The Universal Language Network

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Introduction

Languages differ in a wide array of characteristics; however, this cross-linguistic richness and diversity is severely under-investigated in most psycholinguistic and neurobiological research, with most studies focusing on English and a handful of Western European languages (Bornkessel-Schlesewsky & Schlesewsky, 2016).

To test whether the general functional architecture of language is similar across typologically varied languages, we undertook a large fMRI study spanning 45 languages across 11 language families (Afro-Asiatic, Austronesian, Dravidian, Indo-European, Japonic, Koreanic,Niger-Congo, Sino-Tibetan, Turkic, and Uralic) as well as one isolate (Basque).

Methods

Participants. Neural responses were recorded from 86 participants (2 per language, except three languages where only one participant was tested)

Imaging. Structural and functional MRI data collected on a 3 Tesla Siemens Trio scanner with a 32-channel head coil.

Tasks Participants listened to passages of 'Alice in Wonderland' in their native language, as well as acoustically degraded versions of those passages, and passages in a foreign language. The Alice Localizer will soon be available in http://web.mit.edu/evlab/aliceloc/

To assess the selectivity of the language-responsive areas for language (Fedorenko et al., 2011), participants also performed a) a spatial working memory task and b) an arithmetic addition task.

Finally, participants performed two naturalistic cognition paradigms: a resting state scan, and a ~5-minute long passage in their native language.

Results

1. The activation landscape for the intact>degraded and the intact>foreign contrasts is consistent across languages, covering extensive portions of the lateral surfaces of left frontal and temporal cortices, with stronger activity in the left hemisphere (ps<0.0009)

2. The language-responsive regions showed the largest % signal change to the native intact condition, significantly higher than the degraded condition (p<0.0005) and the foreign condition (p<0.0002).

This response was highly selective to language. Responses to the native intact condition was significantly higher than responses to the math task (p<0.0002) and spatial working memory task (p<0.0002). Both tasks elicit robust responses in the domain-general multiple demand (MD) network (Duncan, 2010).

This pattern is observed across all languages tested, as observed in Fig 1.

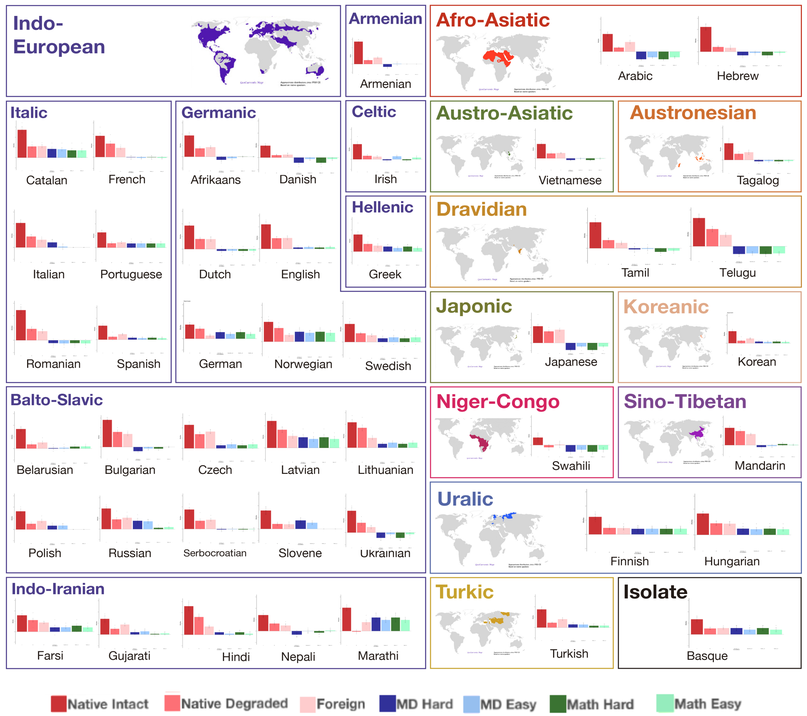

Fig 1. Responses of language responsive regions to the Alice task (Native Intact, Degraded and Foreign), spatial working memory task (MD Hard, MD Easy) and arithmetic task (Math Hard, Math Easy) across language families.

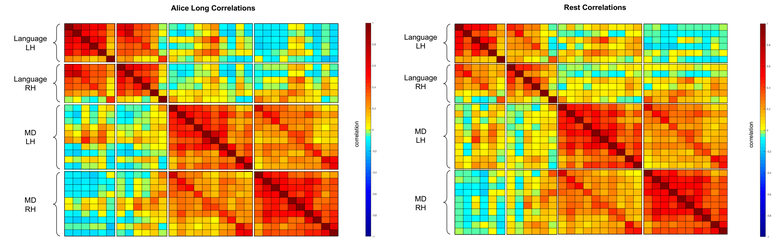

Fig 2. Correlations between the language and MD system while listening to stories (left) and during resting state (left).

3. The functional correlation analyses revealed that the language network is highly internally integrated, with the regions showing strong correlations during both rest and story comprehension, and r=~0 correlation with the regions of the MD network, as seen in figure 2. This replicates Blank et al (2010)'s results from English to other languages.

Conclusion

Here we establish that the language network's universality across 45 different languages in its topography, left-lateralization, selectivity to language over other tasks, and synchronicity during both resting state and a naturalistic language paradigm.

This work lays the foundation for future investigations of fine-grained linguistic manipulations to uncover potential dissociations in their neural implementation cross-linguistically.

References

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