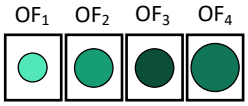
take on only 1 value at a time

Objects individuated **individual properties** encoded

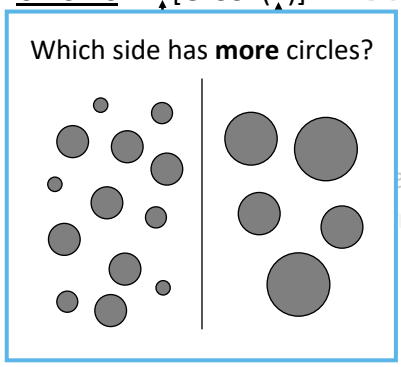


(e.g., Kahnemann et al. 1992; Pylyshyn & Storm 1998; Scholl, Pylyshyn & Feldman 2001; Scholl 2002; Feigenson, Dehaene & Spelke 2004; Carey 2009) 7

Different underlying cognitive systems

Second-order representations (*every*) rely on ensembles

CIRCLES: ∀X[Green(X)] ≈The circles$_X$ are such that all of them$_X$ are green



Objects abstracted away from **summary statistics** encoded

Ensemble$_1$
Center: (x,y)
Cardinality: 4
Avg. Size:

each) rely on object-files

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Objects individuated **individual properties** encoded

(e.g., Ariely 2001; Feigenson, Dehaene & Spelke 2004; Alvarez 2011; Haberman, Brady & Alvarez 2015; Ward, Bear & Scholl 2016; Whitney & Leib 2018) 8

Different representations & cognitive systems

Second-order representations (*every*) rely on ensembles

CIRCLES: ∀X[Green(X)] ≈The circles$_X$ are such that all of them$_X$ are green

take on ≥1 value at a time

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take on only 1 value at a time

Objects individuated **individual properties** encoded

OF$_1$ OF$_2$ OF$_3$ OF$_4$

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Different behavioral predictions

Linking hypothesis: people are biased toward verification strategies that directly compute the relations & operations expressed by the semantic representation under evaluation (Lidz et al. 2011)

First-order (*each*)	**Second-order (*every*)**
CIRCLES: ∀x[Green(x)]	CIRCLES: ∀X[Green(X)]
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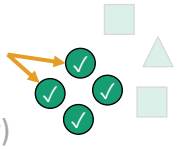
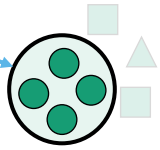
Encode individual properties (e.g., color)



Encode summary statistics (e.g., #)



Abstract away from individual properties

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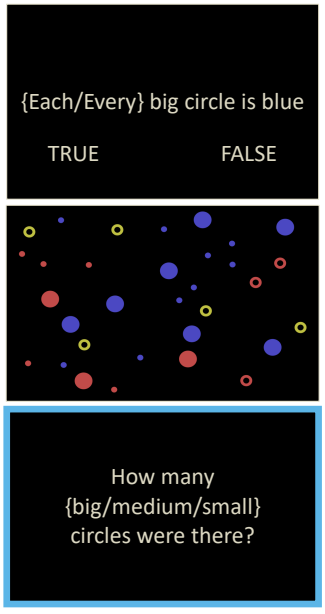
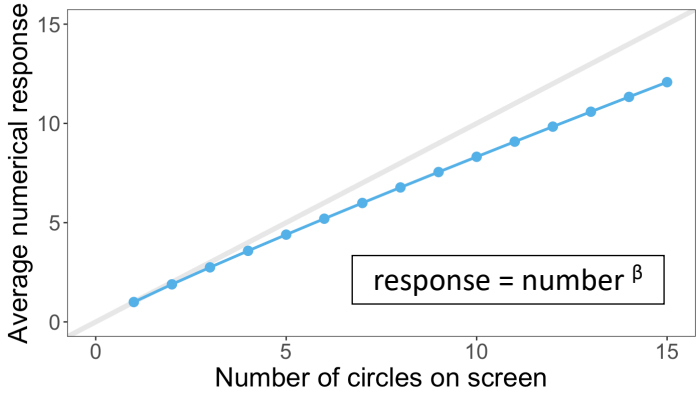


(Knowlton, Pietroski, Halberda & Lidz *CUNY* 2019)

Cardinality (group property)

Measuring #-knowledge (β)



