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Investigating the influence of orthographic and phonological similarity structure of language networks on visual word recognition: Insights from megastudies

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Introduction

- Similarity effects in lexical retrieval
  - Somewhat mixed findings with orthographic neighborhoods in VWR (Andrews, 1997)
  - Similarity appears to help VWR (Siakuluk et al., 2002) but not SWR (Luce & Pisoni, 1998)

- Network science methods can be used to represent the similarity structure of the mental lexicon.
  - Phonology (Vitevitch, 2008)
  - Orthography (Siew, 2018)
- In these language networks, nodes represent words and edges indicate similarity relationships between words.

- This study combines network science approaches with data from megastudies to examine the influence of orthographic and phonological similarity effects on visual word recognition.

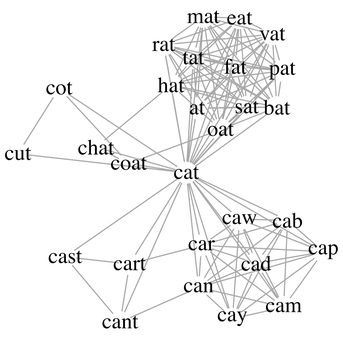

Figure 1. A section of the orthographic language network of English.

Language	Network	Megastudy	Lexical Decision	Naming
English	Hooiser Mental Lexicon (Nusbaum et al., 1984)	English Lexicon Project (Balota et al., 2007)	14826	14826
		British Lexicon Project (Keuleers et al., 2012)	8339	N/A
Dutch	CLEARPOND Dutch (Marian et al., 2012)	Dutch Lexicon Project (Keuleers et al., 2010)	9137	N/A
French	CLEARPOND French (Marian et al., 2012)	French Lexicon Project (Ferrand et al., 2010)	15349	N/A
German	CLEARPOND German (Marian et al., 2012)	Developmental Lexicon Project (Schröter & Schroeder, 2017); YA data	989	990
Malay	Malay Lexicon Project (Yap et al., 2010)	Malay Lexicon Project (Yap et al., 2010)	1511	1511
Total N			50151	17327

Table 1. Summary of databases used for network construction and to obtain behavioral data from.

Methods & Materials

Orthographic and phonological similarity networks

- 1-letter edit distance to define orthographic edges
- 1-phoneme edit distance to define phonological edges

Network measures of similarity

- degree = # neighbors (local measure)
- clustering coefficient = extent to which a word's neighbors are connected to each other
- closeness centrality = inverse of a word's average distance to all other words in the network (global measure)
- network components: largest connected (giant) component (G), lexical island (L), hermit (H)

Letters, phonemes, frequency, orthographic and phonological similarity measures were included as predictors in stepwise regression models to predict word recognition performance in megastudy data.

