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The sensory language: A word embedding based approach to predict modality exclusivity norms

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Introduction

The way we experience the world, what we see, hear, feel, taste, and smell is reflected in our language. According to the sound symbolism hypothesis, there is a relationship between strength of perceptual experience and the word used to express it. Lyontt *et al.* [1] in their pioneering study gathered 55 native English speakers and asked them to rate the strength of 423 words on the five perceptual dimensions i.e. vision, auditory, haptic, olfactory and gustatory. The results clearly showed that most words exhibit multimodality than unimodality i.e. they are perceived through multiple senses than a single sense. This study has been modified and studied later at many levels but the basic premise remains the same, the words evoke sensory experiences. However, these studies require a cohort of participants which brings cost and ethical issues with them. Recently, embedding models like word2vec have been shown to be effective and useful in predicting and describing difficult concepts like semantic relatedness. The most important critique of these distributed models have been on the grounding problem [2], i.e. the word meanings and their usages are because of the physical and perceptual reality. In this work, we show that it is indeed possible to predict the perceptual modality exclusivity norms and distribution based on the vector representations of the words.

Methods

In this work, we have proposed a word embedding based methodology to calculate the perceptual strength ratings corresponding to 5 sensory modalities. Firstly, we constructed a list of seed words characterising the five sensory modalities i.e. ‘see’,’look’, ‘hear’, ‘listen’,’sound’, ‘touch’,’feel’, ‘taste’, and ‘smell. Further, these words are represented as points in the lower dimensional semantic space, where the semantically similar words are placed closer to each other. We have used the publicly available pre-trained 300D word2vec and fastText word embeddings for English language that were created from Google News datasets and Wiki pages, respectively. The semantic space also has the advantage of being linear in nature and word vectors corresponding to the same sensory modality was averaged to get the representative vector. e.g. ‘see’ and ‘look’ word vectors were averaged to represent the visual modality vector. To measure the 5D perceptual strength ratings of any word/concept, we measure the cosine similarity between the distributed representation of sensory modality and that particular word.
To measure the efficacy of our method, we have compared the perceptual ratings generated by our methodology with the human perceptual strength ratings gathered by Lyontt *et al.* [1,3] and

Bodo Winter [4] on a set of words. These datasets contain nouns, verbs and adjectives totalling to 1123 and their corresponding human perceptual ratings.

Results

We calculated the dominant modality i.e. the modality with the highest rating, for every word from the embedding based 5D perceptual strength ratings. Interestingly, we found that the dominant modalities match with the human ratings with the weighted accuracy of 66.40%. It was also found that Visual was the most dominant modality. We later found the precision, recall and f1 score for our algorithm (Fig. 1a). It should be noted that we did not use any other information for learning the models except the words themselves. Fig. 1b shows the first and second components of the principal component analysis of embedding based perceptual ratings. As observed earlier too [1], the auditory sense is quite distinct from the other senses. There is an overlap between haptic and visual modalities and olfactory and gustatory modalities. The 'chemical' senses, i.e. the olfactory and gustatory have the highest recall scores as compared to non-chemical senses.

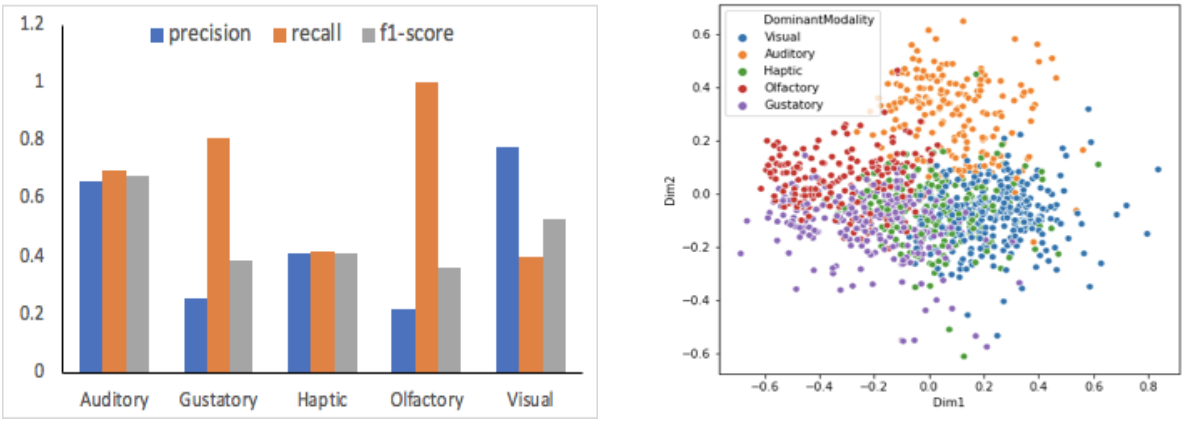

Figure 1 a) Precision, recall and f1-score calculated between embedding based perceptual ratings and human ratings b) PCA visualisation of all words calculated using embedding based ratings.

Discussions

This work showed the possibility of natural language processing and large corpora to calculate the exclusivity norm in low resource setting. The very high recall score of gustatory and olfactory senses from the others presents an opportunity to develop olfactory-gustatory specific vocabulary. The clear categorisation and identification of olfactory vocabulary has been a long standing problem fraught with lack of consensus. This methodology can also be extended to other languages without requiring much resources. This provides a lot of scope in identifying modality exclusivity and perceptual words for other languages which we intend to pursue in future.

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