

The Language Network and Object Categorisation

James Fodor
30th July 2024

Paper for Today




Cerebral Cortex, 2023, **33**, 10380–10400

<https://doi.org/10.1093/cercor/bhad289>

Advance access publication date 9 August 2023

Original Article

The language network is not engaged in object categorization

Yael Benn ^{1,†,*}, Anna A. Ivanova^{2,3,†}, Oliver Clark¹, Zachary Mineroff^{2,3}, Chloe Seikus⁴, Jack Santos Silva⁴, Rosemary Varley^{4,‡},
Evelina Fedorenko^{2,3,‡}

¹Department of Psychology, Manchester Metropolitan University, Manchester M15 6BH, United Kingdom,

²Brain and Cognitive Sciences Department, Massachusetts Institute of Technology, Cambridge, MA 02139, United States,

³McGovern Institute for Brain Research, Massachusetts Institute of Technology, Cambridge, MA 02139, United States,

⁴Division of Psychology & Language Sciences, University College London, London WC1E 6BT, UK

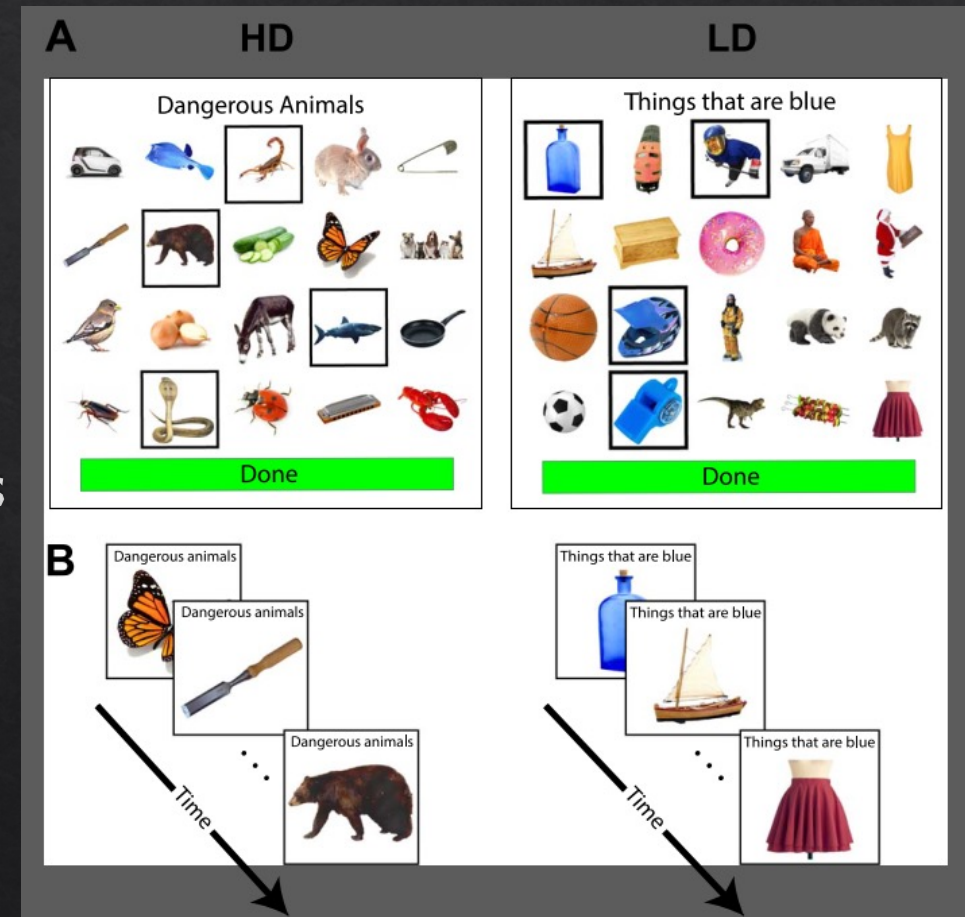
*Corresponding author: Department of Psychology, Manchester Metropolitan University, Brooks Building, Birley Fields Campus, 53 Bonsall Street, Manchester M15 6GX, United Kingdom. Email: y.benn@mmu.ac.uk

