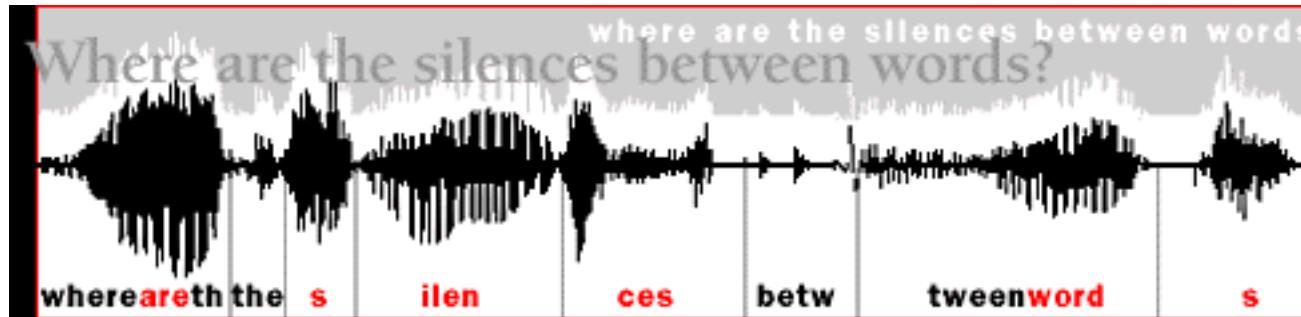


# The role of social information in cross-situational word learning

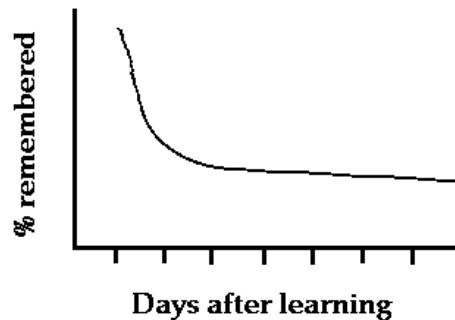
Kyle MacDonald  
Developmental Brownbag  
5/21/14



“BALL”



Curve of Forgetting



# The problem of baby's first Christmas







# Roadmap

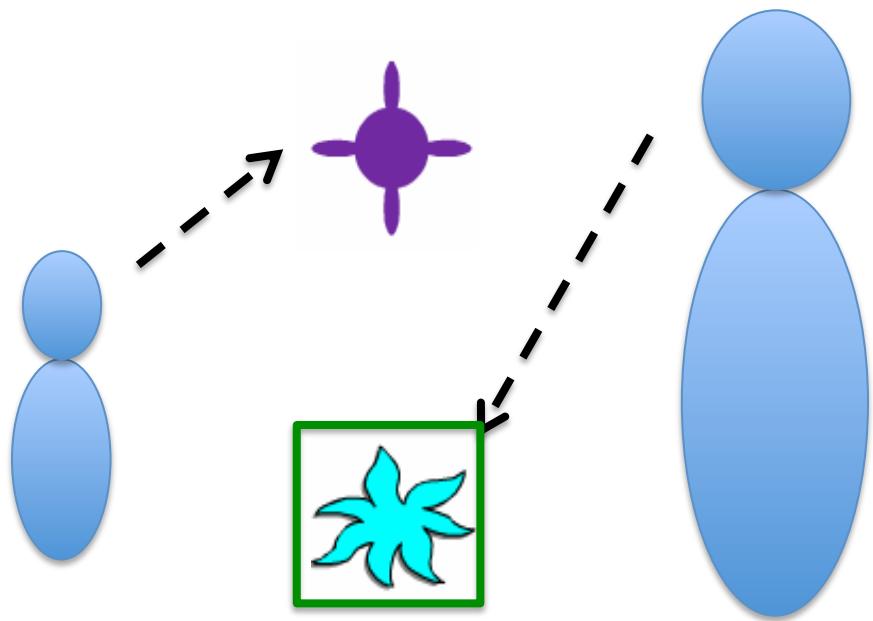
Different ways to reduce referential uncertainty

Debate about the process underlying cross-situational word learning

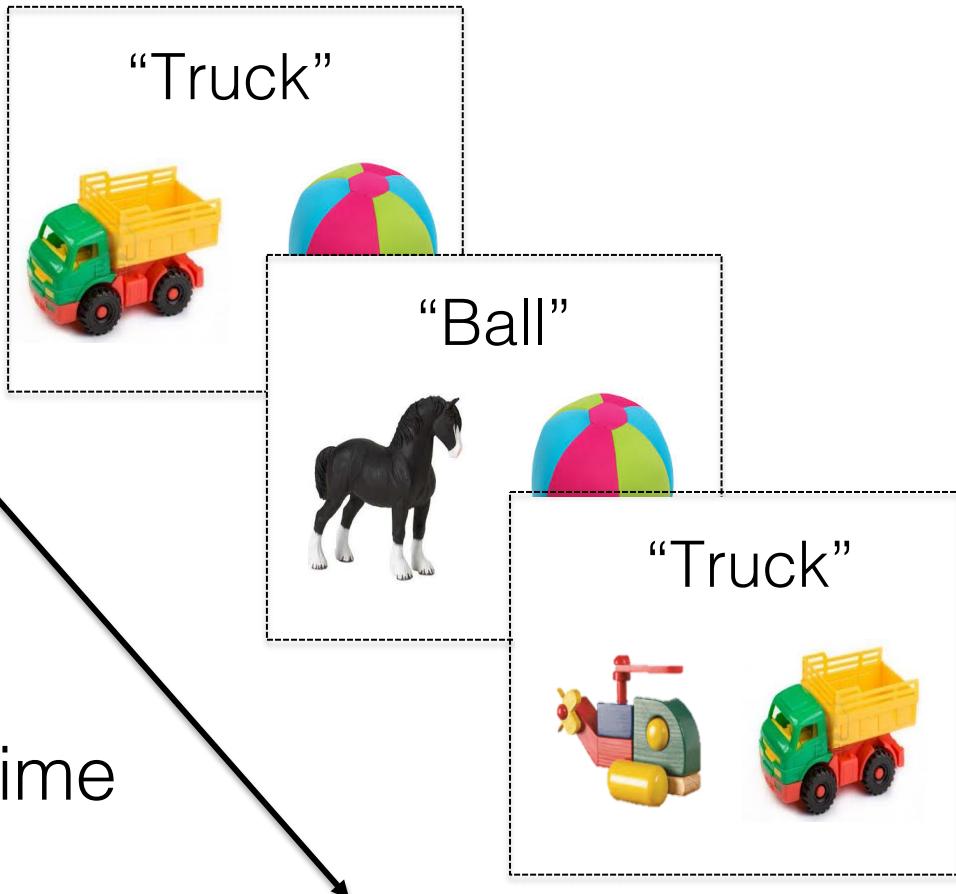
A novel, large-scale experiment and computational model

# Reducing uncertainty during labeling (social cues)





# Reducing uncertainty over time (cross-situational learning)



Truck	2	1		1
Ball		1	1	

# Cross-situational word learning

2	1		1
	1	1	

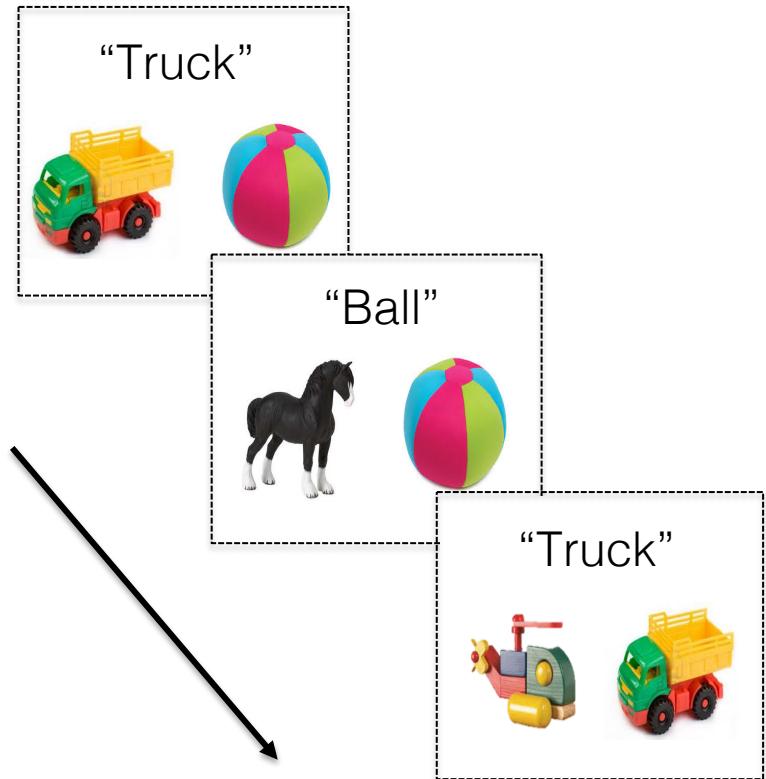
Adults and infants can learn novel words from co-occurrence information

Computational models suggest that language-scale lexicons can be acquired using cross-situational learning

## In-the-moment



## Over time



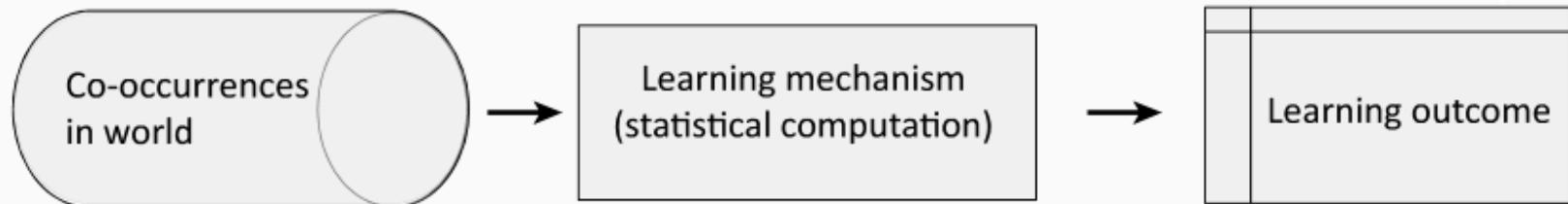
# Roadmap

Different ways to reduce referential uncertainty

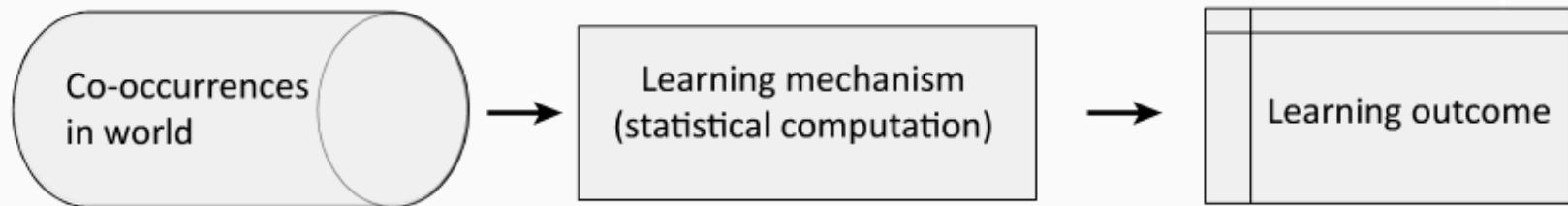
Debate about the process underlying cross-situational word learning

