Orthographic neighbor effects on visual word identification differ across letter positions

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INTRODUCTION

- **Some letter positions may be privileged** in visual word recognition (VWR); for instance, fixations are **guided serially by the degree of entropy** (uncertainty about letter identity) at each position[4,6]
- The size of a word's **orthographic neighborhood** is an important predictor of VWR latencies[1], but this metric ignores possible differences across positions
  - *Neighbors:* Words that differ from target by the substitution of a single letter, regardless of *where* this mismatch is[5]
- Might orthographic neighborhood effects differ based on the degree of entropy at letter position? Does sensitivity to entropy imply serial processing?
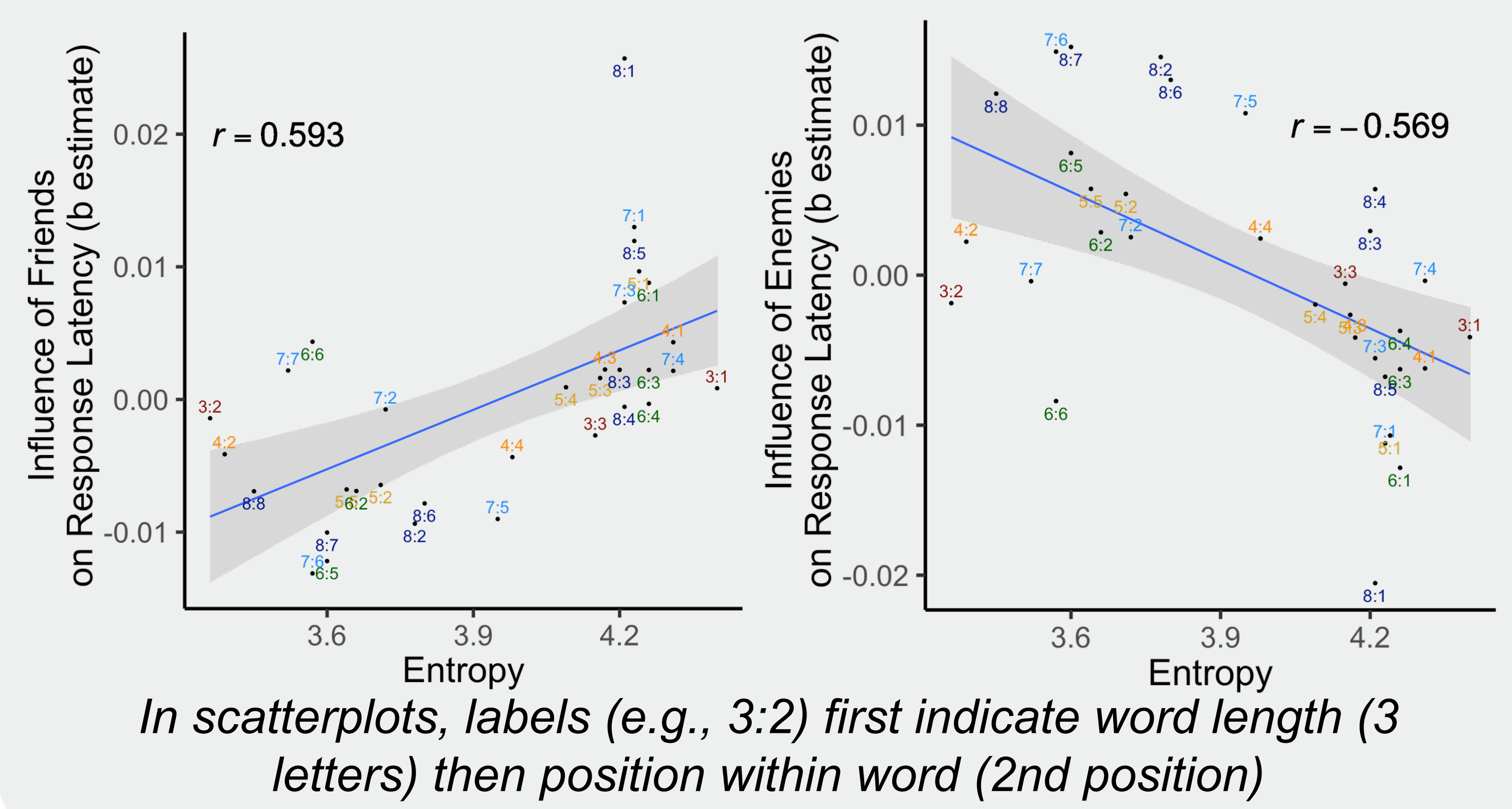
METHODS

