Universal quantifiers: logically equivalent, psychologically distinct

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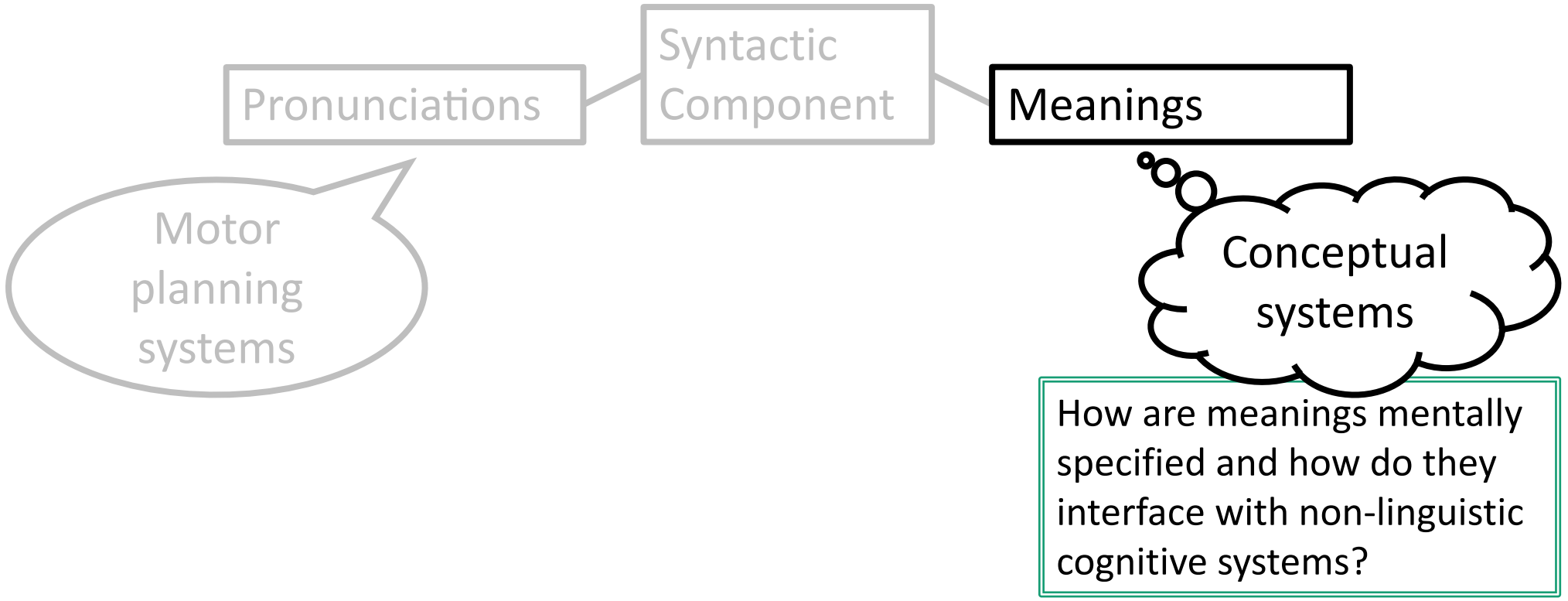
12.1.23

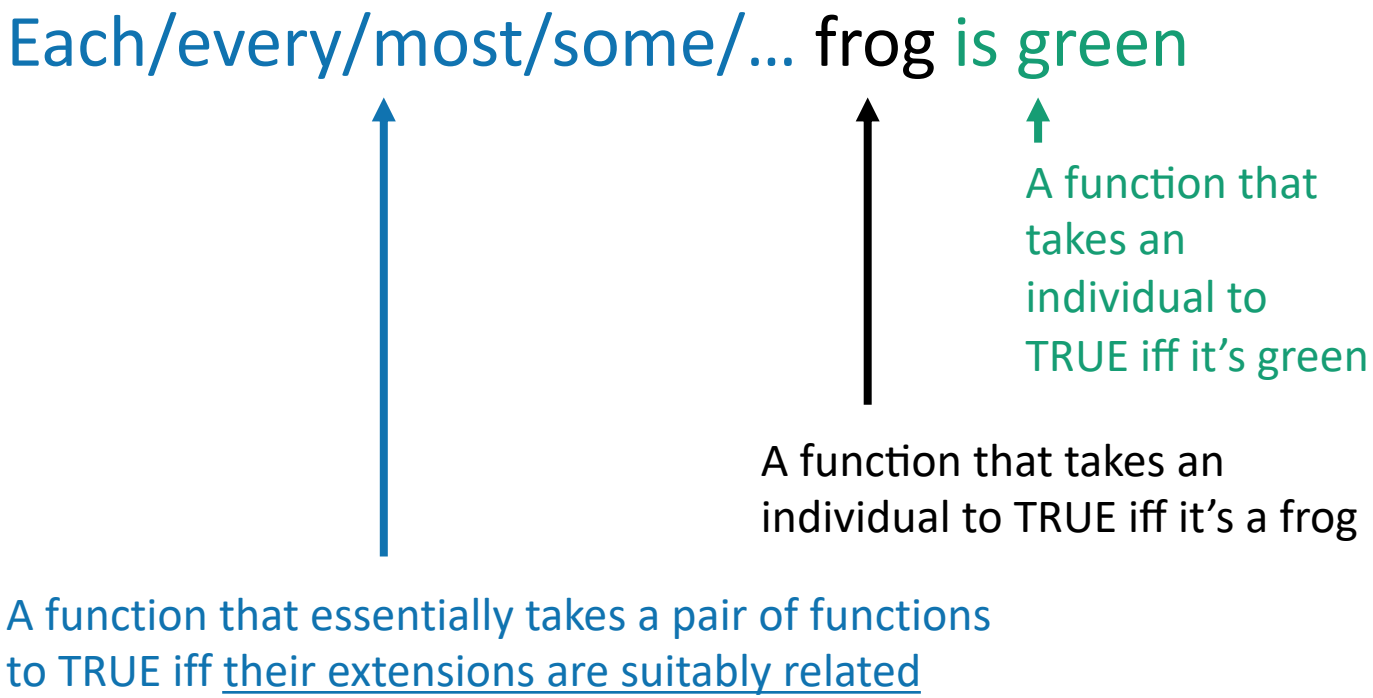
Meanings in mental grammar



e.g., Halle 2003; Liberman & Mattingly 1985; Poeppel, Idsardi & van Wassenhove 2008; Chomsky 1964; Jackendoff 1983; Pietroski 2018; Knowlton et al. 2021

Meanings in mental grammar

Textbook treatment of quantification:



What does it mean for the extensions of "frog" and "is green" to be suitably related?