†Yael Benn and Anna A. Ivanova contributed equally

‡Co-senior authors

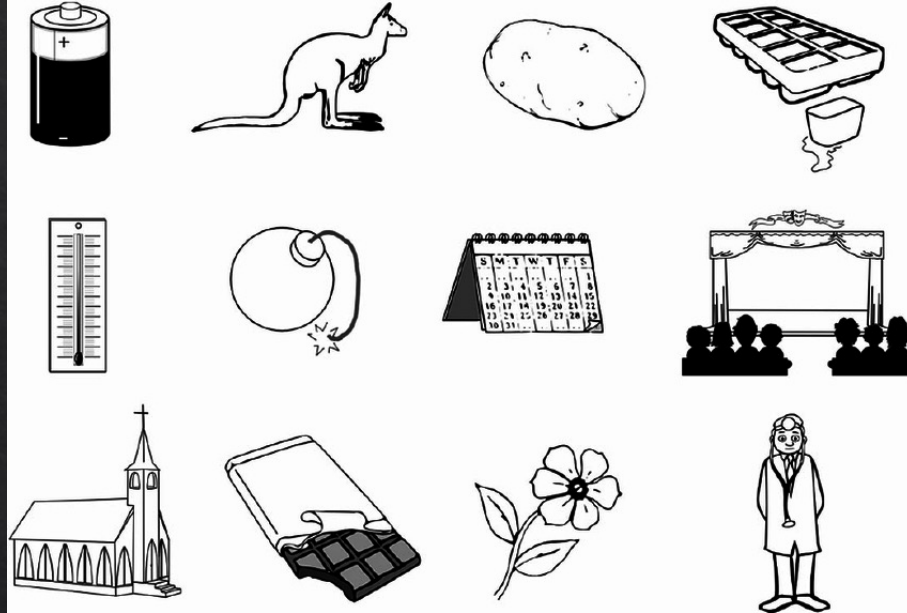
Paper for Today

- ◇ “High-dimensional” (HD): members share many features.
- ◇ “Low-dimensional” (LD): members share few few features.
- ◇ Claim: “language plays a special role in LD categorization... only one to two features are relevant to the task, whereas the rest of the features interfere and have to be inhibited... a verbal label can help maintain focus on the relevant criterion and reduce interference.” (p. 10381)
- ◇ Experiment: test whether LD-selective categorization impairment holds in a sample of individuals with severe anomia.



Next Steps

- ◆ BNT is the Boston Naming Test, a behavioural test based on giving the names of line drawings.



- ◆ Poor performance indicates problems with lexical access. This can be due to problems with lexical representations or problems with retrieval (or both).
- ◆ “Based on Study 2, we therefore concluded that lexical retrieval is not necessary for successful categorization, including categorization based on single features.” (page 10395)

Results: Study 1

Table 1. Participant information, study 1.

Group	Participant	Age	Education	Gender	TPO (months)	BNT	HD accuracy (SD)	LD accuracy (SD)
Neurotypical	1	75	Up to 16	F	-	51	97% (17)	96% (20)
	2	68	Up to 16	F	-	55	98% (15)	97% (17)
	3	68	Up to 16	M	-	55	98% (14)	97% (17)
	4	56	Degree-Level	F	-	59	100% (7)	98% (14)
	5	98	Up to 16	F	-	47	94% (24)	93% (26)
	6	54	Degree-Level	M	-	53	99% (11)	97% (17)
	7	69	Up to 16	M	-	55	98% (14)	97% (17)
	8	76	Up to 16	F	-	52	96% (20)	94% (24)
	9	47	Up to 18	F	-	58	99% (12)	97% (17)
PD	1	60	Postgraduate	M	36	59	99% (9)	98% (14)
	2	58	Degree-Level	M	12	58	99% (9)	99% (11)
	3	80	Up to 18	F	48	58	98% (14)	99% (9)
	4	56	Postgraduate	F	48	54	99% (10)	98% (16)
	5	66	Degree-Level	F	72	59	99% (9)	97% (17)
	6	75	Degree-Level	F	96	56	98% (15)	97% (17)
	7	59	Degree-Level	F	60	55	98% (16)	97% (18)
	8	69	Postgraduate	F	36	54	100% (7)	96% (19)
	9	63	Postgraduate	F	60	56	98% (14)	98% (16)
	10	77	Degree-Level	M	12	46	98% (15)	99% (9)
	11	72	Postgraduate	M	120	53	96% (19)	98% (14)
	12	75	Degree-Level	M	2	58	98% (15)	96% (19)
	13	75	Postgraduate	F	360	53	96% (20)	96% (20)
Aphasia	1	52	Degree-Level	M	120	30	92% (27)	89% (32)
	2	57	Up to 16	M	84	57	99% (10)	98% (14)
	3	52	Up to 18	M	48	52	98% (15)	97% (18)
	4	59	Postgraduate	M	120	43	100% (7)	98% (15)
	5	79	Up to 16	F	36	50	95% (23)	96% (20)
	6	44	Up to 18	F	12	14	98% (16)	95% (21)
	7	81	Up to 16	M	96	57	92% (27)	95% (21)
	8	56	Up to 18	M	60	12	90% (31)	89% (31)
	9	57	Up to 18	M	48	51	100% (7)	98% (14)
	10	60	Up to 16	M	132	34	96% (19)	95% (22)
	11	76	Up to 16	F	84	14	93% (26)	93% (26)

