

The role of memory constraints in regularization of unpredictable variation

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Introduction

- Linguistic variation is usually conditioned on cues (i.e. predictable)
- Regularisation = removing variation from the input, generally by boosting the frequency of one variant
- In artificial language experiments where variation is unconditioned (unpredictable), speakers tend to regularize [1, 2]
- Children regularize more readily than adults, could this be due to their lower memory capacity? [1, 3]**

Objectives

- Compare child regularization effects in contrasting memory conditions: artificial and semi-artificial languages
- In both conditions, investigate if regularization changes:
 - Over time
 - Depending on memory load of task
 - When generalising to novel stimuli
- Relate working memory measures to individual differences in regularization

Methods

Participants

- 40 monolingual children from 2 schools (mean age: 6;3, SD: 0;3, 18 girls)
- Split into 2 equal groups matched on age and gender:
 - Semi-artificial condition
 - Artificial condition

Materials

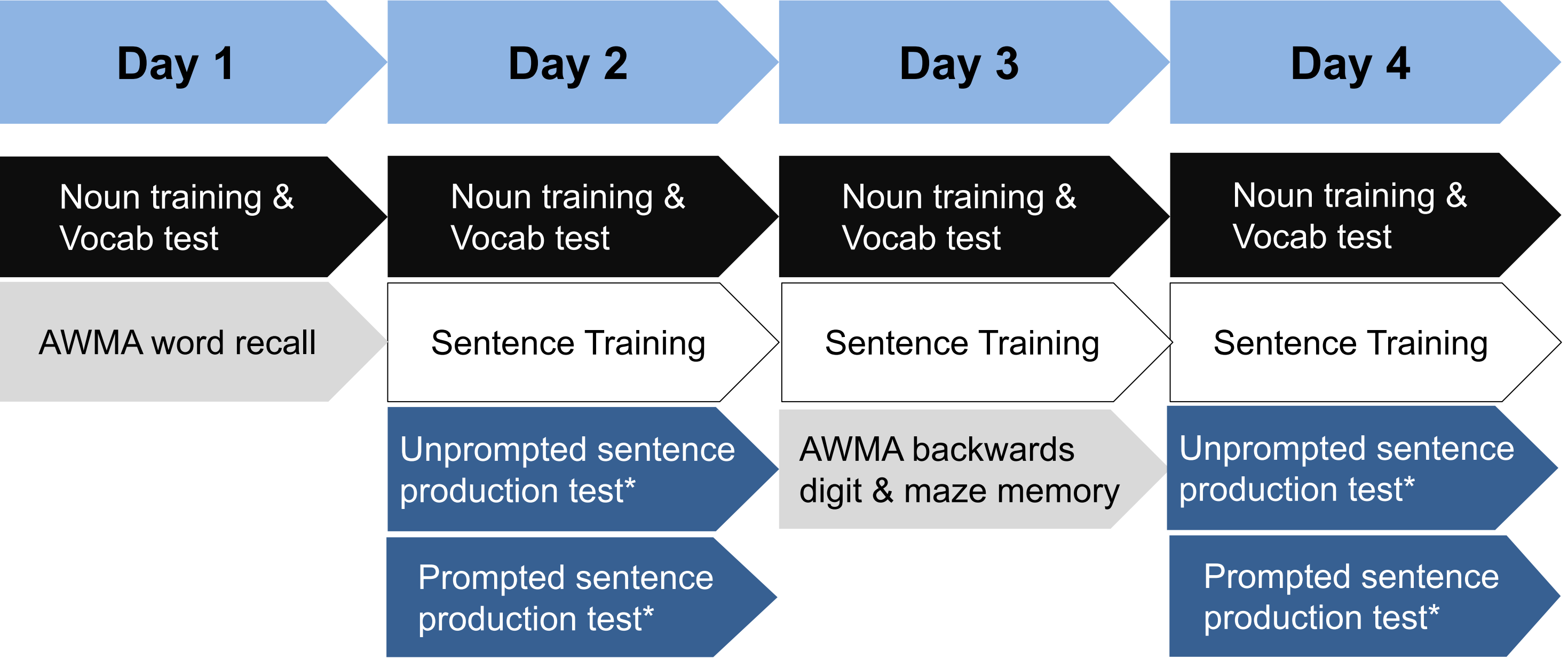
- Two simple languages were created which differed only in the nouns they contained (see Fig. 1)