A novel, large-scale experiment and computational model

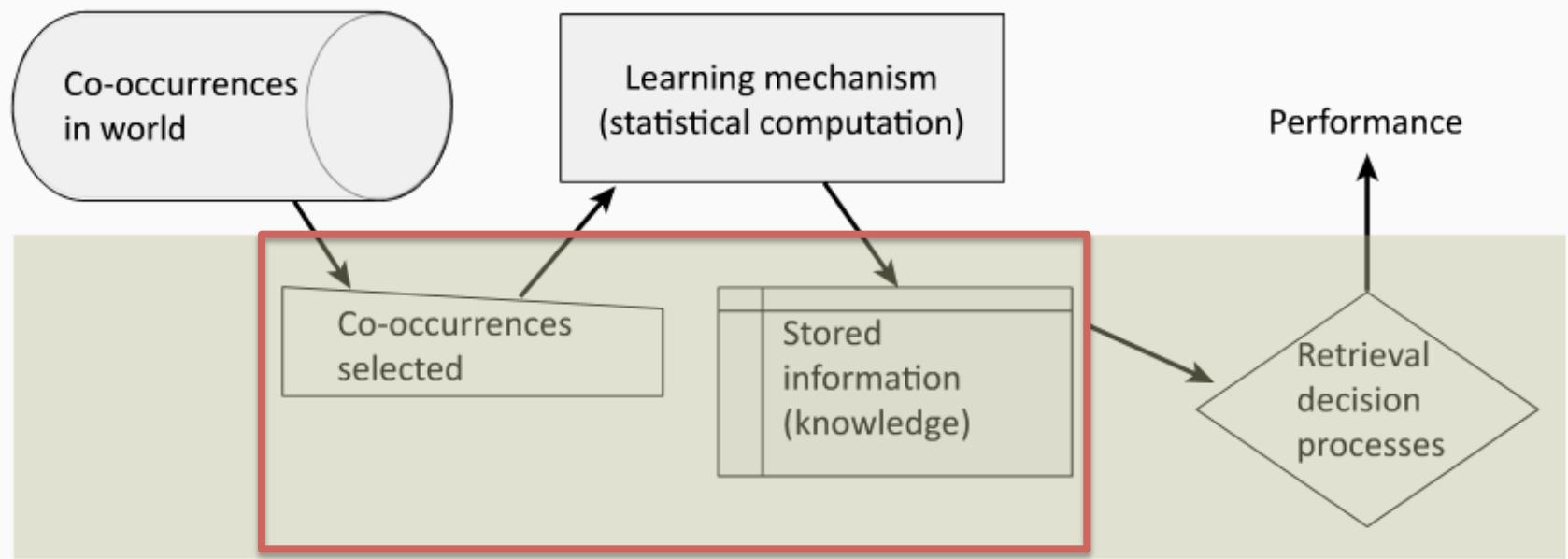
**(A) Computational level**



### (A) Computational level



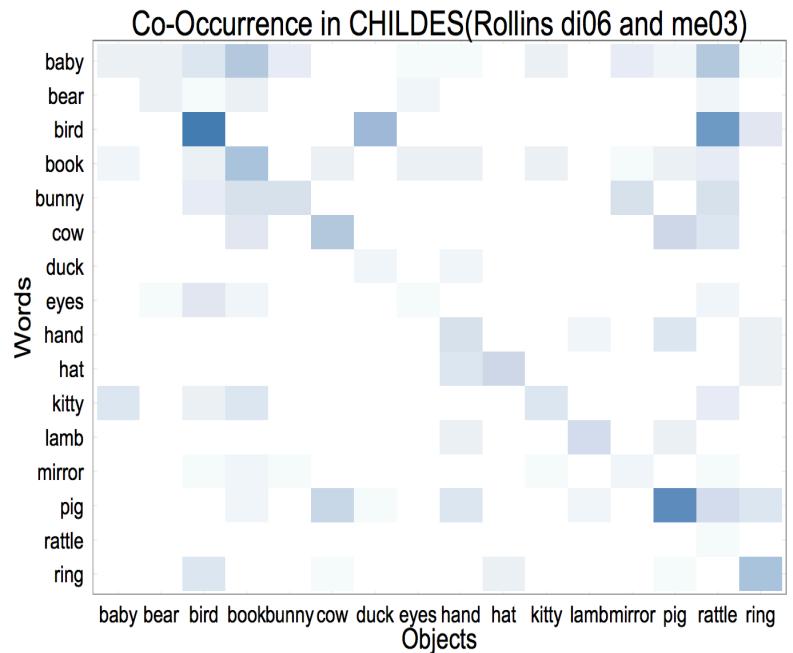
### (B) Process level



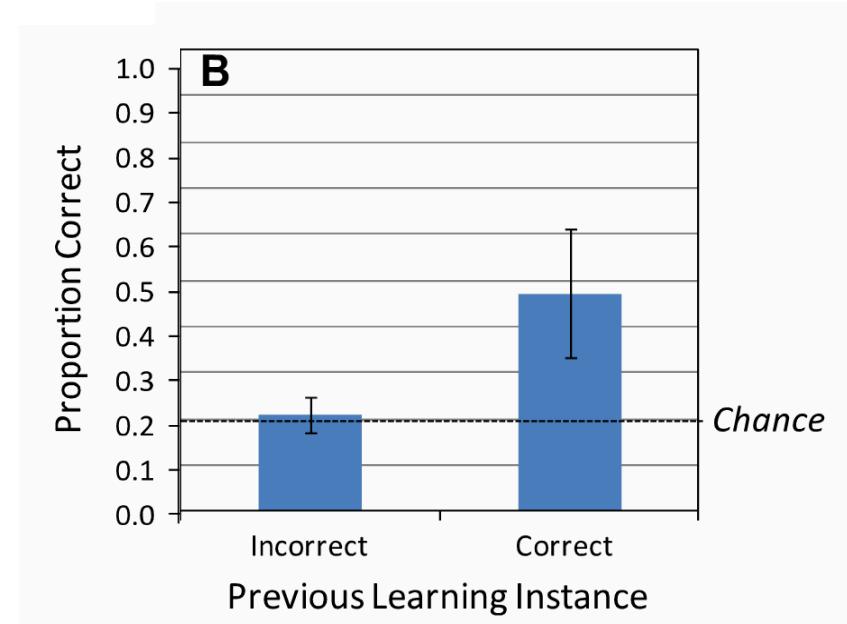
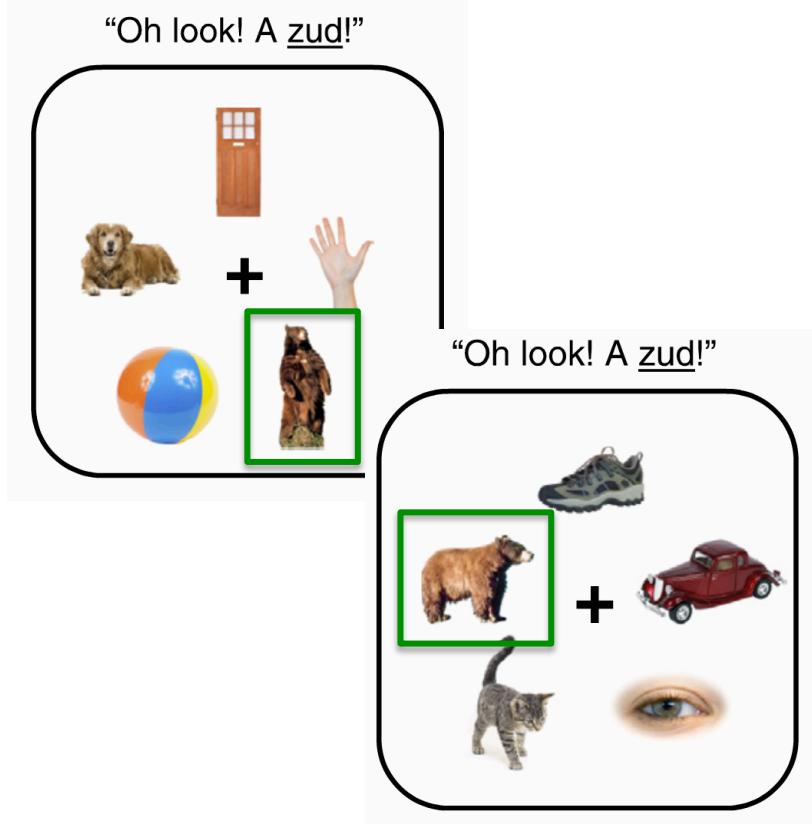
## Single-hypothesis tracker



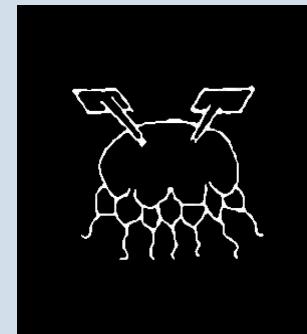
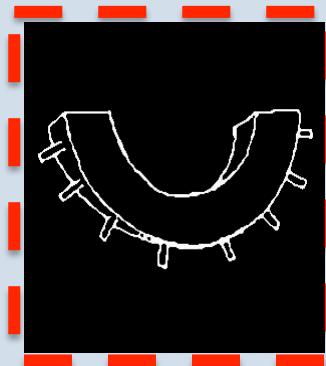
## Co-occurrence tracker



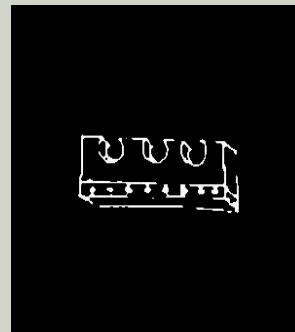
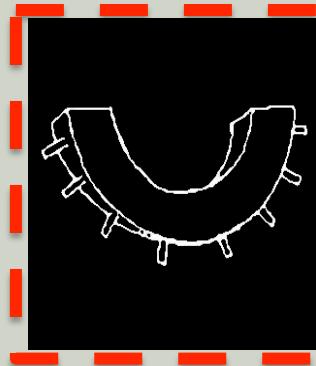
# Evidence for single-hypothesis tracking



## Exposure Trial

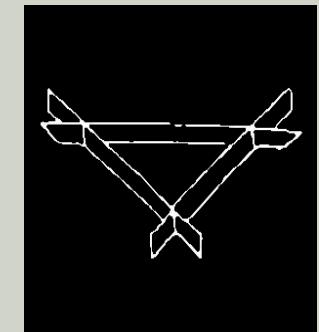
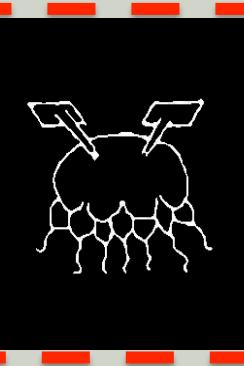


## Test Trial

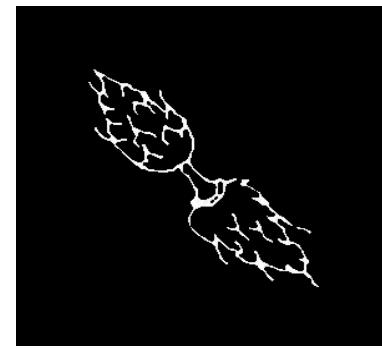
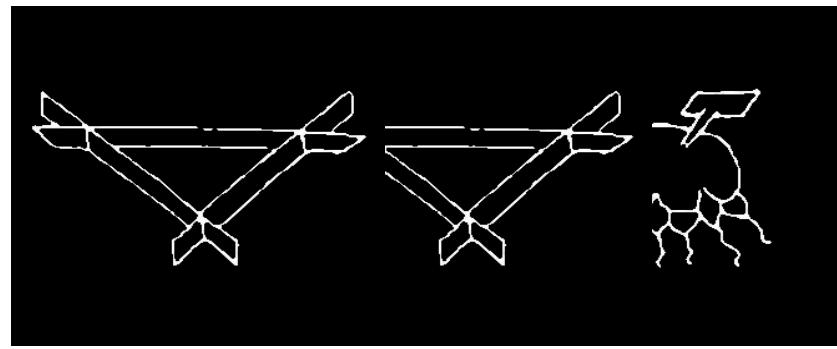
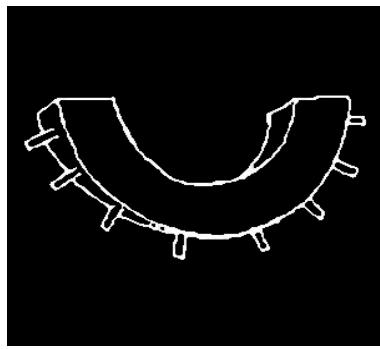
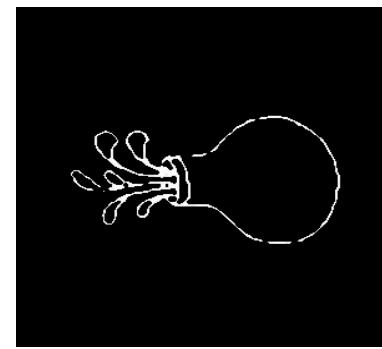
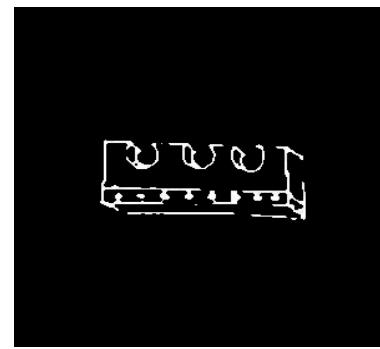
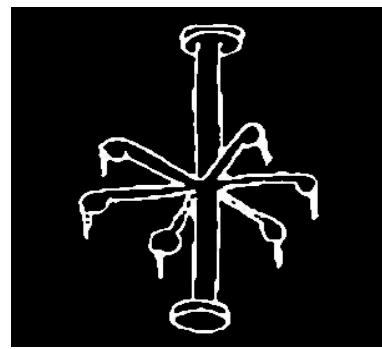
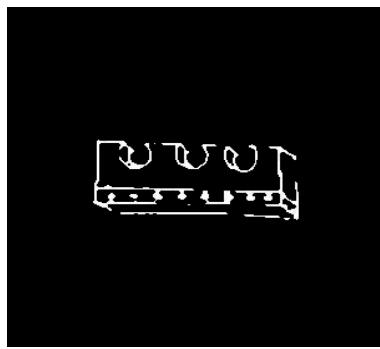


*Grink*

Same



Switch



# Different **delay** conditions

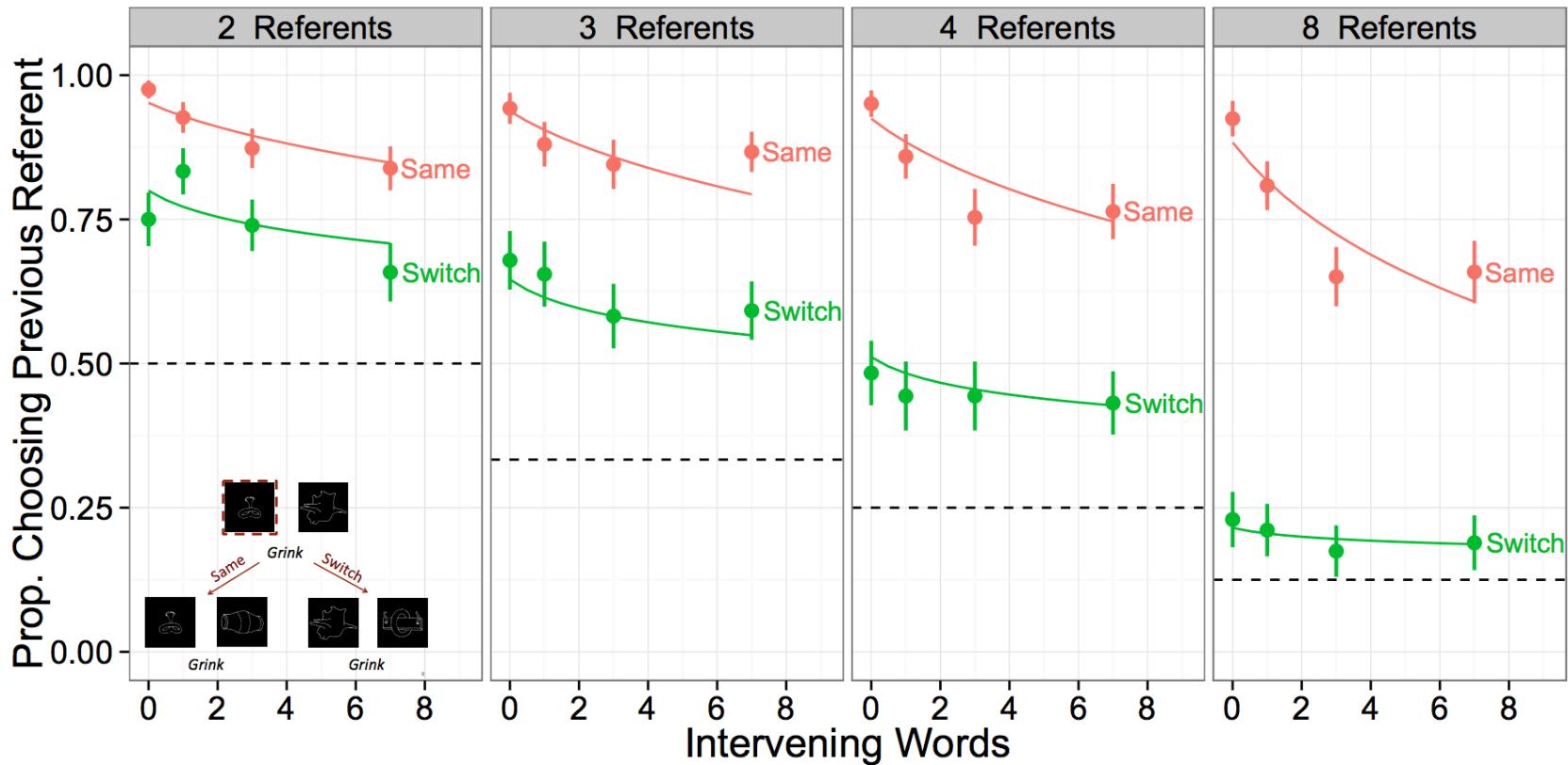
[ Grink  
Grink  
**Roybart**  
**Roybart**  
Esprink  
Esprink  
Jishber  
Jishber  
Glot  
Glot  
**Damumish**  
**Damumish**  
Lorzit  
Lorzit  
**Croshen**  
**Croshen**

[ Grink  
**Roybart**  
Grink  
**Roybart**  
Esprink  
Jishber  
Esprink  
Esprink  
Jishber  
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Lorzit  
**Croshen**  
Grink  
**Roybart**  
Esprink  
Jishber  
Glot  
**Damumish**  
Lorzit  
**Croshen**

# Tracking multiple alternatives at all levels of attention and memory demands



# Type of representation is influenced by **selection strength**

## Statistical Accumulation

“Grink”



“Damumish”

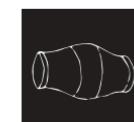


**selection strength**

## Single Referent Tracking



→ “Grink”



→ “Damumish”

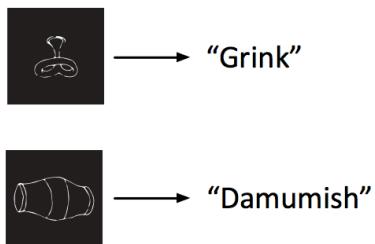
**Hypothesis:** social information modulates selection strength which could influence the learner's representation



**uncertainty**



#### Single Referent Tracking



#### Statistical Accumulation



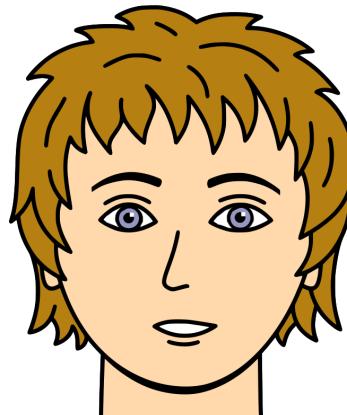
# Roadmap

Different ways to reduce referential uncertainty

Debate about the process underlying cross-situational word learning

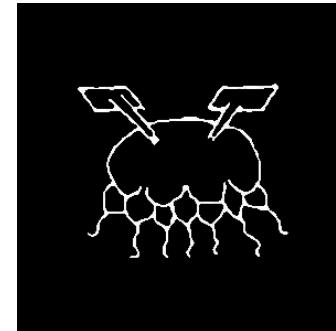
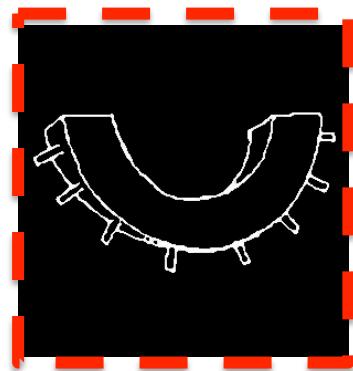
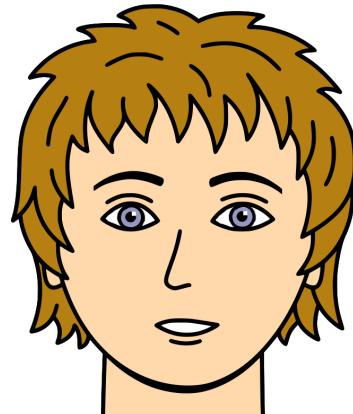
A novel, large-scale experiment and computational model

# Including social information

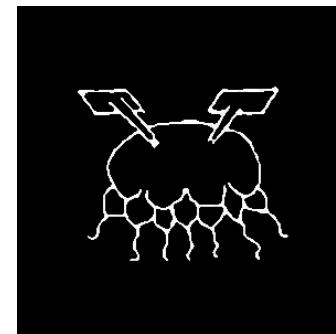
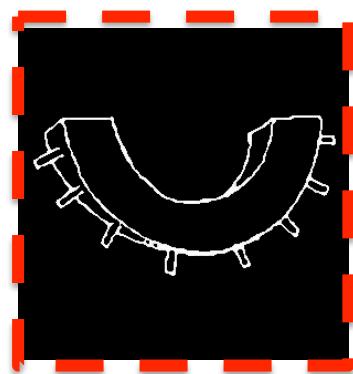
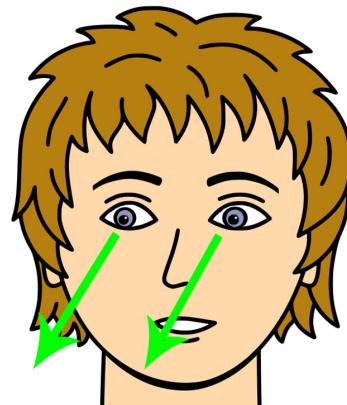


“You will meet a speaker named Tina, who will look at some objects and talk about them.”