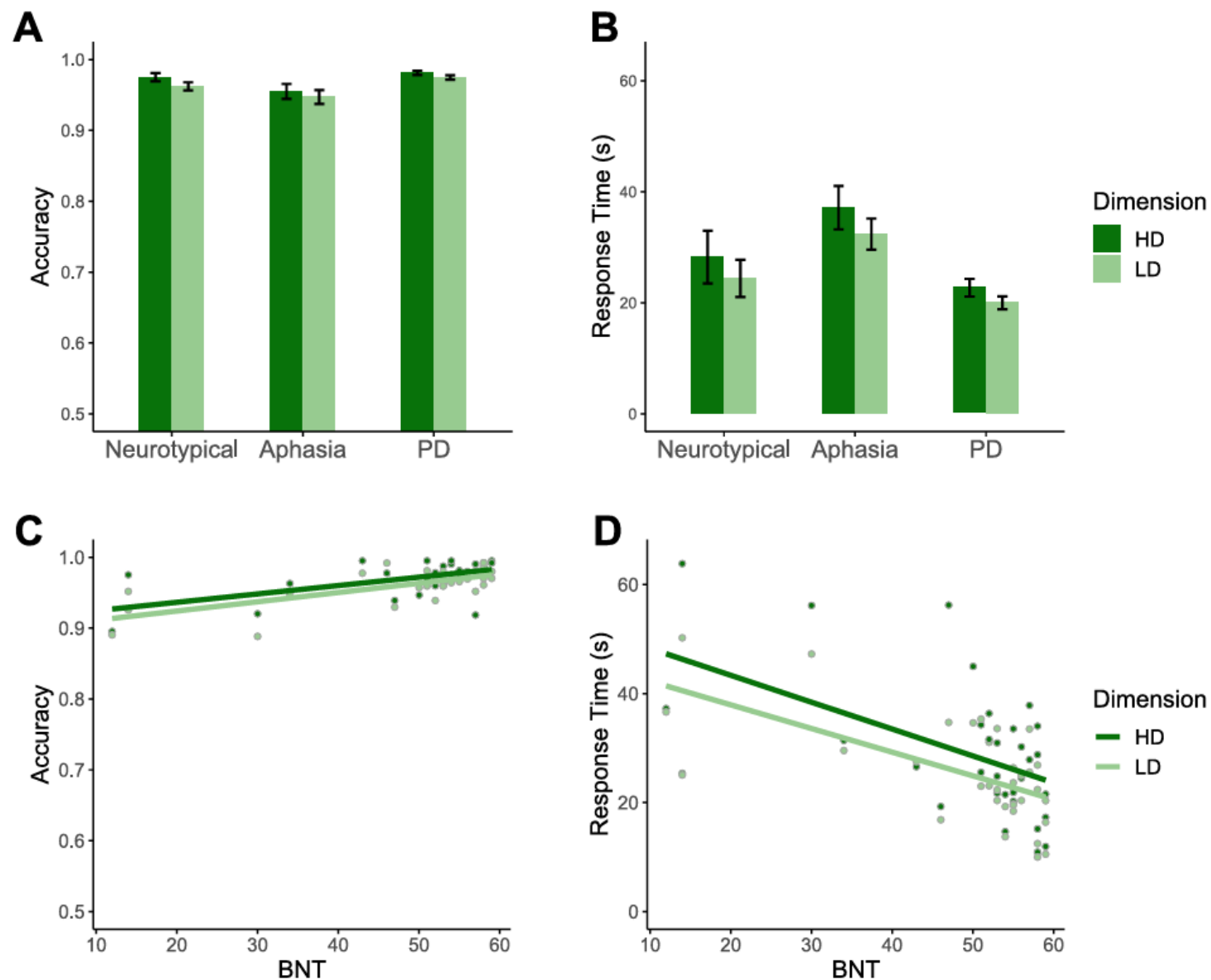
TPO, time post onset; BNT, Boston Naming Test; HD, high dimension categories; LD, low dimension categories; SD, standard deviation

Results: Study 2

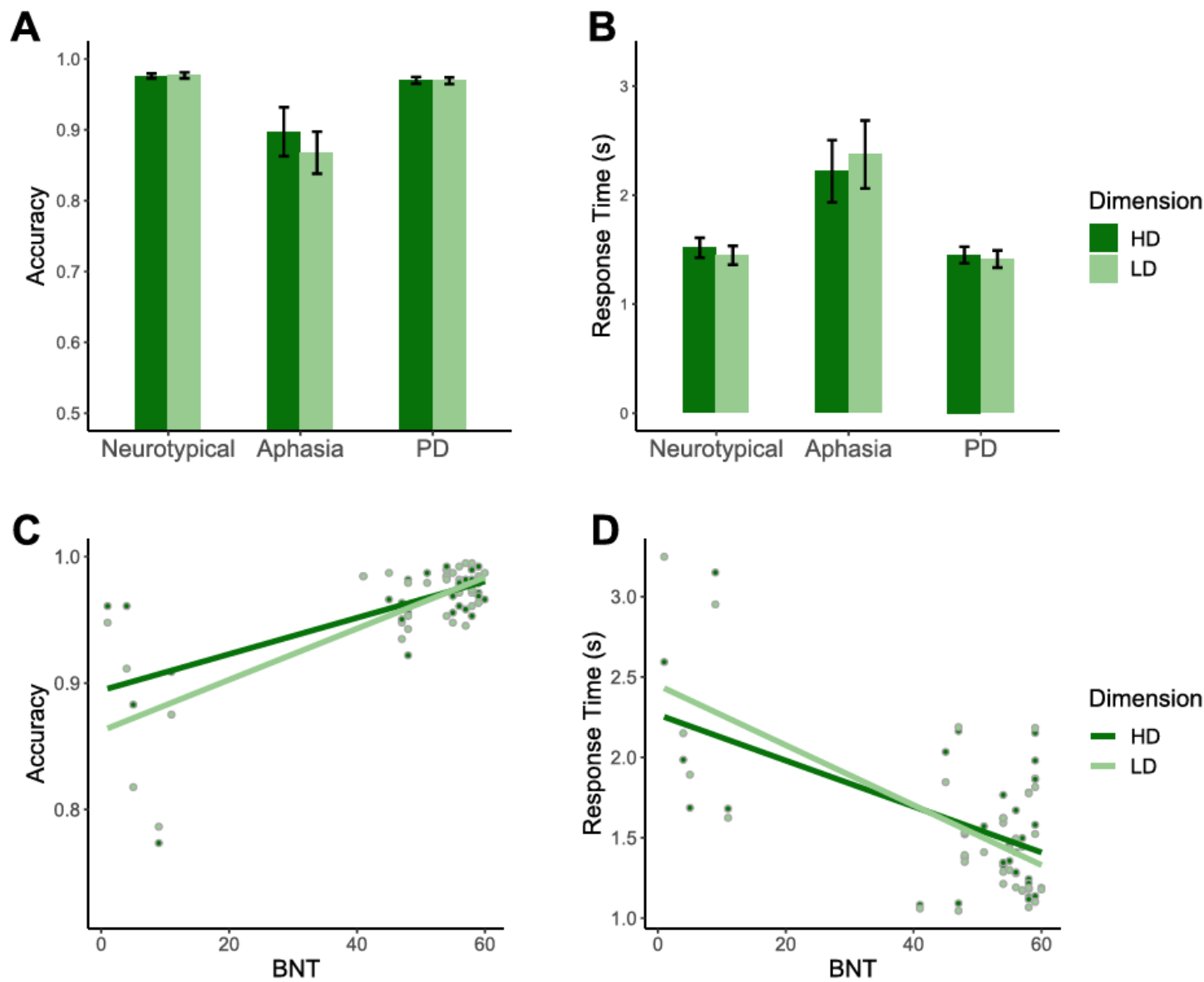
Table 2. Participant information, study 2.

