

# Do Neural Language Representations Learn Physical Commonsense?



**Are cats usually fluffy?**

object → property

human ✓

GloVe ✓  
ELMo ✓  
BERT ✓

**Can you pet cats?**

object → affordance

human ✓

GloVe ✓  
ELMo ✓  
BERT ✓

**If something is fluffy, can you usually pet it?**

affordance → property

human ✓

GloVe ?  
ELMo ?  
BERT ?

## Humans Can Reason about Objects, Properties, and Affordances

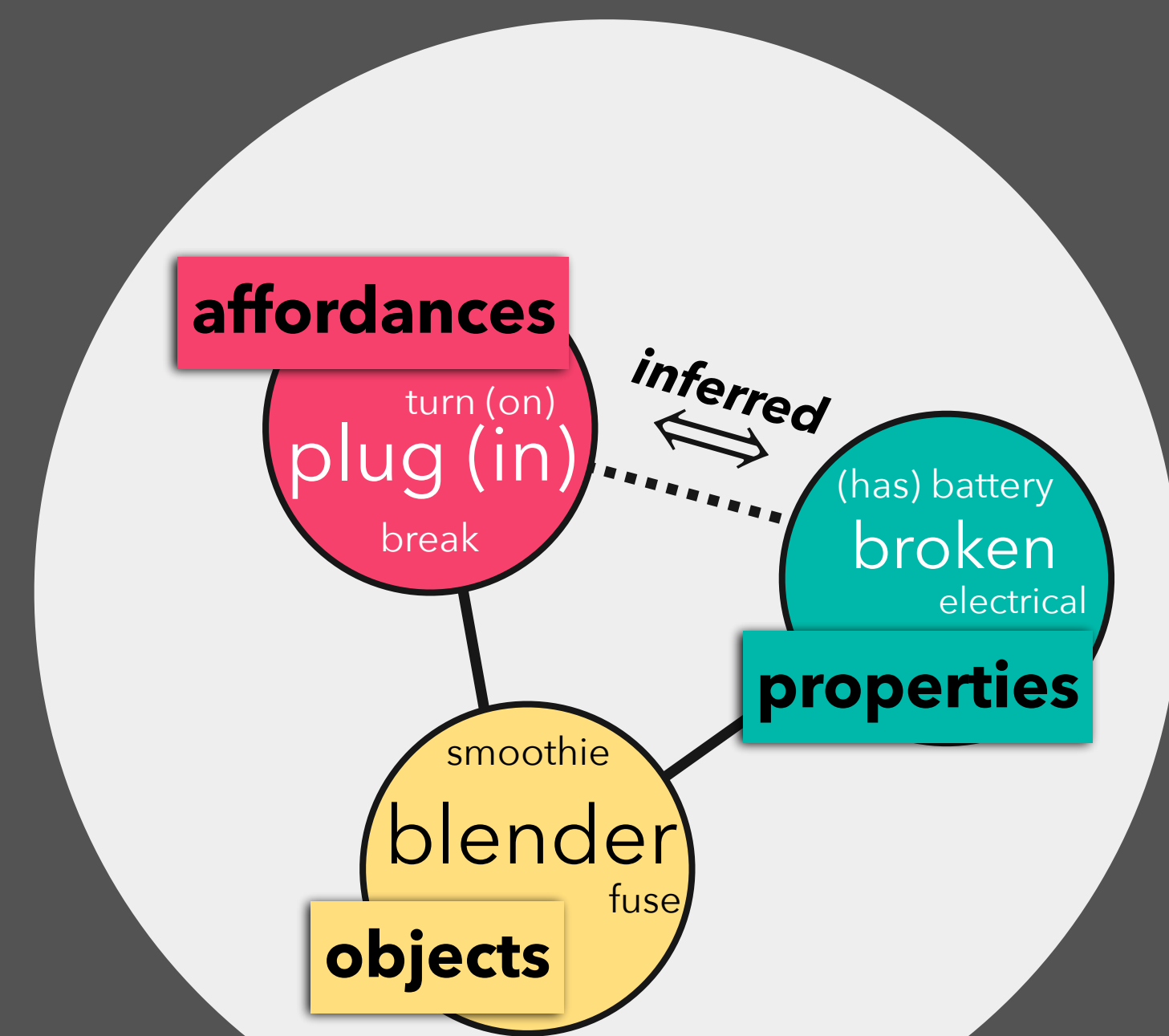
The blender is broken again!

**P** requires\_electricity( blender ) = True  
**P** has\_battery( blender ) = False  
**P** ⇒ **a** ¬ plugged\_in( blender ) ⇒ ¬ functions( blender )

Are you sure it's plugged in?

**P** connected\_to\_power\_source( blender ) = True  
**a** turned\_on( blender ) = True  
**P P** blown\_a\_fuse( outlet\_connected( blender )) = False  
⇒ **P** broken( blender ) = True

Yep, I checked everything. It's broken.