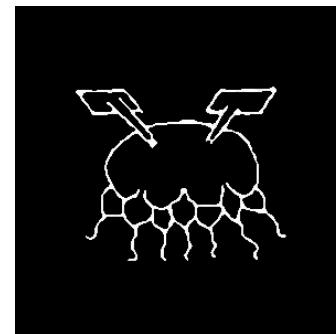
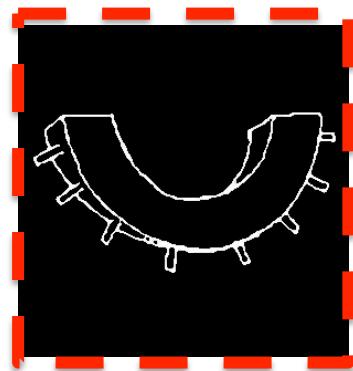
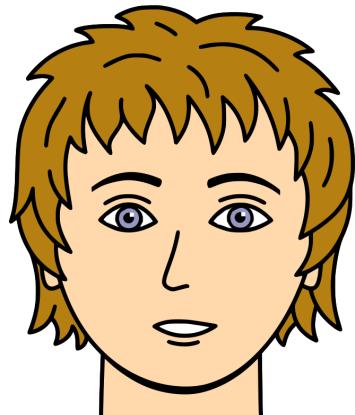
# Non-social exposure trials

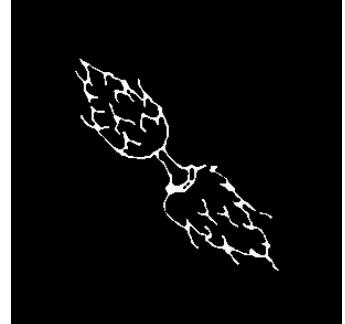
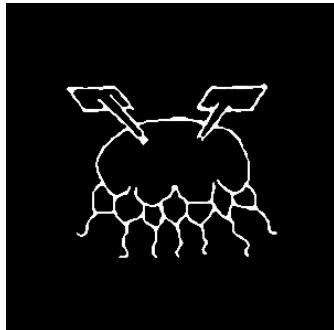
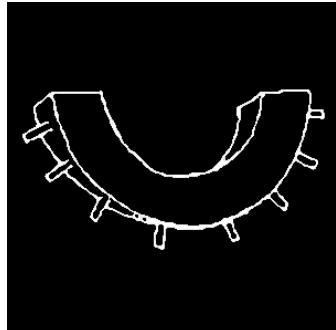
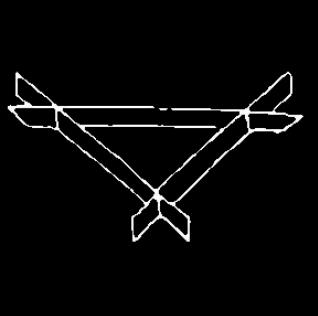
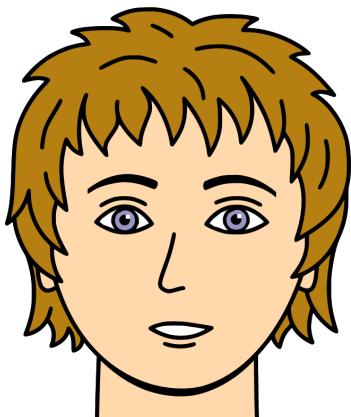
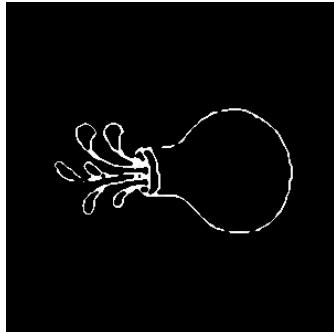
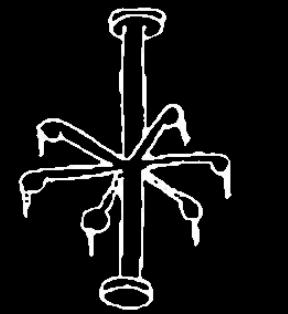


# Social exposure trials



All test trials (same/switch)  
were “non-social”





# Different **delay** conditions

[ Grink  
Grink  
**Roybart**  
**Roybart**  
Esprink  
Esprink  
Jishber  
Jishber  
Glot  
Glot  
**Damumish**  
**Damumish**  
Lorzit  
Lorzit  
**Croshen**  
**Croshen**

[ Grink  
**Roybart**  
Grink  
**Roybart**  
Esprink  
Esprink  
Jishber  
Esprink  
Jishber  
Glot  
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**Croshen**  
Grink  
**Roybart**  
Esprink  
Jishber  
Glot  
**Damumish**  
Lorzit  
**Croshen**

# Large-scale experiment manipulating **attention** and **memory** demands in a cross-situational learning task

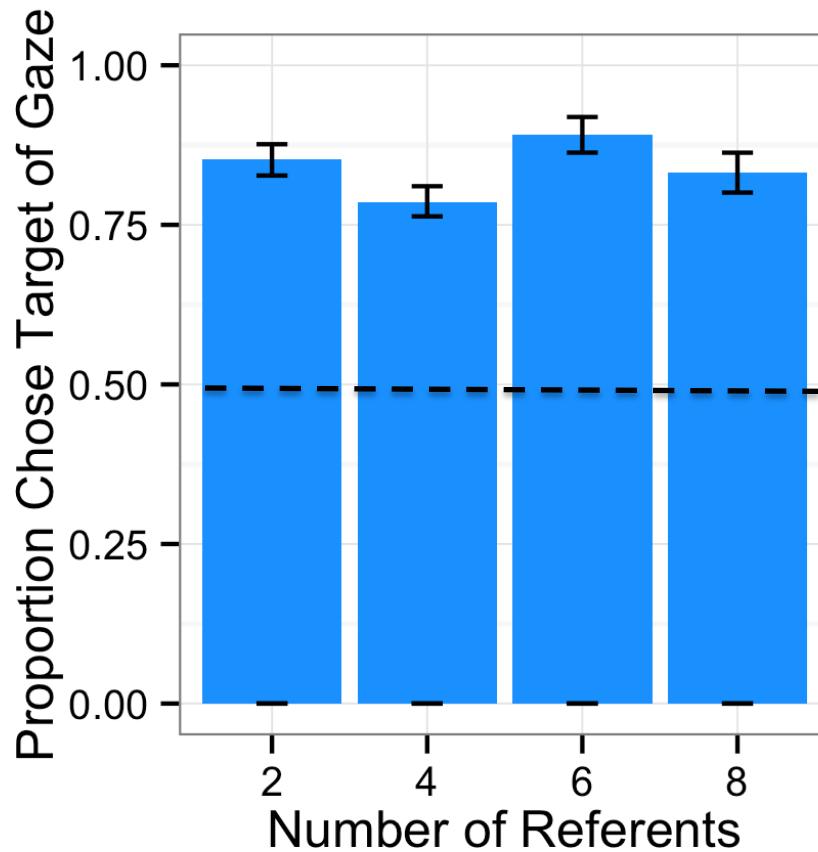
2400 participants on Amazon Mechanical Turk

8 novel words

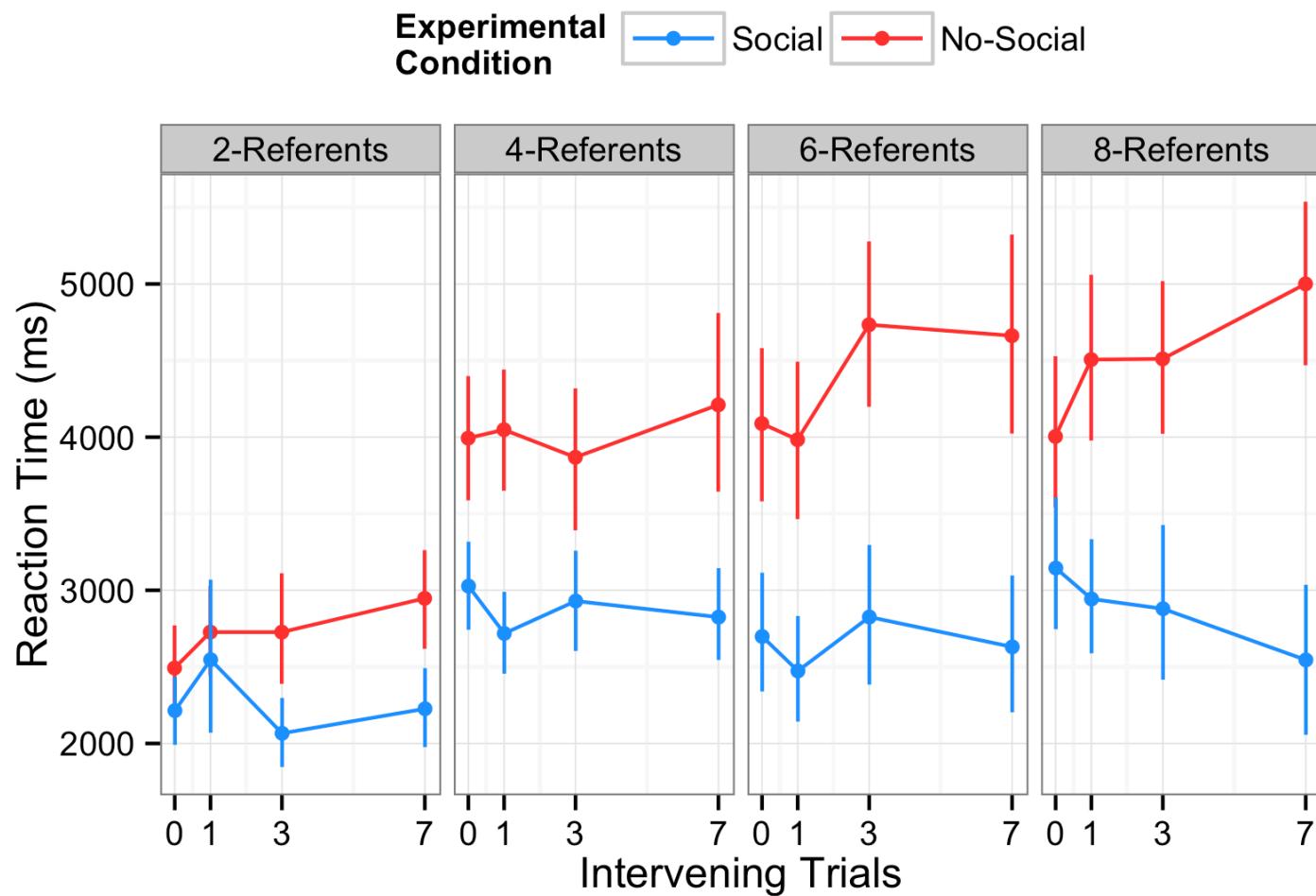
Manipulated:

- presence of social information
- number of referents
- number of intervening trials
- same vs. switch (within-subjects)

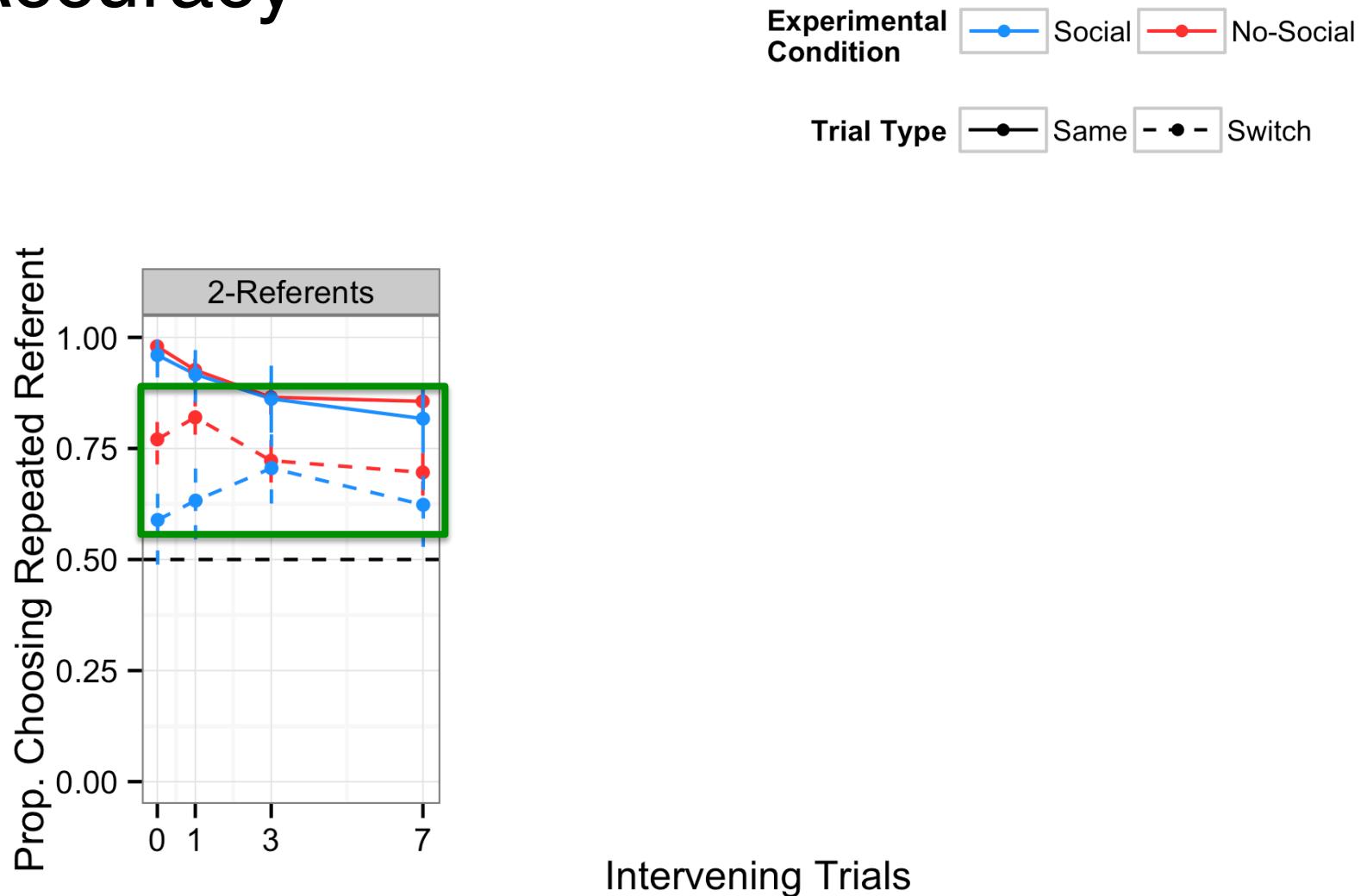
Participants reliably chose the target of eye gaze on exposure trials



Participants in the **Non-social** condition took longer to respond on exposure trials