	Verb	Noun	Particle
Artificial	"glim" meaning "there are two"	12 two-syllable non words, corresponding with animal pictures, e.g. "meeper", "panjol"	2 non-words with no meaning, e.g. "bup", "tid"
Semi-artificial	Used to introduce each sentence	12 two-syllable English words, corresponding with animal pictures, e.g. "camel", "tiger"	Source of unpredictable variation (see below)

Fig. 1: Artificial and semi-artificial language structure

Procedure

- Language training and testing took place over 4 sessions within 5 days at school 1:1 with experimenter, using a laptop and headphones, following schedule in Fig. 2



* Represents order A, in order B sentence production tasks were performed in reverse order

Fig. 2: Experiment procedure

Language Training

- Participants were told they would be learning Ellie the Elephant's language
- Each day they were trained on the same 4 individual nouns (the old nouns)
- For each noun, 75% of training sentences contained **Particle 1** and 25% of sentences contained **Particle 2**
- Thus particle use varied unpredictably (see Fig. 3 for examples)

Language Testing

- Sentence production was tested on Days 2 and 4 in two separate tasks: unprompted and prompted production (see Fig. 3 for examples)
- In the prompted task, both old and new nouns were tested

Working memory measures: Word recall, maze memory and backwards digit recall tests from Automated Working Memory Assessment [4]