Meanings in mental grammar

Each/every/most/some/… frogs are green

#(GREEN ∩ FROGS) > #(¬ GREEN ∩ FROGS)
#(GREEN ∩ FROGS) > #(FROGS) – #(GREEN ∩ FROGS)
OneToOne+(GREEN ∩ FROGS, ¬ GREEN ∩ FROGS)
⋮

There are many logically equivalent
ways of specifying the "*most* relation"

Pietroski et al. 2009; Lidz et al. 2011; Knowlton et al. 2021 *Annals of NYAS*

Meanings in mental grammar

Each/every/most/some/… frogs are green

#(GREEN ∩ FROGS) > #(¬ GREEN ∩ FROGS) predicate negation

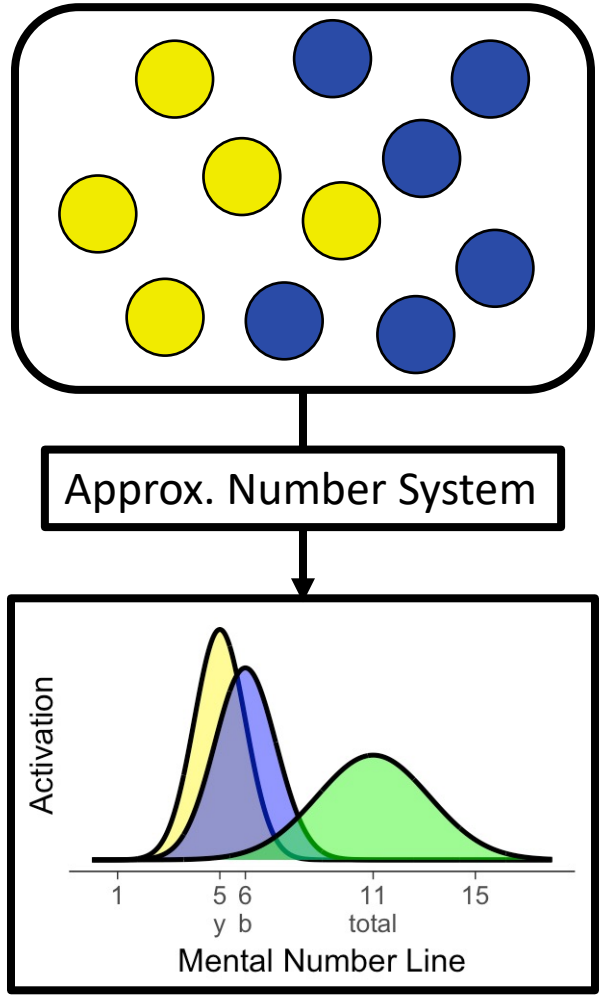
#(GREEN ∩ FROGS) > #(FROGS) – #(GREEN ∩ FROGS) numerical subtraction

OneToOne+(GREEN ∩ FROGS, ¬ GREEN ∩ FROGS) cardinality-free

⋮

There are many logically equivalent **but psychologically distinct** ways of specifying the "*most* relation" … **which one is right?**

Research strategy: leverage what's known about relevant cognitive systems to tease apart hypotheses about "psycho-logical" form



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Roadmap

✓ **Broad goal: Investigating "psycho-logical forms"**

➥ e.g., how *most* is mentally specified (cardinality vs. correspondence; negation vs. subtraction; …)

Current Case Study: *Each* vs. *Every*

➥ Proposed difference: first-order (individuals only) vs. second-order (group implicating) logic

➥ Proposed connection to non-linguistic cognition: object-files & ensembles

Evidence from sentence verification

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Downstream pragmatic consequences

➥ Quantifying over small vs. large domains

➥ *Every NP* is better able to provide a plural antecedent than *Each NP*

Different ways of specifying *each/every frog is green*

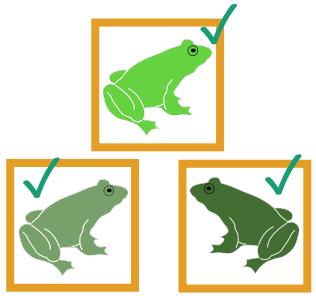
First-order representation

∀x:Frog(x)[Green(x)]

≈ Any individual that satisfies 'Frog'

is such that it satisfies 'Green'

each



***Each* is 'more individualistic' whereas *Every* is 'friendlier to groups'**

(e.g., Vendler 1962; Beghelli & Stowell 1997; Beghelli 1997; Tunstall 1998; Landman 2003; Surányi 2003)

#The press is each person who writes about the news

The press is every person who writes about the news

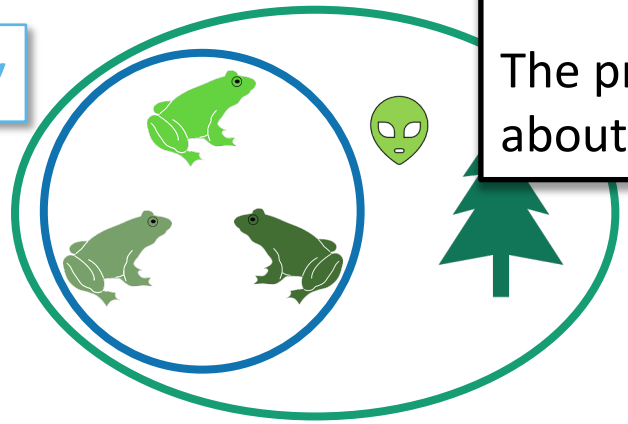
Second-order representation

TheX:Frog(X) ⊆ TheY:Green(Y)

≈ The Frogs are among

The Green Things

every



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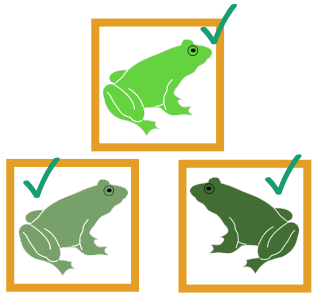

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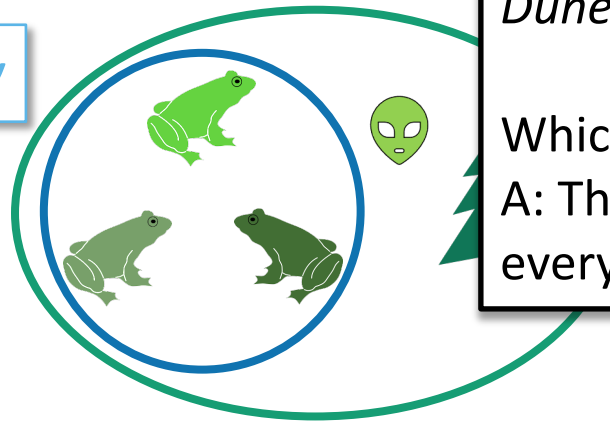

***Each* is ‘more individualistic’ whereas *Every* is ‘friendlier to groups’**

(e.g., Vendler 1962; Beghelli & Stowell 1997; Beghelli 1997; Tunstall 1998; Landman 2003; Surányi 2003)

Which book did you give each student?
A: I gave *Foundation* to Frank, *Dune* to Dani, and *Artemis* to Allie

Which book did you give every student?
A: There’s no one book that I gave to every student…

Different ways of specifying *each/every frog is green*

First-order representation

∀x:Frog(x)[Green(x)]

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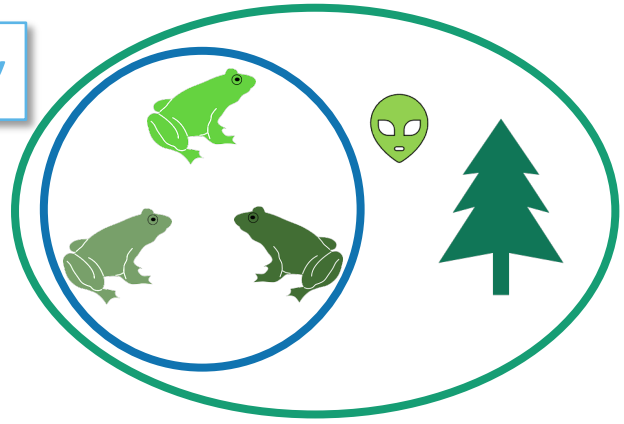

Theoretical and empirical reasons to reject this relational specification
(Knowlton et al. 2023 *Nat. Lang. Sem.*)

Different ways of specifying *each/every frog is green*

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≈ Any individual that satisfies 'Frog'

is such that it satisfies 'Green'

each

Object-file representation

Index an individuated object and anchor list of associated individual properties (e.g., color, size, …)