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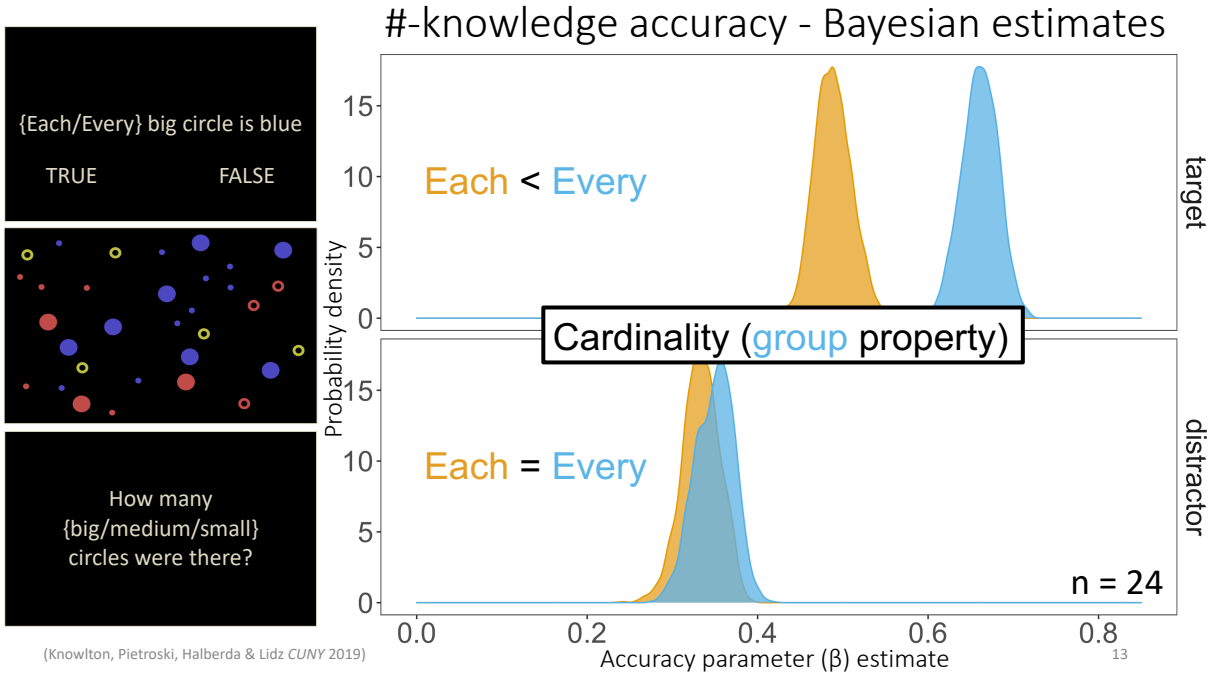

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Every-sentences trigger ensemble (group) representations

- ➥ Evaluating *every*-sentences leads participants to encode cardinality

Each-sentences trigger object-file (individual) representations

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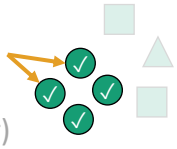
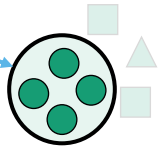
First-order (*each*)	**Second-order (*every*)**
CIRCLES: ∀x[Green(x)]	CIRCLES: ∀X[Green(X)]
≈*The individual circles$_x$ are such that each one$_x$ is green*	≈*The circles$_X$ are such that all of them$_X$ are green*

Encode individual properties (e.g., color)



Encode summary statistics (e.g., #)



Abstract away from individual properties

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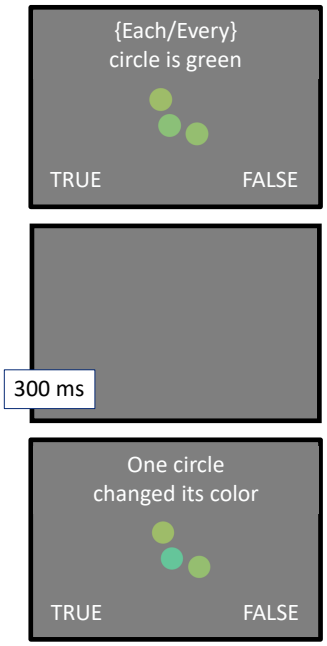
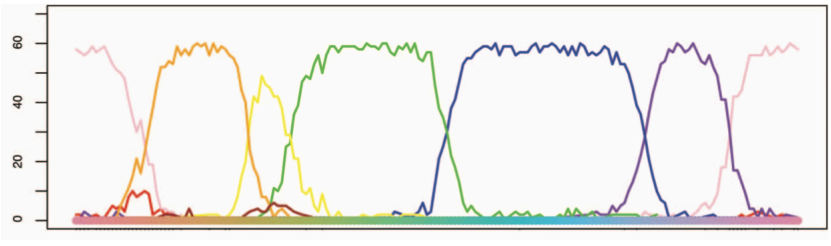


Color (individual property)

Color category naming task



(Bae, Olkkonen, Allred & Flombaum 2015)

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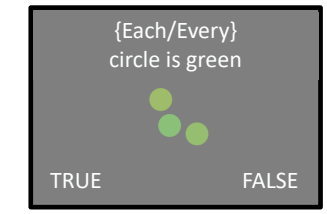

