

Appendix 1: statistical analyses for main experiments

1. Experiment 1: learnability, three syntax conditions, adposition training

Summary table for binomial mixed effects model of comprehension task in Experiment 1.

<i>Row</i>	<i>Estimate</i>	<i>Std..Error</i>	<i>z.value</i>	<i>Pr(z)</i>
(level 2/branching/head-initial)	3.97	0.37	10.66	<.001
level 3	-1.70	0.39	-4.38	<.001
crossed	-0.21	0.32	-0.66	0.51
crossed/CE mean	-0.25	0.17	-1.47	0.14
head-final	-0.43	0.25	-1.70	0.09
level 3/crossed	0.02	0.32	0.08	0.94
level 3/crossed/CE mean	0.33	0.17	1.96	0.05
level 3/head-final	0.02	0.25	0.09	0.93
crossed/head-final	0.39	0.32	1.22	0.22
crossed/CE mean/head-final	-0.13	0.17	-0.79	0.43
level 3/crossed/head-final	-0.38	0.32	-1.18	0.24

level 3/crossed/CE mean/head-final	0.29	0.17	1.72	0.09
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Summary table for mixed effects model of production task for Experiment 1. Level is coded as numeric.

<i>Row</i>	<i>Estimate</i>	<i>Std..Error</i>	<i>df</i>	<i>t.value</i>	<i>Pr(< t)</i>
(level 1/branching/head-initial)	0.94	0.01	112.25	72.77	<.001
level	-0.06	0.01	114.00	-9.76	<.001
crossed	-0.01	0.02	112.17	-0.65	0.52
crossed/ CE mean	-0.02	0.01	112.33	-2.09	0.04
head-final	-0.01	0.01	112.25	-0.96	0.34
level/crossed	0.01	0.01	113.95	1.37	0.17
level/crossed/ CE mean	0.01	<.001	114.06	1.94	0.05
level/head-final	-0.03	0.01	114.00	-4.04	<.001
crossed/head-final	0.03	0.02	112.17	1.84	0.07
crossed/ CE mean/head-final	-<.001	0.01	112.33	-0.38	0.70
level/crossed/head-final	-0.02	0.01	113.95	-2.31	0.02
level/crossed/ CE mean/head-final	0.01	<.001	114.06	2.20	0.03

Summary table for mixed effects model of production task on seen vs. novel arrays, Experiment 1.

<i>Row</i>	<i>Estimate</i>	<i>Std..Error</i>	<i>df</i>	<i>t.value</i>	<i>Pr(< t)</i>
(level 2/branching/head-initial/seen)	0.87	0.02	116.09	55.71	<.001
level 3	-0.08	0.01	123.55	-6.50	<.001
crossed	.001	0.02	116.04	0.16	0.87
center-embedded	-0.02	0.01	116.15	-1.44	0.15
head-final	-0.04	0.02	116.09	-2.85	0.01
unseen	-.001	<.001	2624.64	-0.03	0.98
level 3/crossed	0.01	0.01	123.44	0.35	0.73
level 3/center-embedded	0.01	0.01	123.65	0.85	0.40
level 3/head-final	-0.04	0.01	123.55	-3.58	<.001
crossed/head-final	0.02	0.02	116.04	1.03	0.30
center-embedded/head-final	-.001	0.01	116.15	-0.25	0.80
level 3/unseen	.001	0.01	2624.64	0.35	0.72

crossed/unseen	-0.01	0.01	2624.64	-1.04	0.30
center-embedded/unseen	<-.001	<.001	2624.64	-1.25	0.21
head-final/unseen	-0.01	<.001	2624.64	-2.17	0.03
level 3/crossed/head-final	-0.03	0.01	123.44	-2.17	0.03
level 3/center-embedded/head-final	0.02	0.01	123.65	2.69	0.01
level 3/crossed/unseen	0.01	0.01	2624.64	1.55	0.12
level 3/center-embedded/unseen	<.001	<.001	2624.64	0.58	0.56
level 3/head-final/unseen	<.001	0.01	2624.64	0.69	0.49
crossed/head-final/unseen	-0.01	0.01	2624.64	-2.44	0.01
center-embedded/head-final/unseen	-0.01	<.001	2624.64	-1.56	0.12
level 3/crossed/head-final/unseen	0.02	0.01	2624.64	2.16	0.03
level 3/center-embedded/head-final/unseen	<.001	<.001	2624.64	0.81	0.42

Summary table for mixed effects model of production task on seen arrays only, Experiment 1.