(e.g., Kahneman & Treisman 1984; Kahneman, Treisman, & Gibbs 1992; Xu & Chen 2009; Carey 2009; Green & Quilty-Dunn 2020)

Only *every*'s meaning has a semantic constituent corresponding to a grouping of its 1st arg. (The Frogs)

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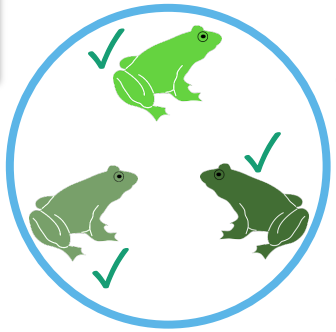

Ensemble representation

Abstract away from individual properties and encode collection in terms of summary statistics (e.g., average hue, cardinality, …)

(e.g., Ariely 2001; Chong & Treisman 2003; Haberman & Whitney 2011; Whitney & Yamanashi Leib 2018)

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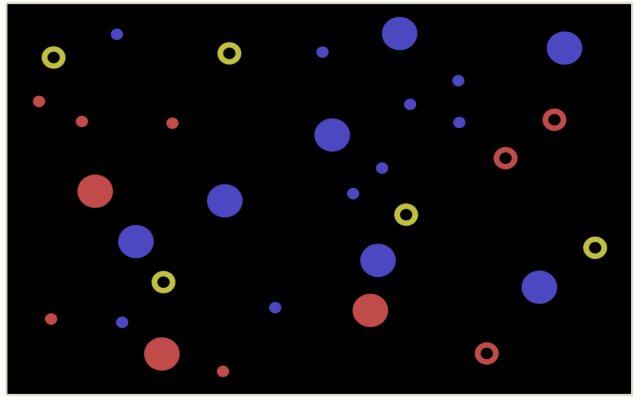
{Each/Every} big circle is blue

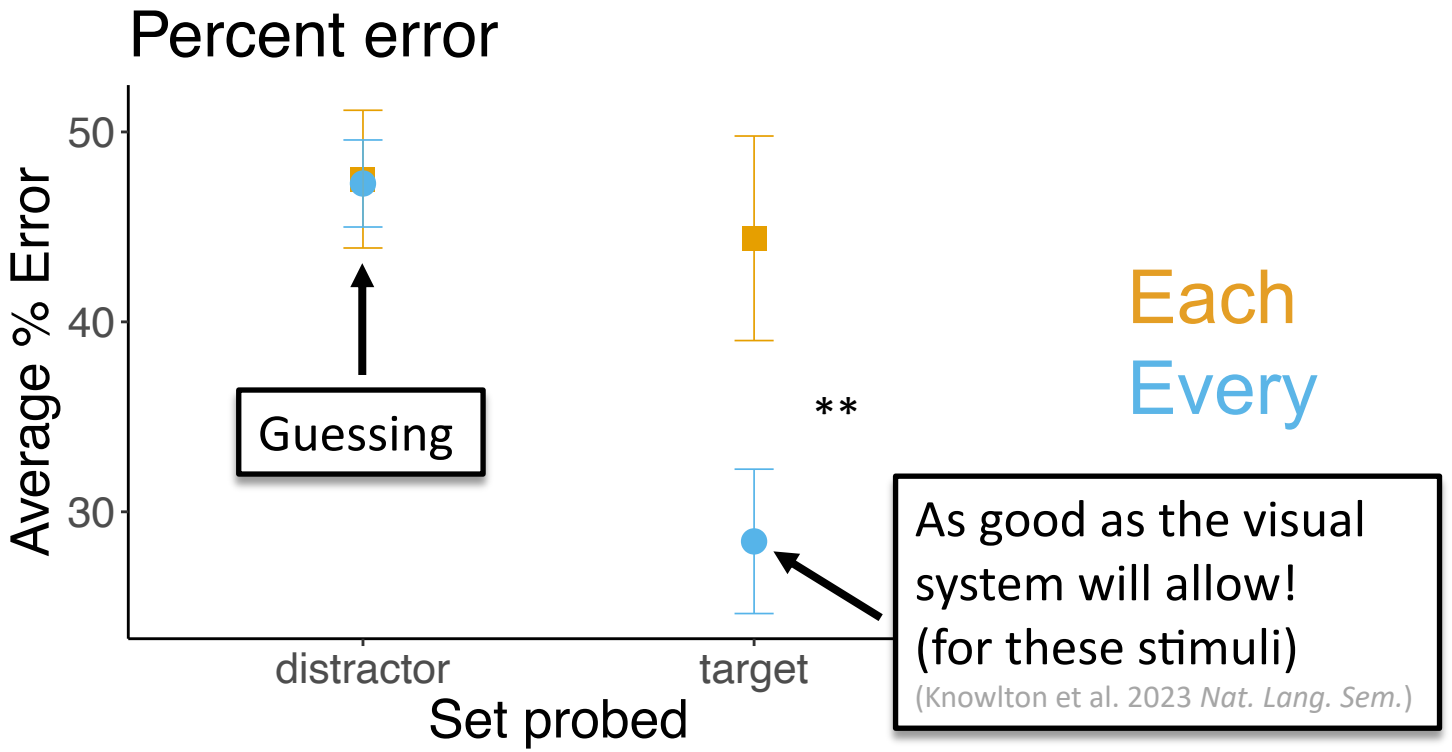
TRUE FALSE



How many {big/medium/small} circles were there?

Cardinality (ensemble property)

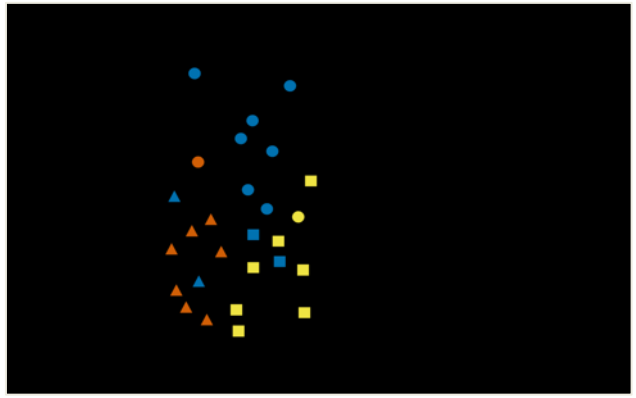
➥ If you initially represented the big circles, you should have a good estimate of their cardinality



n = 12

Is {each/every} circle blue?