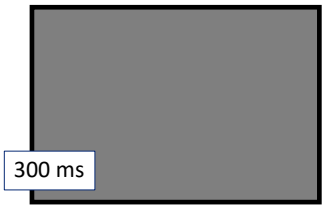

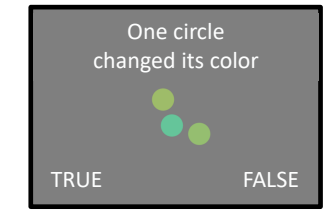

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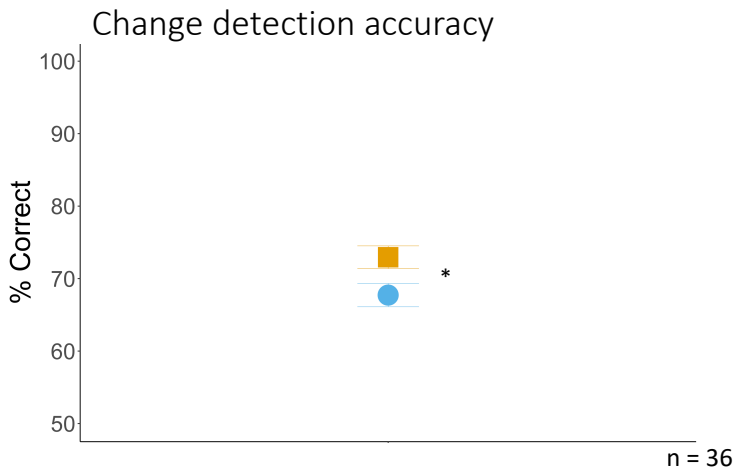

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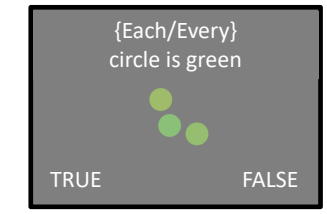

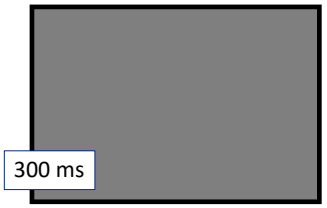

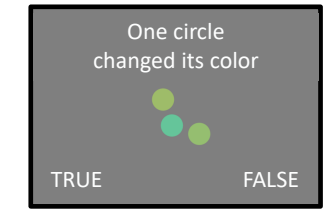

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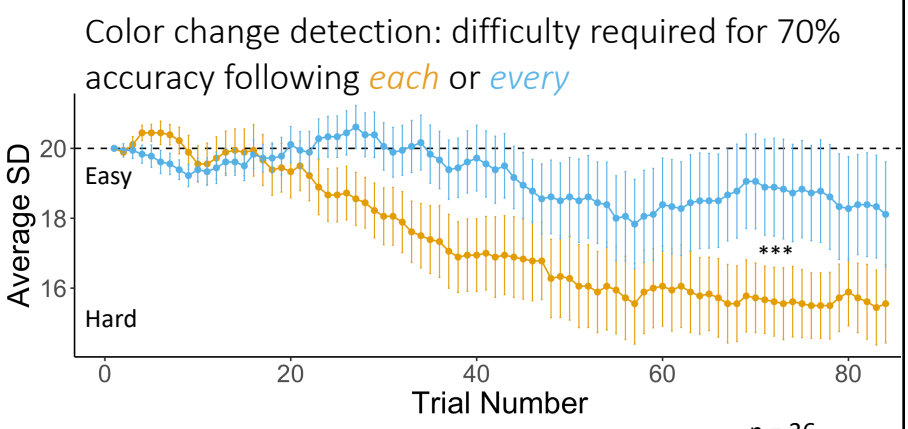

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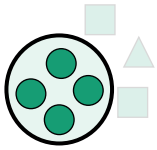
How are universal quantifiers mentally represented?

Second-order / group-implicating: *Every*

The circles$_x$ are such that all of them$_x$ are green

CIRCLES: ∀X[Green(X)]

➥ Ensemble representations



First-order / individual-implicating: *Each*

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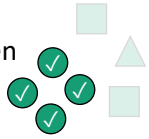
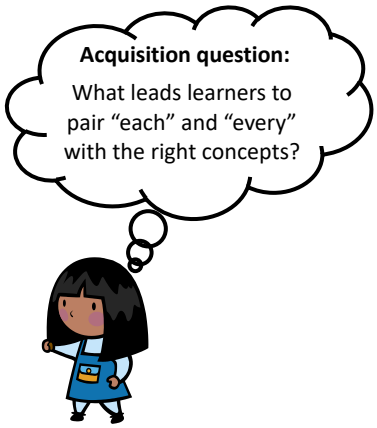
➥ Object-file representations





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How are universal quantifiers mentally represented?

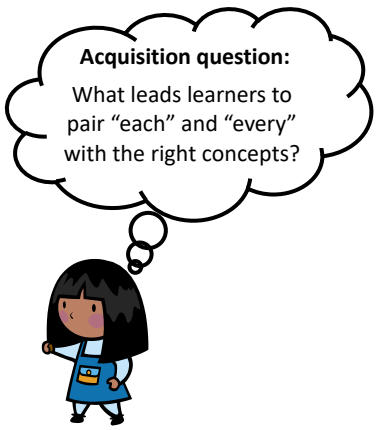
Differences in child-directed speech

Each – generalize over local domain

"You have to ring up each thing"
"Could you put a flower on each plate?"
"Put sugar in each coffee"

Every – project beyond the local domain

"Every time I ask a question, you say you don't know"
"You turn into a wild man every time we get out"
"She watches every movie they make"



(Knowlton & Lidz *forthcoming*)

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