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Questions

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Two measures have been shown to correlate with response times and neural activity:

Transition Probabilities between morphemes, indicating that the visual language processing system keeps track of local statistical relations of subparts of words. Thus far, this has mainly been studied with single derivational affixes. [1–15]

Background

Relative Entropy between whole words, indicating that the visual language processing system keeps track of global comparisons between whole words with other whole words. [16-24]

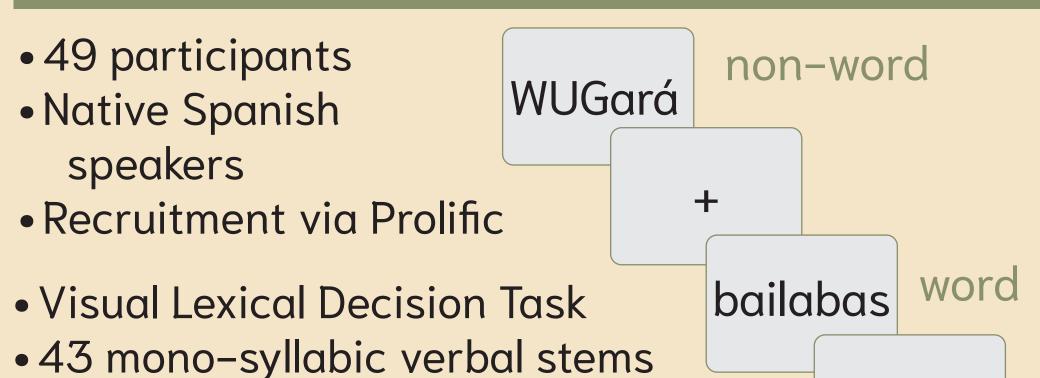
Despite a large literature finding support for both measures, no study has thus far directly compared the two.

- 1. Are Transition Probabilities or Relative Entropies a better predictor of response time?
- 2. Is there evidence for multiple decomposition of inflectional suffix clusters?

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Stimuli

Methods



				3 S	uff	ixe:	S		
	<u>stem</u>	SI	uffix 1	S	<u>suffix</u>	2		<u>suf</u>	fix 3
								sg.	<u>pl.</u>
<u>ا</u> ن	bail	+	ar				1st	Ø	mos
Future	bail com part	+	er	+	ía	+	2nd	S	n
11	part	+	ir				3rd	Ø	n

Control

• 13 suffixes

• 43 mon-syllabic pseudo stems

- Trial Number
- Average bigram frequency of stimulus
- Log frequency of stimulus
- Experimental session

Control Model				
Variable	Estimate	P-val.		
Intercept	1.109e+02	0.192		
Trial Number	-8.978e-02	<2e-16 ***		
Avg. Bigram Freq.	3.205e-07	0.587		
Word Log. Freq.	-3.822e+01	<2e-16 ***		
Session	4.884e+02	<2e-16 ***		
AIC	304844.2			

Control Model				
Variable	Estimate	P-val.		
Intercept	1.843e+02	0.044 *		
Trial Number	-9.148e-02	<2e-16 ***		
Avg. Bigram Freq.	1.253e-06	0.183		
Word Log. Freq.	-4.648e+01	2.68e-15 ***		
Session	4.767e+02	<2e-16 ***		
AIC	132826			

Single Transition Probability Model

1.795e+02

-9.152e-02

9.988e-07

-9.077e+01

Estimate

P-val.

0.04962 *

<2e-16 ***

0.29377

132781.3

0.00174 **

Variable

Intercept

AIC

Trial Number

Avg. Bigram Freq.

Word Log. Freq.

Transition Probability

Calcuation:

Transition Probability $(M_1 \rightarrow M_2)$

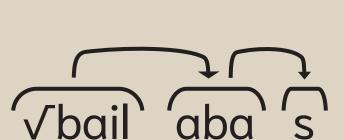
$$= P(M_2 | M_1) = \frac{P(M_1 + M_2)}{P(M_1)}$$

Transition Probability

Single Transition
Probability Model:

Value of the state of the state

Full Transition
Probability Model:

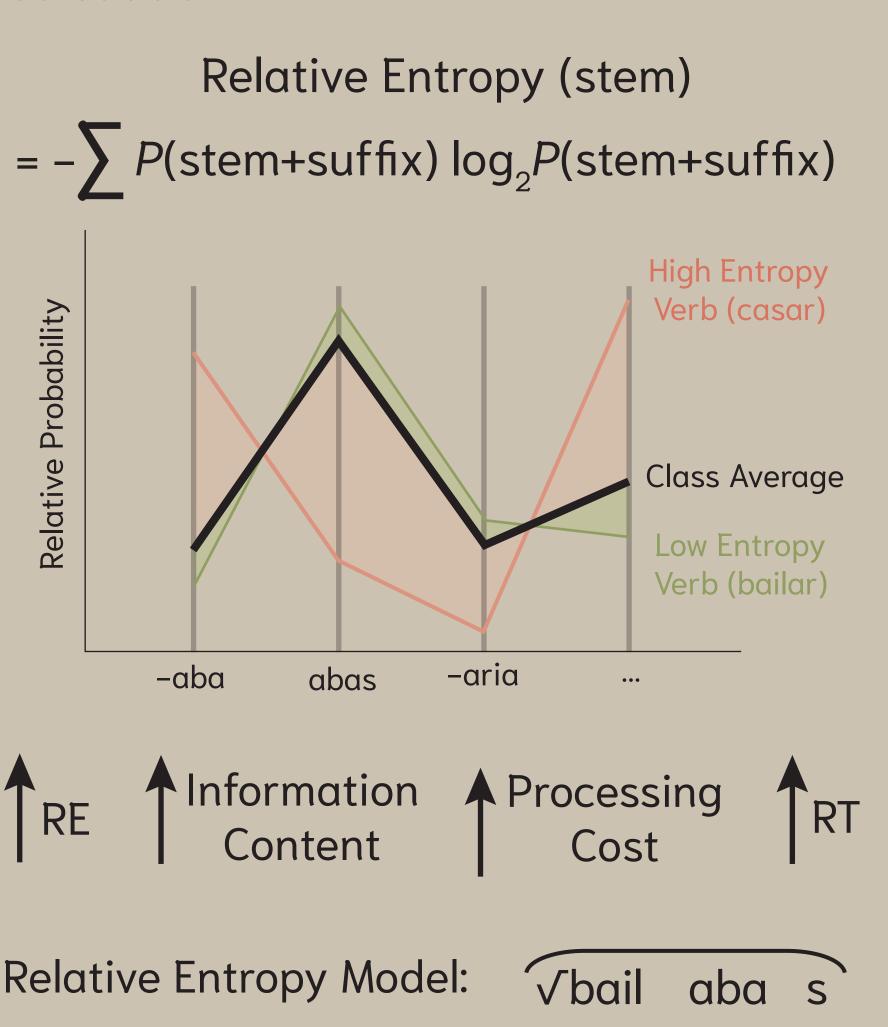


Single Transition Probability Model					
Variable	Estimate	P-val.			
Intercept	1.018e+02	0.23061			
Trial Number	-8.980e-02	<2e-16 ***			
Avg. Bigram Freq.	1.001e-07	0.86554			
Word Log. Freq.	-7.087e+01	2.33e-09 ***			
Session	4.884e+02	<2e-16 ***			
TP	1.836e+02	0.00376 **			
AIC	304827.7				
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Full Irans	ition Probability	<u>/ Model</u>			
Variable	Estimate	P-val.			
Intercept	-3.330e+01	0.7470			
Trial Number	-8.983e-02	<2e-16 ***			
Avg. Bigram Freq.	2.764e-07	0.6458			
Word Log. Freq.	-4.573e+01	<2e-16 ***			
Session	4.884e+02	<2e-16 ***			
TP 1	5.077e+01	0.1640			
TP 2	1.492e+02	0.0058 **			
AIC	304822				

Session	4.767e+02	<2e-16 ***		
TP	2.417e+02	0.11625		
AIC	132813.6			
Full Transition Probability Model				
Variable	Estimate	P-val.		
Intercept	8.310e+02	0.000219 ***		
Trial Number	-9.116e-02	<2e-16 ***		
Avg. Bigram Freq.	2.858e-06	0.005601 **		
Word Log. Freq.	-4.620e+01	1.58e-11 ***		
Session	4.767e+02	<2e-16 ***		
TP 1	-2.824e+02	0.016869 *		
TP 2	-5.680e+02	0.001975 **		
TP 3	7.733e+01	0.288961		