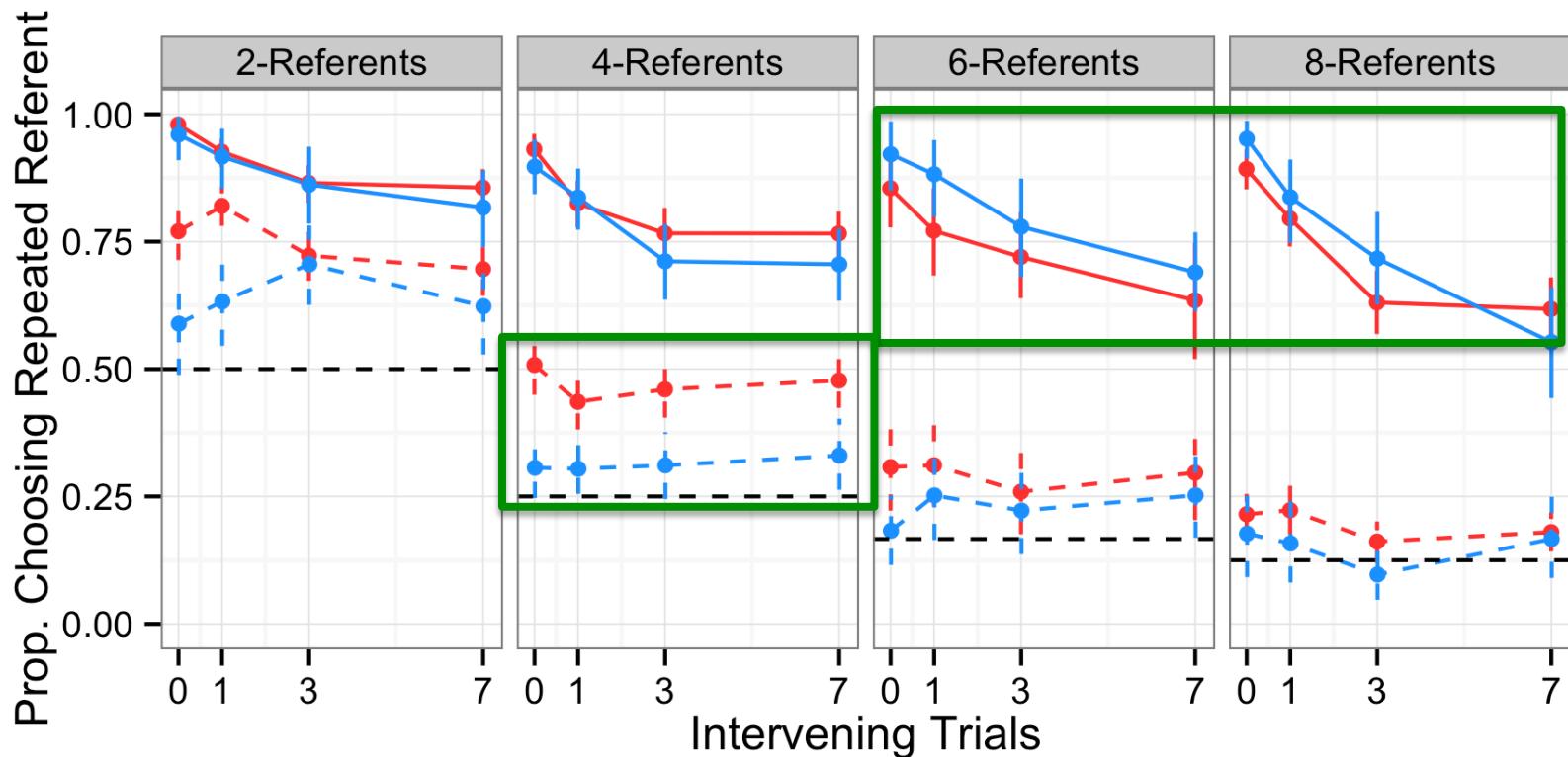
# Accuracy



# Accuracy

Experimental Condition  
Social (Blue solid line with circles) No-Social (Red solid line with circles)

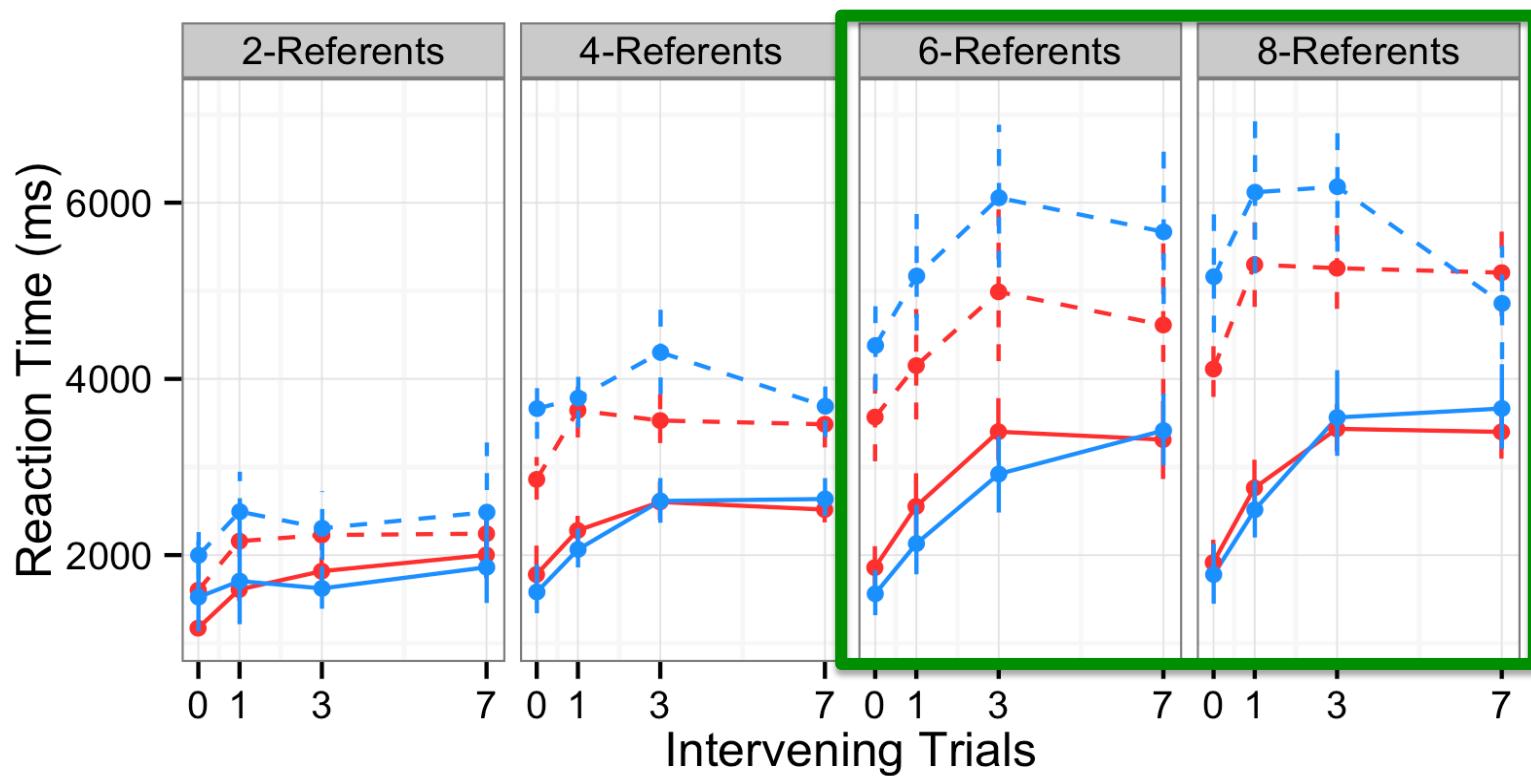
Trial Type  
Same (Solid line with circles) Switch (Dashed line with circles)



# Reaction time

Experimental Condition  
Social (Blue) No-Social (Red)

Trial Type  
Same (Solid line) Switch (Dashed line)



# Main findings

Even at a higher level of certainty – i.e., with a social cue – learners still tracked multiple alternatives

Tradeoff between reducing referential uncertainty and tracking alternatives

Some evidence that the influence of social cues interacts with attention demands

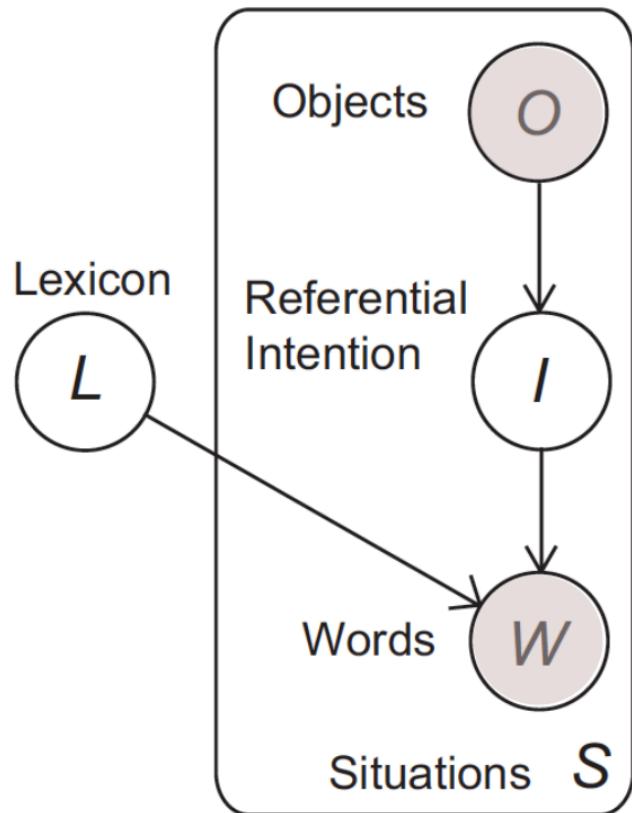
# Roadmap

Different ways to reduce referential uncertainty

Debate about the process underlying cross-situational word learning

A novel, large-scale experiment and computational model

# Computational-level model with cognitive constraints



$\sigma \rightarrow$  selection

$\lambda \rightarrow$  decay

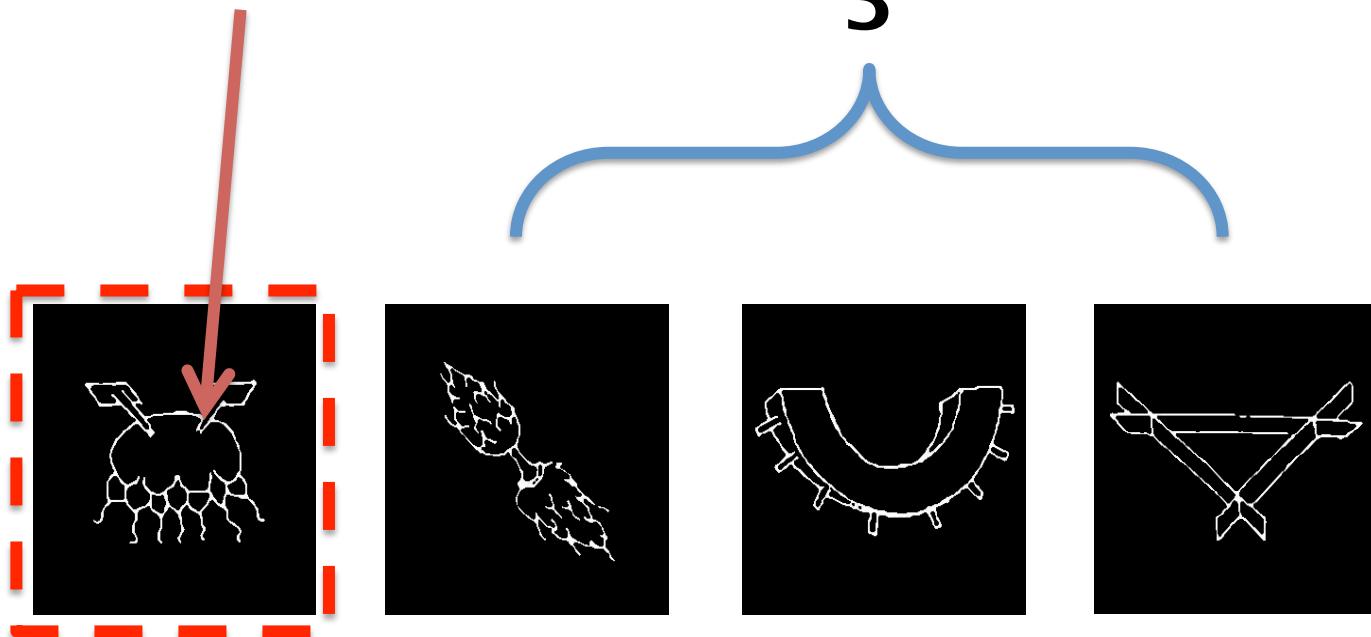
$\Upsilon \rightarrow$  encoding

# Inferring the referential intention

**selection**

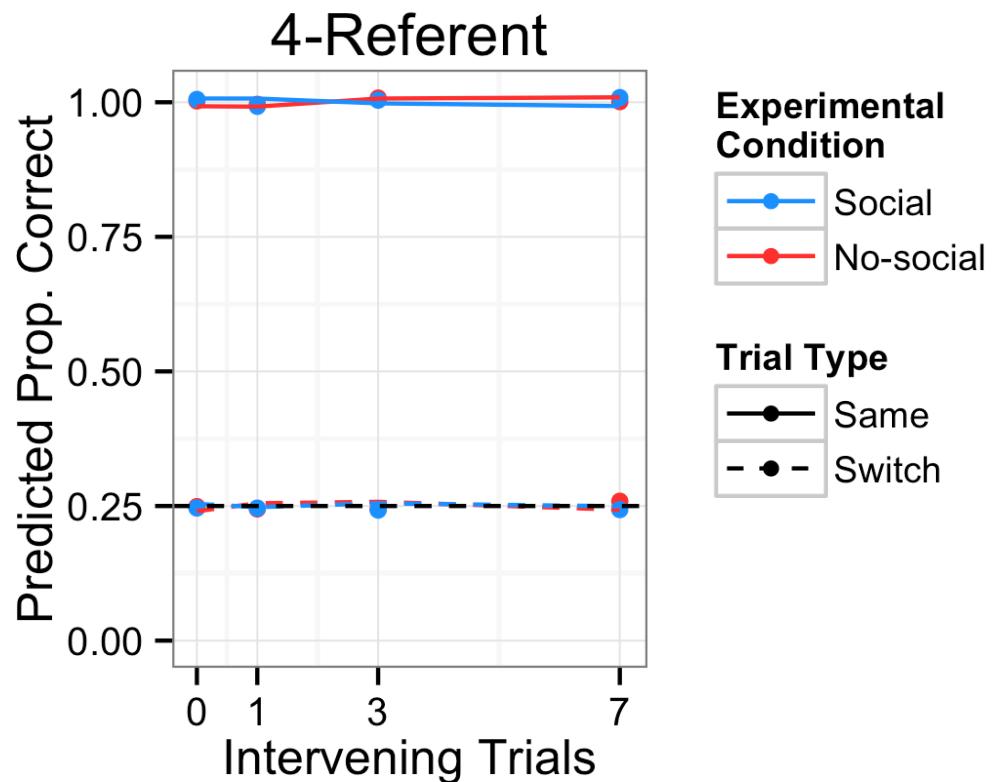
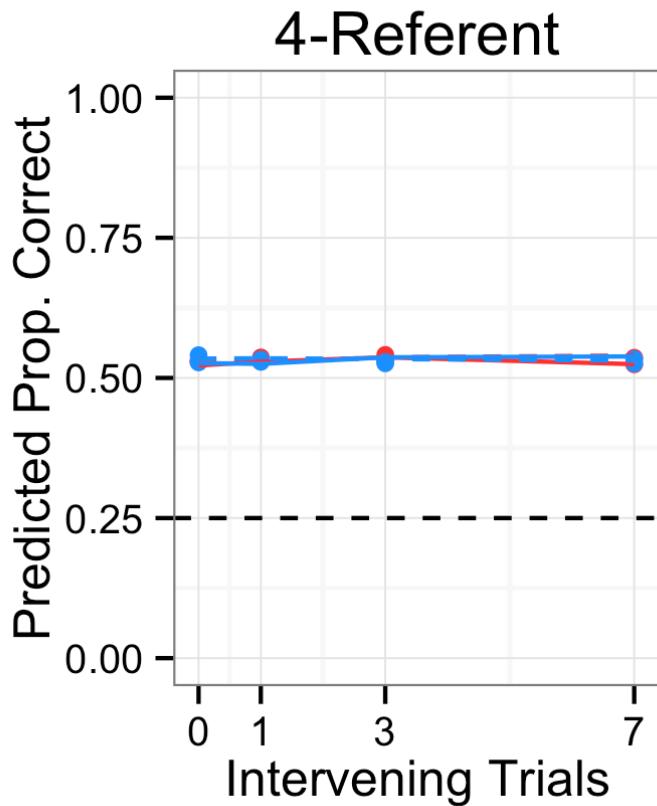
**1 - selection**