<i>Row</i>	<i>Estimate</i>	<i>Std..Error</i>	<i>df</i>	<i>t.value</i>	<i>(Pr> t)</i>
(level 1/branching/head-initial)	0.88	0.01	113.32	70.13	<.001
level2-1	-0.11	0.01	113.42	-7.53	<.001
level3-2	-0.08	0.01	114.01	-5.90	<.001
crossed	0.01	0.02	113.34	0.71	0.48
center-embedded	<.001	0.01	113.31	0.54	0.59
head-final	-0.03	0.01	113.32	-2.61	0.01
level2-1/crossed	0.02	0.02	113.51	1.34	0.18
level3-2/crossed	-0.01	0.02	114.05	-0.65	0.52
level2-1/center-embedded	-0.01	0.01	113.33	-0.85	0.40
level3-2/center-embedded	<.001	0.01	113.96	0.20	0.84
level2-1/head-final	-0.05	0.01	113.42	-3.39	<.001
level3-2/head-final	-0.05	0.01	114.01	-3.54	<.001

crossed/head-final	-0.01	0.02	113.34	-0.66	0.51
center-embedded/head-final	-0.01	0.01	113.31	-1.10	0.27
level2-1/crossed/head-final	0.02	0.02	113.51	1.00	0.32
level3-2/crossed/head-final	-0.05	0.02	114.05	-3.20	<.001
level2-1/center-embedded/head-final	-0.01	0.01	113.33	-1.04	0.30
level3-2/center-embedded/head-final	0.02	0.01	113.96	1.68	0.10

Summary table for mixed effects model of production task, unseen arrays only, Experiment 1.

<i>Row</i>	<i>Estimate</i>	<i>Std..Error</i>	<i>df</i>	<i>t.value</i>	<i>Pr(> t)</i>
(level 2/branching/head-initial)	0.81	0.02	113.93	46.84	<.001
level3-2	-0.07	0.01	114.10	-5.55	<.001
level4-3	-0.02	0.01	114.00	-2.12	0.04
crossed	0.01	0.02	113.94	0.70	0.48
center-embedded	-<.001	0.01	113.93	-0.22	0.83
head-final	-0.07	0.02	113.93	-4.20	<.001
level3-2/crossed	-0.01	0.02	114.18	-0.34	0.73
level4-3/crossed	-0.03	0.01	114.00	-2.55	0.01
level3-2/center-embedded	-0.01	0.01	114.02	-1.49	0.14
level4-3/center-embedded	-0.02	0.01	114.00	-2.20	0.03
level3-2/head-final	-0.04	0.01	114.10	-2.79	0.01
level4-3/head-final	0.02	0.01	114.00	2.08	0.04

crossed/head-final	-0.02	0.02	113.94	-1.02	0.31
center-embedded/head-final	<.001	0.01	113.93	-0.12	0.91
level3-2/crossed/head-final	-0.05	0.02	114.18	-2.82	0.01
level4-3/crossed/head-final	-0.02	0.01	114.00	-1.60	0.11
level3-2/center-embedded/head-final	-0.01	0.01	114.02	-0.72	0.47
level4-3/center-embedded/head-final	<.001	0.01	114.00	0.65	0.51

Summary table for linear regression of grammar distribution entropy, Experiment 1.

