

# Dyr Bul Shchyl\*

## Proxying Sound Symbolism With Word Embeddings

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### Abstract

This paper explores modern word embeddings in the context of sound symbolism. Using basic properties of the representations space one can construct semantic axes. A method is proposed to measure if the presence of individual sounds in a given word shifts its semantics of that word along a specific axis. It is shown that, in accordance with several experimental and statistical results, word embeddings capture symbolism for certain sounds.

### 1 Introduction

Sound symbolism is a term used to describe a hypothetical relation between sound and meaning (Hinton et al., 2006). This idea recurrently emerges in various cultures and languages dating as far back as Plato’s *Cratylus*. Statements on sound symbolism can also be found in Japanese Buddhist monk Kukai’s work *Sound, word, reality* (Kasulis, 1982). Upanishads contain a good deal of material about sound symbolism, for example, declaring that “the mute consonants represent the earth, the sibilants the sky, the vowels heaven” (Max-Muller, 1879). Early in the twentieth century, the rise of artistic symbolism and a general interest in form, as developed in (Shklovsky, 1919) and (Kruchenykh, 1923) gave rise to several artistic movements. (Sapir, 1929) made the first systematic attempt to find empirical evidence of sound symbolism.

To our knowledge, the issue of sound symbolism has still not been studied from the representation learning perspective. This submission addresses the question of whether some aspects of sound symbolism can be captured by the FastText embeddings (Bojanowski et al., 2016)<sup>1</sup>. We show

<sup>1</sup>[https://en.wikipedia.org/wiki/Dyr\\_bul\\_shchyl](https://en.wikipedia.org/wiki/Dyr_bul_shchyl)

<sup>1</sup>We also want to explicitly state that we do not see any reason why other embeddings that to a certain extent support semantic arithmetic can not be used for this task.

that the representations do seem to capture the sound symbolism of the English language to the extent that it is covered by the research literature. We also discuss the potential usage of such representations in the future, particularly for generative tasks.

### 2 Related work

Despite the fact, that sound symbolism is a relatively old theoretical notion, until the second half of the twentieth century there were only a few empirical results that would definitively prove it’s existence in natural languages. More recently, (Whissell, 1999) has shown that certain sounds tend to be over-represented in songs or poetry to address specific emotions, but also in names (Whissell, 2006). (Shinohara and Kawahara, 2010) have demonstrated that certain sounds in the English language are associated with attributes of size. (Wrembel, 2010) has addressed the role of sound symbolism in language acquisition. (Perniss et al., 2010) provide evidence for non-arbitrary relationships at multiple levels of language, from phonology to syntax. (Adelman et al., 2018) have shown that specific sounds in English or Spanish are associated with higher levels of valence or *emotional sound symbolism*. Even more impressively, in a massive study across nearly two-thirds of the world’s languages (Blasi et al., 2016) managed to demonstrate that a considerable proportion of 100 essential vocabulary items carry strong associations with specific kinds of human speech sounds, occurring persistently across continents and linguistic lineages.

More importantly for this work, (Otis and Sagi, 2008) have introduced a corpus-based method that can be used to test whether an association between sound and meaning exists within a given corpus. This result was partially reproduced in (Abramova

et al., 2013), who also showed that the semantic content of at least some phonesthemes could be identified automatically using WordNet. Finally, (Auracher et al., 2010) have demonstrated the potential of sound symbolism for automatic text analysis. Their study claims that, at least in poetic language, the ratio of plosive versus nasal sounds in a text predicts its emotional tone as readers perceive. In other words, poems that have a relatively high frequency of plosive sounds are more likely to express a pleasant mood with high activation, whereas a relatively high frequency of nasal sounds indicates an unpleasant mood with low activation.