**3**

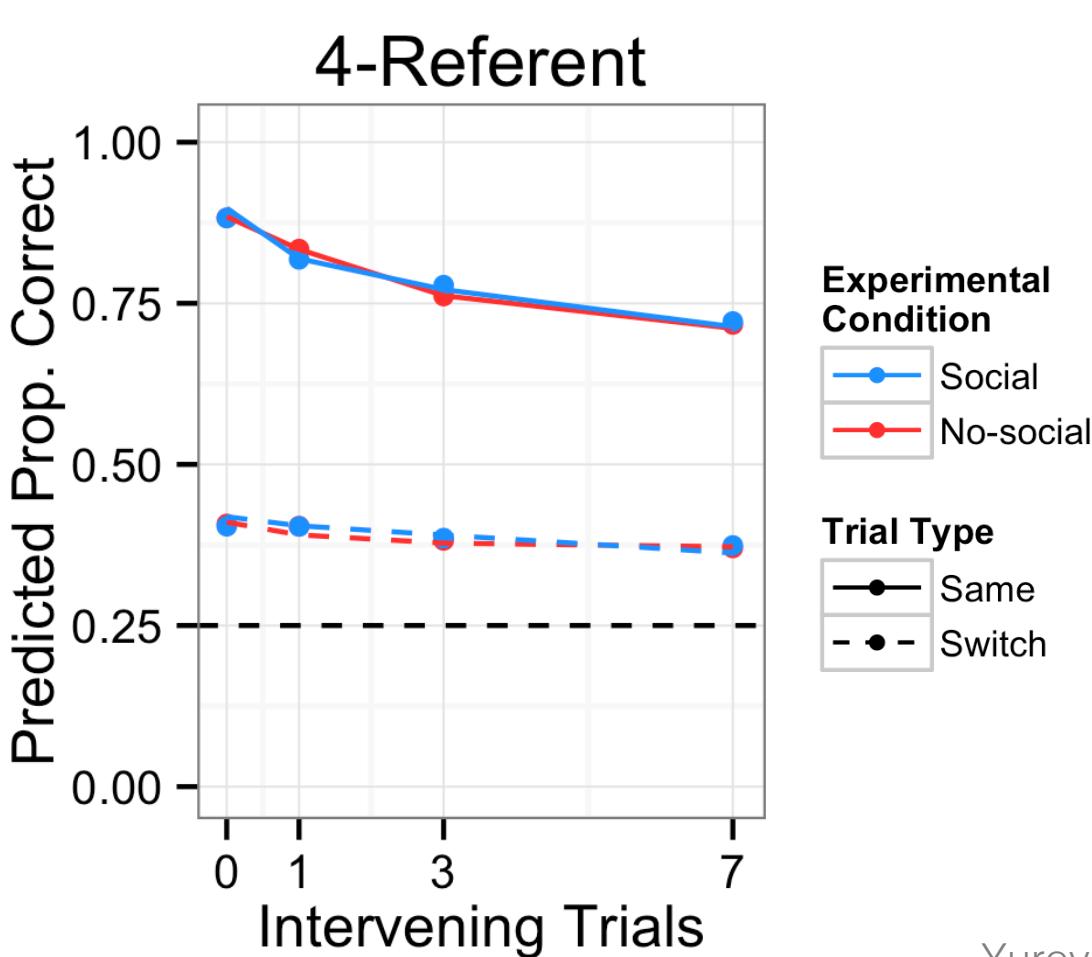


$$\text{selection} = \frac{1}{\# \text{ pics}}$$

$$\text{selection} = 1$$

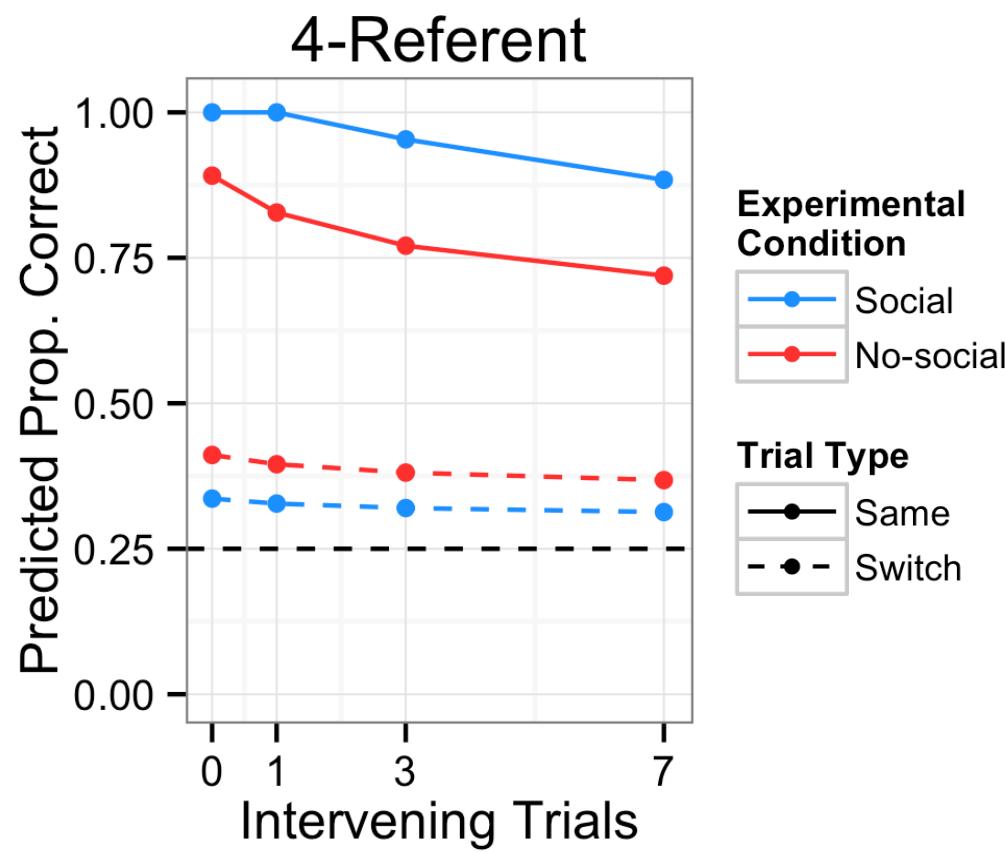


# Varying selection, decay, and encoding



**selection = 0.57**  
**decay = 0.15**  
**encoding = 1.5**

# Is social information a boost to selection strength?

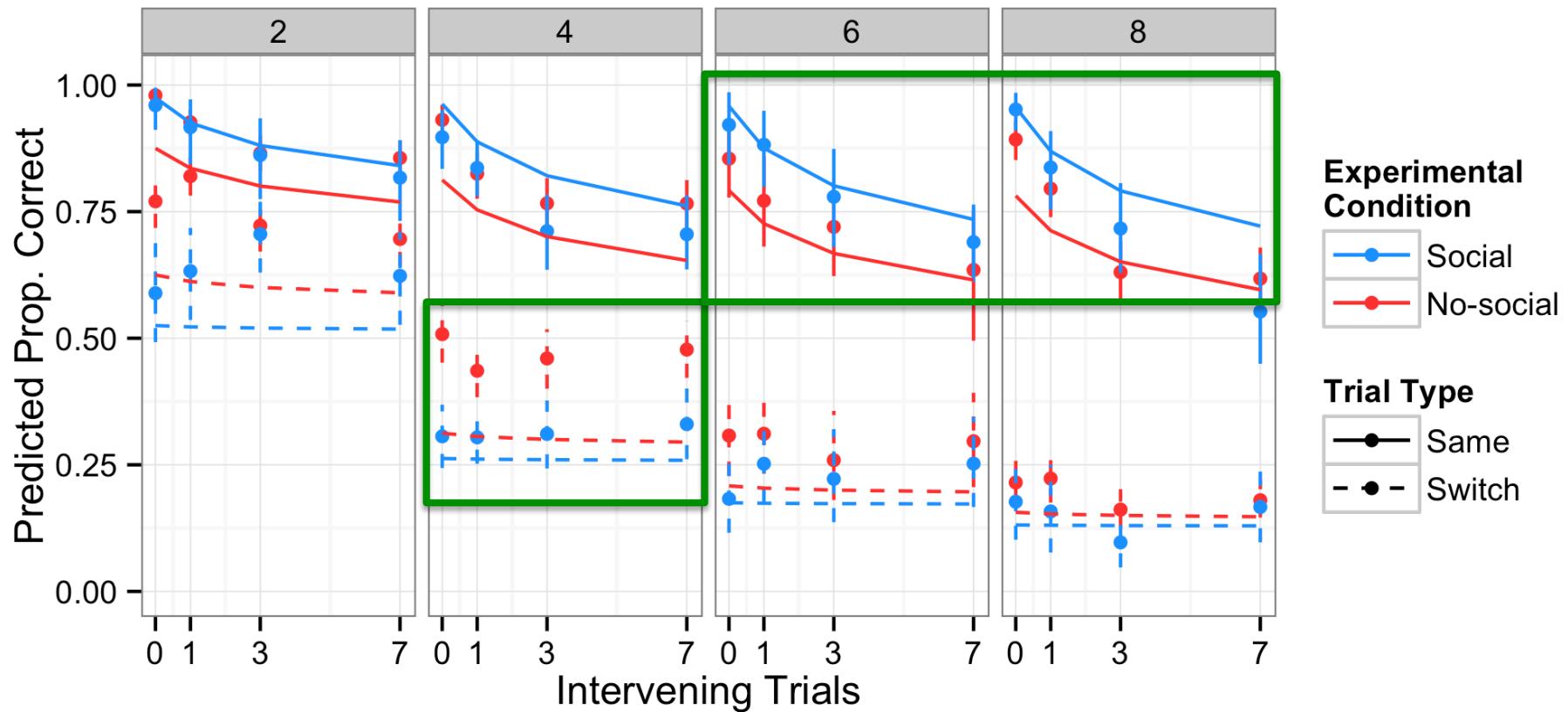


**selection = 0.57**

**decay = 0.15**

**encoding = 1.5**

## Model-Data Fits



# Alternative models of social information

Spotlights for attention

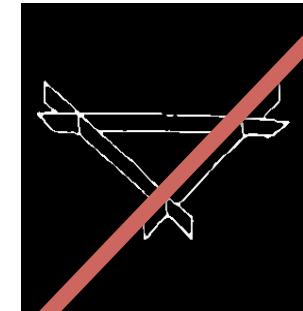
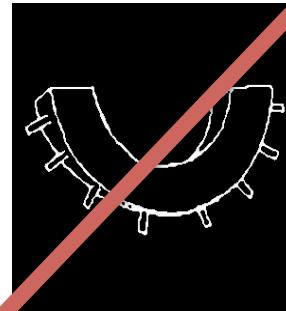
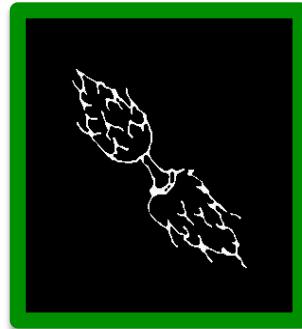
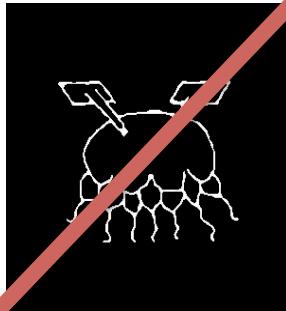
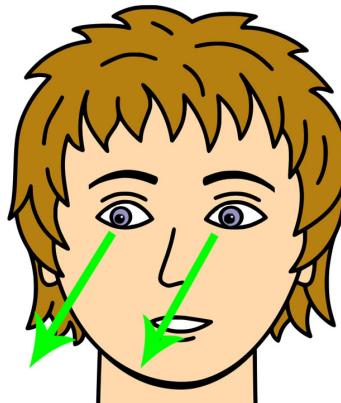
Information about referential intent

Pedagogical information

# Double-edged sword of pedagogy



# Eye gaze as pedagogical





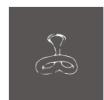
# uncertainty

---

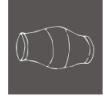


## Statistical Accumulation

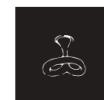
“Grink”



“Damumish”



## Single Referent Tracking



→ “Grink”



→ “Damumish”

# Acknowledgements

Michael Frank

Dan Yurovsky

Frank Lab

Markman Lab

Devostuds

First-year cohort



Thank you for your **attention**

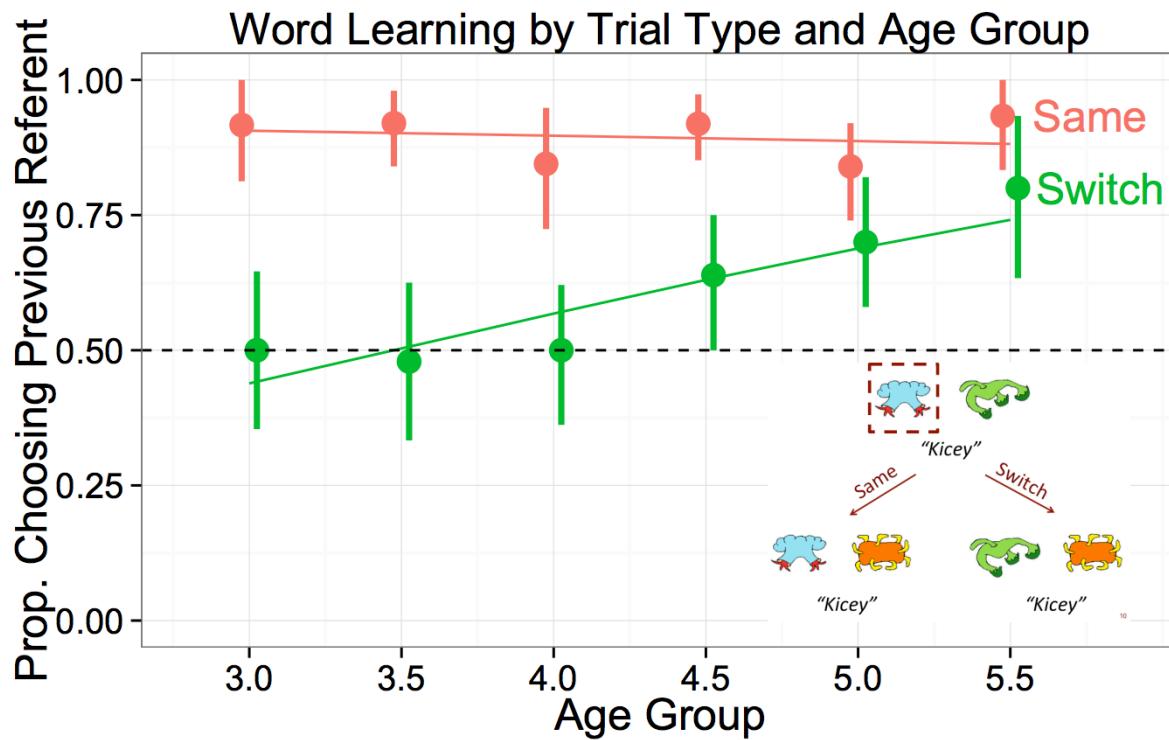
# Model

(prob correct for each trial type)

- **same\_trial\_strength** <- gamma \* sigma \*  
$$(int+1)^{-\lambda}$$
- **switch\_trial\_strength** <- gamma \*  $((1-\sigma) / (numPic-1)) * (int+1)^{-\lambda}$
- gamma=1.5, # strength of initial encoding
- lambda=.15, # rate of memory decay
- sigma=.5, # amt of belief given to initial hypothesis
- numPic=4, # number of pics
- int=0 # number of intervening words

<b>condition</b>	<b>intervalNum</b>	<b>numPicN</b>	<b>freq</b>	<b>condition</b>	<b>intervalNum</b>	<b>numPicN</b>	<b>freq</b>	
<b>1</b>	No-Social 0	2	127	<b>17</b>	Social	0	2	48
<b>2</b>	No-Social 0	4	114	<b>18</b>	Social	0	4	82
<b>3</b>	No-Social 0	6	39	<b>19</b>	Social	0	6	37
<b>4</b>	No-Social 0	8	117	<b>20</b>	Social	0	8	43
<b>5</b>	No-Social 1	2	120	<b>21</b>	Social	1	2	44
<b>6</b>	No-Social 1	4	118	<b>22</b>	Social	1	4	88
<b>7</b>	No-Social 1	6	35	<b>23</b>	Social	1	6	44
<b>8</b>	No-Social 1	8	114	<b>24</b>	Social	1	8	44
<b>9</b>	No-Social 3	2	115	<b>25</b>	Social	3	2	47
<b>10</b>	No-Social 3	4	117	<b>26</b>	Social	3	4	87
<b>11</b>	No-Social 3	6	36	<b>27</b>	Social	3	6	40
<b>12</b>	No-Social 3	8	114	<b>28</b>	Social	3	8	43
<b>13</b>	No-Social 7	2	129	<b>29</b>	Social	7	2	47
<b>14</b>	No-Social 7	4	115	<b>30</b>	Social	7	4	90
<b>15</b>	No-Social 7	6	34	<b>31</b>	Social	7	6	38
<b>16</b>	No-Social 7	8	114	<b>32</b>	Social	7	8	38