Group	Participant	Age	Education	Gender	TPO (months)	BNT	HD Accuracy (SD)	LD Accuracy (SD)
Neurotypical	1	68	Degree-Level	F	-	51	99% (11)	98% (14)
	2	61	Postgraduate	F	-	41	98% (12)	98% (12)
	3	85	Degree-Level	F	-	54	99% (10)	95% (21)
	4	73	Postgraduate	F	-	58	95% (21)	96% (19)
	5	72	Up to 18	F	-	58	99% (9)	99% (9)
	6	77	Postgraduate	F	-	55	96% (21)	99% (11)
	7	77	Degree-Level	F	-	59	97% (17)	98% (12)
	8	66	Degree-Level	F	-	57	98% (13)	99% (7)
	9	66	Postgraduate	F	-	54	98% (12)	98% (12)
	10	76	Degree-Level	F	-	59	99% (9)	98% (14)
	11	65	Postgraduate	F	-	56	98% (15)	98% (13)
	12	80	Up to 18	F	-	45	97% (18)	99% (11)
	13	74	Postgraduate	F	-	54	98% (12)	99% (10)
	14	71	Degree-Level	F	-	57	96% (20)	95% (23)
	15	76	Degree-Level	F	-	47	96% (19)	95% (22)
PD	1	71	Degree-Level	M	24	58	98% (13)	97% (17)
	2	78	Degree-Level	M	24	47	95% (22)	93% (25)
	3	64	Postgraduate	M	30	48	98% (13)	95% (21)
	4	72	Postgraduate	M	18	59	98% (14)	96% (19)
	5	54	Degree-Level	M	204	58	97% (16)	97% (16)
	6	72	Degree-Level	M	4	48	96% (21)	98% (14)
	7	62	Postgraduate	F	120	56	98% (14)	99% (9)
	8	65	Postgraduate	M	17	59	97% (17)	98% (13)
	9	74	Up to 18	M	96	56	96% (19)	97% (17)
	10	67	Up to 16	M	60	54	99% (9)	98% (13)
	11	67	Postgraduate	M	72	59	98% (14)	96% (19)
	12	59	Postgraduate	M	30	58	99% (10)	99% (7)
	13	59	Degree-Level	M	48	60	97% (18)	99% (11)
	14	67	Degree-Level	M	18	55	97% (17)	95% (22)
	15	68	Degree-Level	M	98	48	92% (27)	94% (23)
Aphasia	1	58	Up to 18	M	42	5	88% (32)	82% (39)
	2	68	Up to 16	M	68	9	77% (42)	79% (41)
	3	77	Up to 18	M	111	11	91% (29)	88% (33)
	4	57	Degree-Level	M	34	1	96% (19)	95% (22)
	5	73	Up to 18	M	326	4	96% (19)	91% (28)

Results: Study 1



Results: Study 2



Interpretation of Aphasia Results

- ◆ “Based on Study 2, we therefore concluded that lexical retrieval is not necessary for successful categorization, including categorization based on single features.” (page 10395)
- ◆ This is a fair interpretation, but note that lexical retrieval is not the same as general language capability.

Next Steps

- ◇ “All groups showed a good performance on the conceptual and the semantic subtests, suggesting preservation of high-level cognitive and semantic processes. In contrast, subjects evidenced poorer performances in syllabic identification, indicating a disruption of lower level mechanisms which are assumed to retrieve and process formal lexical representations. Results support the view that aphasic anomia originates from a difficulty in accessing the formal lexical representation and not from a semantic problem.”

