Psychology | Lancaster University

The importance of nonlinguistic variability to early language learning: the case of colour

Katie Twomey, Shirly Ma & Gert Westermann

k.twomey@lancaster.ac.uk
malizhi110@hotmail.com
g.westermann@lancaster.ac.uk

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chimp!
Learning words
isn't easy

How do they do it?

Nonetheless, children learn words quickly and apparently easily

By 6mo, infants have begun to understand words for things they see

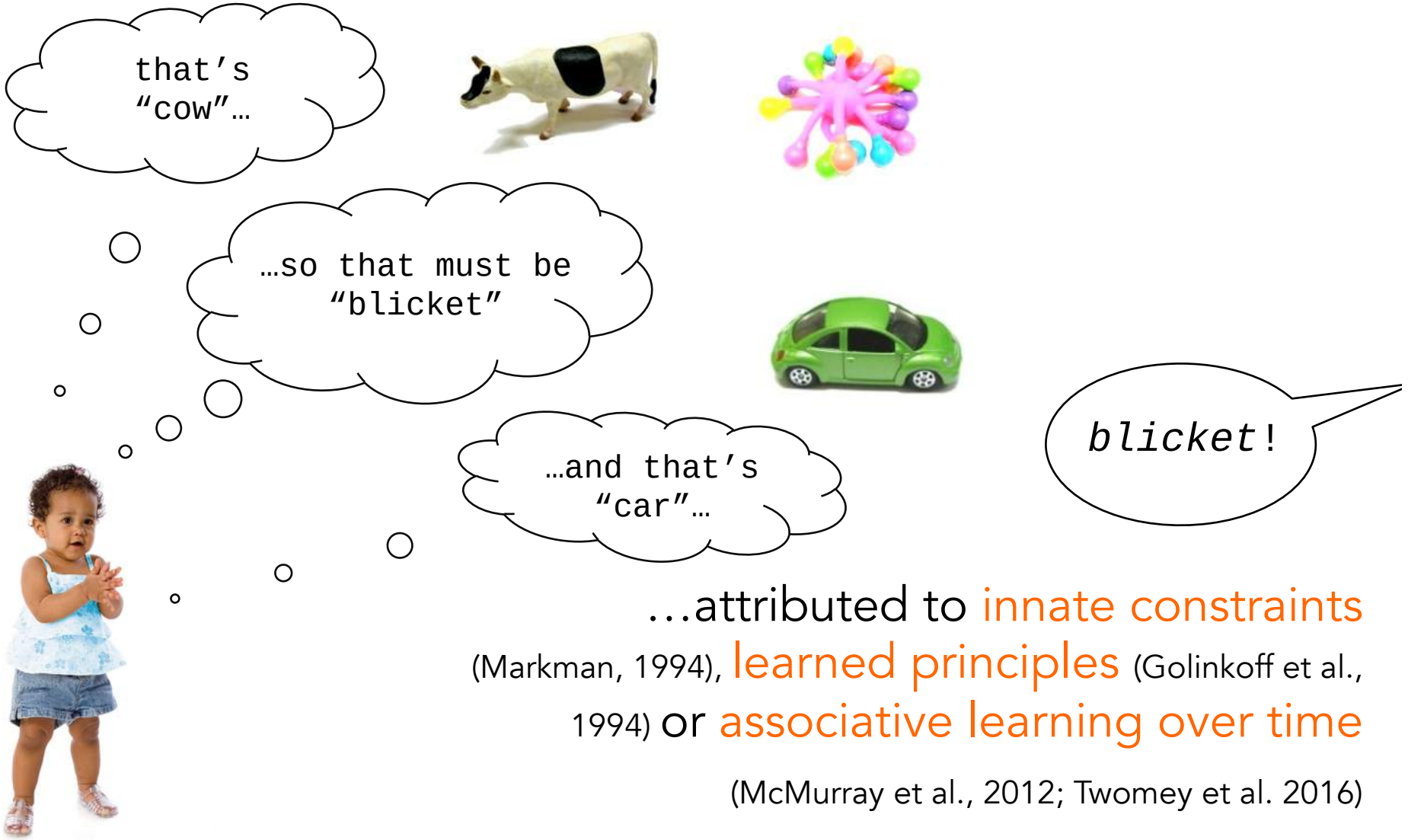
(Berger & Swingley, 2012)

by 36mo, they say around about 600!

(Fenson et al. 1994)

share dog blanket cat mine shoes sheep socks treebus Mummy hug naughty her happy bye bye foot baby blue boy hat apple bump park Daddy sleep bed sing hot flower more cow juice cup look milk arm red shoe friend

From around 18mo, children rapidly map new words to objects in (fairly) predictable ways



…attributed to innate constraints (Markman, 1994), learned principles (Golinkoff et al., 1994) or associative learning over time (McMurray et al., 2012; Twomey et al. 2016)

But "fast mapping" doesn't necessarily lead to word learning (Horst & Samuelson, 2008; *Infancy*)

Word learning is a fragile, incremental process (Smith & Yu, 2008; *Cognition*) affected by task characteristics such as repetition (Mather & Plunkett, 2009; *Infancy*), pragmatics (Grassman, Stracke & Tomasello, 2009; *Cognition*), referent motion (Matatyaho-Bullaro, Gogate,Mason, Cadavid, & Abdel-Mottaleb, 2014; *JECP*) to name a few..