- English Lexicon Project (ELP)[3] has trial-by-trial data for speeded naming and lexical decision tasks
  - Lexical metrics (frequency, number of orthographic neighbors) for 40,480 words
- Neighborhood characterized as positional **enemies** (words that mismatch at position) and **friends** (words that match at positions; neighbors - enemies)

	C	A	T
all neighbors	bat	cot	cab
	eat	cut	cad
	fat		cam
	hat		can
	mat		cap
	oat		car
	pat		
	rat		
	sat		
	vat		
enemies	10	2	6
friends	8	16	12

- Also computed **entropy** (uncertainty about letter identity) at each position (independently at each position, not serially / contingently[4])
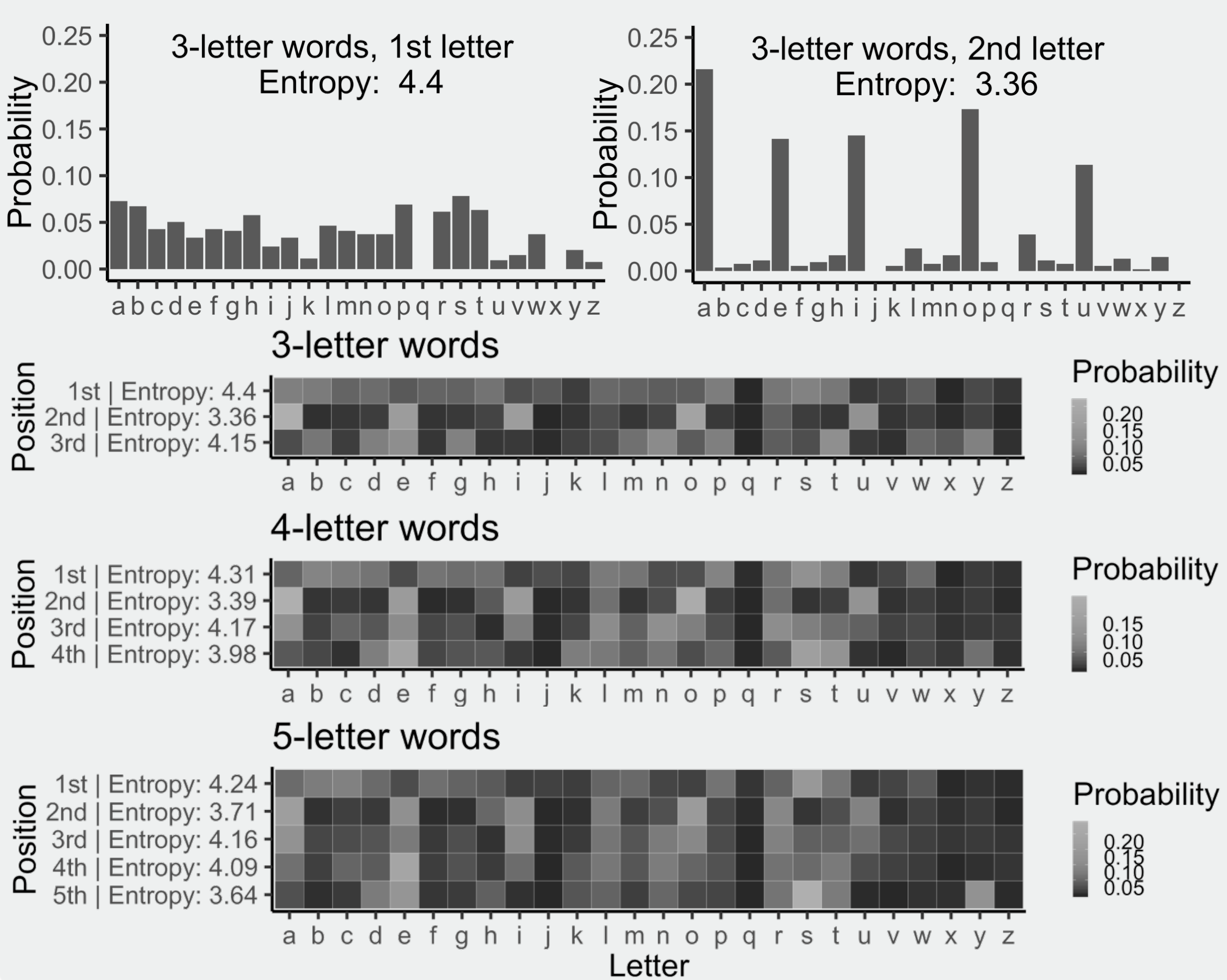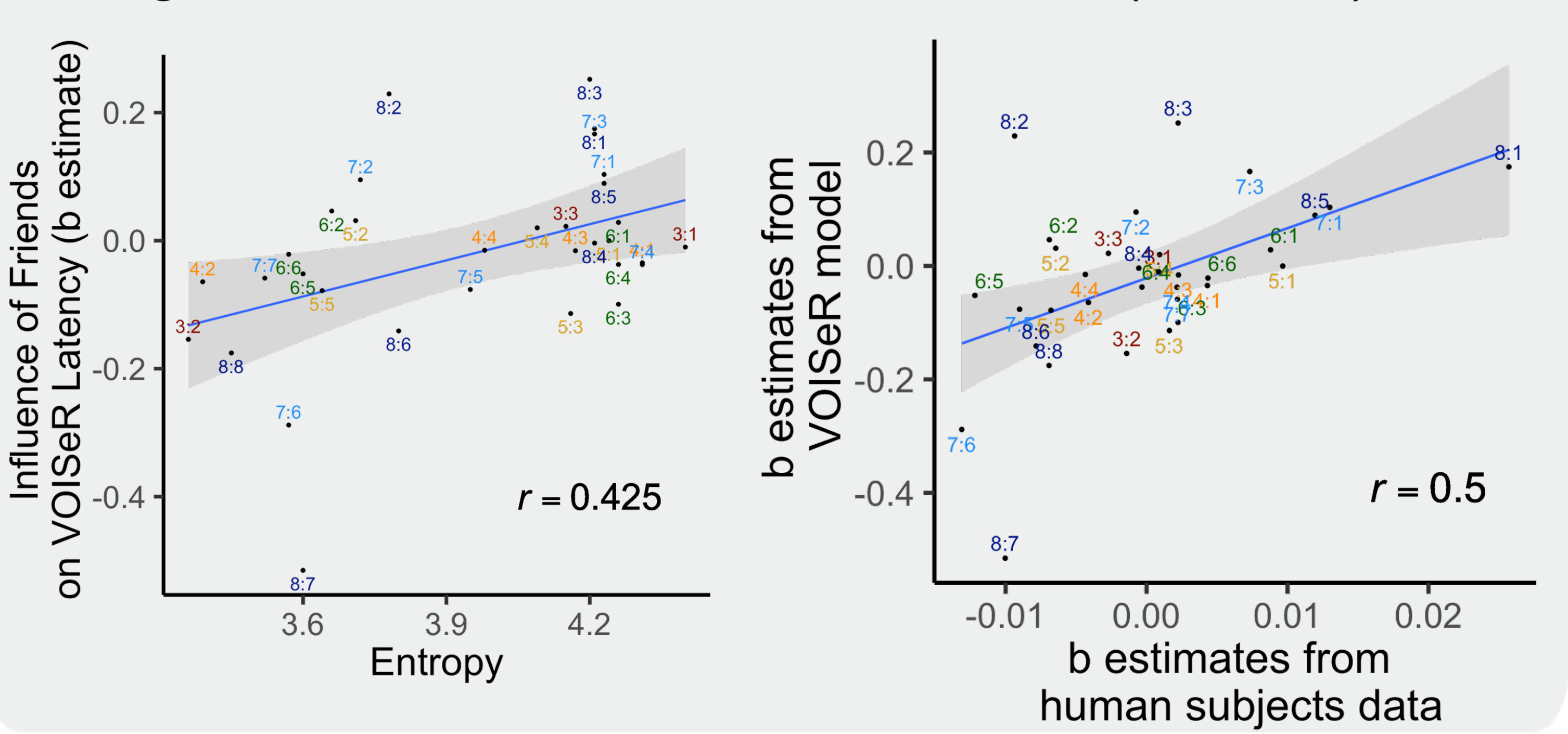