Anomia in Moderate Aphasia: Problems in Accessing the Lexical Representation

GUYLAINE LE DORZE

*Laboratoire Théophile Alajouanine, Centre de Recherche du Centre Hospitalier
Côte-des-Neiges, Montréal, and Hôpital Marie-Clarac, Montréal*

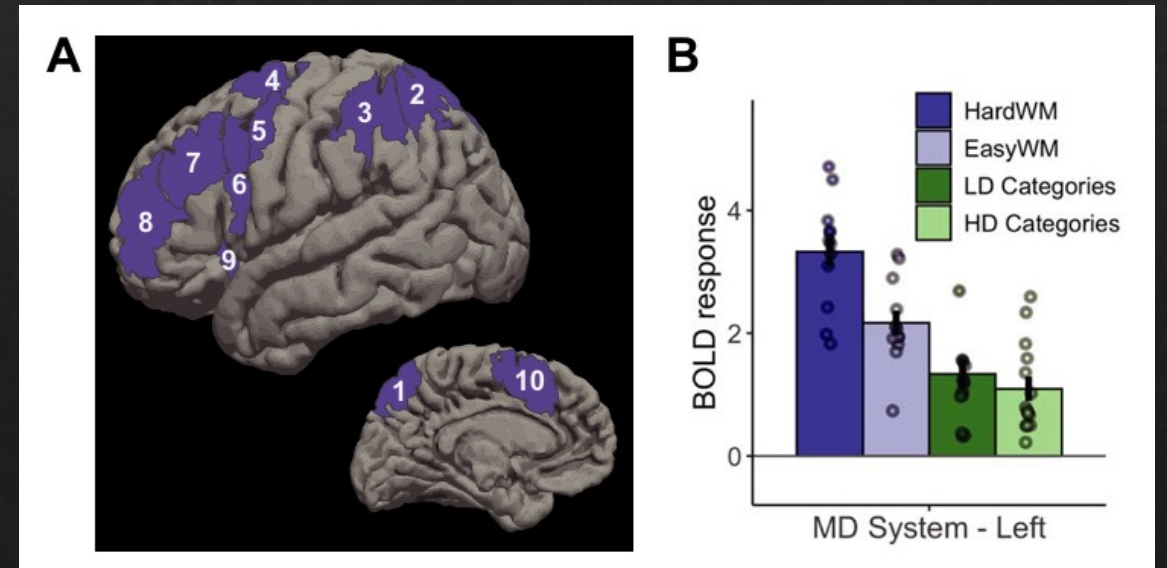
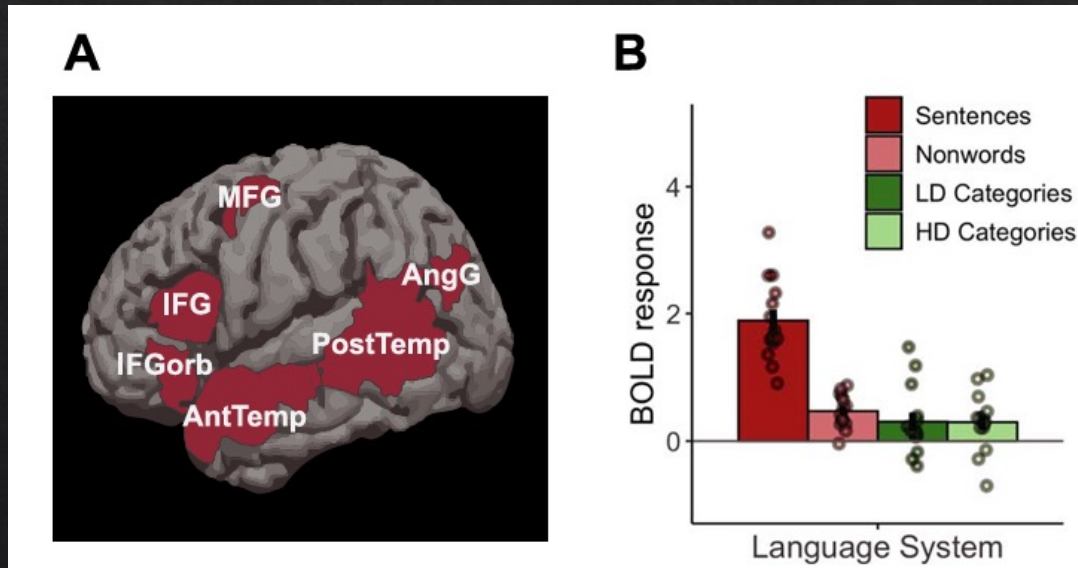
AND

JEAN-LUC NESPOULOUS

*Laboratoire Théophile Alajouanine, Centre de Recherche du Centre Hospitalier Côte-
des-Neiges, Montréal, and Département de Linguistique et Philologie, Université
de Montréal*

Results: Study 3

- ◇ fMRI imaging of healthy participants reading sentences, nonwords, a working memory task, and performing categorisation task.
- ◇ Found that the language network is much more responsive to sentences than the categorisation task.