Variability is important in language acquisition, but evidence is mixed

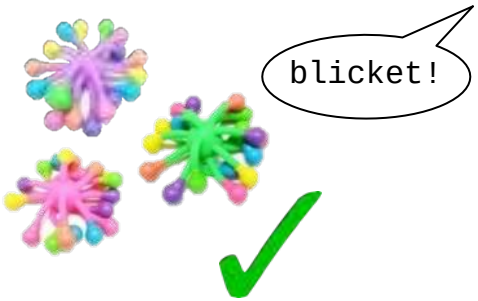
Linguistic variability helps
(Rost & McMurray, 2009; *Dev. Sci*)

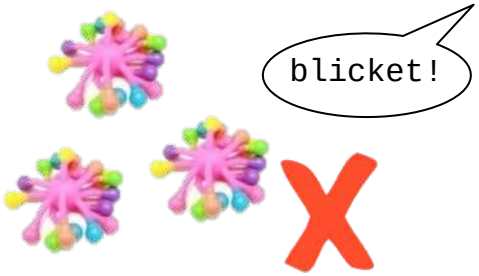
14mos learn novel word-object associations only when word was spoken by multiple speakers

buk (7 times at 2-sec interval)

puk (7 times at 2-sec interval)

Nonlinguistic target variability helps
(Twomey, Ranson & Horst, 2014; *Inf. Chi. Devt*)

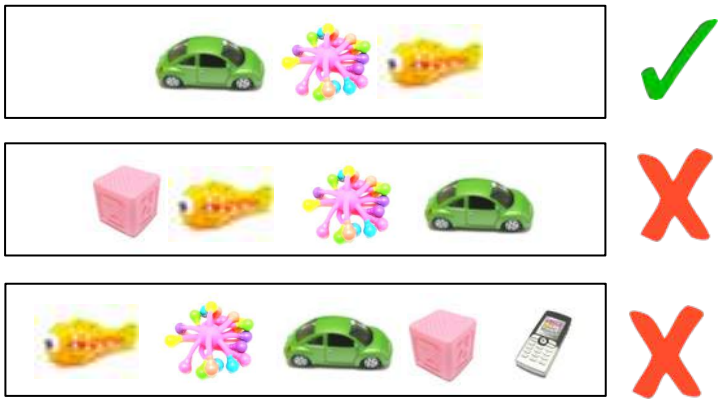




30mos learn words when only when target object is variable

Competitor variability hinders

(Horst, Scott & Pollard, 2010; *Dev. Sci*; Twomey et al., 2016; *Interaction Studies*)

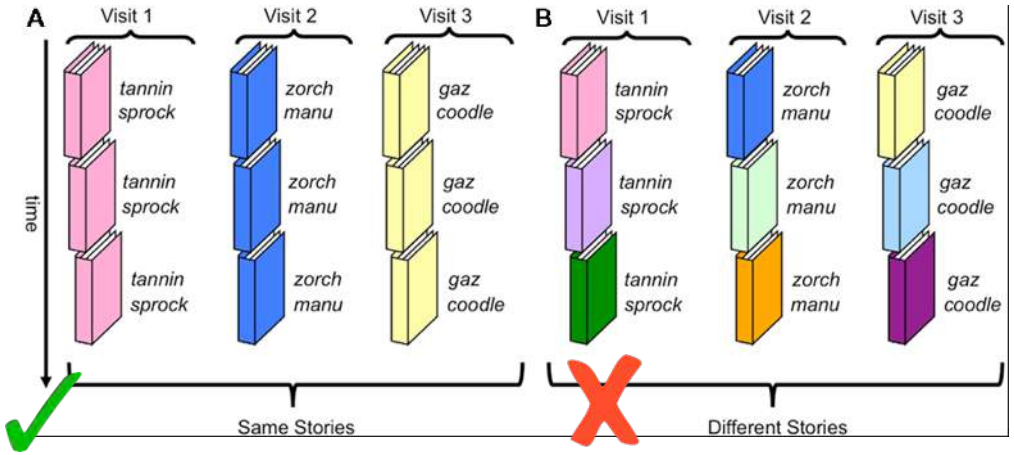


24mos learn words only when context is minimally variable

Context variability in reading hinders

(Horst, Parsons & Bryan, 2011; *Front. Pscyh.*)

43mos learn words when read the same book multiple times



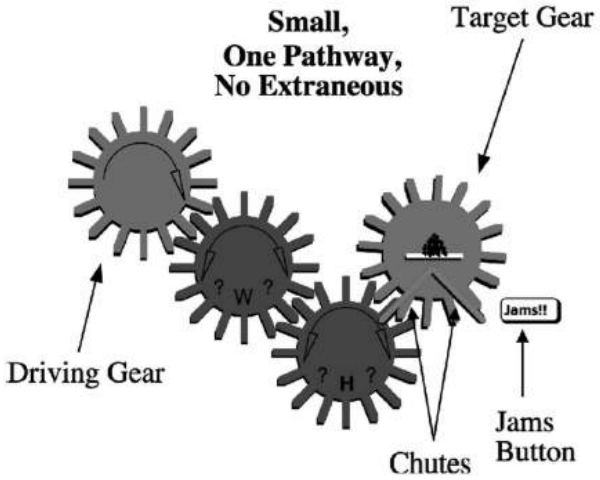
How does variability affect language learning?
Overall, a mixed picture

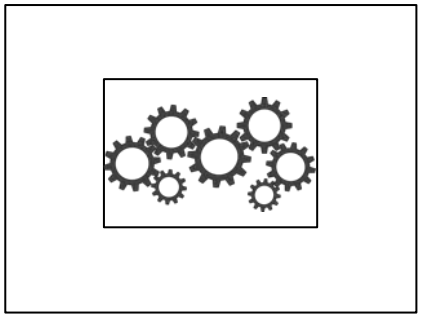
Target variability
(words, items) helps

Context variability
(story, competitor objects) hinders

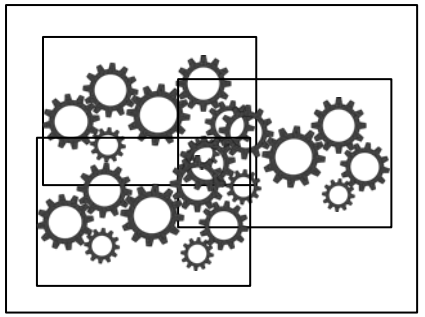
What about low-level, background variability?