## Neural Language Representations Struggle to Reason between Affordances and Properties

**DATASETS**

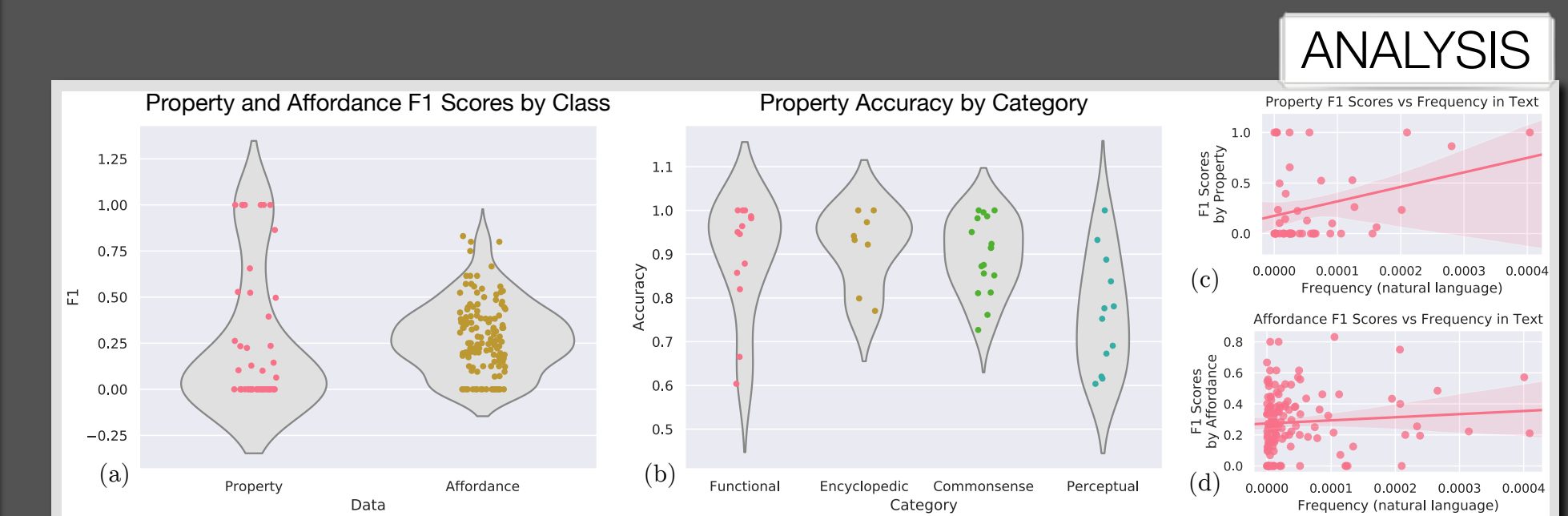
Statistics	Total	Statistics
Abstract	514	411 train / 103 test
Objects	50	objprop: 60 median (3 min, 202 max)
Properties	77,100	propobj: 8 median (1 min, 23 max)
Annotations	1,024	3 anns/datum
Situated	50	80 unique, split: 64 train / 16 test
Objects	5072	3 affordances / object (by design)
Properties	156,672	3 anns/datum

**MODELS**

$$r(w_i, w_j) = \begin{cases} \langle m(w_i), m(w_j) \rangle & \text{if } m \in \{\text{GloVe, D.E.}\} \\ m_{[i,j]}^1(s) & \text{if } m = \text{ELMo} \\ \sum_{\ell \in \{-d, \dots, -1\}} m^\ell(s) & \text{if } m = \text{BERT} \end{cases}$$
$$\hat{s}_{w_i, w_j} \propto \sigma(w_2^T a(w_1^T r(w_i, w_j) + b_1) + b_2)$$
$$\mathcal{L}(w_i, w_j, y, \theta, \lambda) = (y - \hat{s}_{w_i, w_j})^2 + \lambda \|\theta\|_2^2$$

**QUANTITATIVE RESULTS**

	Abstract				Situated				A			
	obj	prop	μ F1	sig	obj	prop	μ F1	sig	obj	prop	μ F1	sig
RANDOM	0.25	0.26	0.26	***	0.24	0.25	0.22	***	0.53	0.62	0.51	***
MAJORITY	0.34	0.11	0.31	***	0.16	0.05	0.17	***	0.82	0.68	0.82	***
GloVe	0.63	0.47	0.63	***	0.55	0.39	0.57	***	0.85	0.73	0.86	***
DEF-EMBS	0.62	0.42	0.60	***	0.54	0.36	0.54	***	0.84	0.67	0.84	*
ELMo	0.67	0.55	0.67	**	0.58	0.44	0.58	***	0.84	0.71	0.85	**
BERT	0.74	0.67	0.74	←	0.64	0.59	0.67	←	0.87	0.77	0.88	←
HUMAN	0.78	0.80	0.67		0.70	0.69	0.61		0.83	0.93	0.80	



**Project webpage**  
mbforbes.github.io/physical-commonsense

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