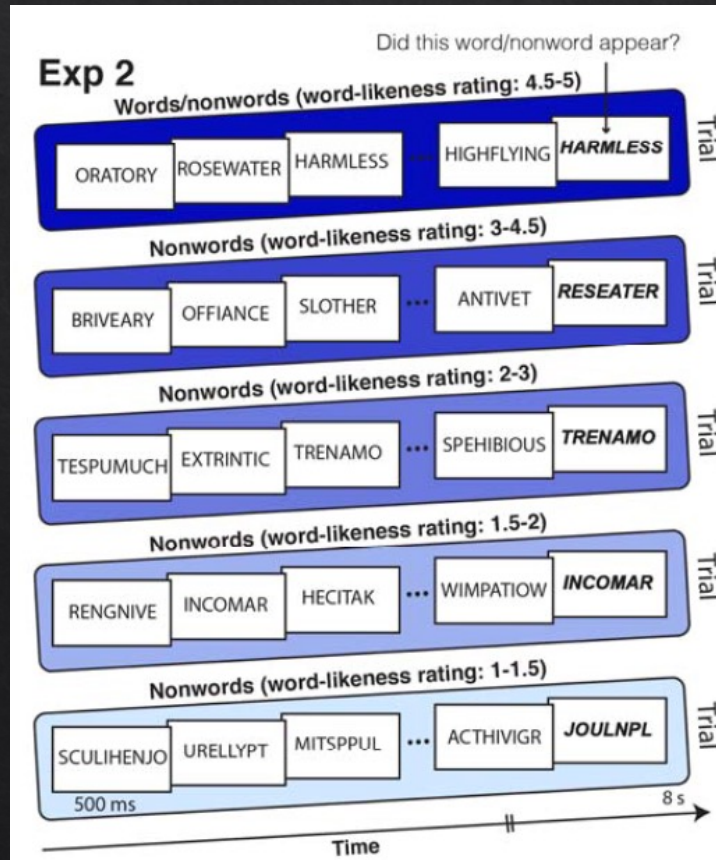


Interpretation of fMRI Results

- ◆ They define language as “meaningfully structured word sequences” (Language is primarily a tool for communication, 575)
- ◆ “The language network exhibited low responses to both categorization tasks, which did not differ from activations elicited by reading of nonword sequences (a low-level control condition).... Thus, we conclude that ... the language network is not at all engaged in object categorization, highlighting a dissociation between linguistic processing and non-linguistic semantic cognition.” (page 10393)
- ◆ “If access to linguistic representations were necessary for categorization, categorizing images would take longer than categorizing words; instead, they take approximately the same amount of time.” (page 10396)

Additional Background

- ◇ More word-like nonwords elicit higher activity.
- ◇ Word-likeness determined by online participant rating.



Cerebral Cortex, 2024, 34, bhae077
<https://doi.org/10.1093/cercor/bhae077>
 Advance access publication date 17 March 2024
 Original Article

OXFORD

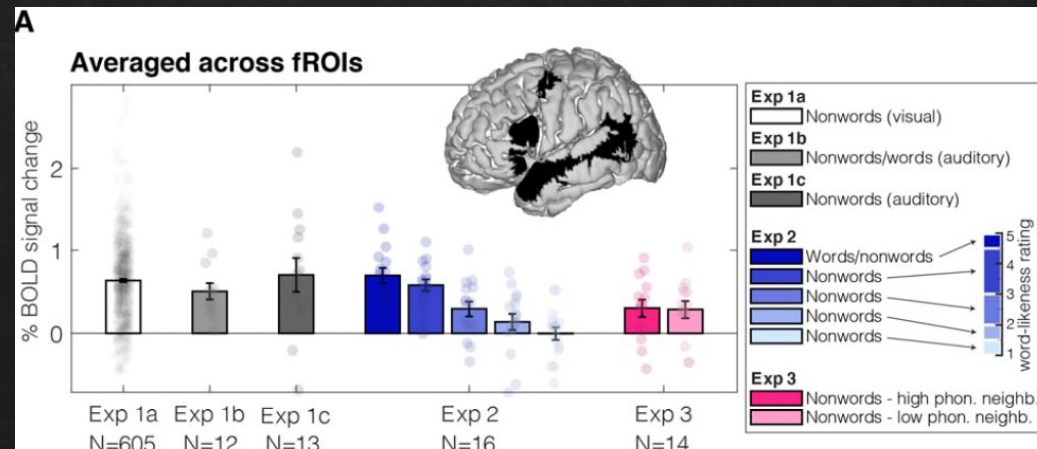
High-level language brain regions process sublexical regularities

Tamar I. Regev^{1,2,*}, Hee So Kim^{1,2}, Xuanyi Chen^{1,2,3}, Josef Affourtit^{1,2}, Abigail E. Schipper¹, Leon Bergen⁴, Kyle Mahowald^{5,†}, Evelina Fedorenko^{1,2,6,†}

¹Department of Brain and Cognitive Sciences, MIT, Cambridge, MA 02139, United States
²McGovern Institute for Brain Research, MIT, Cambridge, MA 02139, United States
³Department of Cognitive Sciences, Rice University, Houston, TX 77005, United States
⁴Department of Linguistics, University of California San Diego, San Diego CA 92093, United States
⁵Department of Linguistics, University of Texas at Austin, Austin, TX 78712, United States
⁶The Harvard Program in Speech and Hearing Bioscience and Technology, Boston, MA 02115, United States

*Corresponding author: Department of Brain and Cognitive Sciences, MIT, 43 Vassar Street, Room 46-4127B, Cambridge, MA 02139, United States.
 Email: tamarr@mit.edu






[†]Kyle Mahowald and Evelina Fedorenko Co-senior authors.



Additional Background

◆ Non-linguistic but meaningful stimuli activate the language network.