Adding entropy to a task speeds up learning in adults
(Stephen, Dixon & Eisenhower, 2009; *JEP:HPP*)





Slower learning



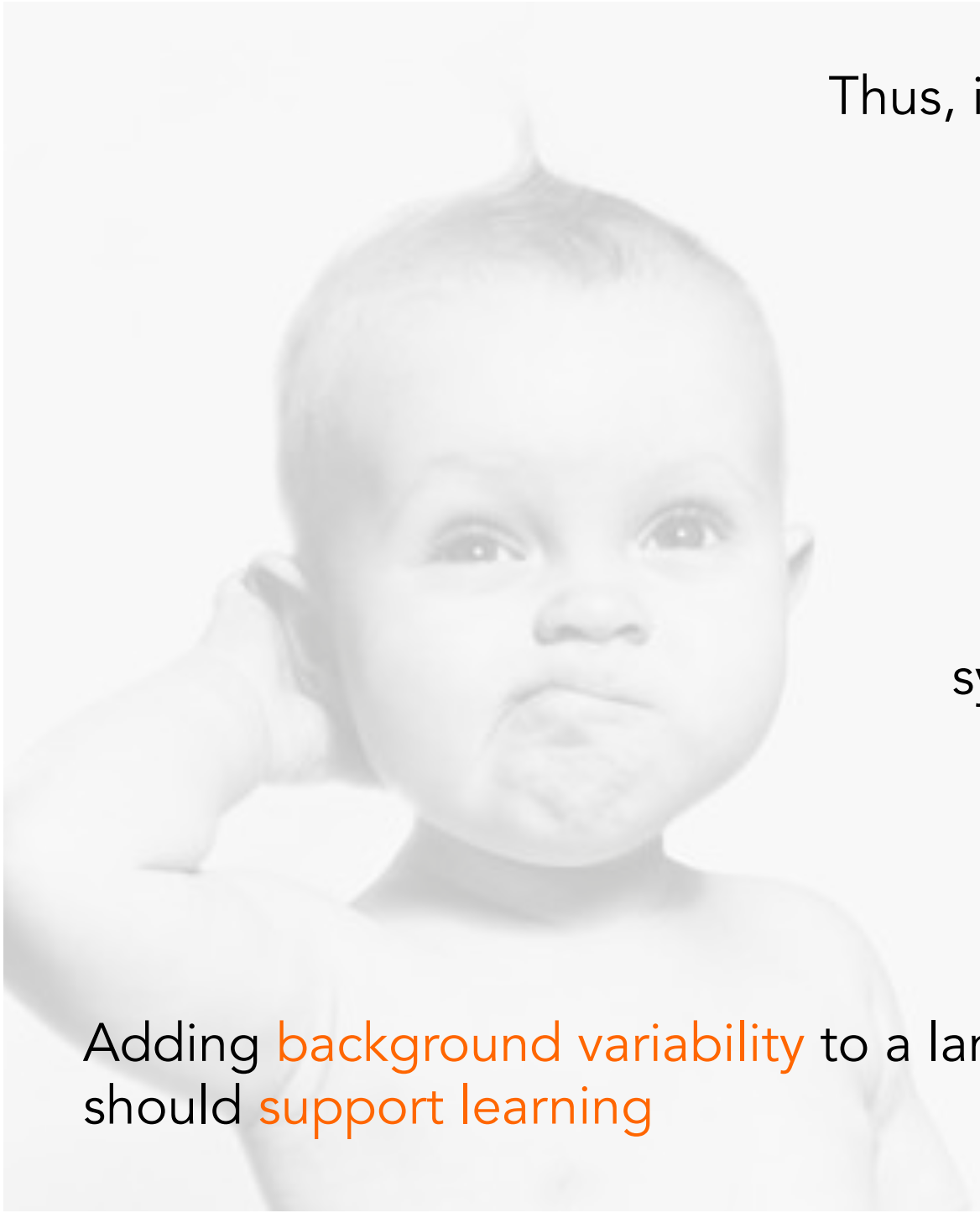
Faster learning

- Learner (e.g., child)
- Learning history (e.g., known vocabulary, experience with objects)
- Environment (e.g., visual scene)

A "behaviour" is when these components interact in a stable, predictable way (e.g., pointing to the correct referent)

"Learning" is the transition from one stable behavioural state to the next (e.g., being consistently able to correctly generalize a word)

Formally, adding low-level entropy or background noise speeds up this transition
(Stephen et al. 1999; *JEP:HPP*)



Thus, if behaviour is a property
of a dynamic system,

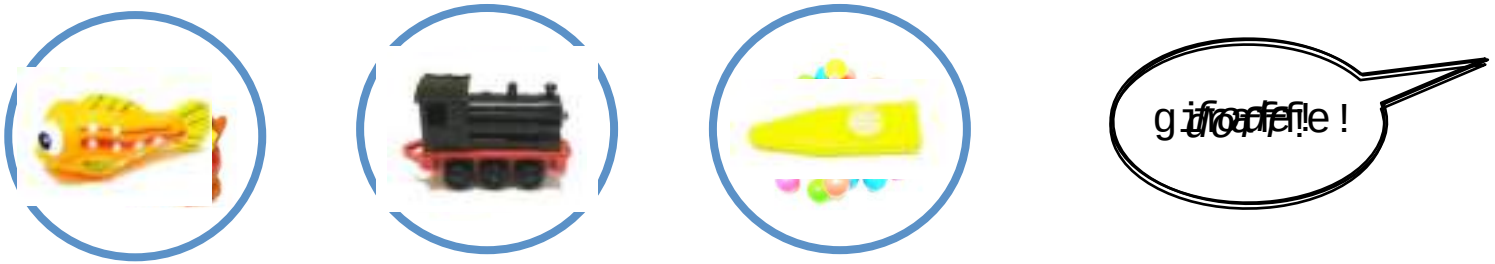
then language
– a human behaviour –
must also be part of a
dynamic system;

so, what affects dynamic
systems in general should
also affect language
in particular