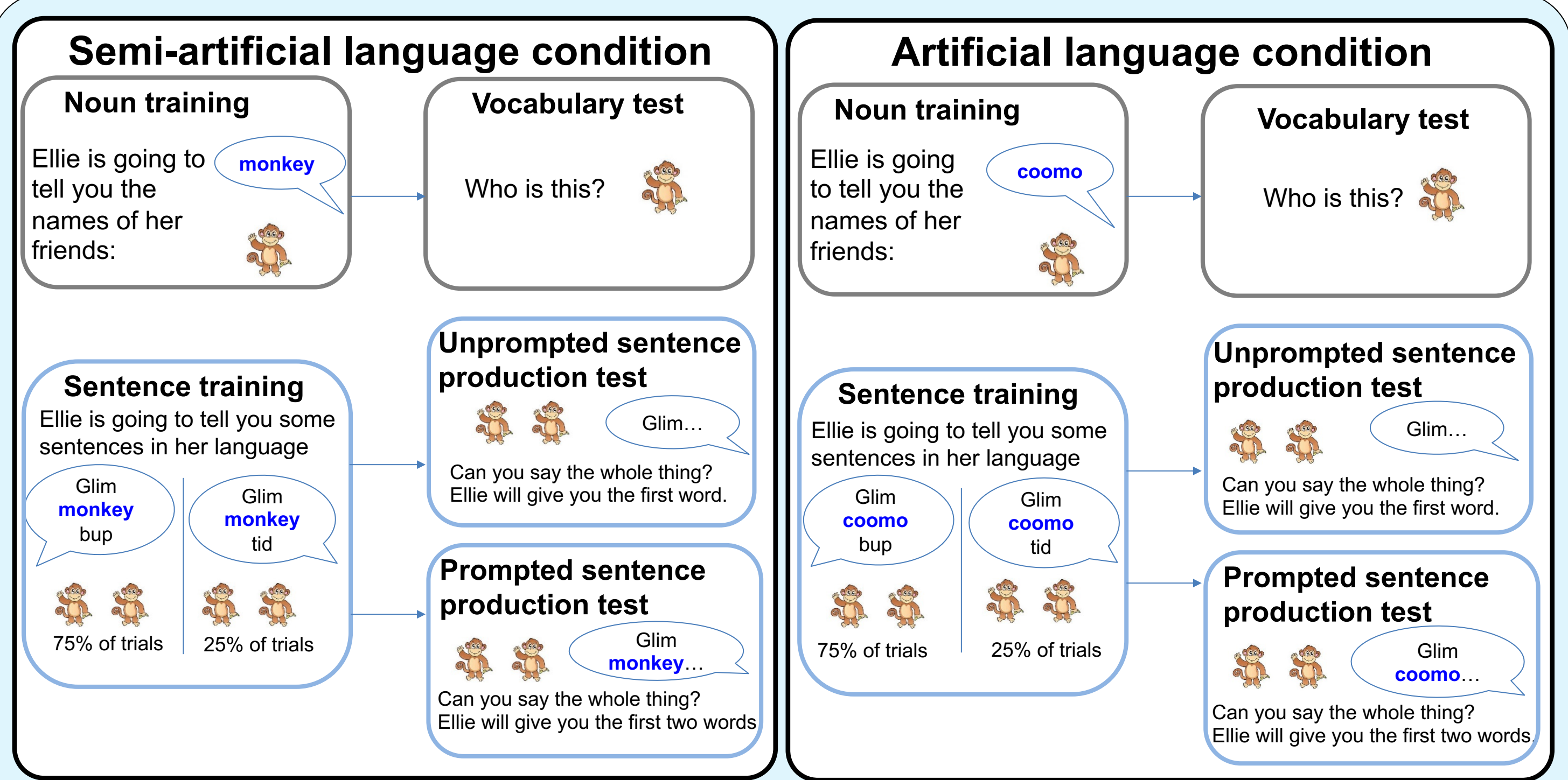


Fig. 3: Example training and testing stimuli

Results

- Vocab test confirmed that artificial language was sig. harder to learn than the semi-artificial one
- Entropy measure derived from each child's particle use pattern
- Entropy is a measure of systematicity regardless of the pattern imposed (e.g. if a child uses all det1 or all det2)

Entropy = $-\sum P(i) \log_2 P(i)$, where $P(i)$ is the frequency of particle i in a participant's productions (low entropy = high regularization)