WORD NAMING TASK: HUMAN SUBJECTS

- 23,709 words (3-8 letters) sampled across 471 participants (ELP)
- Regression analyses to assess influence of **friends** on naming latency
  - Separate regressors for each letter position and control regressor for word frequency
  - Separate analyses by word length (since word length determines number of regressors)
  - Complementary analyses for enemies
- **Influence of friends/enemies differs across letter positions and is predicted by degree of entropy**

In scatterplots, labels (e.g., 3:2) first indicate word length (3 letters) then position within word (2nd position)

WORD NAMING TASK: COMPUTATIONAL MODEL

- Based on influence of entropy on time course of fixations in reading, Blais et al. (2009)[4] modeled VWR as entropy-guided serial processing
- New computational model: **VOISeR (Visual Orthographic Input, Serial Reader)**
- Orthographic input clamped on
- Output is over-time sequence of phonemes (phonetic feature vectors, 1 per time step)
- Trained on 37.6K words for 10K epochs (backprop through time)
- Model RT: cosine similarity (produced to target vector)
- Significant correlation with human RT ($r = 0.33$)

LEXICAL DECISION TASK: HUMAN SUBJECTS

- Does this effect generalize across VWR tasks?
- 24,398 words (3-8 letters) sampled across 797 participants in ELP lexical decision task
- **No significant relationship between influence of friends/enemies and entropy in LD task**
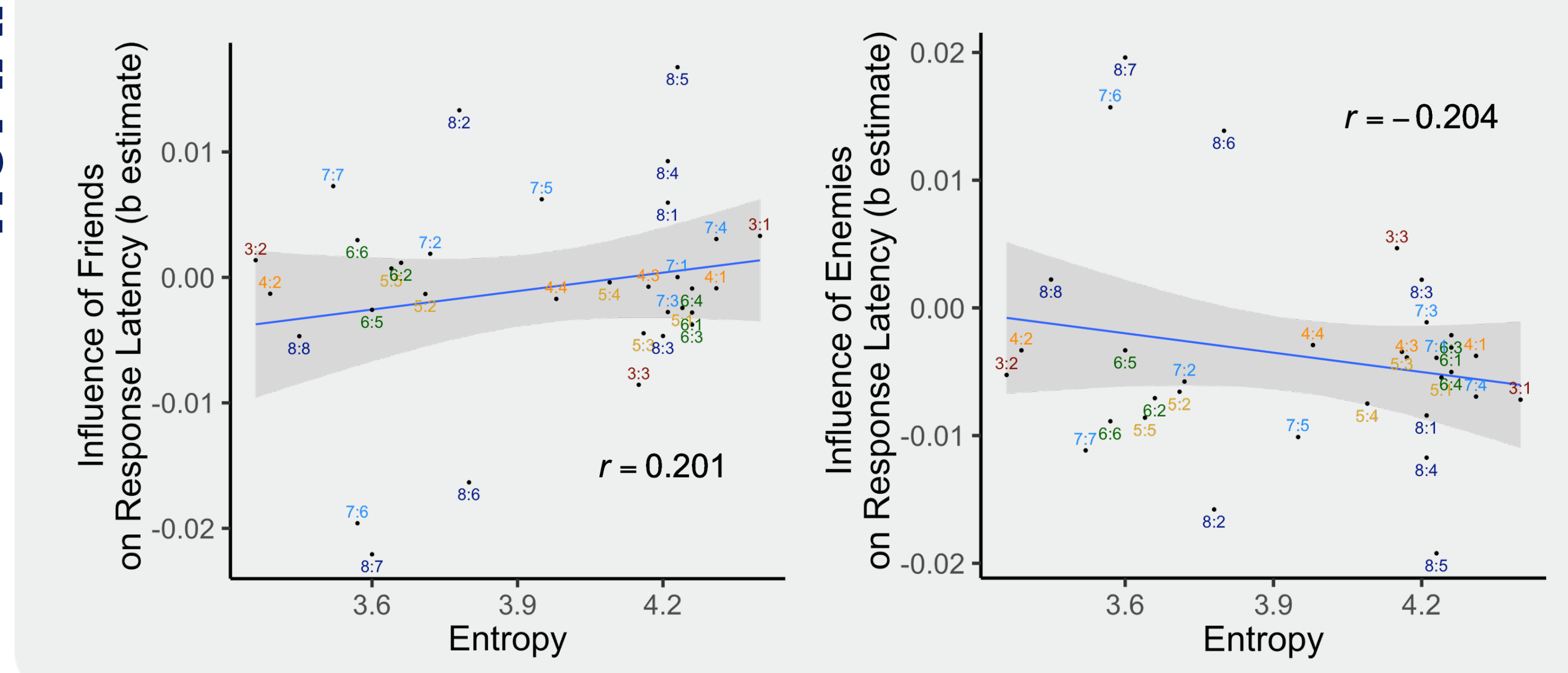
DISCUSSION

- Influence of orthographic neighbors varies with positional entropy for **word naming**
  - **Friends are increasingly facilitative in low-entropy positions**, while enemies are increasingly inhibitory in low-entropy places