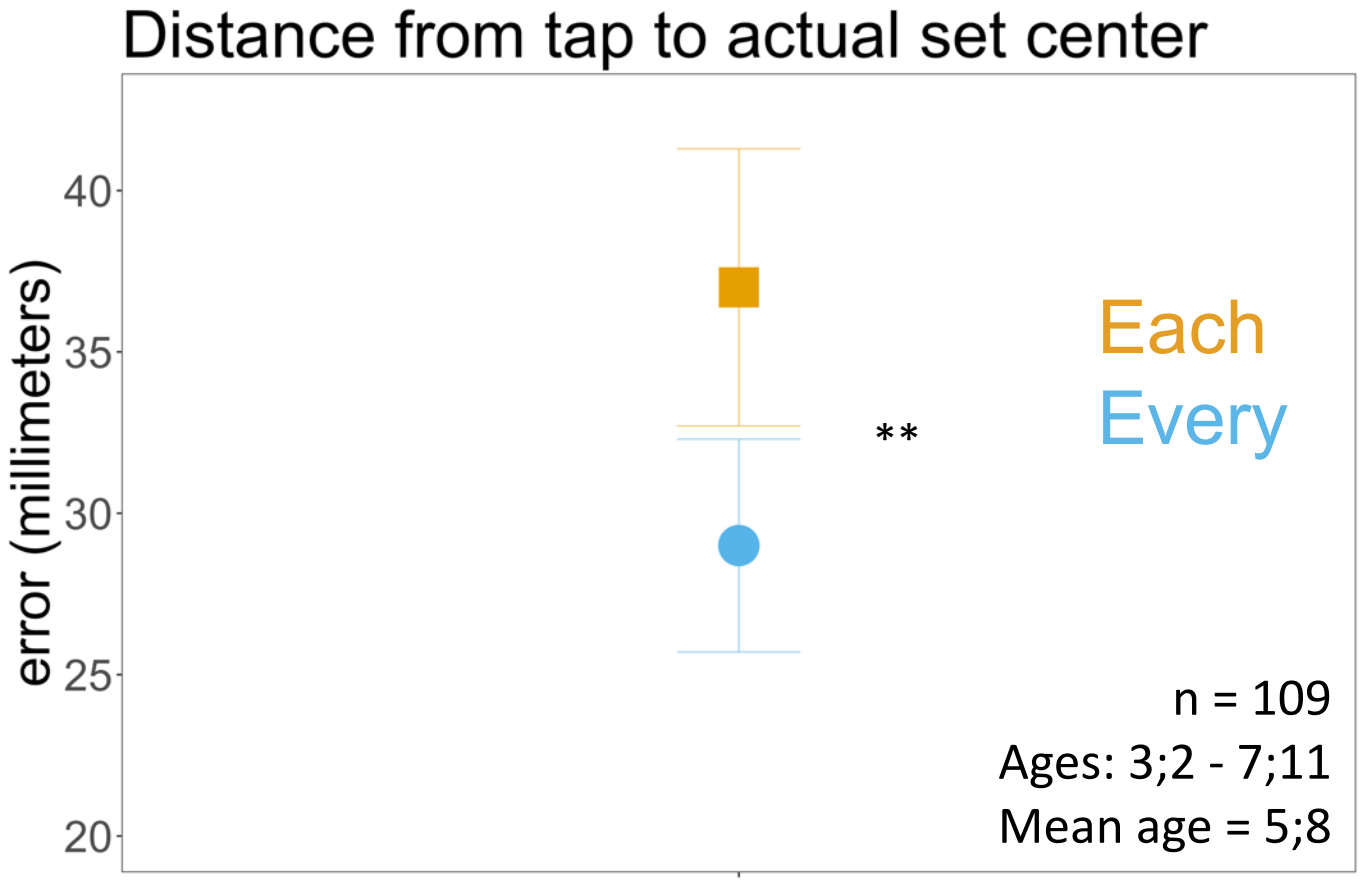
"Yes" "No"

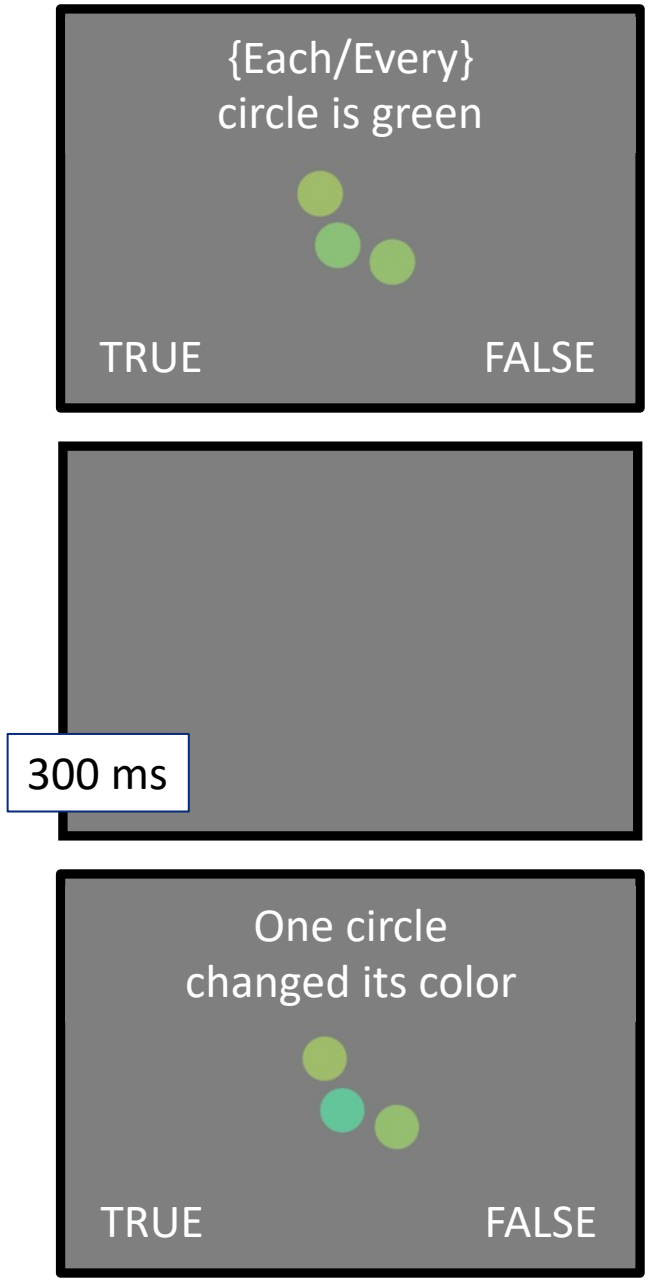


Where was the middle of the circles?

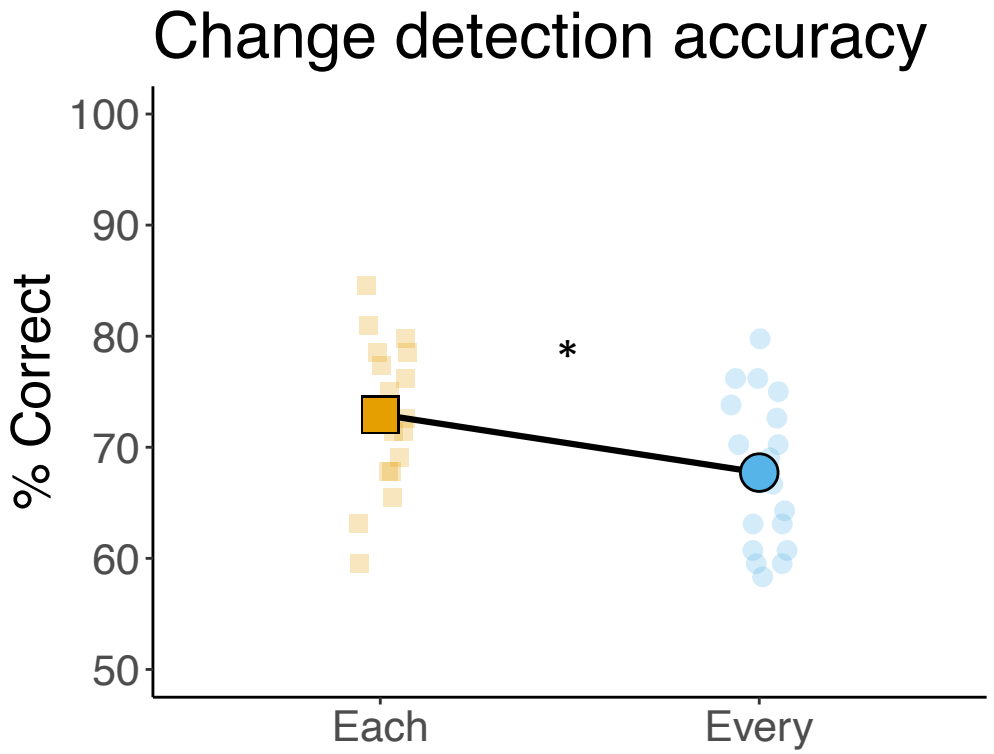
Center of Mass (ensemble property)