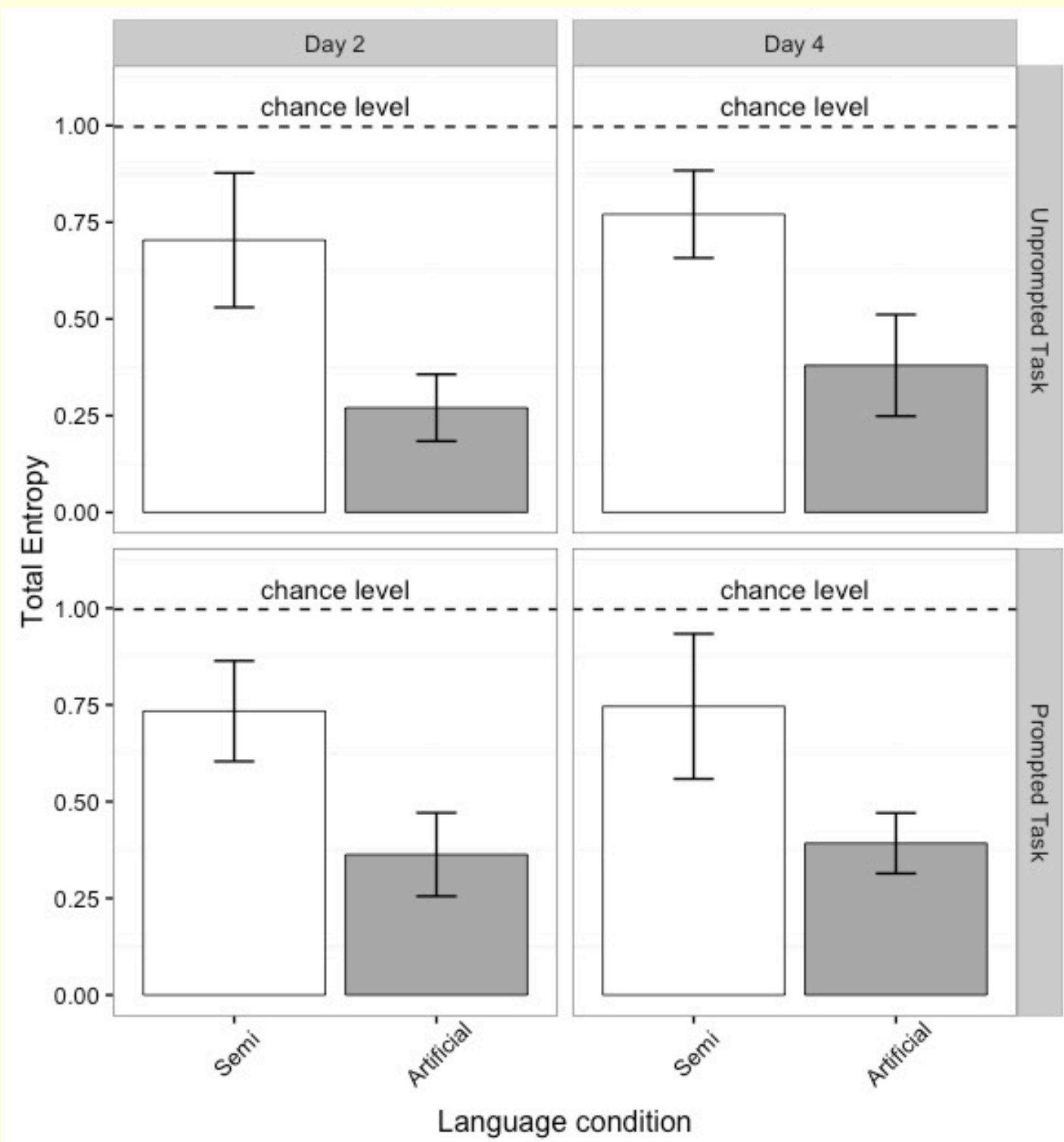


Fig. 4: total entropy by language, day and task, with 95% CI

- Lower entropy (=greater regularization) in artificial vs. semi-artificial language, no sig. effect of time
- Memory prompts did not sig. influence regularization (no effect of prompted vs. unprompted task)
- Word familiarity did not sig. influence regularization (no effect of old vs. new nouns in prompted task)

- Entropy correlated positively with backwards digit recall in the artificial language group = less regularization in children with stronger memory skills

Measure	1	2	3	4	5	6	7
Semi-artificial condition (n=20)							
1. AWMA word	-						
2. AWMA maze	-.020	-					
3. AWMA back. digit		-.111	-				
4. Day 2 TE unprompt.		-.083	.101	-			
5. Day 4 TE unprompt.		-.180	.042	-.151	-		
6. Day 2 TE prompt.		-.131	.027	-.127	.073	-	
7. Day 4 TE prompt.			.524*	.878**	.867**	.317	-
Artificial condition (n=20)							
1. AWMA word	-						
2. AWMA maze	.447	-					
3. AWMA back. digit	.470*	.503*	-				
4. Day 2 TE unprompt.		.250	-.169	-			
5. Day 4 TE unprompt.		.469*	.269	.411	-		
6. Day 2 TE prompt.			.618**	.573*	.809**	-	
7. Day 4 TE prompt.					.815**	.770**	-

Table 1: Pearson correlations total entropy vs. working memory

Discussion

- Language condition influenced regularization: when variation is unpredictable, child regularization susceptible to task manipulation
- No effect of day on regularization. May have emerged in longer experiment or if had an earlier baseline measure
- No effect of memory prompt. Possible that although the prompts supported the task, production was still difficult for children, whereas for adults prompt may have sig. effect [5]
- No effect of noun type on regularization. Previous contrary findings for adults [6] and children [2] may have been due to retrieval pressures of remembering new nouns, which did not apply here due to task design
- Working memory is implicated in regularization of unpredictable variation in the lab, however additional constraints may also be present when such variation occurs in natural learning situations
- Further investigation is needed to dissociate the mechanisms of encoding and retrieval for child learners

References:

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[2] Samara, A., Smith, K., Brown, H., & Wonnacott, L. (2017). Cognitive Psychology, 94, 85-114.
[3] Perfors, A. (2012). Journal of Memory and Language, 67, 486-506.
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[6] Wonnacott, E., & Newport, E. L. (2005). In A. Brugos, M. Clark-Cotton, & S. Ha (Eds.), BUCLD 29: Proceedings of the 29th Annual Boston University Conference on Language Development. Somerville, MA: Cascadia Press. 1-11.