Adding background variability to a language learning task
should support learning

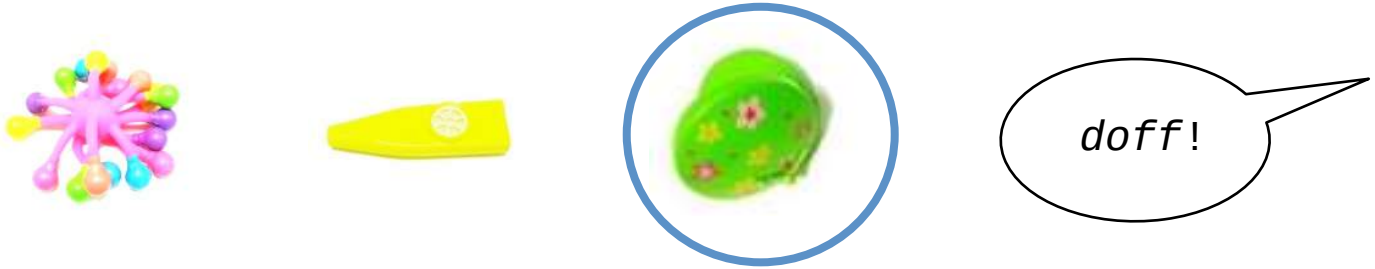
General methods

Referent selection: teach children novel words by presenting an array of objects, all-but-one known



Five-minute break

Retention:
present just-seen objects and ask for each in turn



Procedure and design

- Run 30 x 23mo toddlers in a computerised word learning task and record looking times using an eyetracker
- Teach toddlers 3 novel words across 15 trials (3 novel 2 known per block)

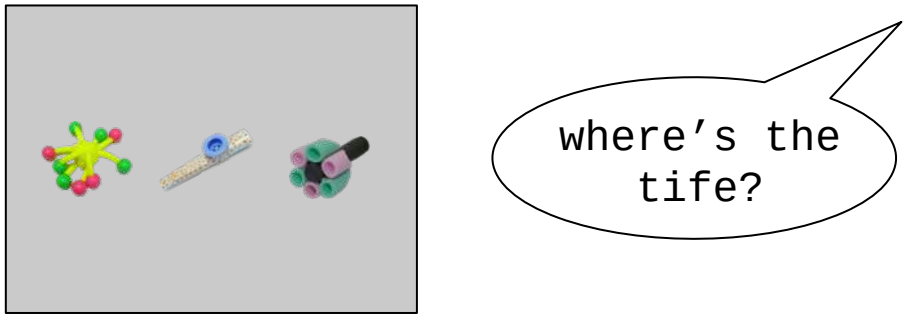
2 conditions:

- half see white backgrounds (constant colour),
- half see multiple different coloured backgrounds (variable colour)

Everything else kept identical between conditions

Test / retention

Six test trials, two per object

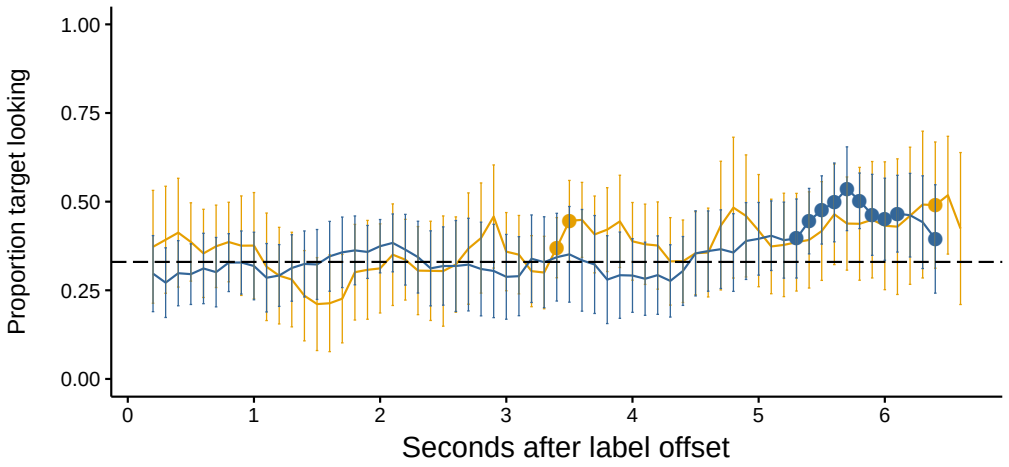


Test trials identical between conditions

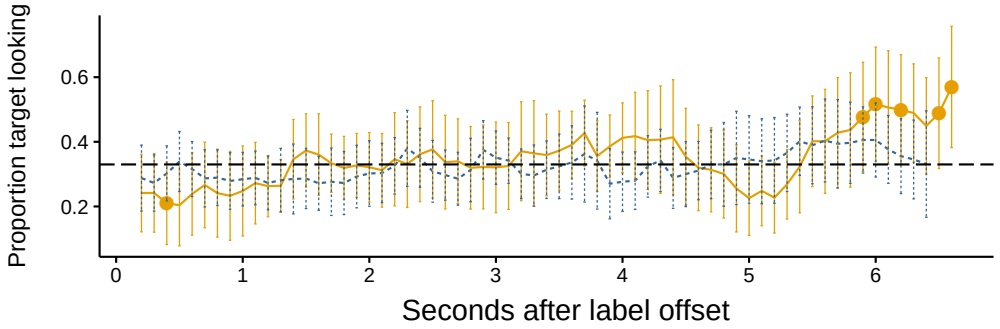
Test trials always presented on grey background