  - This may be partially attributable to the relative rarity of enemies in low-entropy positions
- Effect also emerges in a computational model (VOISeR) where inputs are presented in parallel
  - **Suggests serial processing not required for positional entropy effects to emerge?**
  - But: does recurrent network allow serial "attention"? *Analyses under development*
- Entropy-friend relationship not observed in **lexical decision**
  - Is this because lexical decision may be a poor measure of lexical access[2], or because it does not require serial processing? *Experiments under development*

REFERENCES

[1]Andrews, S. (1997). The effect of orthographic similarity on lexical retrieval: Resolving neighborhood conflicts. *Psychonomic Bulletin & Review, 4*(4), 439-461.
[2]Balota, D. A., & Chumbley, J. I. (1984). Are lexical decisions a good measure of lexical access? The role of word frequency in the neglected decision stage. *Journal of Experimental Psychology: Human Perception and Performance, 10*(3), 340-357.
[3]Balota, D. A., Yap, M. J., Hutchison, K. A., Cortese, M. J., Kessler, B., Loftis, B., Neely, J. H., Nelson, D. L., Simpson, G. B., & Treiman, R. (2007). The English lexicon project. *Behavior Research Methods, 39*, 445-459.
[4]Blais, C., Fiset, D., Arguin, M., Jolicoeur, P., Bub, D., & Gosselin, F. (2009). Reading between eye saccades. *PLoS One, 4*(7), e6448.
[5]Coltheart, M., Davelaar, E., Jonasson, T., & Besner, D., (1977). Access to the internal lexicon. In S. Dornic (Ed.), *Attention and Performance VI*. Hillsdale, NJ: Erlbaum.
[6]O'Regan, J. K., Lévy-Schoen, A., Pynte, J., & Brugaillère, B. É. (1984). Convenient fixation location within isolated words of different length and structure. *Journal of Experimental Psychology: Human Perception and Performance, 10*(2), 250-257.