### 3 Sound symbolism in word representations

Semantic arithmetic is one of the key features of Word2Vec (Mikolov et al., 2013) and other modern vector representations. This property allows us to subtract a vector that corresponds to the word 'male' from the vector that represents the word 'king'. We can then add vector that represents 'female' to obtain a new vector in the proximity of representation for the word 'queen.' Using semantic arithmetic one can naturally form certain semantic axes in the space of representations. To do this, we can list a pair of antonyms, say 'good' and 'bad,' and draw a line defined by these two words. We can expect that, up to a certain level of correspondence, the projections of other word representations on this axis will correspond with their semantic relation to one of the two attributes. To make such semantic lines more robust, we defined the opposing semantic points as an average of several synonyms for each of the two words that were forming a semantic axis. The full list of the axes that were tested can be found in the Appendix. The English phonetics of the words was retrieved from a proprietary dictionary.

To test whether word embeddings capture certain elements of sound symbolism, we have carried the following experiment:

- out of pretrained FastText word embeddings 10 000 most frequent words were filtered;
- the representations of the words were projected on every semantic axis;
- the obtained distribution of the projections for the words that start with a given sound

Sound	Semantics
[ʌ]	<i>passive</i> '
[ʌ]	<i>awful</i> *
[ʌ]	<i>ugly</i> *
[ʌ]	<i>slow</i> ?*
[ɪ]	<i>active</i> *
[ɪ]	<i>strong</i> *
[ɪ]	<i>hot</i> *
[ɪ]	<i>ugly</i> !*
[ɪ]	<i>difficult</i> !*
[ɪ]	<i>sad</i> !*
[ɪ]	<i>loud</i> ?*
[ɪ]	<i>short</i> ?#
[ɪ]	<i>powerful</i> *
[d]	<i>evil</i> *
[d]	<i>difficult</i> *
[d]	<i>sad</i> *
[ə]	<i>difficult</i>
[ɑ:]	<i>grand</i> **

Table 1: Associations between a sound and a semantic axis in latent space representation with Mann–Whitney U test p-value below 0.001; associations marked with ' correspond to the ones mentioned in (Wrembel, 2010), marked with \* correspond with the ones, found in (Adelman et al., 2018), with \*\* correspond with ones found in (Shinohara and Kawahara, 2010); with # correspond with ones found in (Blasi et al., 2016); while associations with !\* weakly contradict with (Adelman et al., 2018), see discussion for further details; associations marked with ? show weak correspondence with the results in the literature.

was compared to the distribution of projections for the words without it.

Table 1 and Table 2 summarize the results that were obtained with p-values below 0.001 and 0.01 respectively. Figures 1 - 3 show examples of the obtained distributions for different axes and sounds.

## 4 Discussion

As we can see from Table 1 and Table 2, there are several sounds which have a specific symbolic aspect that is in line with some of the previous empiric results. There are also new sound-semantic associations which have not been studied in the context of sound symbolism and could potentially be interesting for further empirical investigations. Such cases have been flagged with a question mark. The sound [ɪ] is the only sound which contradicts some of the previous findings. It might be associated with something ugly, sad or

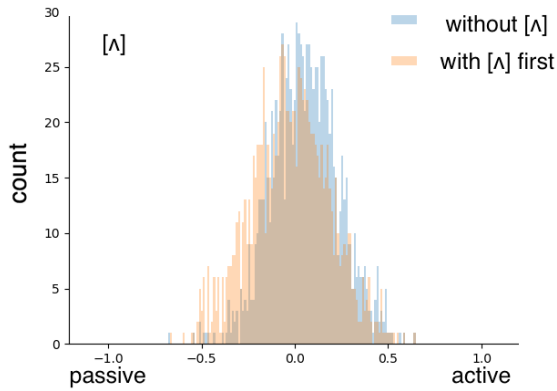


Figure 1: Distributions of representation projections on the 'passive - active' axis. Sound [ʌ] in the first position shifts the words towards the 'passive' semantic aspect.

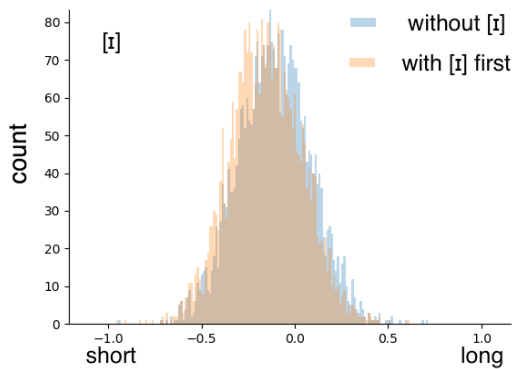


Figure 2: Distributions of representation projections on the 'short - long' axis. Sound [ɪ] in the first position shifts the words towards the 'short' semantic aspect.