# Developmental predictions



# Statistical learning at scale

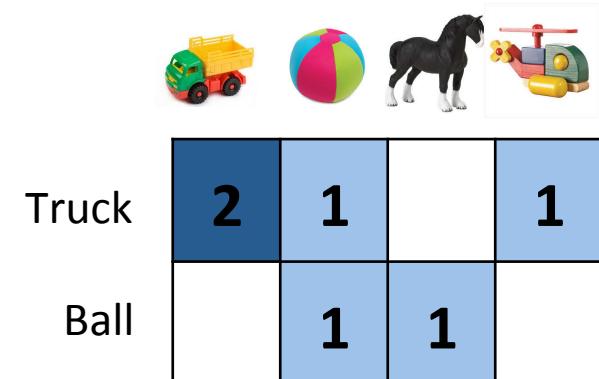
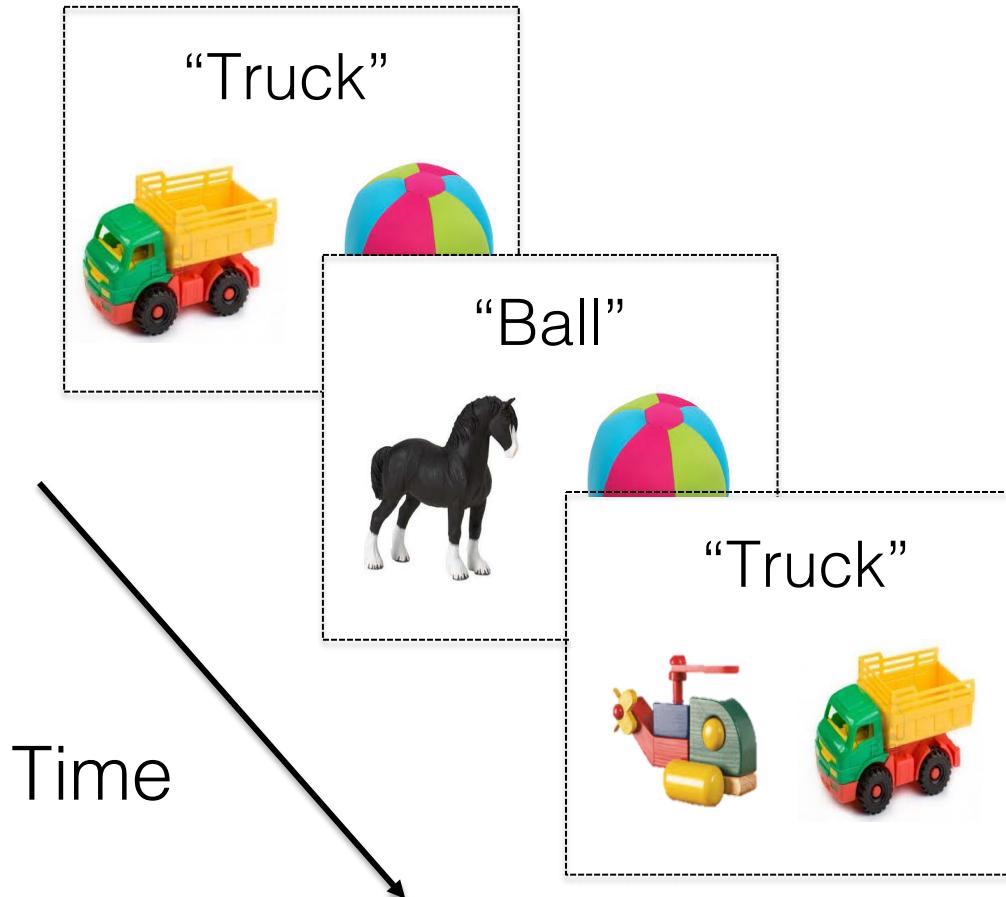
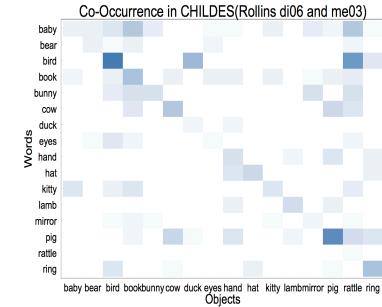
These differences may make contenders for the label's referent more memorable across trials, and they may limit the number of contenders – even when not clearly indicating the correct one.

**The accessibility of (potentially misleading) social cues may also differ between the views.**

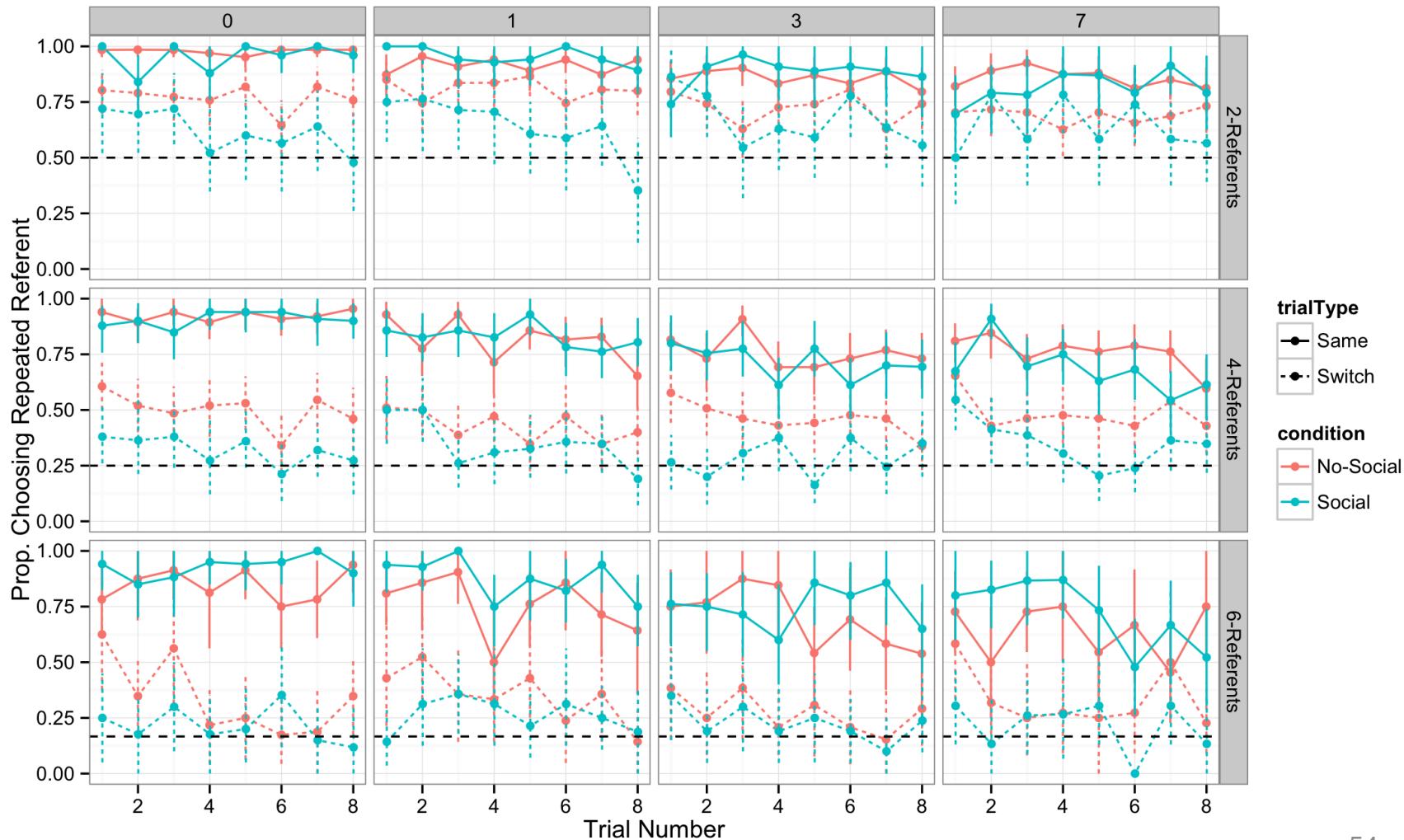
**For instance, mother's gaze does not reliably predict reference in many naming events (Frank et al., in press).**

While analyses of head-camera views suggest that children access their mother's gaze infrequently (Franchak, Kretch, Soska & Adolph, 2011; Smith et al., 2011), the third-person view makes gaze more readily available.

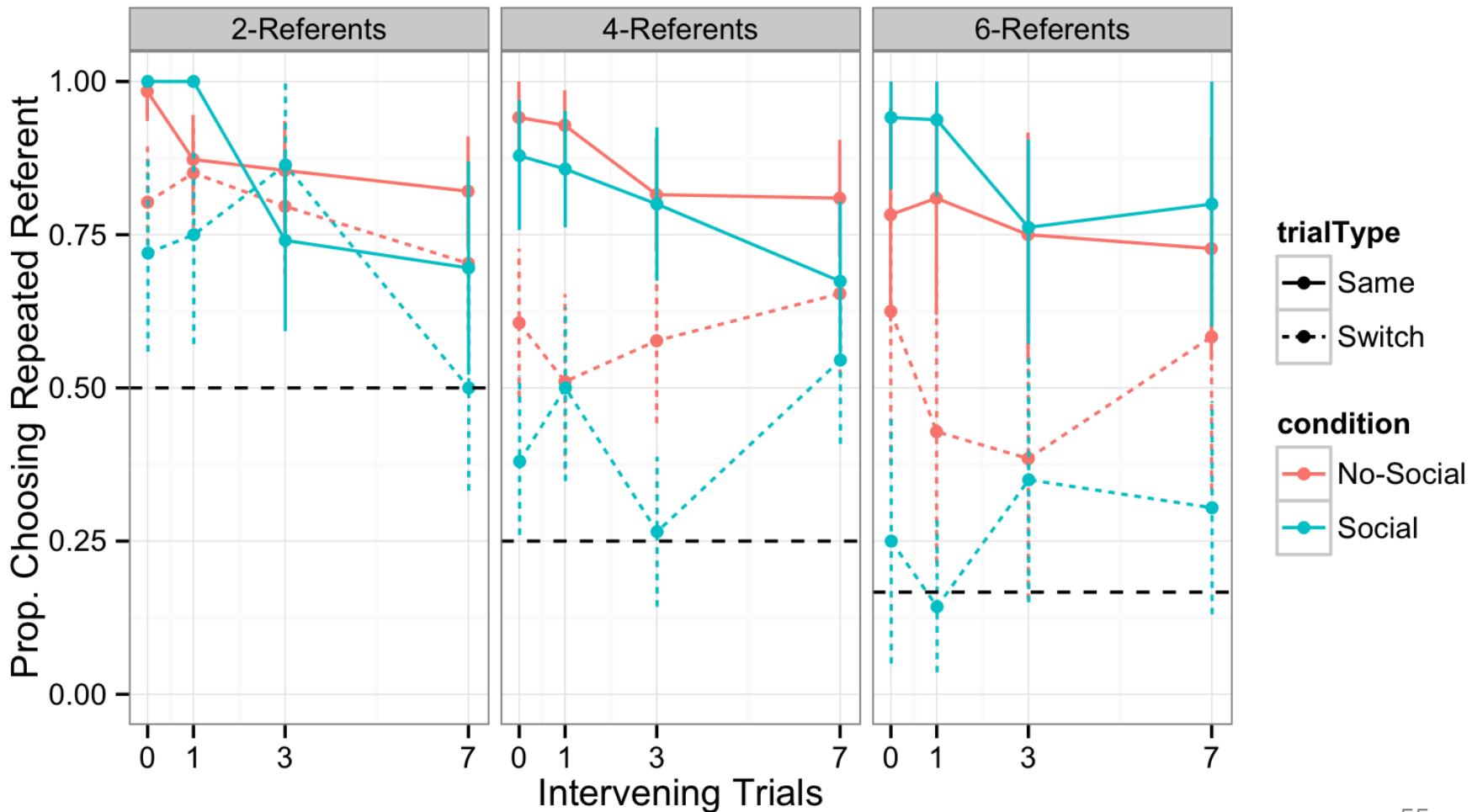
Infants track statistics in the input, create a co-occurrence matrix, and learn the meaning of “truck” over time



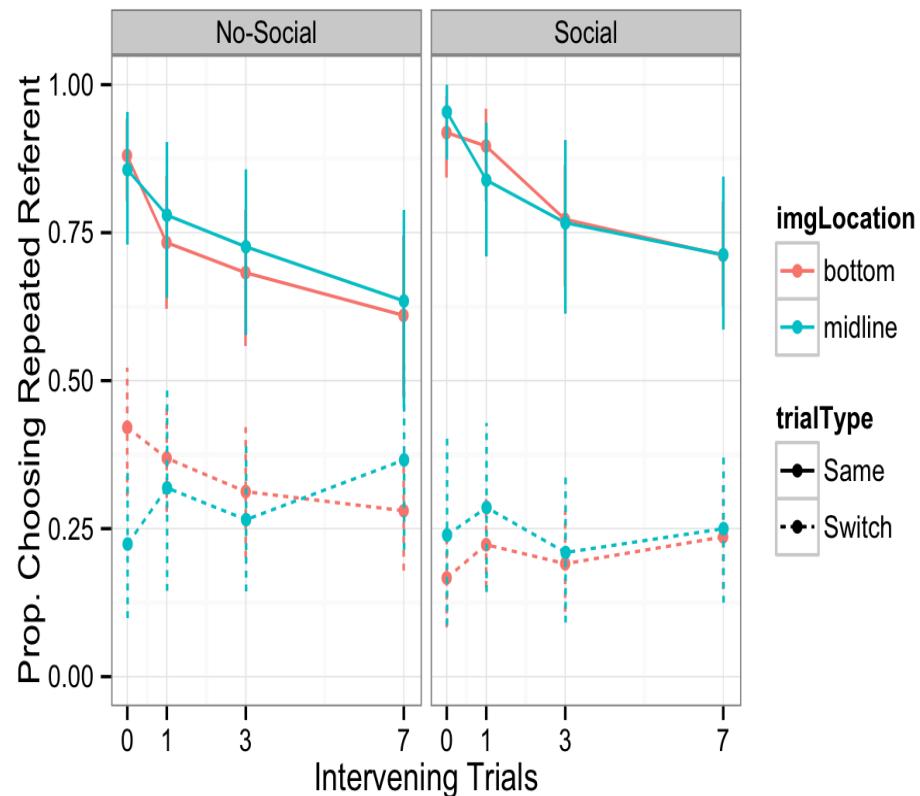
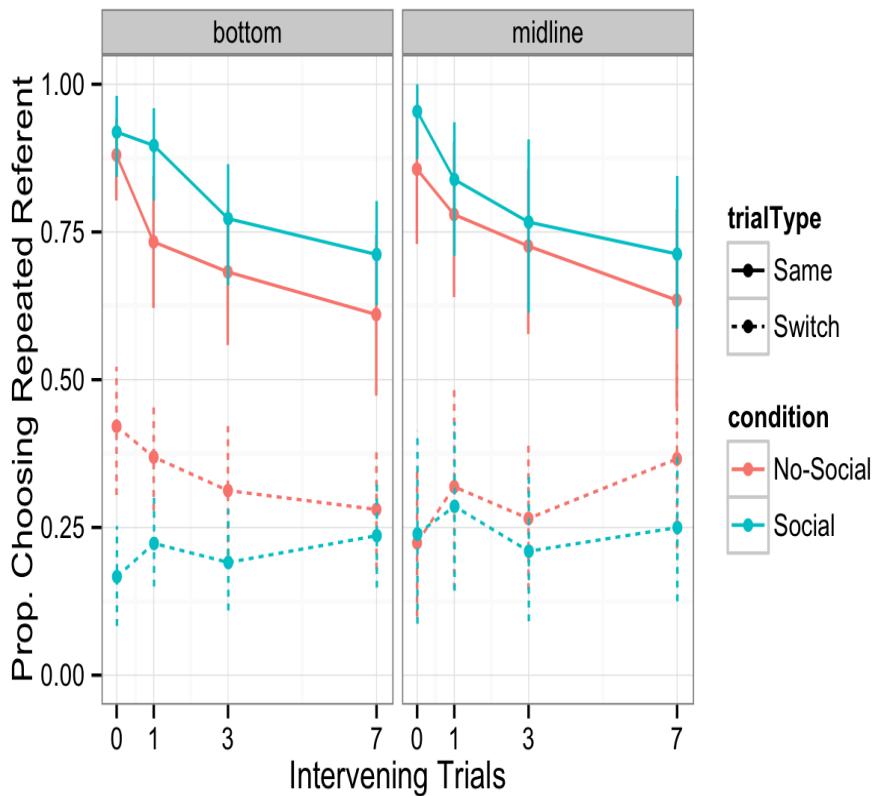
# Order Analysis