(with 3- to 8-year-olds)



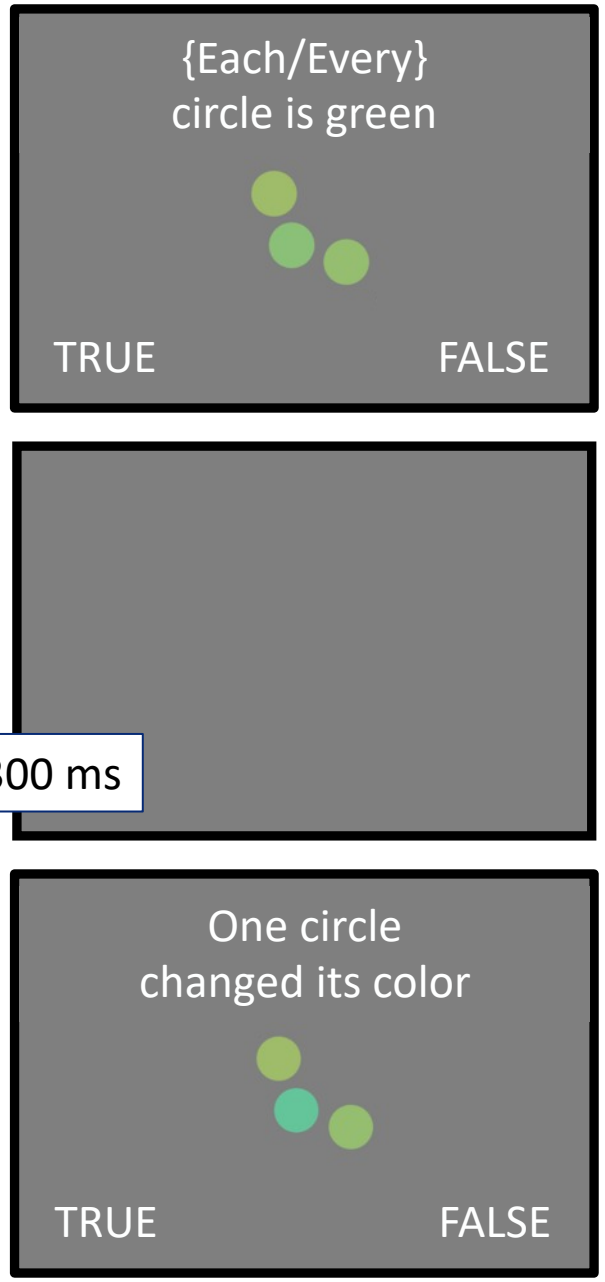


Color (individual property)



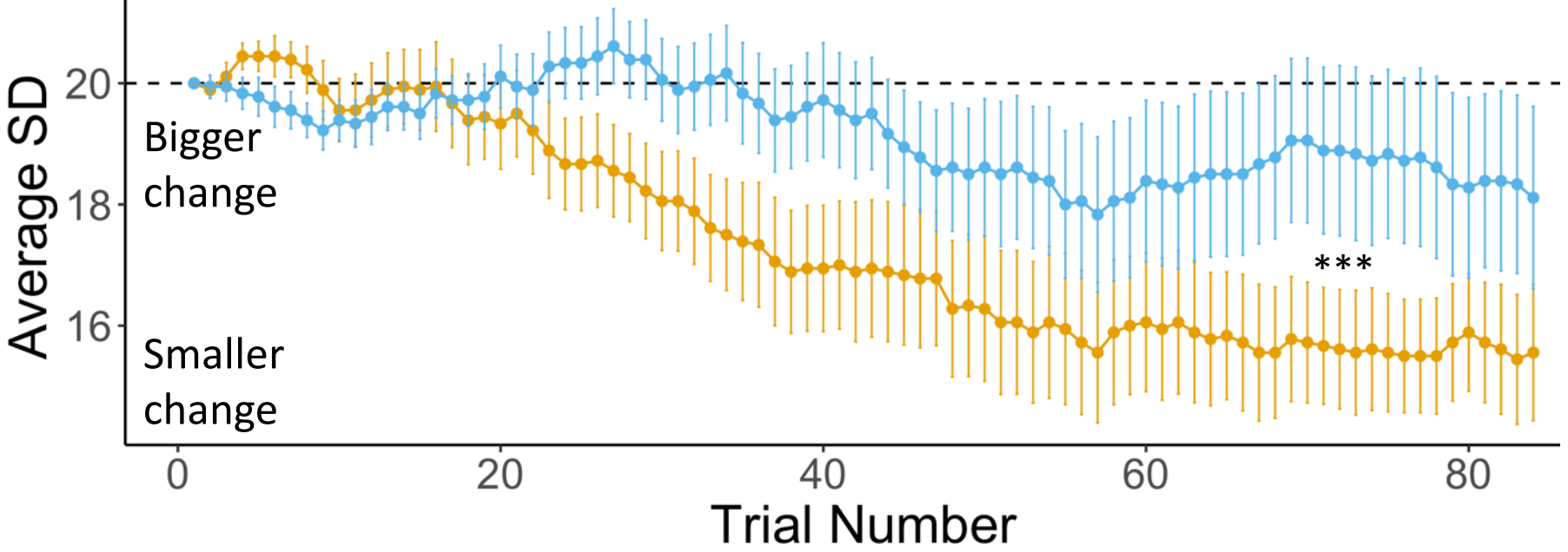
Each
Every

n = 36



Color (individual property)

Color change detection: difficulty required for 70% accuracy following *each* or *every*



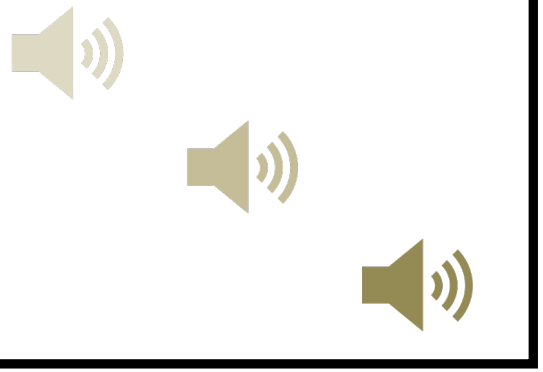
n = 36

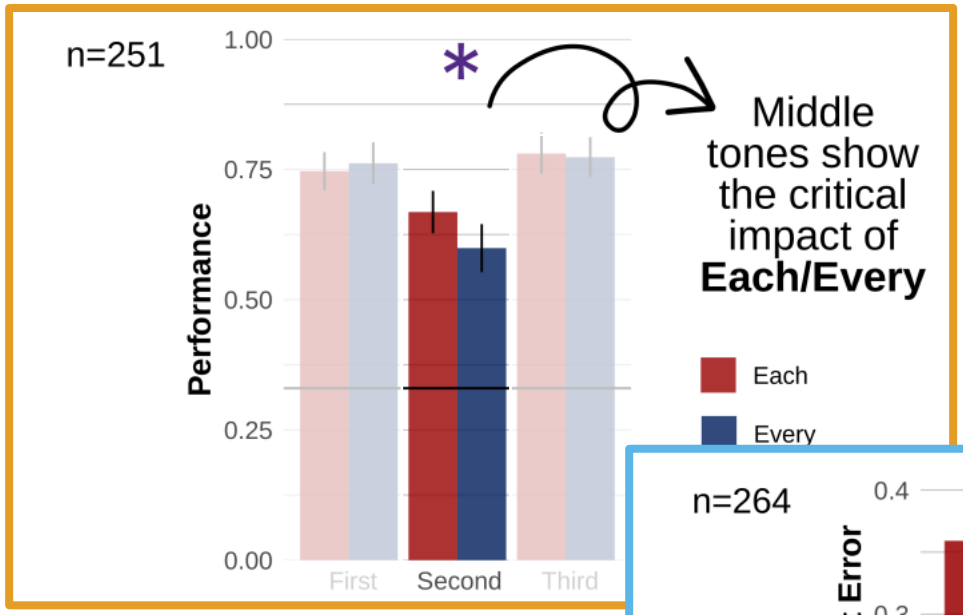
Position (individual property) & Average (ensemble property)