<i>Row</i>	<i>Estimate</i>	<i>Std..Error</i>	<i>df</i>	<i>t.value</i>	<i>Pr(> t)</i>
(level 2/branching/head-initial/seen)	0.87	0.02	116.09	55.71	<.001
level 3	-0.08	0.01	123.55	-6.50	<.001
crossed	0.03	0.02	116.12	1.33	0.19
center-embedded	0.01	0.01	116.07	0.58	0.56
head-final	-0.04	0.02	116.09	-2.85	0.01
unseen	<.001	<.001	2624.64	-0.03	0.98
level 3/crossed	-0.01	0.01	123.60	-0.56	0.58
level 3/center-embedded	-0.01	0.01	123.50	-0.73	0.47
level 3/head-final	-0.04	0.01	123.55	-3.58	<.001
crossed/head-final	0.01	0.02	116.12	0.74	0.46
center-embedded/head-final	-0.01	0.01	116.07	-0.77	0.44
level 3/unseen	<.001	0.01	2624.64	0.35	0.72

crossed/unseen	<.001	0.01	2624.64	0.56	0.58
center-embedded/unseen	0.01	<.001	2624.64	1.53	0.13
head-final/unseen	-0.01	<.001	2624.64	-2.17	0.03
level 3/crossed/head-final	-0.05	0.01	123.60	-3.42	<.001
level 3/center-embedded/head-final	<.001	0.01	123.50	0.54	0.59
level 3/crossed/unseen	<.001	0.01	2624.64	0.27	0.79
level 3/center-embedded/unseen	-0.01	<.001	2624.64	-1.63	0.10
level 3/head-final/unseen	<.001	0.01	2624.64	0.69	0.49
crossed/head-final/unseen	<.001	0.01	2624.64	0.14	0.89
center-embedded/head-final/unseen	0.01	<.001	2624.64	2.89	<.001
level 3/crossed/head-final/unseen	<.001	0.01	2624.64	0.38	0.70
level 3/center-embedded/head-final/unseen	-0.01	<.001	2624.64	-2.28	0.02

2. Experiment 2: iteration, adposition training

Summary table for binomial mixed effects model of comprehension task in Experiment 2.

Comprehension task

<i>Row</i>	<i>Estimate</i>	<i>Std. Error</i>	<i>z value</i>	<i>Pr(> z)</i>
(level 2/generation 1)	2.314	0.326	7.105	< .001
level3	-0.747	0.359	-2.08	0.037
generation	-0.092	0.107	-0.856	0.392
level3/generation	0.007	0.14	0.049	0.961

Summary table for mixed effects model of caption consistency for captions seen in training, Experiment 2.

Consistency of captions: arrays seen in training

<i>Row</i>	<i>Estimate</i>	<i>Std. Error</i>	<i>df</i>	<i>t value</i>	<i>Pr(> t)</i>
(level 1/generation 0)	0.732	0.029	11.611	24.931	< .001
level2-1	-0.324	0.057	18.816	-5.669	< .001
level3-2	-0.106	0.049	80.876	-2.162	0.034
generation	0.033	0.015	11.25	2.25	0.045
level2-1/generation	0.05	0.024	13.891	2.047	0.06
level3-2/generation	0.011	0.021	34.663	0.542	0.591

Summary table for mixed effects model of caption consistency for captions on novel arrays, Experiment 2.

Consistency of captions: novel arrays

<i>Row</i>	<i>Estimate</i>	<i>Std. Error</i>	<i>df</i>	<i>t value</i>	<i>Pr(> t)</i>
(level 2/generation 1)	0.404	0.021	28.372	18.807	< .001
level2-1	-0.015	0.053	33.146	-0.283	0.779
level3-2	-0.021	0.05	98.276	-0.411	0.682
generation	0.118	0.013	11.801	9.074	< .001
level2-1/generation	-0.023	0.022	20.033	-1.068	0.298
level3-2/generation	0.004	0.021	52.828	0.183	0.855

Summary table of linear regression model of grammar distribution entropy over generations, Experiment 2.

Entropy

<i>Row</i>	<i>Estimate</i>	<i>Std. Error</i>	<i>df</i>	<i>t value</i>	<i>Pr(> t)</i>
(Generation 0)	3.826	0.145	52.898	26.298	< .001
Generation	-0.207	0.033	59	-6.251	< .001