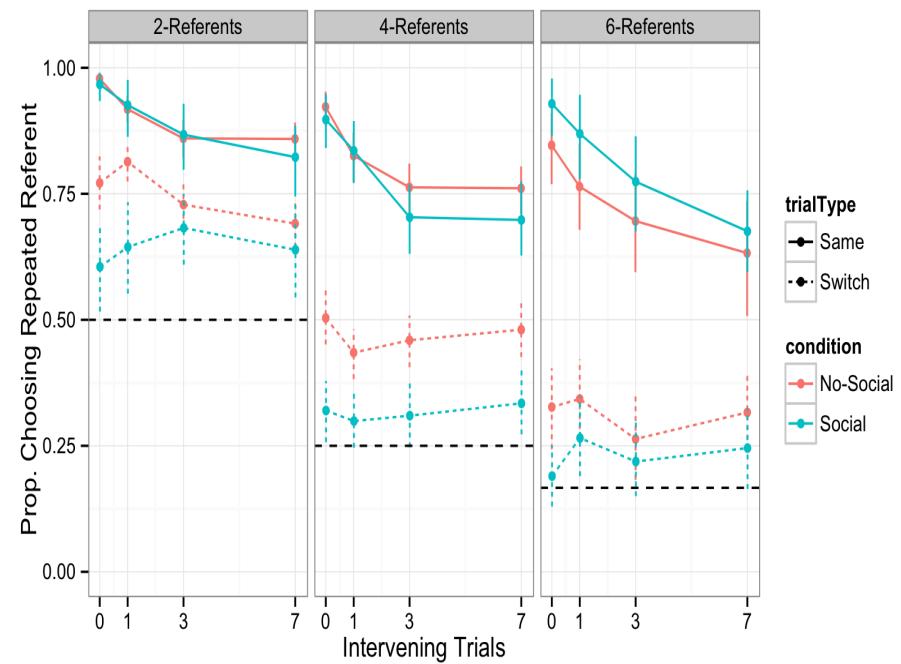
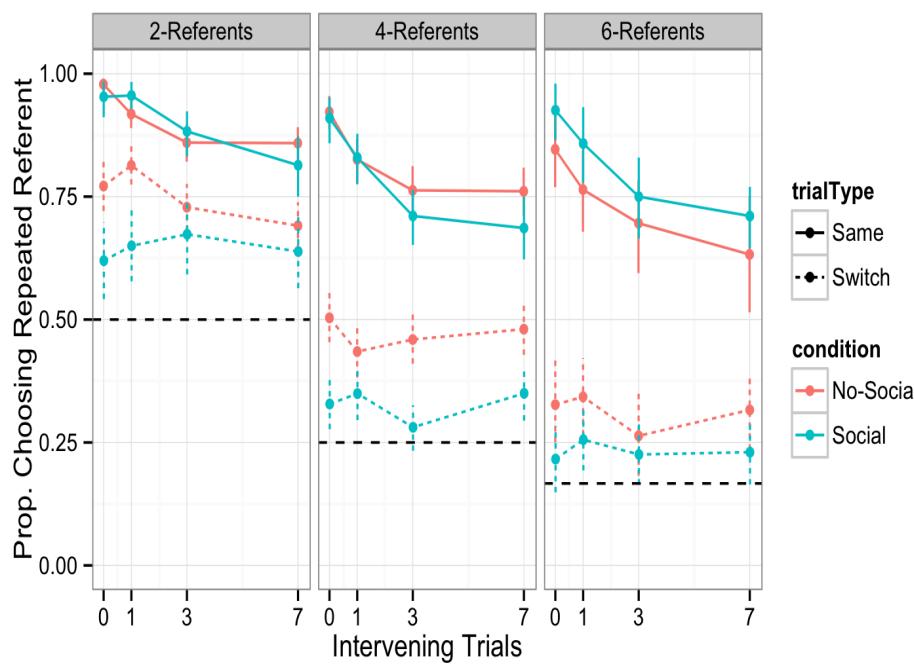
# First trial analysis



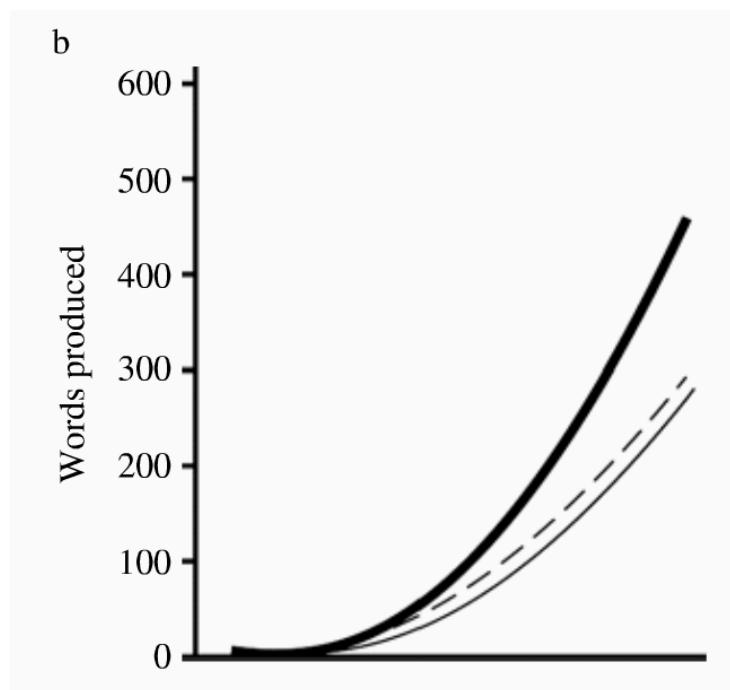
In the 6-referent condition, image location (bottom/midline) does not change the results



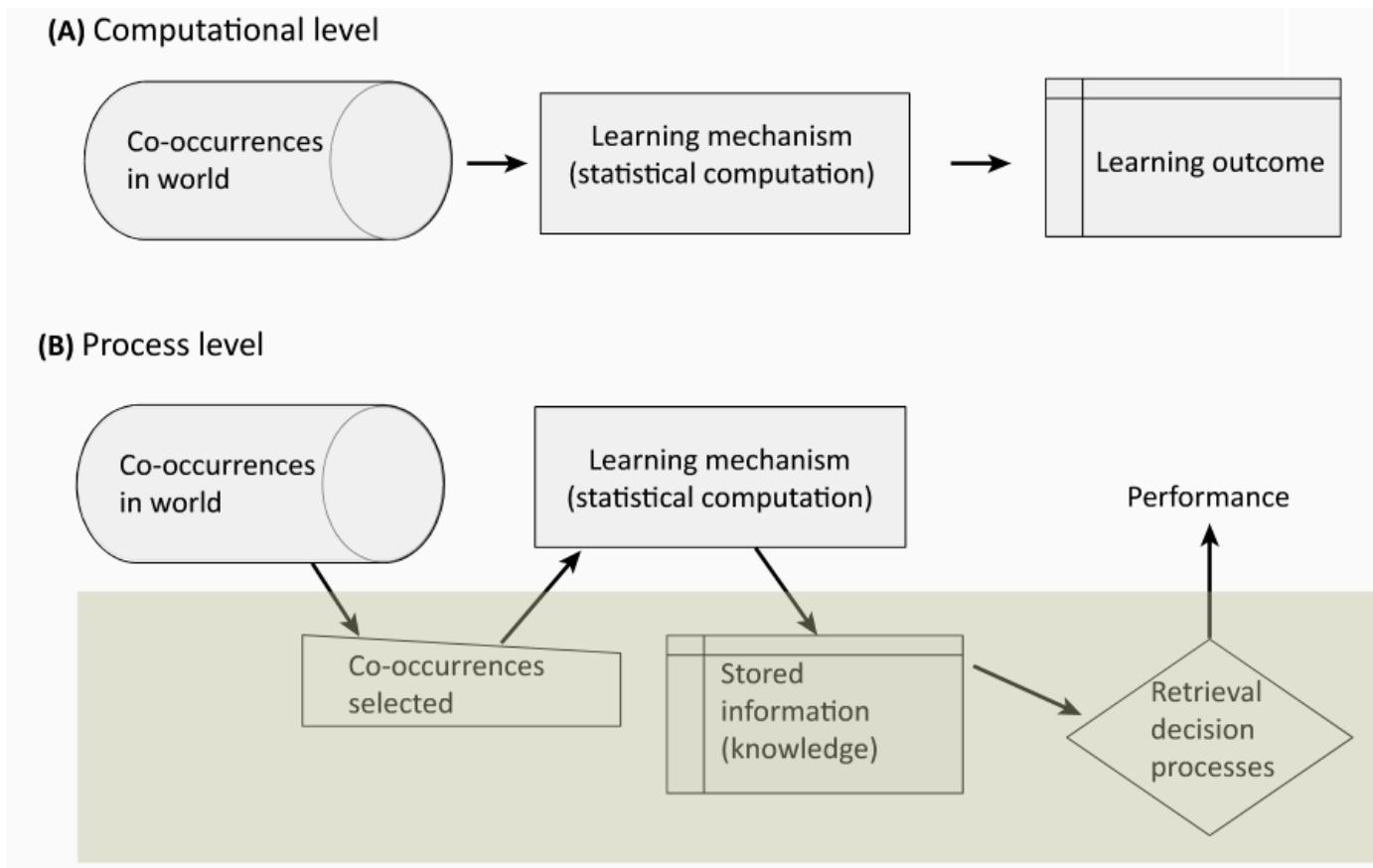
# Removing trials on which subjects failed to choose the target of eye gaze does not change results



Correlational data shows that gaze-following at 10 months predicts **faster vocabulary growth**



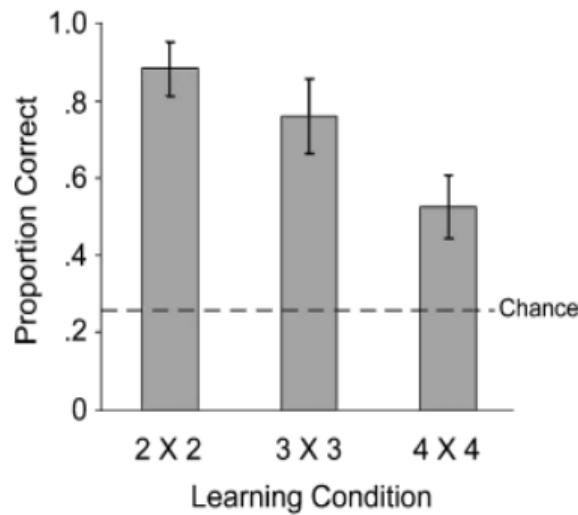
# Researchers debate about the **underlying processes** that support cross-situational word learning



Experimental work shows that both adults and infants can learn novel words from co-occurrence information

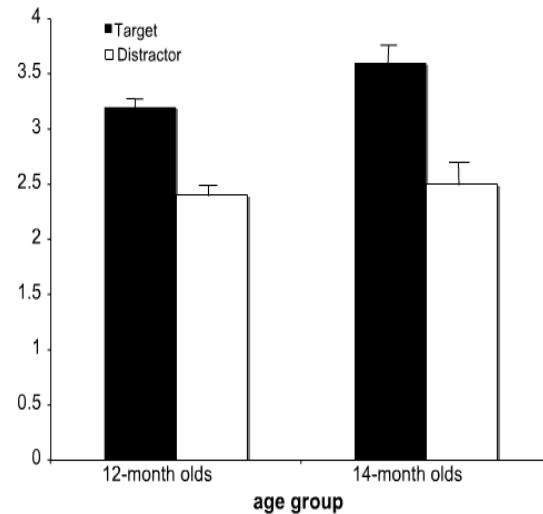
2	1		1
	1	1	

Adults



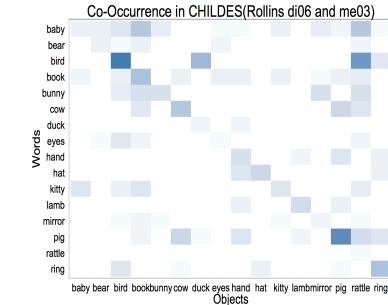
(Yu & Smith, 2007)

Infants

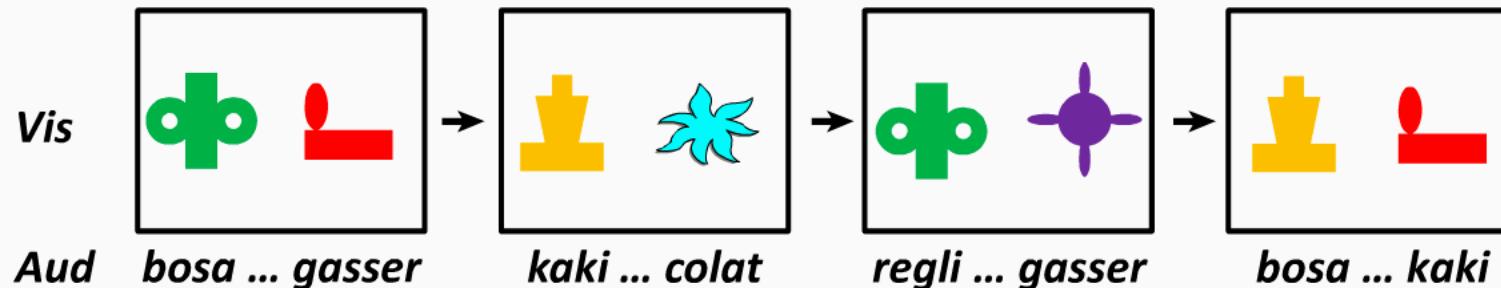


(Smith & Yu, 2008)

Infants track statistics in the input,  
**create a co-occurrence matrix**, and  
learn the meaning of “bosa” over time



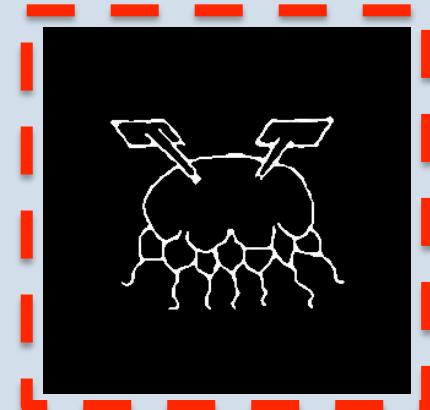
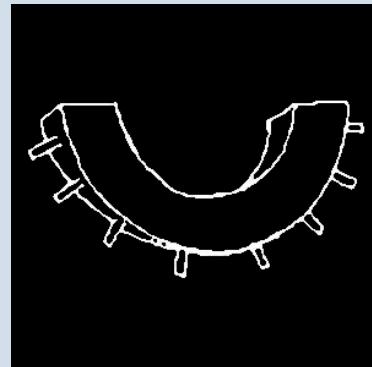
(B) Semi-random presentation: smith & Yu (2008)



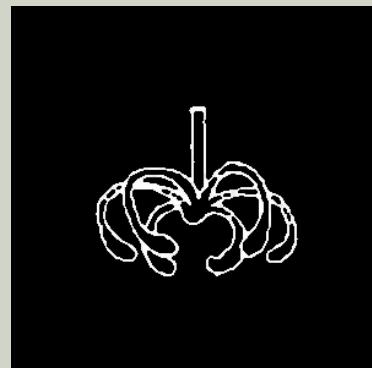
<i>bosa</i>					
<i>regli</i>					
<i>kaki</i>					
<i>gasser</i>					
<i>colat</i>					

