Parents fine-tune their speech to children's vocabularies (SOM-R)

Ashley Leung, Alexandra Tunkel, and Daniel Yurovsky

S1 Estimating ages of acquisition for animal words

In designing the stimuli for our experiment, our goal was to use a set of target animals that varied in their average age of acquisition (AoA). To do this, we used two sources of information: (1) Concurrent parent-report estimates of their children's vocabularies (Wordbank; Frank, Braginsky, Yurovsky, & Marchman, 2017), and (2) Retrospective self-report estimates from a large group of adults on Amazon Mechanical Turk (Kuperman, Stadthagen-Gonzalez, & Brysbaert, 2012).

Wordbank is a large and growing repository of administrations of the MacArthur-Bates Communicative Development Inventory (CDI; Fenson et al., 2007)–a checklist of words and other items administered to parents in order to estimate their child's vocabulary. Because Wordbank contains a mixture of cross-sectional and longitudinal data, and we wanted to ensure independence of data across measurements, we used only the first administration for each American English-learning child in the database, yielding 4706 children. For each animal word, we fit a separate robust general linear model, estimating the proportion of children whose parents reported their producing the word from eight to 30 months (including data from both the Words and Gestures and Words and Sentences forms). Each word's normative age of acquisition was defined to be the first month of age at which 50% or more children were estimated to know the animal.

Because only a subset of the animals in the Rossion & Pourtois (2004) image set are included on the MacArthur-Bates Child Development Inventory, and thus available in Wordbank, we also used adult self-report norms from Kuperman et al. (2012) to derive estimates for the remaining animals. Typically, adult self-report estimates of age of acquisition are highly correlated with parent-report estimates, and they were for the 30 animals in both data sources (r = 0.8, t = 7.11, p < .001). However, self-report estimates were made on a 1-7 Likert scale rather than on the scale of months.

In order to estimate the age of acquisitions for animals missing from Wordbank, the fit a a general linear model estimating Wordbank age of acquisition from Kuperman et al. (2012) age of acquisition for all animals in both sets (`Wordbank ~ Kuperman + 1`). We then used this model to scale age of acquisitions for the 23 animals in the Kuperman et al. (2012) set missing from Wordbank. Table S1 shows the final estimated ages of acquisition for each animal in the Rossion & Pourtois (2004) set as estimates from Wordbank, Kuperman et al. (2012), and our regression models. For comparison, Figure S1 shows the proportion of parents of 2-2.5-year-olds in our study who reported that their child knew each of the tested animals. These proportions were highly correlated with the model-predicted ages of acquisition (r = -0.94, t = -10.3, p < .001).

Table S1: Estimated age of acqusition (AoA) for each animal in months.

animal	Wordbank	Kuperman	model estimate	AoA
alligator	26.00	57.36	23.76	26.00
ant	25.00	51.84	22.40	25.00
bear	20.00	42.96	20.20	20.00
bee	22.00	60.00	24.42	22.00
beetle		63.84	25.37	25.37
bird	18.00	42.24	20.02	18.00
butterfly	23.00	44.04	20.47	23.00
camel		61.32	24.74	24.74
cat	18.00	44.16	20.50	18.00
caterpillar		62.04	24.92	24.92
chicken	23.00	39.12	19.25	23.00
cow	20.00	47.28	21.27	20.00
deer	27.00	62.04	24.92	27.00
dog	15.00	33.60	17.88	15.00
donkey	29.00	72.00	27.39	29.00
duck	18.00	42.00	19.96	18.00
eagle		69.96	26.88	26.88
elephant	23.00	57.60	23.82	23.00
fish	19.00	48.60	21.60	19.00
fly		36.60	18.62	18.62
fox		60.21	24.47	24.47
frog	22.00	51.84	22.40	22.00
giraffe	25.00	60.00	24.42	25.00
goat		62.52	25.04	25.04
gorilla		68.88	26.62	26.62
grasshopper		69.36	26.73	26.73
horse	21.00	49.80	21.89	21.00
kangaroo		66.60	26.05	26.05
leopard		82.08	29.88	29.88
lion	23.00	53.04	22.69	23.00
lobster		89.28	31.67	31.67
monkey	22.00	50.52	22.07	22.00
mouse	23.00	59.28	24.24	23.00
ostrich		77.04	28.64	28.64
owl	24.00	74.52	28.01	24.00
peacock		69.16	26.69	26.69
penguin	27.00	68.16	26.44	27.00
pig	21.00	46.08	20.97	21.00
rabbit	21.00	47.28	21.27	21.00
raccoon		81.48	29.74	29.74
rhinoceros		72.00	27.39	27.39
rooster	28.00	76.92	28.61	28.00
seahorse		69.96	26.88	26.88
seal		65.04	25.67	25.67
sheep	23.00	51.00	22.19	23.00
skunk		63.84	25.37	25.37
snail		69.48	26.76	26.76
snake		61.20	24.71	24.71
spider		41.16	19.75	19.75
squirrel	25.00	53.28	22.75	25.00
swan		75.81	28.33	28.33
tiger	24.00	48.00	21.45	24.00
turtle	23.00	50.04	21.95	23.00
zebra	25.00	57.48	23.79	25.00