Results, referent selection

Constant



Variable



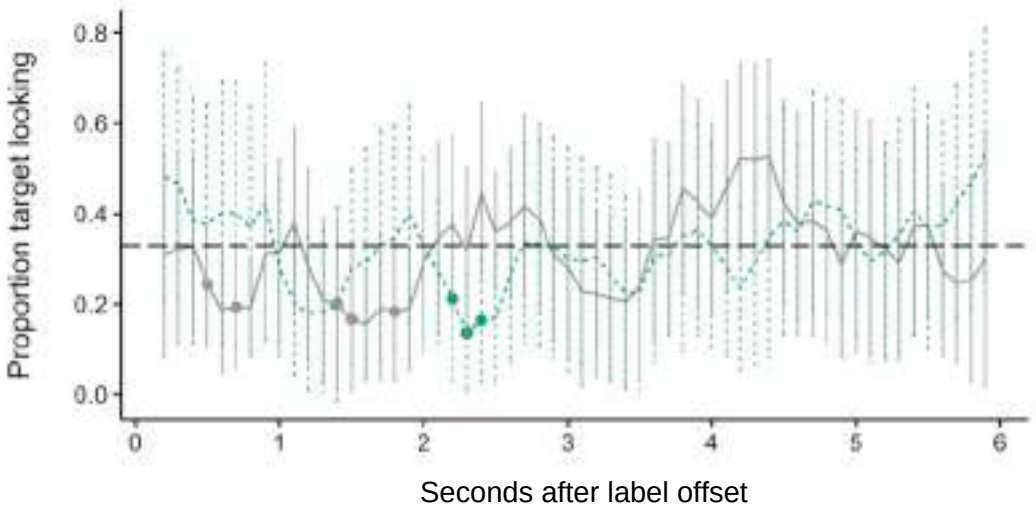
Overall increase in looking over time (beta = 0.0022, $p < .001$)

But faster on known than novel trials for children in the variable condition (known: beta = 0.0022; novel: beta = 0.0019; *p*s < .001)

No consistent above-chance target looking

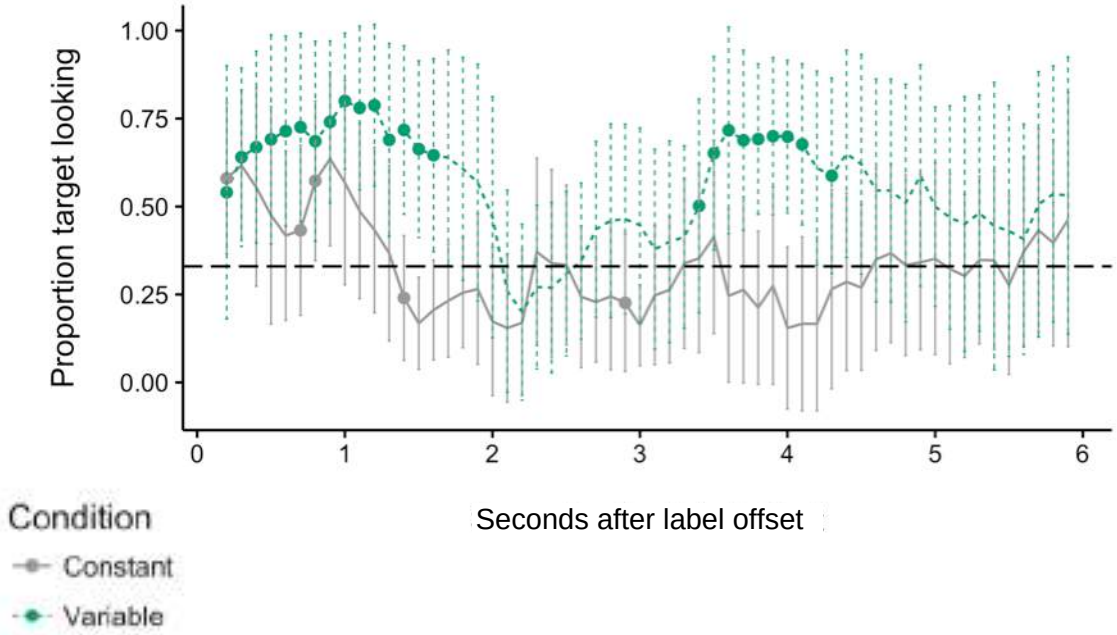
Trial type known novel

Results, retention



Block 1

Increase in looking over time (beta = 0.0019, p = .0012)



Block 2

Decrease in looking over time (beta = 0.0029, p < .001)

More target looking in variable condition (beta = 0.25, p = .0032)

Overall our hypothesis is supported: only children who saw **variable** backgrounds learned novel nouns

Theoretically, adding entropy to the word learning system sped up a change in behavioural state

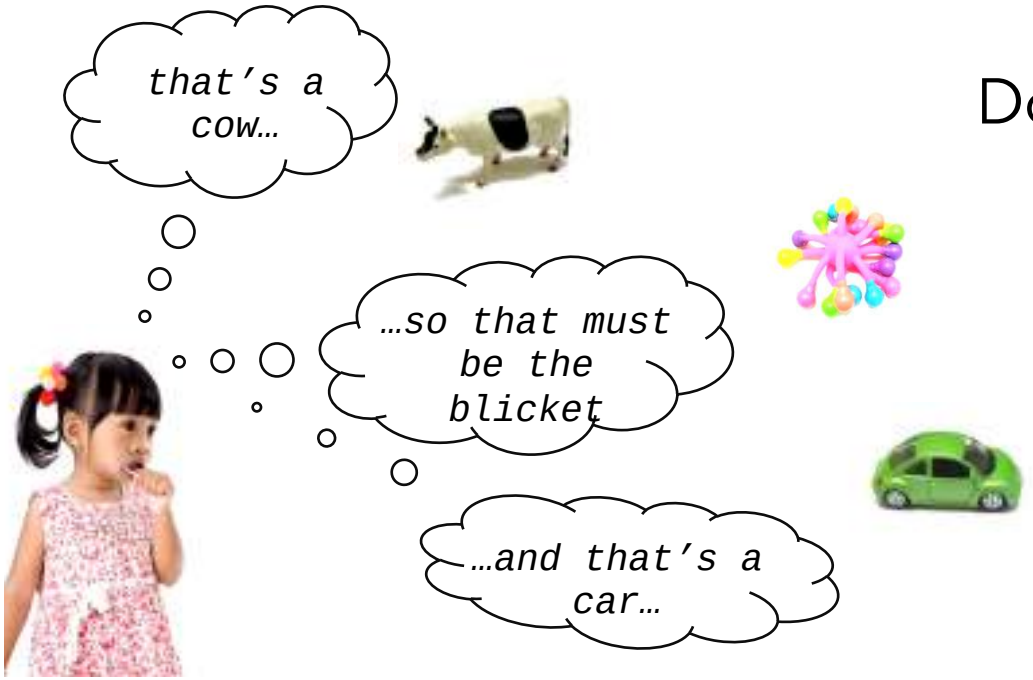
But, only children in constant condition showed evidence of identifying targets during referent selection