# Same trials

Exposure Trial

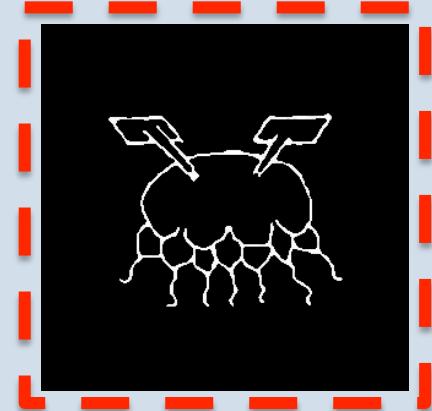
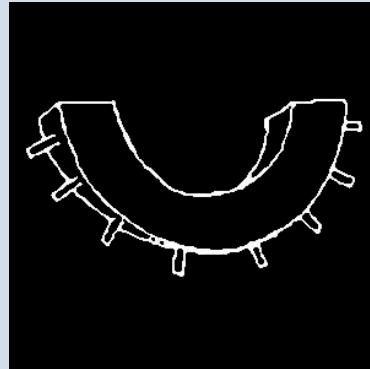


Test Trial

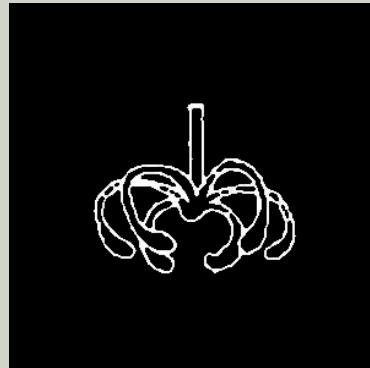


# Switch trials

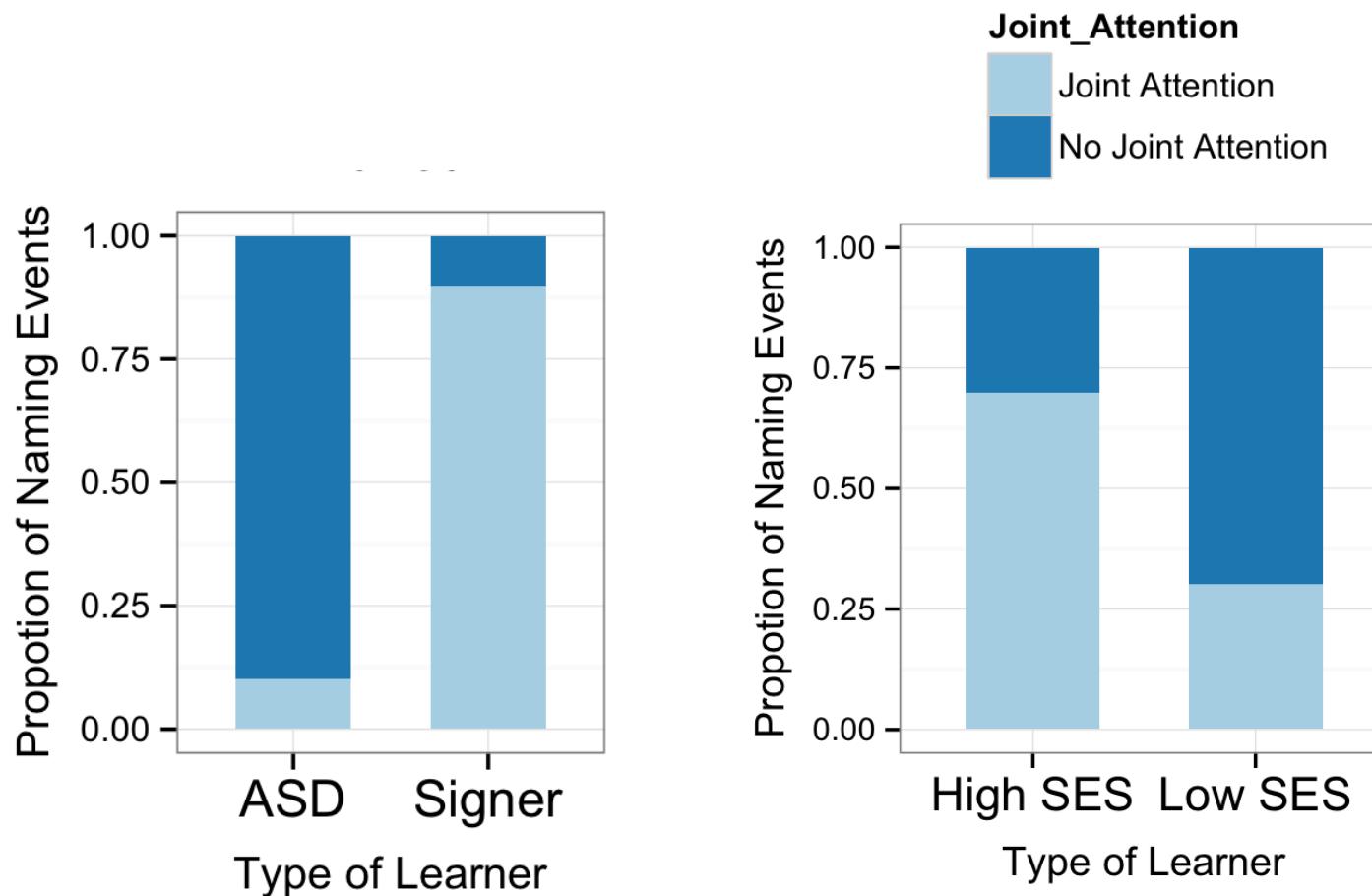
Exposure Trial



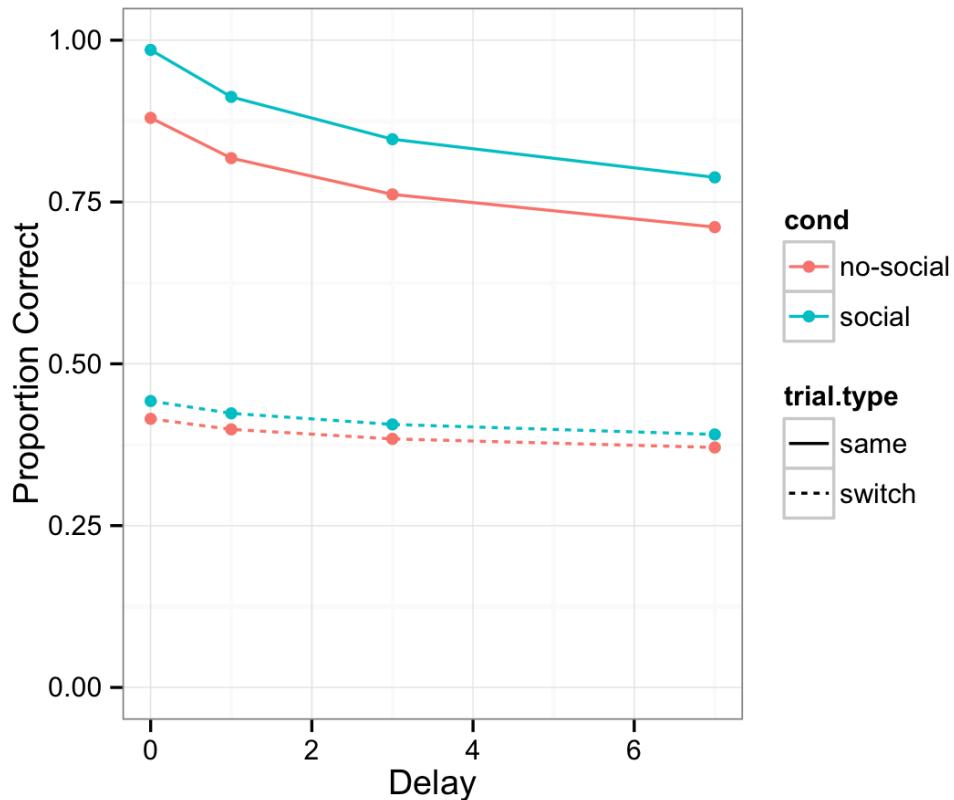
Test Trial



Learners might experience a different proportion of their naming events under uncertainty



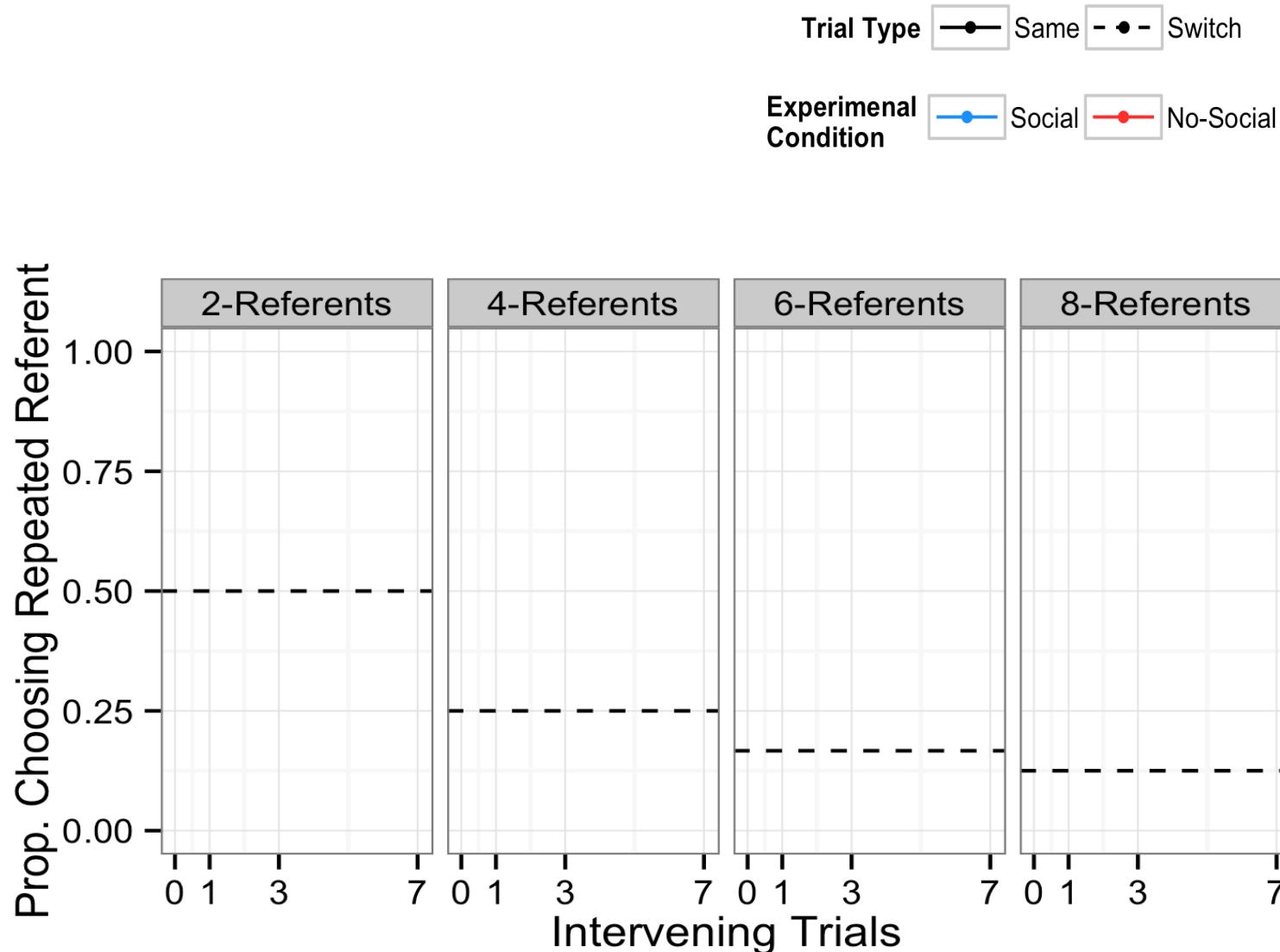
# Is social information a boost to gamma?

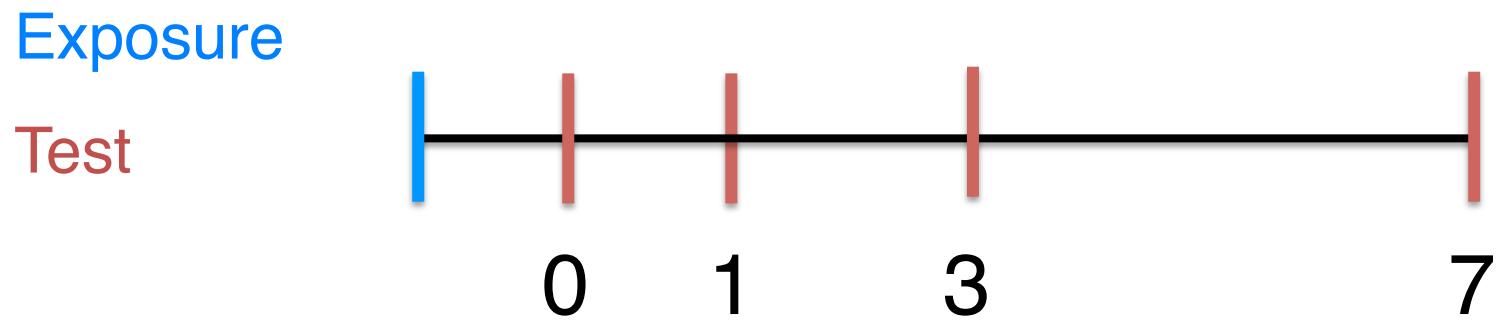


$$\sigma = 0.57$$

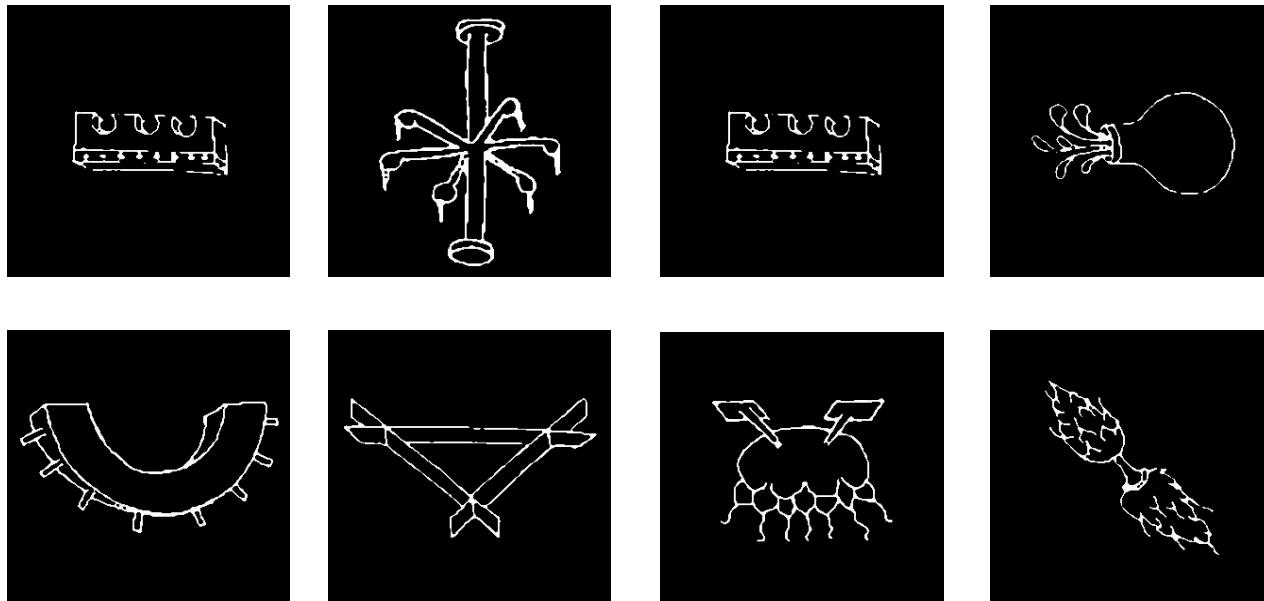
$$\gamma = 1.5$$

$$\lambda = 0.15$$



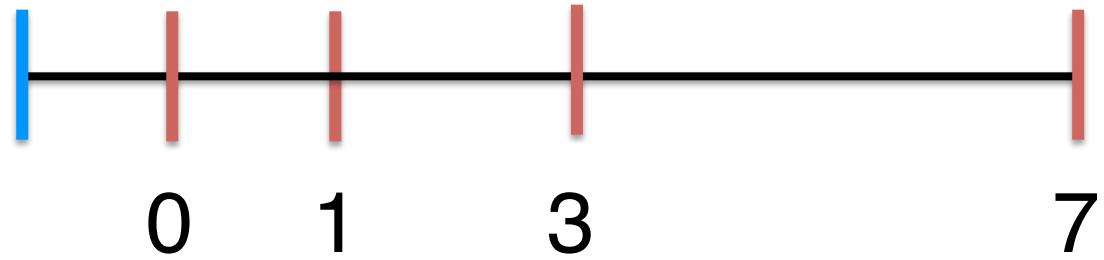


Number of  
Intervening Words



Exposure

Test



Number of  
Intervening Words