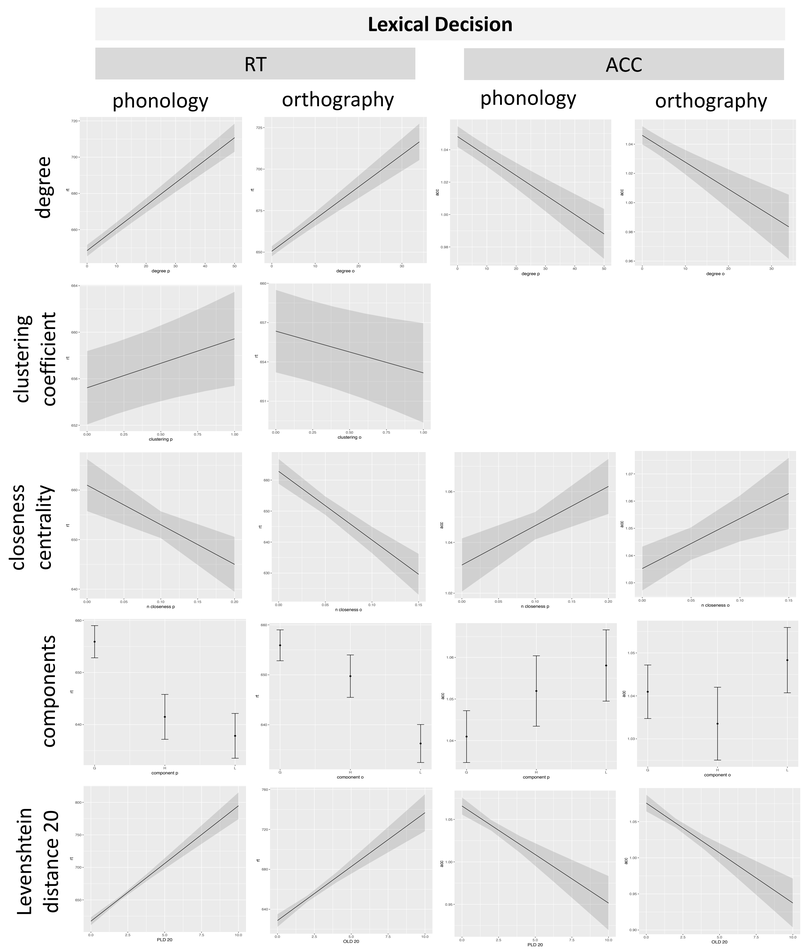

Table 3. Marginal effects of phonological and orthographic similarity measures on lexical decision RTs and ACCs.

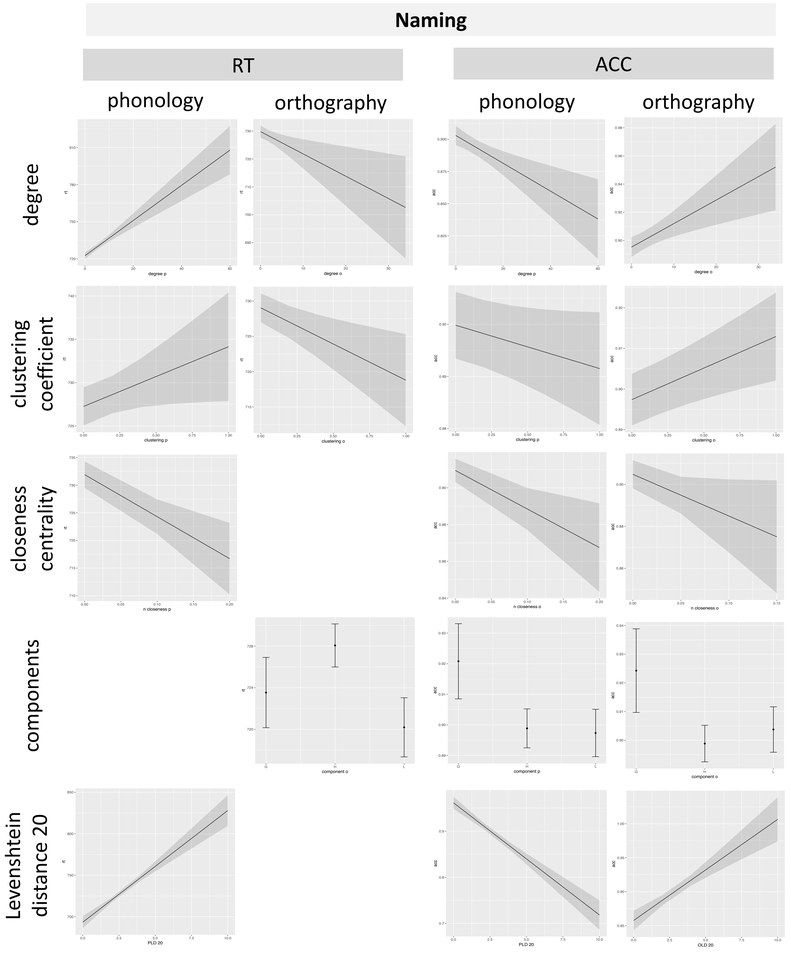

Table 4. Marginal effects of phonological and orthographic similarity measures on naming RTs and ACCs.

