Multilingual BERT, Ergativity, and Grammatical Subjecthood

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We investigate how Multilingual BERT (mBERT) encodes grammar by examining how the high-order grammatical feature of morphosyntactic alignment (how different languages define what counts as a “subject”) is manifested across the embedding spaces of different languages.

Continuing a line of inquiry into how deep neural models process language (Manning et al., 2020; Linzen et al., 2016), our goal is to understand whether, and how, large pretrained models encode abstract features of the grammars of languages. To do so, we analyze the notion of subjecthood in Multilingual BERT (mBERT) across diverse languages with different morphosyntactic alignments. Alignment is a feature of the grammar of a language, rather than of any single word or sentence, letting us analyze mBERT’s representation of language-specific high-order grammatical properties.

For 24 languages, we train small classifiers to distinguish the mBERT embeddings of nouns that are subjects of transitive sentences from nouns that are objects. We then test these classifiers on out-of-domain examples within and across languages. We go beyond standard probing methods (which rely on classifier accuracy to make claims about embedding spaces) by (a) testing the classifiers out-of-domain to gain insights about the shape and characteristics of the subjecthood classification boundary and (b) testing for awareness of morphosyntactic alignment, which is a feature of the grammar rather than of the classifier inputs.

In Experiment 1, we test our subjecthood classifiers on out-of-domain intransitive subjects (subjects of verbs which do not have objects, like “I slept”) in their training language. Whereas in English and many other languages, we think of intransitive subjects as grammatical subjects, ergative languages have a different morphosyntactic alignment system that aligns intransitive subjects with objects (Dixon, 1979; Du Bois, 1987). We find evidence that a language’s alignment is represented in mBERT’s embeddings, as shown in Figure 2.

In Experiment 2, we perform successful zero-shot cross-linguistic transfer of our subject classifiers, finding that higher-order features of the grammar of each language are represented in a way that is parallel across languages. Zero-shot transfer of subjecthood classification is effective across languages. The average accuracy across all source-destination pairs for a high-performing mBERT layer (layer 10) is 82.61%. We can then look at how S is classified: does the subjecthood...
The behavior of subjecthood classifiers across mBERT layers (x-axis). For each layer, the proportion of the time that the classifier predicts arguments to be A, separated by grammatical role. In higher layers, A and O are reliably classified correctly, and S is mostly classified as A. When the source language is ergative or split-ergative (see gray outlined boxes), S is more intermediate between A and O.

In Experiment 3, we characterize the basis for these classifier decisions by studying how they vary as a function of linguistic features like passive constructions, animacy and grammatical case. We find that subjects which are passive are less likely to be categorized as subjects, as are subjects that are inanimate (as shown in Figure 3 or in less agentive cases (e.g., not nominative or ergative). We take this as evidence for a multifactored, probabilistic notion of subjecthood, as has been argued by Comrie (1981) and Hopper and Thompson (1980).

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