Raises two puzzling questions…

Children in the variable don't look at the novel target at above-chance levels during referent selection, but they do show retention. How?

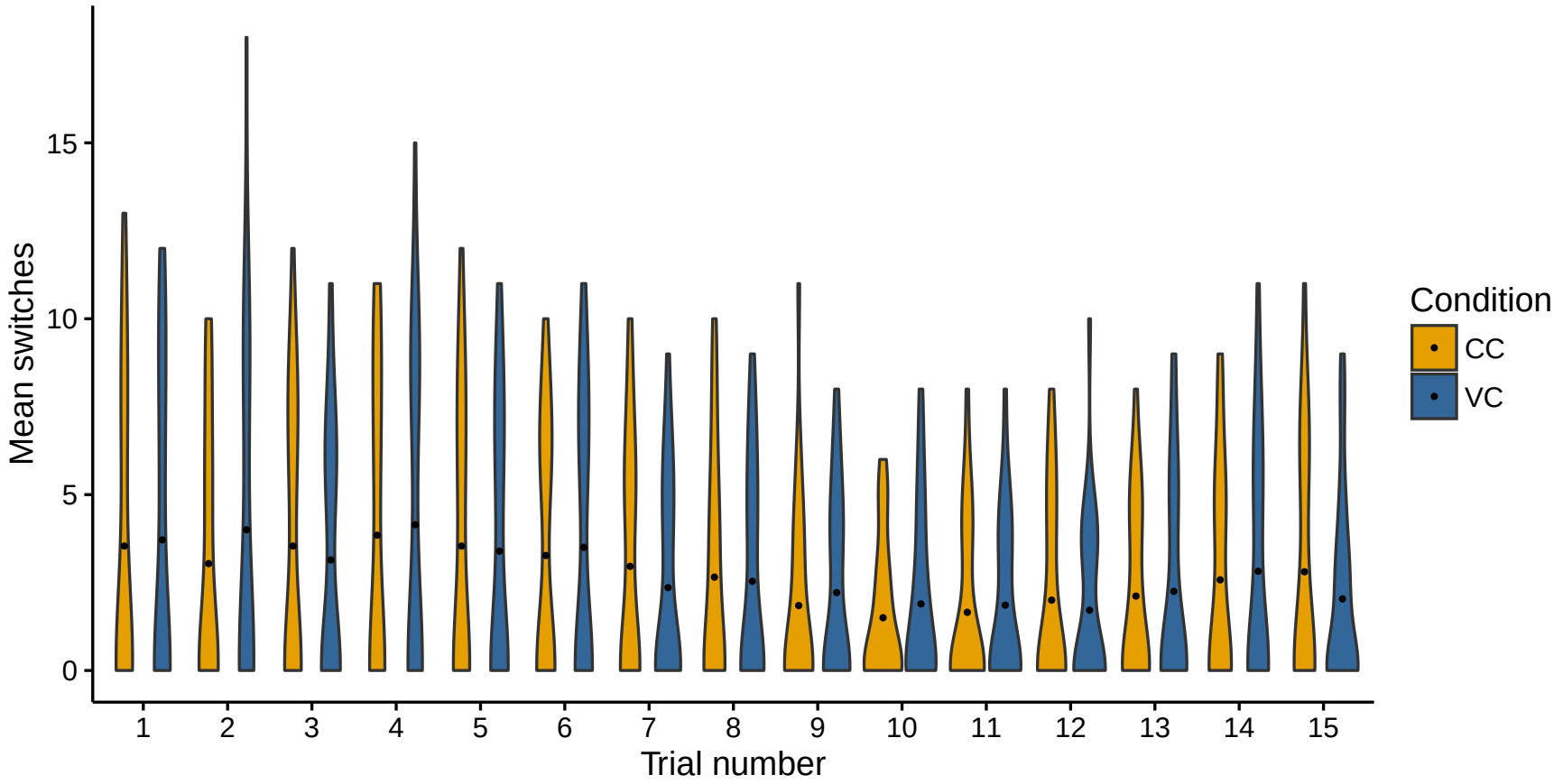
Increasing empirical and computational evidence that children disambiguate in word learning tasks (Bion et al., 2013; *Cognition*; McMurray, Horst & Samuelson, 2012; *Psych. Rev*; Twomey et al., 2016; *Interaction Studies*)

Thus, children look at competitors objects, working out what's *not* the *blicket*



Don't need to learn *everything* about the target to learn the association between a target and a word: incremental word learning

(Yurovsky, Fricker, Yu & Smith, 2014)