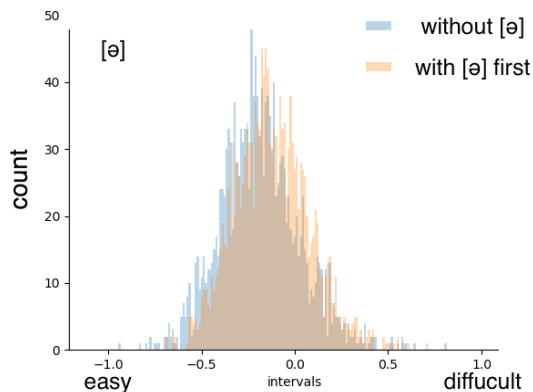


Figure 3: Distributions of representation projections on the 'easy - difficult' axis. Sound [ə] in the first position shifts the words towards the 'difficult' semantic aspect.

Sound	Semantics
[ɪ]	<i>big<sup>?*</sup></i>
[ɪ]	<i>strong<sup>?*</sup></i>
[ɪ]	<i>sad<sup>*</sup></i>
[m]	<i>feminine</i>
[m]	<i>not smooth</i>
[m]	<i>long</i>
[ɪ]	<i>dark<sup>!*,'</sup></i>
[ɪ]	<i>angular</i>
[ə]	<i>active</i>
[ə]	<i>fast</i>
[ə]	<i>sad</i>
[w]	<i>weak</i>
[ʌ]	<i>slow<sup>*</sup></i>
[ʌ]	<i>evil<sup>*</sup></i>
[əʊ]	<i>not smooth</i>
[k]	<i>safe</i>
[ɒ]	<i>benign</i>
[b]	<i>feeble<sup>?*</sup></i>
[g]	<i>feeble<sup>?*</sup></i>

Table 2: Associations between a sound and a semantic axis in the latent space representation with Mann-Whitney U test p-value below 0.01; associations marked with ' correspond to the ones mentioned in (Wrembel, 2010), marked with \* correspond with the ones, found in (Adelman et al., 2018); associations with !\* weakly contradict with (Adelman et al., 2018), see discussion for further details; associations marked with ? show weak correspondence with the results in the literature.

difficult according to our results, yet it is placed in the category of mildly positive valence in (Adelman et al., 2018). It could also be associated with something dark, which is in line with (Wrembel, 2010), but contradicts (Adelman et al., 2018). Further examination is needed to give a definitive answer as to the reason for this contradiction, but the most probable explanations can be summed up as follows: (Adelman et al., 2018) show that [ɪ] is associated with valence with a p-value above 0.1, and the predictive power of phonemes for valence in English is the lowest out of four languages studied in the paper. This probably means that the signal is too low to give a definitive answer about this sound. What is more interesting is that the method we used also points out several new sounds that might have a symbolic component, but have not been closely studied before. For example, [ə] in the context of difficulty, speed, activity and mood, [m] in the contexts of femininity, roughness and length, or [k] in context of safety.

## 5 Conclusion

This paper shows that word embeddings such as FastText can capture sound symbolism along several semantic axes. Applying the obtained sound symbolism information to generative tasks, one can expect to generate more expressive poetry in line with the results of (Auracher et al., 2010). This new approach combined with such generative methods as (Potash et al., 2016), (Tikhonov and Yamshchikov, 2018), (Vechtomova et al., 2018) or (Wołk et al., 2019). The possibility of testing specific associations between sounds and semantics computationally without any behavioral laboratory experiments or surveys might also significantly facilitate further studies of semantic symbolism. Additional research questions that naturally arise from this result include cross-lingual studies of sound symbolism captured by word embeddings and experimental research of the potential connections between sounds and semantics.

