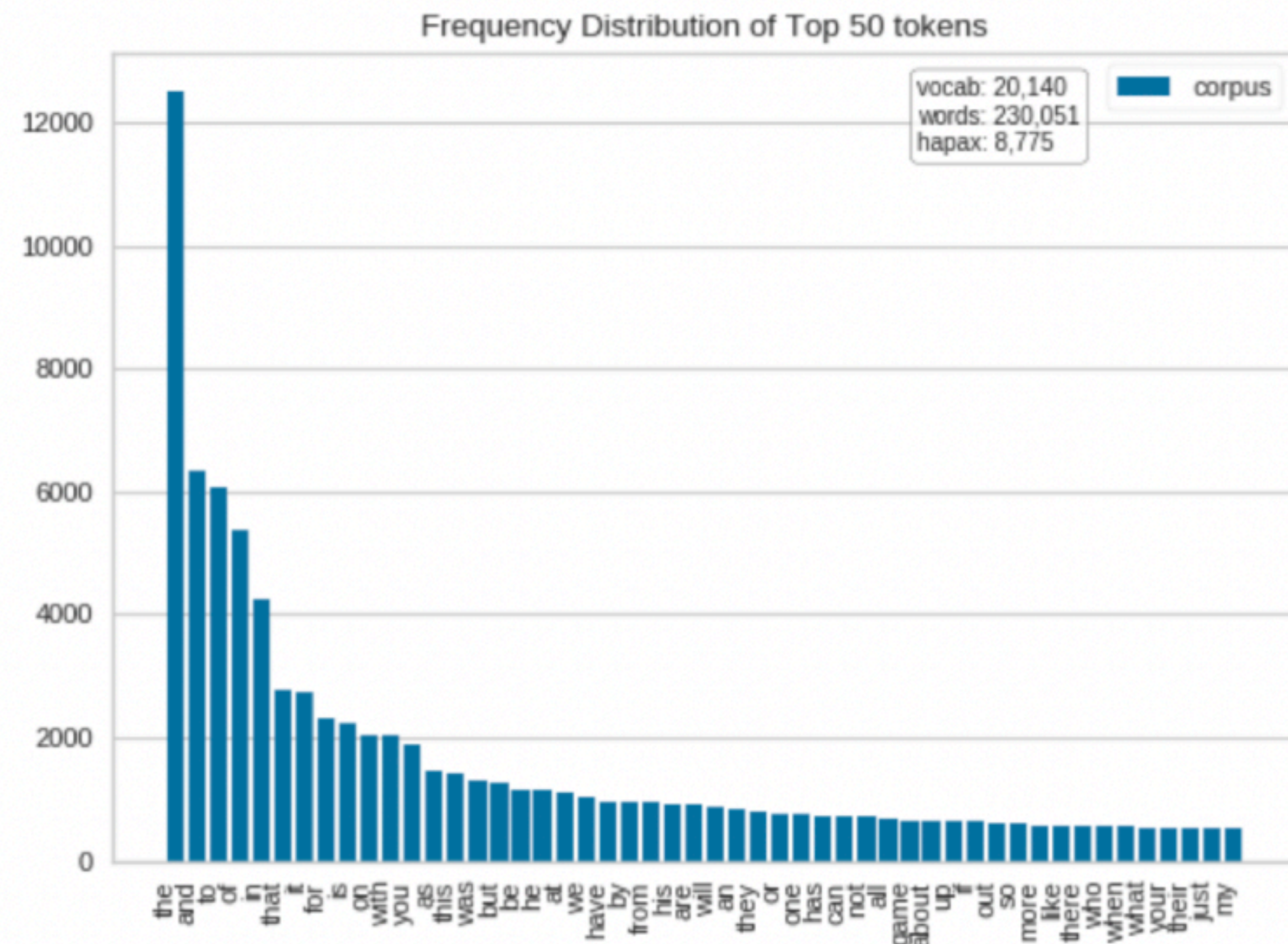


Important problem areas

- AI assistants fall far short of human level interaction. At the highest level, this might/probably suggest(s) that learning textual representations alone is not sufficient to achieve this goal. In some ways this seems obvious. The problems of reference resolution and broad domain knowledge seem to be primary culprits, though this is a small slice of the problems that exist. **This means NLP is an exciting field to be in!**
- AIs built on structured representations of text are naturally equipped to perform logic & arithmetic, e2e AIs built on DNNs are not.
- Learning from voice/text, not surprisingly, means learning biases in those data; building systems around those biases propagates those biases. Technology should be for the benefit of society, thus fair and inclusive. Making systems fair and inclusive is an important area of R&D.

Why is modeling human language hard?

Non-uniform word distribution



The frequency of the k^{th} most frequent word is \sim proportional to $1/k$

- Zipf, 1949

Compositionality

Language is **compositional**: units such as words can combine to create phrases, which can combine by the very same principles to create larger phrases. For example, a **noun phrase** can be created by combining a smaller noun phrase with a **prepositional phrase**, as in *the whiteness of the whale*. The prepositional phrase is created by combining a preposition (in this case, *of*) with another noun phrase (*the whale*). In this way, it is possible to create arbitrarily long phrases, such as,

(1.1) ...huge globular pieces of the whale of the bigness of a human head.²

The meaning of such a phrase must be analyzed in accord with the underlying hierarchical structure. In this case, *huge globular pieces of the whale* acts as a single noun phrase, which is conjoined with the prepositional phrase *of the bigness of a human head*. The interpretation would be different if instead, *huge globular pieces* were conjoined with the prepositional phrase *of the whale of the bigness of a human head* — implying a disappointingly small whale. Even though text appears as a sequence, machine learning methods must account for its implicit recursive structure.

- Eisenstein, 2019, Chp 1