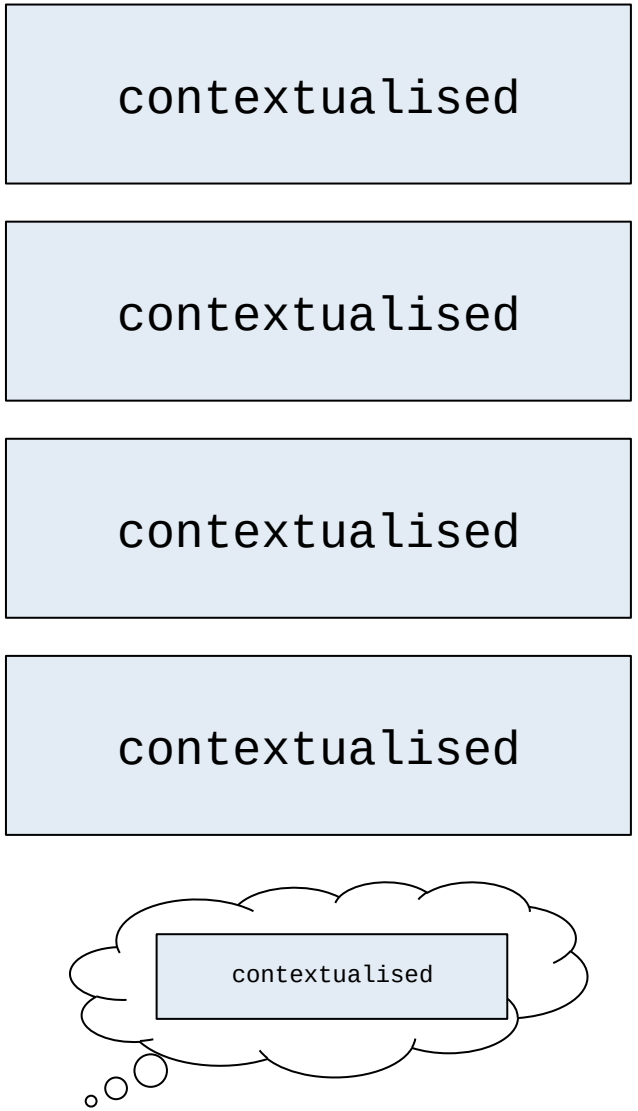


Implications for our interpretation of looking time and word learning tasks:

learning is not necessarily contingent on robust responding during training

Why did only children in the variable condition learn?

Adult learning literature: representations are either context-dependent (Godden & Baddeley, 1975; *BJPsych*)

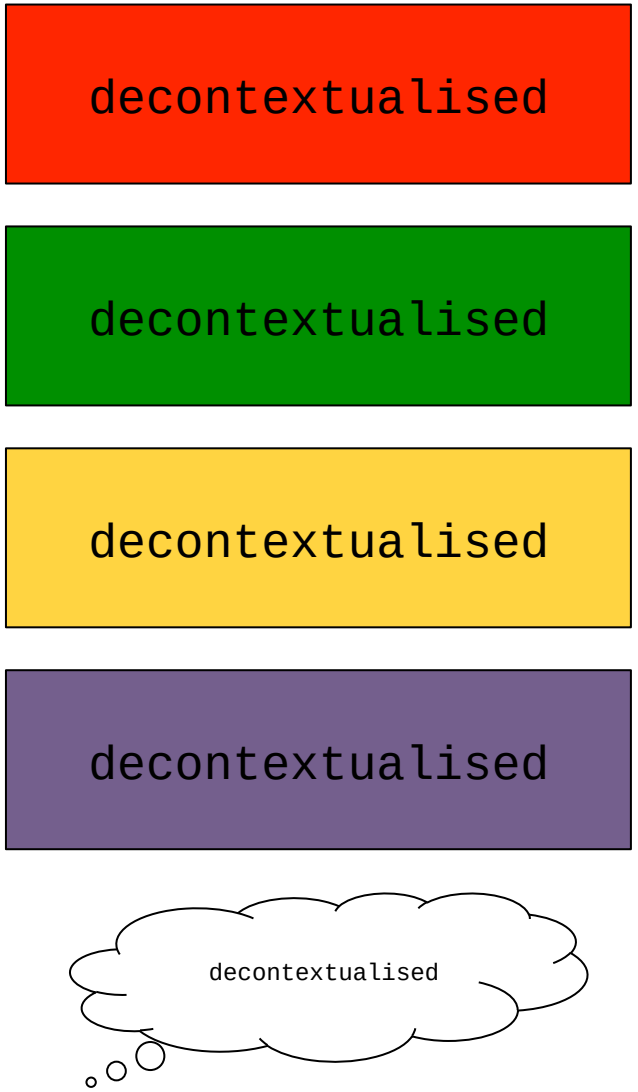


Why did only children in the variable condition learn?

Adult learning literature: representations are either context-dependent (Godden & Baddeley, 1975; *BJPsych*)

or *decontextualised* when leaning is repeated across contexts

Recall in same context is easier for for context-dependent representations, but generalisation to new contexts is easier for decontextualised representations