Julia Ongchoco

Each/Every tone is pleasant

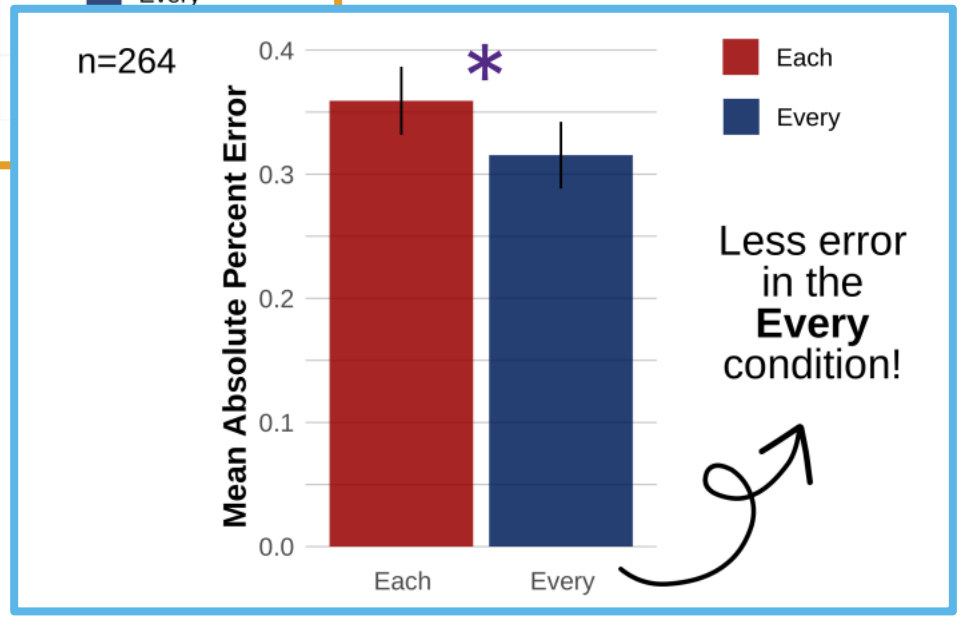
TRUE FALSE

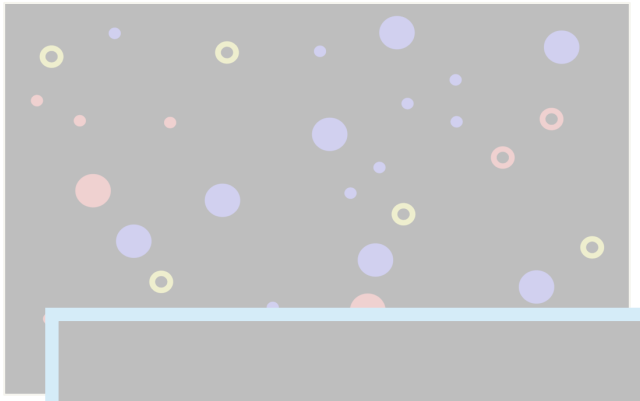




Was this the first, second, or third tone?

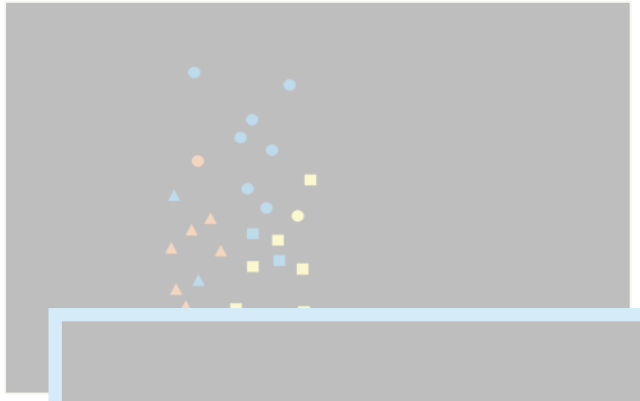
Reproduce the average tone





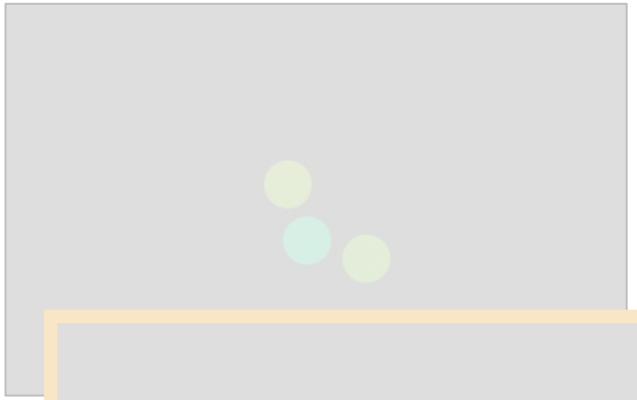
How many big circles were there?

Every > *Each*



Where was the middle of the circles?

Every > *Each*



Did one circle change its color?

Each > *Every*

➥ *Every NP* encourages grouping the things that satisfy *NP* as an ensemble;
Each NP encourages representing each thing that satisfies *NP* as an object-file

Was this the first, second, or third tone?

Each > *Every*

Reproduce the average tone

Every > *Each*

Roadmap

✓ **Broad goal: Investigating "psycho-logical forms"**

➥ e.g., how *most* is mentally specified (cardinality vs. correspondence; negation vs. subtraction; …)

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Downstream pragmatic consequences?

First-order representation

∀x:Frog(x)[Green(x)]

≈ Any individual that satisfies 'Frog'

is such that it satisfies 'Green'

each

Strict working memory limit of 3

(e.g., Vogel et al. 2001; Feigenson & Carey 2005; Wood & Spelke 2005; Alvarez & Franconeri 2007)

Object-file representation

Index an individuated object and anchor list of associated individual properties (e.g., color, size, …)

(e.g., Kahneman & Treisman 1984; Kahneman, Treisman, & Gibbs 1992; Xu & Chen 2009; Carey 2009; Green & Quilty-Dunn 2020)

Only *every*'s meaning has a semantic constituent corresponding to a grouping of its 1st arg. (The Frogs)

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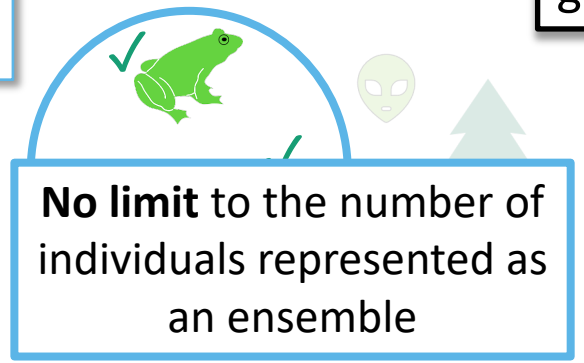
every