The Language Network Reliably “Tracks” Naturalistic Meaningful Nonverbal Stimuli

Yotaro Sueoka^{1,2} , Alexander Paunov^{1,3,4} , Alyx Tanner³, Idan A. Blank⁵ , Anna Ivanova⁶ , and Evelina Fedorenko^{1,3,7} 

¹Department of Brain and Cognitive Sciences, Massachusetts Institute of Technology, Cambridge, MA, USA

²Department of Neuroscience, Johns Hopkins University, Baltimore, MD, USA

³McGovern Institute for Brain Research, Massachusetts Institute of Technology, Cambridge, MA, USA

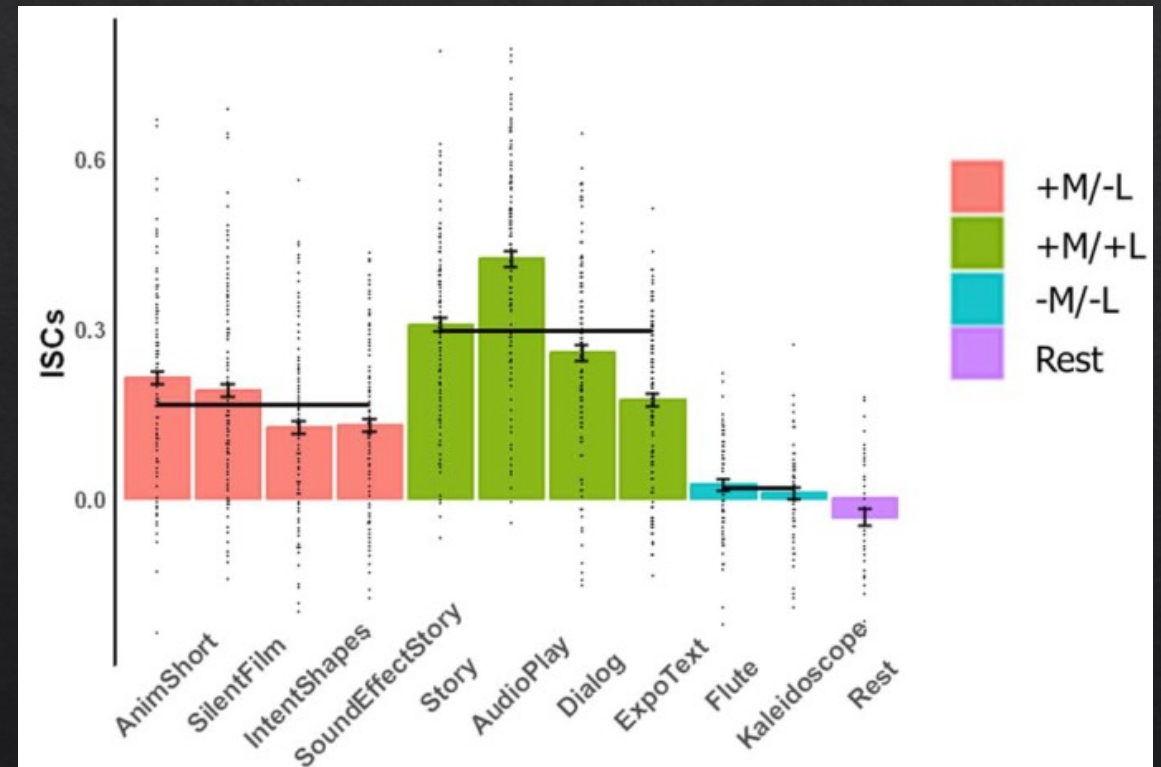
⁴Cognitive Neuroimaging Unit, INSERM, CEA, CNRS, Université Paris-Saclay, NeuroSpin center, Gif/Yvette, France

⁵Department of Psychology and Linguistics, University of California Los Angeles, Los Angeles, CA, USA

⁶School of Psychology, Georgia Institute of Technology, Atlanta, GA, USA

⁷Program in Speech and Hearing Biosciences and Technology, Harvard University, Cambridge, MA, USA

Keywords: fMRI, intersubject correlation, language network, naturalistic stimuli, nonverbal semantics



Additional Background

◆ Syntax and semantics separately increase language network activation.