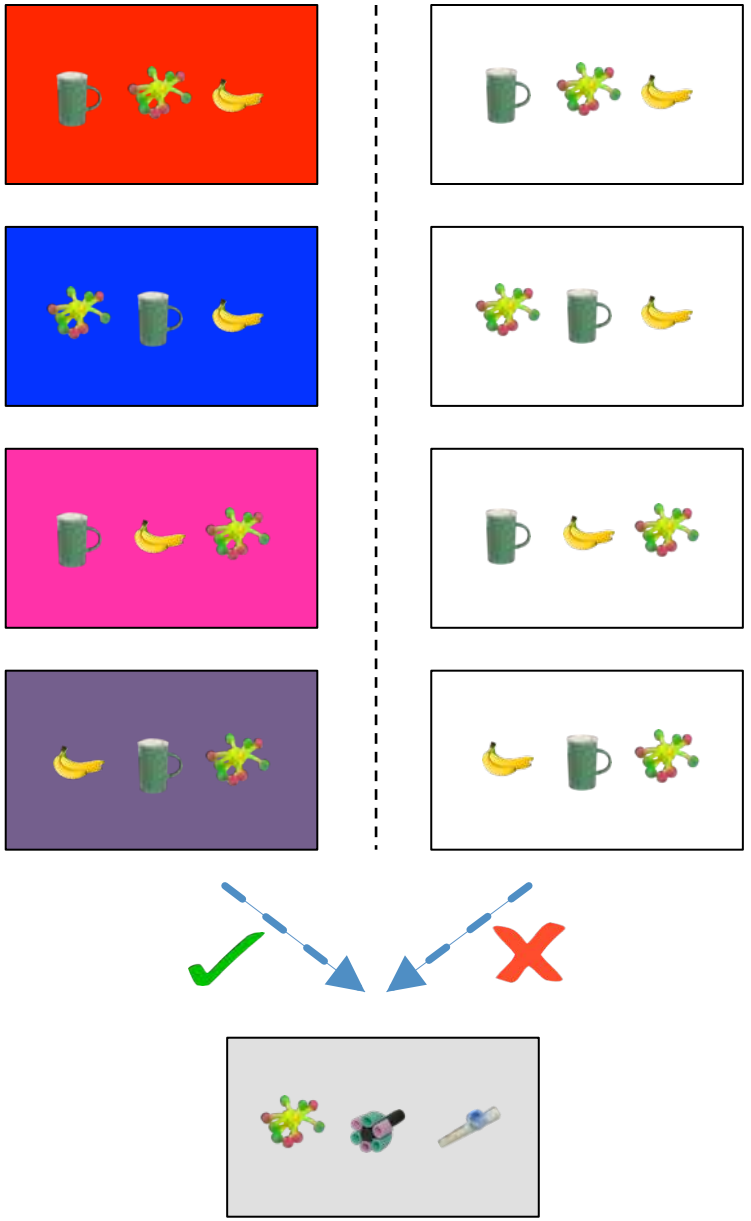


- variable condition = decontextualised
- constant condition = contextualised
- All children had to generalise to a context at test

Easier for children in the variable condition to generalize

Importantly: lack of a behaviour != lack of learning

How do results from looking time studies relate to behavioural results?

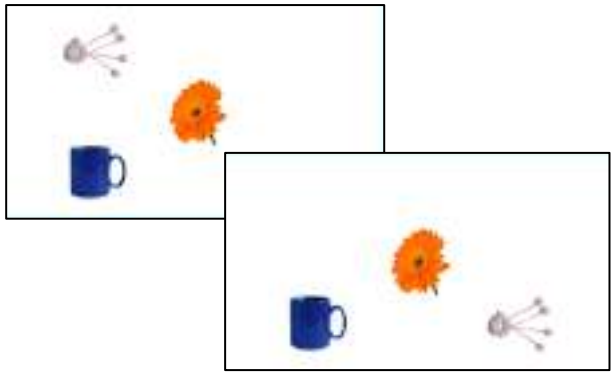


Overall, background variability supports word learning!

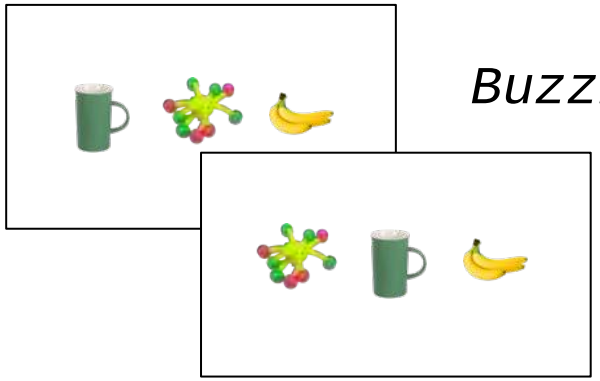
But is this effect restricted to the visual modality?

If this is a dynamic systems phenomenon, could entropy in other modalities have a similar effect?

Spatial location?



Sound?



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Language (acquisition) isn't about words in isolation, or language-specific cognitive structure….

To understand language (acquisition), we must consider all components of that system

Twomey, Ma & Westermann (under revision).
All the right noises: background variability facilitates early noun learning.
Cognitive Science.

Huge thanks to all the parents and toddlers who took part, and to our funders

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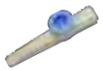
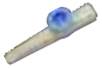
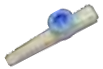
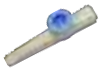
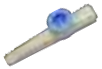
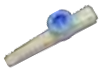
Trial	Stimuli	Color	Target
Engagement 1		n/a	n/a
Warm-up 1			*ball*
Warm-up 2			*fork*
Warm-up 3			*cup*
RS block 1 trial 1			*banana*
Attention getter 1		n/a	n/a
RS block 1 trial 2			*tife*
RS block 1 trial 3			*cup*
RS block 1 trial 4			*tife*
Attention getter 2		n/a	n/a
RS block 1 trial 5			*tife*
RS block 2 trial 1			*apple*
RS block 2 trial 2			*zorch*
Attention getter 3		n/a	n/a
RS block 2 trial 3			*zorch*
RS block 2 trial 4			*fork*
Attention getter 4		n/a	n/a
RS block 2 trial 5			*zorch*
RS block 3 trial 1			*car*
Attention getter 5		n/a	n/a
RS block 3 trial 2			*blick*
RS block 3 trial 3			*ball*
RS block 3 trial 4			*blick*
Attention getter 6		n/a	n/a
RS block 3 trial 5			*blick*
Well done!		n/a	n/a
Five-minute break			

Trial	Stimuli	Color	Target
Engagement 2		n/a	n/a
Warm-up	  		*car*
Ret trial 1	  		*tife*
Ret trial 2	  		*zorch*
Ret trial 3	  		*blick*
Ret trial 4	  		*zorch*
Ret trial 5	  		*blick*
Ret trial 6	  		*tife*
Well done!		n/a	n/a