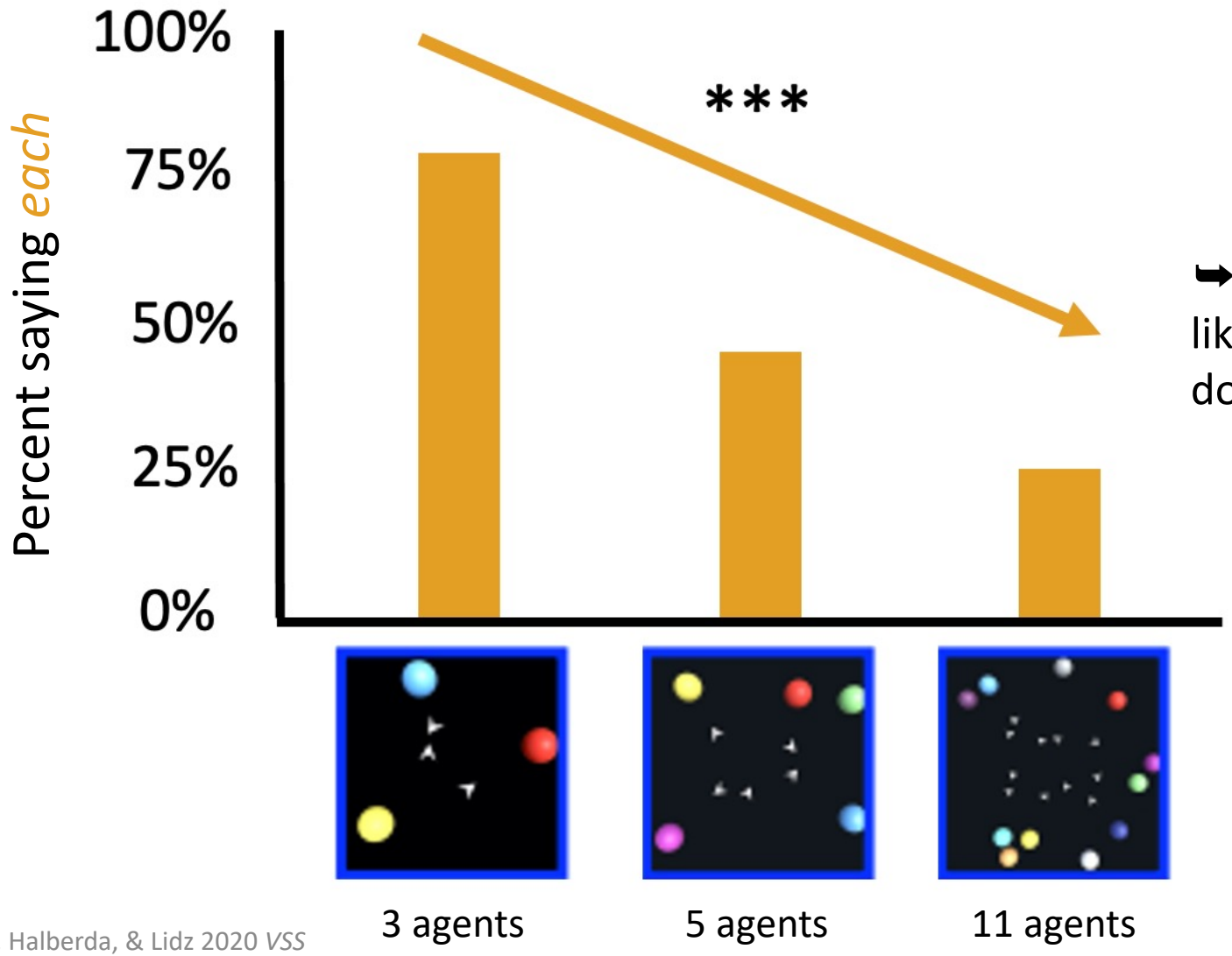
No limit to the number of individuals represented as an ensemble

Ensemble representation

Abstract away from individual properties and encode collection in terms of summary statistics (e.g., average hue, cardinality, …)

(e.g., Ariely 2001; Chong & Treisman 2003; Haberman & Whitney 2011; Whitney & Yamanashi Leib 2018)

Effects of domain size in spontaneous descriptions

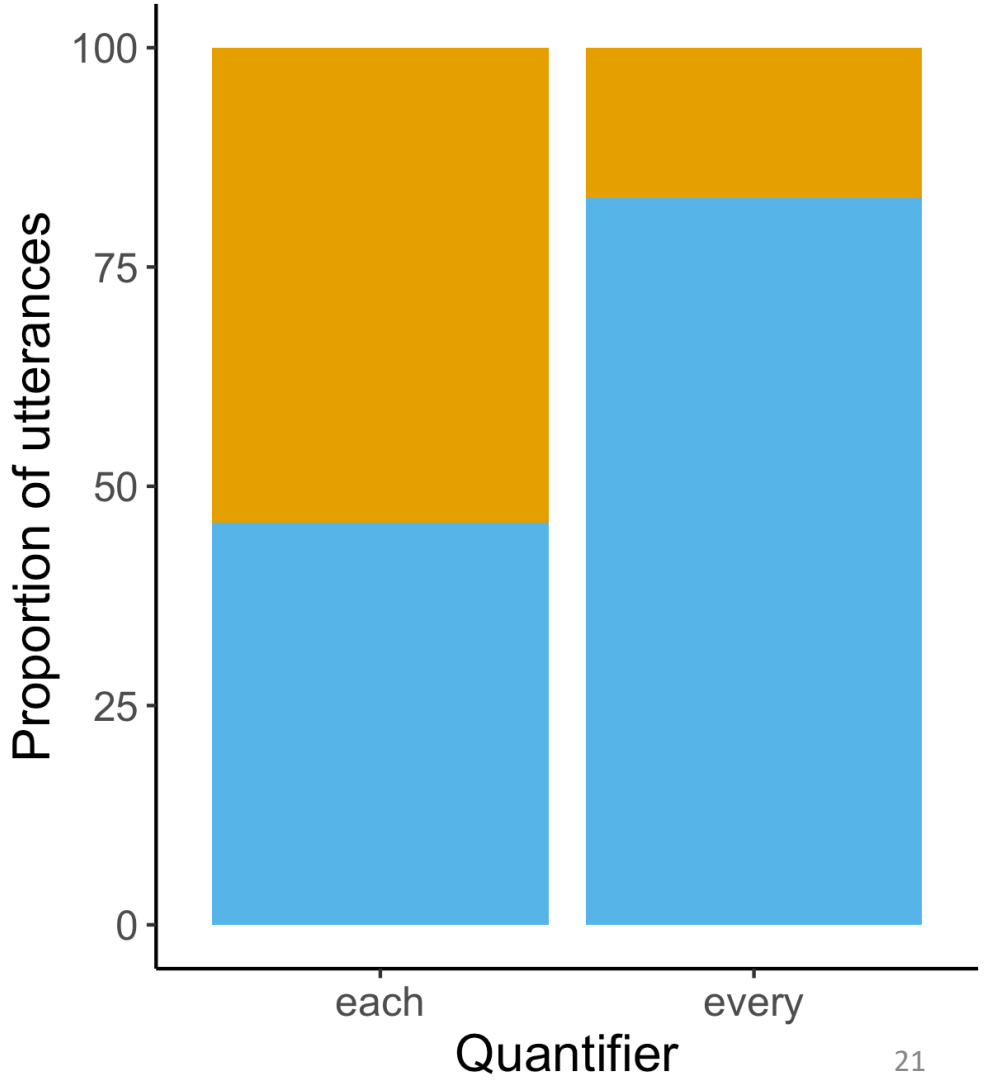


➥ Participants are more likely to use *each* when domains are small!