Contents lists available at SciVerse ScienceDirect

Neuropsychologia

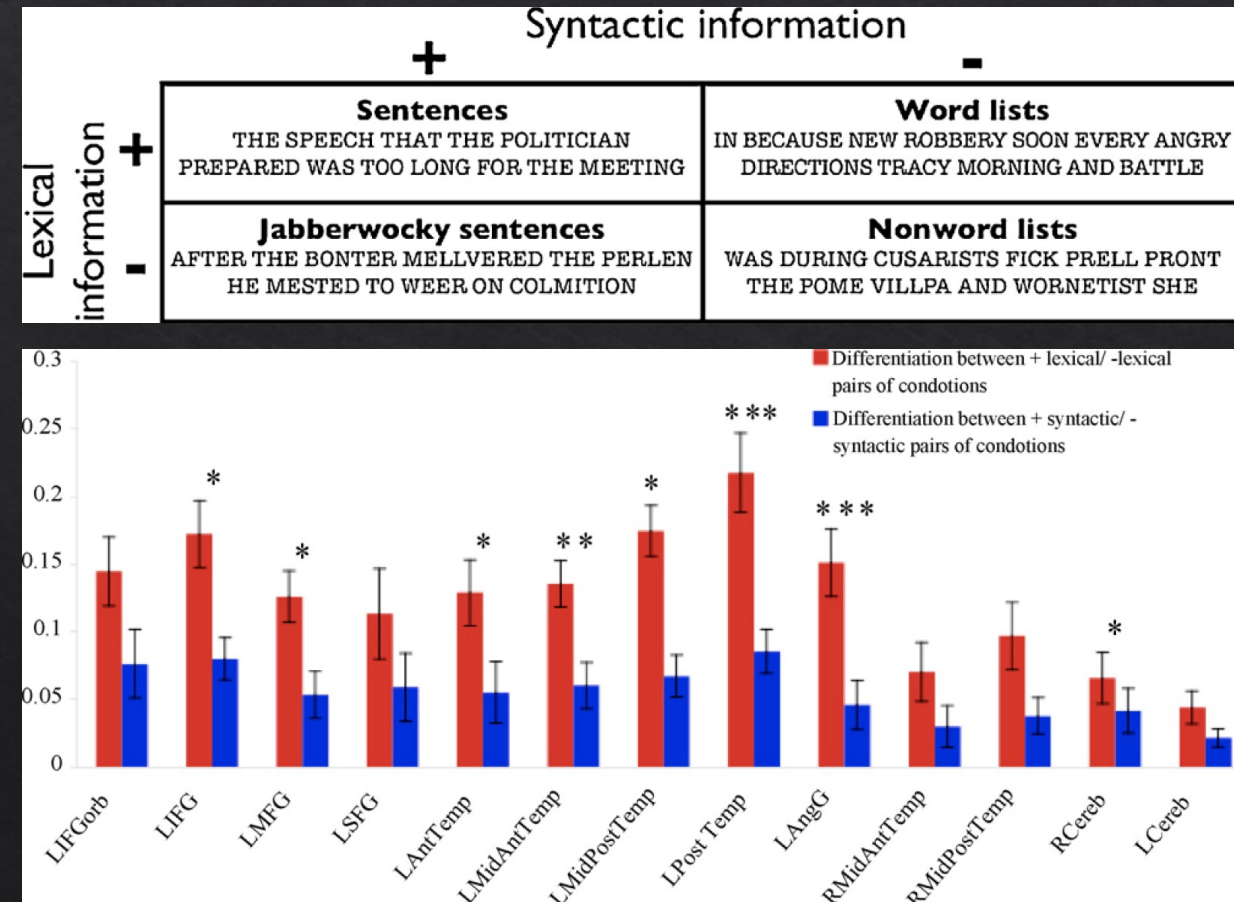
journal homepage: www.elsevier.com/locate/neuropsychologia

ELSEVIER

Lexical and syntactic representations in the brain: An fMRI investigation with multi-voxel pattern analyses

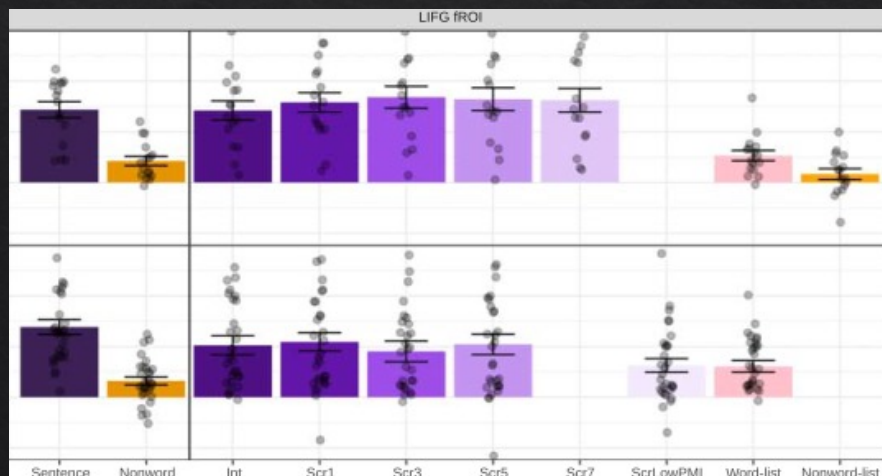
Evelina Fedorenko*, Alfonso Nieto-Castañón, Nancy Kanwisher

Brain & Cognitive Sciences Department, MIT, 43 Vassar Street, 46-4141C, Cambridge, MA 02139, United States



Additional Background

- ◇ Syntax and semantics separately increase language network activation.



Composition is the Core Driver of the Language-selective Network

Francis Mollica^{1*}, Matthew Siegelman^{2*}, Evgeniia Diachek³, Steven T. Piantadosi⁴, Zachary Mineroff⁵, Richard Futrell⁶, Hope Kean⁷, Peng Qian⁷, and Evelina Fedorenko^{7,8,9}

¹School of Psychological Sciences, University of Melbourne

²Psychology Department, Columbia University

³Psychology Department, Vanderbilt University

⁴Psychology Department, UC Berkeley

⁵The METALS Program, Carnegie Mellon University

⁶Linguistics Department, UC Irvine

⁷Brain & Cognitive Sciences Department, MIT

⁸McGovern Institute for Brain Research, MIT

⁹Psychiatry Department, Massachusetts General Hospital

*Equal contributors.

Keywords: fMRI, compositionality, semantics, syntax, information theory, mutual information

My Interpretation of Results

- ◆ Aphasia results: on an easy task, severely anomic patients perform somewhat worse. This is consistent with modest language network involvement in the task.
- ◆ fMRI results: on a superficial semantic task, healthy participants show small but non-zero activation of language network. This is expected given the non-linguistic stimuli.
- ◆ Conclusion: all evidence points to graded response of language network to aspects of natural language. As such, a small but non-zero response to an easy semantic task is not evidence of non-engagement of the language network.