Relative Entropy

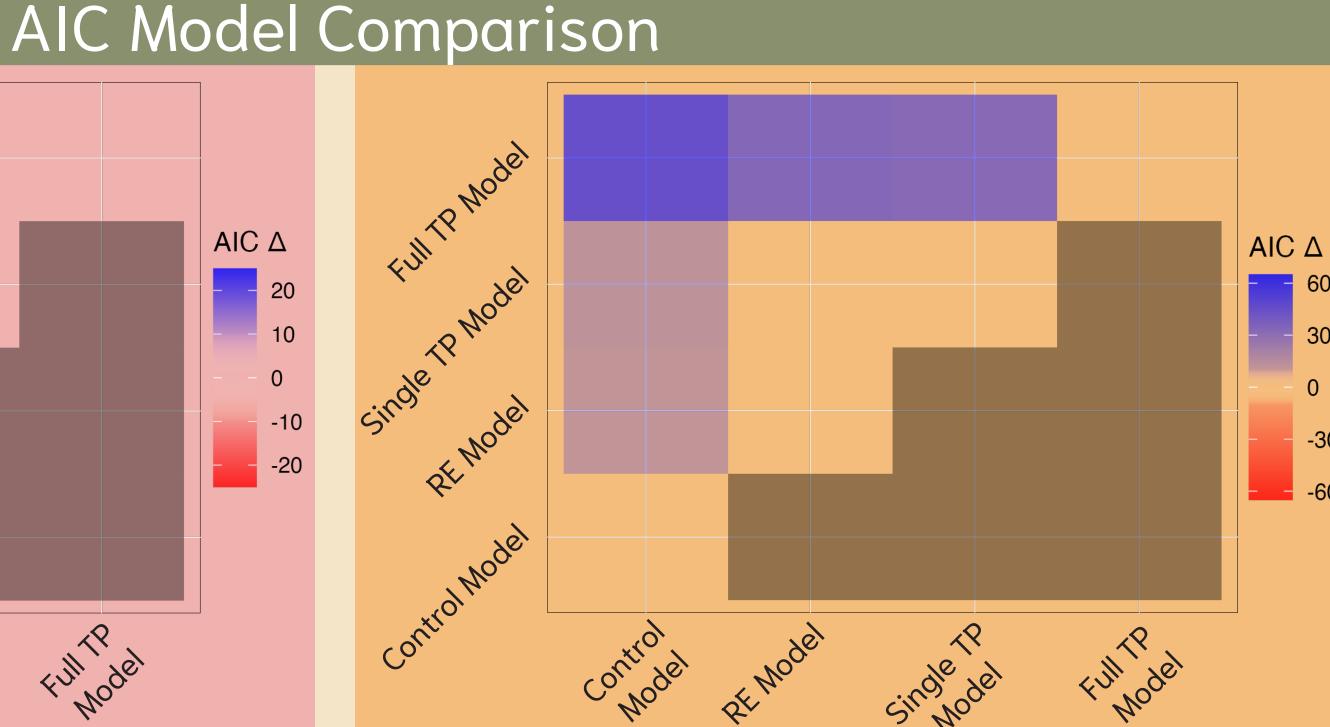
Calcuation:



Relative Entropy Model				
Variable	Estimate	P-val.		
Intercept	1.095e+02	0.198		
Trial Number	-8.978e-02	<2e-16 ***		
Avg. Bigram Freq.	3.058e-07	0.607		
Word Log. Freq.	-3.817e+01	<2e-16 ***		
Session	4.884e+02	<2e-16 ***		
RE	2.480e+00	0.814		
AIC	304839.6			

Relative Entropy Model			
Variable	Estimate	P-val.	
Intercept	2.062e+02	0.0255 *	
Trial Number	-9.148e-02	<2e-16 ***	
Avg. Bigram Freq.	1.681e-06	0.0759	
Word Log. Freq.	-4.728e+01	5.64e-16 ***	
Session	4.767e+02	<2e-16 ***	
RE	-4.075e+01	0.0165 *	
AIC	132814.7		

Single IP model Control model Cont



Conclusions

Transition Probability (i.e. local morpheme to morpheme statistical relations) better predicts response time data than Relative Entropy (i.e. global word to word statistical relations). Models that incorporate multiple decomposition of affixes better predict response time data than those that treat an entire suffix cluster as a single suffix.

This supports theoretic and processing models that treat morphemes as obligatorily distinct units compared to models that treat whole words as the minimal unit of representation.

Citations

[1–15] Zweig & Pylkkänen 2009; Vartiainen et al. 2009; Solomyak & Marantz 2009; Solomyak & Marantz 2010; Lehtonen et al. 2011; Lewis et al. 2011; Fruchter & Marantz 2015; Neophytou et al. 2018; Gwilliams & Marantz 2018; Ohta et al. 2019; Wilder et al. 2019; Stockall et al. 2019; Oseki et al. 2020; Wray et al. 2022; Cayado et al. (in press);

[16-24] Kostić et al. 2003; Baayen & Moscoso del Prado 2005; Milin et al. 2009a; Milin et al. 2009b; Nenadić et al. 2016; Hendirx et al. 2017; Filipović-Đurđević & Gatarić 2018; Filipović-Đurđević & Milin 2019; Nenadić et al. 2021;