Effects of domain size in child-directed speech

How many things are being quantified over in speech to kids? (362 utterances)

"You want one bite of each piece, huh?"



Effects of domain size: forced-choice judgment

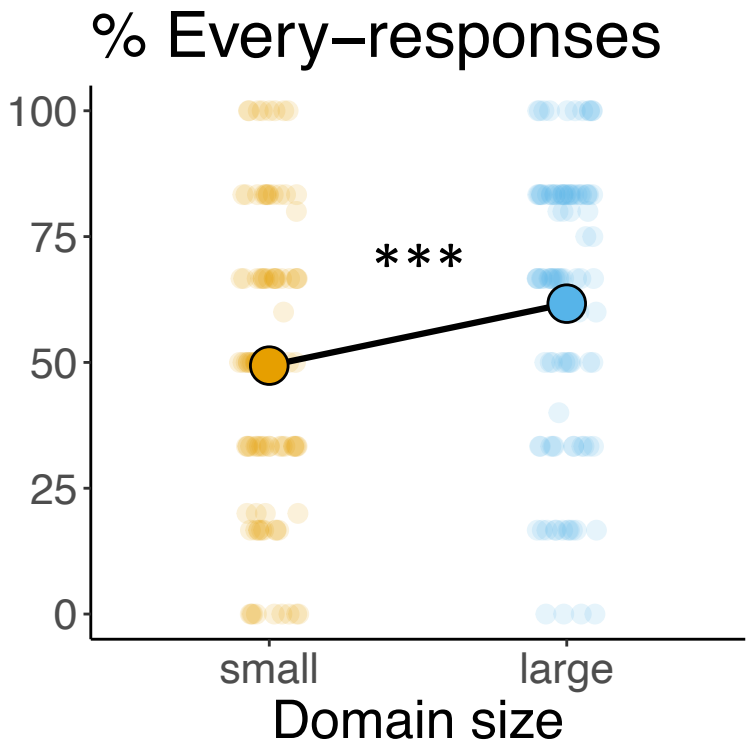
The bartender at the local tavern has made

three martinis/three thousand martinis.

He said that (select a word) martini he made

each
every

had an olive.



12 items; within-subjects; n=100

Effects of domain size: free response

If someone said

Each martini I made has an olive

Every martini I made has an olive

% responses below “4”:
Each: 67%
Every: 30%

how many martinis would you guess they have in mind?

1 item; n=198

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Predicates with *same* require a comparison class

(1) a. #Kermit is the same color (same as what??)

b. The frogs are the same color

Prediction: Because *every frog* implicitly introduces the frogs, it should behave more like (1b);

each frog doesn't introduce such a group, so should behave more like (1a)

see e.g., Kuhn 2015; Brasoveanu & Dotlačil 2015

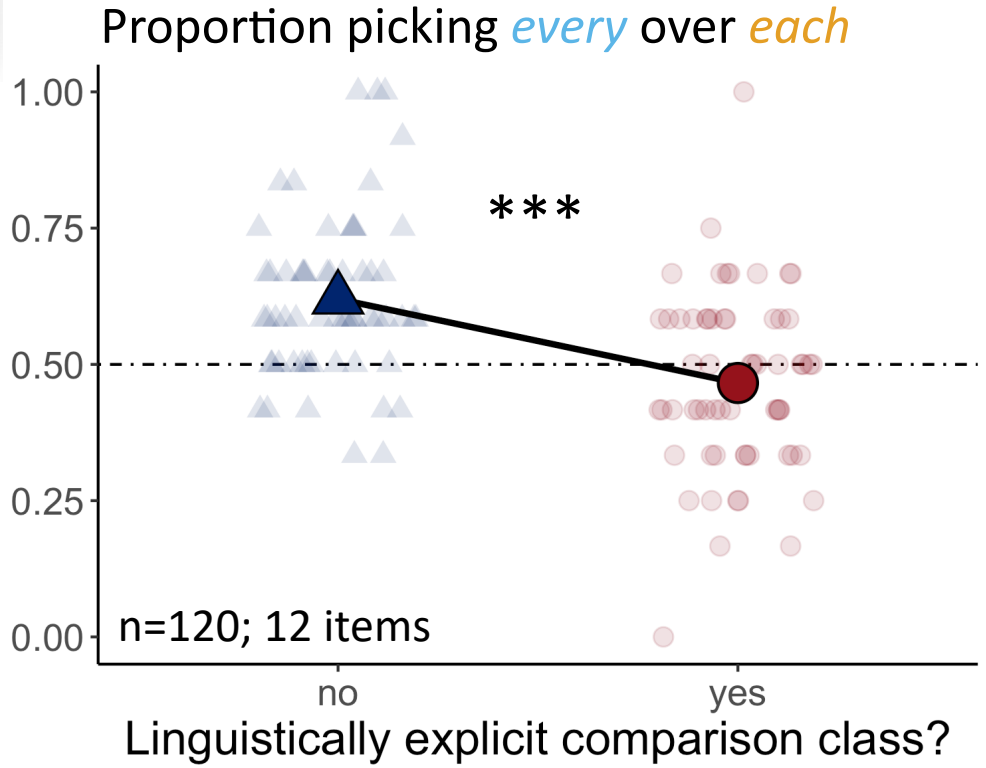
Sentence-internal *same*: forced-choice judgment

Ann and John decided to throw a school Halloween party.

Surprisingly, (select a word) student showed up in the same costume { Ø. / as their classmates. }

each
every

➥ Participants favored *every* in the absence of another source of the comparison class for *same*

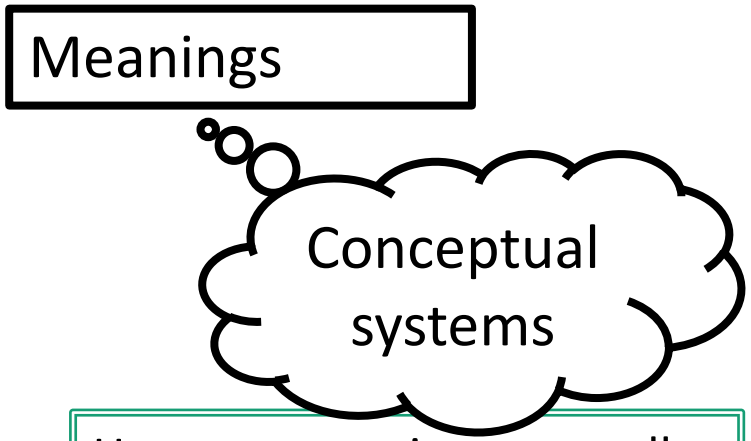


➥ This preference disappeared when the comparison class was made linguistically explicit

Meanings in mental grammar

Leveraging details of **non-linguistic cognitive systems** to tease apart distinctions in **psycho-logical forms**

- ➥ Case study: First-order *each*; (partially) Second-order *every*
  - ➪ Connections to Object-files and Ensembles
  - ➪ Consequences for pragmatics
  - ➪ Consequences for language acquisition



How are meanings mentally specified and how do they interface with non-linguistic cognitive systems?

Broader goal: building up inventory of vocabulary for mentally specifying linguistic meanings

- ➥ Cardinality; Subtraction; First-order/Second-order distinction
- ➥ But maybe not: predicate negation; set-theoretic relations; …

Thanks (to each & every one of you) for listening!

Collaborators on presented work: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