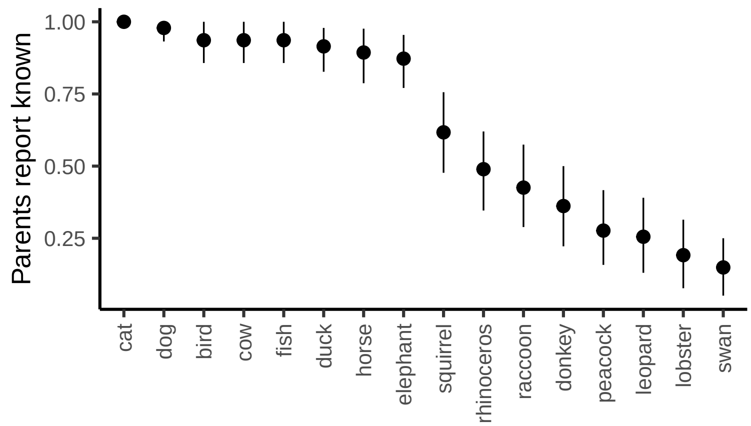

Figure S1: Proportion of parents who reported that their child understood the word for each of our target animals. Error bars indicate 95% confidence intervals computed by non-parametric bootstrap.

Table S2: Model was specified as `understands ~ type + (type | subj) + (1 | animal)`

term	estimate	std.error	z-value	p-value
intercept	7.47	2.10	3.56	$< .001$
type late	-8.83	2.11	-4.18	$< .001$

S2 Model Details

For readability, the main text includes only the key effects for each statistical model rather than a full specification. We include those here. In all cases, we began we the maximal model justified by the design. If the model did not converge, we removed effects iteratively beginning with interactions. We always prioritized random slopes of theoretical importance (e.g. random slopes of word knowledge for each participant) over control variables. Each mode included at least a random intercept for each subject and item. Models were estimated using version 1.1-23 of the `lme4` package (Bates, Mächler, Bolker, & Walker, 2015).

S2.1 Target animal difficulty

To validate that parents were more likely to say that their children knew early age of acquisition animals than late age of acquisition animals, we fit a mixed-effects model predicting parents' judgments from *a priori* early and late categories (defined above). The model specification and output are shown in Table S2.

S2.2 Selection accuracy

To confirm that parent-child dyads communicated successfully in the reference game, we analyzed children's choices. We fit 2 models. First, we asked whether children selected the target animal on each trial above chance levels (33%). To do fit a mixed-effects model in which the only fixed effect was an intercept, and we used an offset of $log(\frac{1}{3})$ so that an intercept different from zero would indicate above chance performance. The results of this model are presented in Table S3. We then

Table S3: Model was specified as `correct` ~ `1 + offset(log(1/3)) + (1 | subj) + (1 | animal)`

term	estimate	std.error	z-value	p-value
intercept	2.07	0.20	10.35	$< .001$

Table S4: Models were specified as `correct` ~ `1 + offset(log(1/3)) + (1 | subj) + (1 | animal)` separately for known and unknown animals

term	estimate	std.error	z-value	p-value
known intercept	2.61	0.24	10.93	$< .001$
unknown intercept	1.23	0.15	8.35	$< .001$

repeated the same analysis separately for animals that parents judged that their children knew, and animals that they judged that their children did not (Table S4).

After confirming that parents were successfully communicated, we asked what predicted children's success at picking the correct animal on each trial. We predicted success on each trial from (Table S5).

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Table S5:

term	estimate	std.error	z-value	p-value
intercept	1.41	0.63	2.23	.026
(log) length	-0.40	0.15	-2.69	.007
unknown animal	-1.86	0.41	-4.55	$< .001$
vocab size	0.03	0.01	3.19	.001
(log) length · unknown animal	0.46	0.20	2.24	.025

References

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