From Words to Stories: Engagement of language-specific and domain-general neural mechanisms in native and second language comprehension

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INTRODUCTION

There are well-documented differences in how a native (L1) and a second language (L2) are processed in the brain [1]. These differences are associated with:

- increased cognitive control demands in L2 compared to L1 (e.g., [2])
- differences in L1 and L2 representations in the brain [3,4]

These differences have been attributed to language-specific or domain-general mechanisms, however, limited number of studies used precision fMRI to disentangle domain-general and language specific contributions

? How is the native and non-native language processing reflected in language and domain-general networks?
? Are there regions outside of language and domain-general networks that respond differently to L1 and L2?

Previously, L2 > L1 differences were mostly studies using single-word stimuli

? Are differences between languages similar in single words and more complex utterances?

METHODS: design

31 Polish-English bilinguals

Reading task:

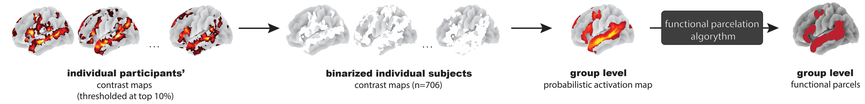
- L1 and L2 passive reading
- word lists, sentences, stories

Task desing:

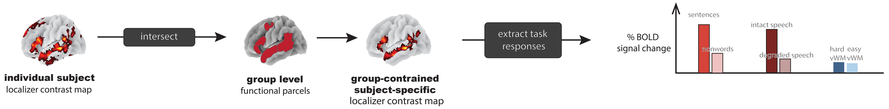
- 30s-long blocks
- 2 repetitions per condition per run
- 4 runs - 8 repetitions per condition in total

METHODS: analysis

Creating group-level functional parcels [5]

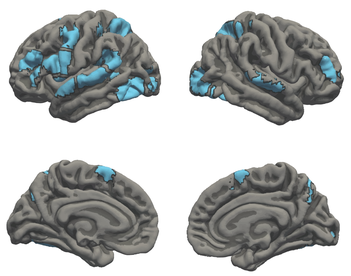


Creating individual-level functional ROIs



RESULTS

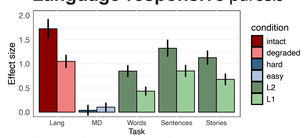
Regions that show a stronger response to **L2 over L1**



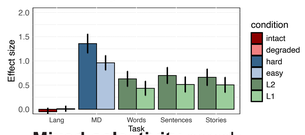
- Collapsed over words, sentences, and stories
- Data-driven parcellation
- Parcels show **3 different functional profiles**

3 classes of regions showing different functional profiles:

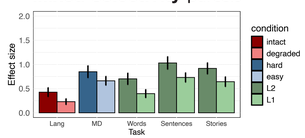
Language-responsive parcels



Domain-general parcels

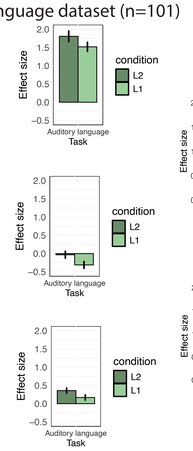


Mixed-selectivity parcels



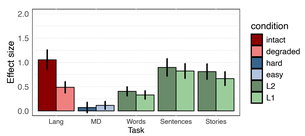
Replication:

auditory [6] language dataset (n=101)

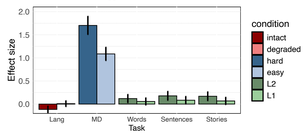


standard language and MD parcels

Language network [5]

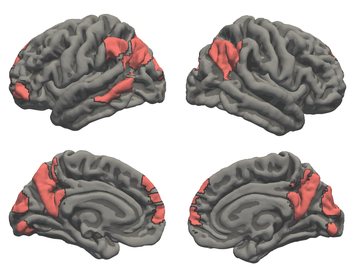


Domain-general MD network [7]



Exploratory analysis

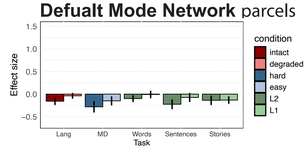
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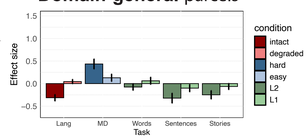
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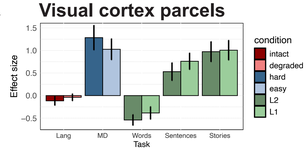
Defualt Mode Network parcels



Domain-general parcels



Visual cortex parcels



CONCLUSIONS

Both L1 and L2 processing engage language-specific and domain-general resources.

Within the language system, sentences and stories are linked to stronger responses than wordlists, but stories do not engage language system more than sentences.

L2 > L1

Processing of L2 engages additional resources in both systems in both reading and auditory comprehension

This effect is **not modulated** by utterance complexity

L2 > L1

L1 seems to engage **DMN regions** more than L2:

? deeper processing of native language
? smaller demands on control mechanisms

References: [1] Sulpizio, S., Del Maschio, N., Fedeli, D., & Abutalebi, J. (2020). Bilingual language processing: A meta-analysis of functional neuroimaging studies. Neuroscience & Biobehavioral Reviews, 108, 834-853; [2] Abutalebi, J., & Green, D. W. (2016). Neuroimaging of language control in bilinguals: neural adaptation and reserve. Bilingualism: Language and cognition, 19(4), 689-698; [3] Klein, D., Zatorre, R. J., Chen, J. K., Milner, B., Crane, J., Belin, P., & Bouffard, M. (2006). Bilingual brain organization: A functional magnetic resonance adaptation study. Neuroimage, 31(1), 366-375; [4] Xu, M., Baldauf, D., Chang, C. Q., Desimone, R., & Tan, L. H. (2017). Distinct distributed patterns of neural activity are associated with two languages in the bilingual brain. Science advances, 3(7), e1603309;[5] Fedorenko, E., Hsieh, P. J., Nieto-Castañón, A., Whitfield-Gabrieli, S., & Kanwisher, N. (2010). New method for fMRI investigations of language: defining ROIs functionally in individual subjects. Journal of neurophysiology, 104(2), 1177-1194; [6] Rampinini, A., Balboni, I., Kepinska, O., Berthele, R., & Golestani, N. (2025). NEBULA101: an open dataset for the study of language aptitude in behaviour, brain structure and function. Scientific Data, 12(1), 19; [7] Fedorenko, E., Duncan, J., & Kanwisher, N. (2013). Broad domain generality in focal regions of frontal and parietal cortex. Proceedings of the National Academy of Sciences, 110(41), 16616-16621.
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