	Lexical Decision (RT)				Lexical Decision (ACC)				Naming (RT)				Naming (ACC)			
Predictors	std. Beta	std. SE	t	p	std. Beta	std. SE	t	p	std. Beta	std. SE	t	p	std. Beta	std. SE	t	p
(Intercept)			194.46	<0.001			56.39	<0.001			170.69	<0.001			84.37	<0.001
letters	0.04	0.01	4.66	<0.001	0.30	0.01	38.58	<0.001	0.11	0.01	8.86	<0.001	-0.02	0.02	-1.55	0.121
phonemes	0.10	0.01	10.14	<0.001					0.15	0.01	10.38	<0.001				
log frequency	-0.71	0.01	-132.41	<0.001	0.87	0.01	125.47	<0.001	-0.38	0.01	-69.90	<0.001	0.49	0.01	54.47	<0.001
Phonological measures																
degree_p	0.10	0.01	15.75	<0.001	-0.06	0.01	-7.61	<0.001	0.07	0.01	7.94	<0.001	-0.06	0.02	-3.66	<0.001
clustering_p	0.01	0.00	2.56	0.011					0.01	0.01	2.04	0.041	-0.02	0.01	-1.72	0.085
closeness_p	-0.05	0.01	-3.36	0.001	0.06	0.02	3.31	0.001	-0.04	0.01	-3.99	<0.001	-0.12	0.04	-3.07	0.002
comp_hermit_p	-0.06	0.01	-5.60	<0.001	0.03	0.01	2.16	0.031					-0.09	0.03	-2.86	0.004
comp_island_p	-0.06	0.01	-7.18	<0.001	0.04	0.01	3.40	0.001					-0.07	0.02	-3.02	0.003
PLD20	0.14	0.01	13.61	<0.001	-0.06	0.01	-5.72	<0.001	0.11	0.01	10.42	<0.001	-0.22	0.02	-11.10	<0.001
Orthogrraphic measures																
degree_o	0.07	0.01	11.84	<0.001	-0.04	0.01	-5.62	<0.001	-0.02	0.01	-2.81	0.005	0.06	0.02	3.37	0.001
clustering_o	-0.01	0.00	-2.19	0.028					-0.02	0.01	-3.10	0.002	0.03	0.01	3.31	0.001
closeness_o	-0.08	0.01	-7.61	<0.001	0.04	0.01	3.16	0.002					-0.08	0.04	-1.98	0.048
comp_hermit_o	-0.03	0.01	-2.75	0.006	-0.02	0.01	-1.66	0.098	0.02	0.01	1.90	0.057	-0.11	0.04	-3.01	0.003
comp_island_o	-0.08	0.01	-9.59	<0.001	0.02	0.01	1.79	0.074	-0.01	0.01	-1.47	0.142	-0.06	0.03	-2.41	0.016
OLD20	0.09	0.01	8.90	<0.001	-0.07	0.01	-6.31	<0.001					0.13	0.02	6.51	<0.001
Dummy variables for megastudy group (baseline: BLP)																
LP_Dutch	-0.53	0.01	-91.02	<0.001	0.74	0.01	99.52	<0.001								
LP_ELP	0.41	0.00	98.05	<0.001	0.00	0.01	-0.69	0.491								
LP_French	-0.31	0.01	-47.58	<0.001	0.89	0.01	104.73	<0.001								
LP_German	-0.16	0.00	-51.09	<0.001	0.22	0.00	51.88	<0.001	-0.59	0.00	-126.44	<0.001	0.20	0.01	21.67	<0.001
LP_Malay	-0.19	0.00	-51.39	<0.001	0.26	0.00	55.47	<0.001	-0.61	0.01	-102.18	<0.001	0.26	0.01	26.95	<0.001
Observations	50151				50151				17327				17327			
R^2 / adjusted R^2	0.596 / 0.596				0.326 / 0.326				0.708 / 0.707				0.216 / 0.215			

Table 2. Summary of fixed effects of final regression models. Blank cells indicate variables removed from the model based on the stepwise search procedure.

Discussion & Conclusions

- Similarity measures from language networks were significant predictors of word recognition performance, after taking other predictors into account.
- Generally, local similarity inhibits VWR; global similarity facilitates VWR.

- Lexical processes are sensitive to the local and global similarity structure of language.
- Future work will use advanced network science methods to model phonological and orthographic similarity effects simultaneously instead of treating them as separate influences.