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## 6 Appendices

The list of semantic axes that were tested:

- Angular - Round; 'plump', 'lumpy', 'circular', 'round', 'rounded', 'angular', 'gnarled', 'gnarly', 'craggy', 'awkward', 'angled'
- Bad - Good; 'good', 'well', 'nice', 'pretty', 'fine', 'satisfactory', 'solid', 'fair', 'handsome', 'desirable', 'bad', 'poor', 'ill', 'amiss', 'evil', 'cheap', 'defective', 'inferior', 'low', 'mean'
- Cold - Hot; 'cold', 'chill', 'chilly', 'inclement', 'wintry', 'frozen', 'frosty', 'hot', 'ardent', 'passionate', 'violent', 'warm', 'cordial', 'thermal', 'fervent', 'heated'
- Complex - Simple; 'plain', 'simple', 'ordinary', 'elementary', 'common', 'straightforward', 'easy', 'complex', 'complicated', 'sophisticated', 'compound', 'intricate', 'composite', 'elaborate', 'tricky'
- Cowardly - Brave; 'brave', 'gallant', 'courageous', 'valiant', 'redoubtable', 'bold', 'cowardly', 'coward', 'dastardly', 'sneaky', 'sneaking'
- Dangerous - Secure; 'secure', 'sure', 'safety', 'permissible', 'foolproof', 'safe', 'wholesome', 'terrible', 'frightful', 'dreadful', 'awful', 'agonizing', 'fearful', 'formidable', 'horrible', 'desperate', 'tremendous'
- Dark - Luminous; 'light', 'clear', 'bright', 'blond', 'blonde', 'fair', 'luminous', 'lucid', 'dark', 'black', 'murky', 'shadowy', 'gloomy', 'shady'
- Difficult - Easy; 'difficult', 'hard', 'laborious', 'serious', 'severe', 'grave', 'oppressive', 'painful', 'heavy', 'weighty', 'easy', 'light', 'lucky', 'facile', 'slight', 'gentle', 'airy', 'ready', 'dolly'
- Evil - Benign; 'beneficent', 'good', 'benign', 'decent', 'gentle', 'gracious', 'kind', 'wicked', 'evil', 'vicious', 'malicious', 'spiteful', 'angry', 'fierce', 'severe', 'bad', 'mordant'
- Faded - Bright; 'bright', 'vivid', 'shining', 'cheerful', 'striking', 'glowing', 'garish', 'colorful', 'faded', 'withered', 'delicate', 'languid', 'bleak', 'flat', 'faint', 'sickly'
- Feeble - Strong; 'powerful', 'mighty', 'strong', 'vigorous', 'vibrant', 'powerfully', 'mightily', 'strongly', 'sickly', 'feeble', 'frail', 'weakly', 'puny', 'spindly'
- Masculine - Feminine; 'masculine', 'manly', 'virile', 'masculine', 'manly', 'feminine', 'womanly', 'ladylike'
- Passive - Active; 'active', 'dynamic', 'stirring', 'energetic', 'dynamical', 'favourable', 'ambitious', 'busy', 'industrious', 'passive', 'dormant', 'quiescent', 'floppy', 'unemotional', 'tame', 'effortless', 'flaccid'
- Quiet - Loud; 'loud', 'noisy', 'notorious', 'pompous', 'quiet', 'calm', 'soft', 'low', 'gentle', 'flat'
- Rough - Tender; 'tender', 'affectionate', 'gentle', 'delicate', 'soft', 'sweet', 'subtle', 'fond', 'sentimental', 'affectionate', 'rude', 'rough', 'gross', 'coarse', 'crude', 'tough', 'brute', 'barbaric', 'barbarous', 'beastly'
- Sad - Joyful; 'merry', 'gay', 'cheerful', 'airy', 'glad', 'jolly', 'joyful', 'jaunty', 'sad', 'sorrowful', 'dreary', 'deplorable', 'elegiac', 'lamentable', 'melancholy', 'sorry'
- Short - Long; 'long', 'tall', 'gaunt', 'spindly', 'lanky', 'voluminous', 'lengthy', 'short', 'brief', 'small', 'little', 'skimpy'
- Slow - Quick; 'quick', 'fast', 'swift', 'agile', 'prompt', 'speedy', 'rapid', 'ready', 'brief', 'slow', 'long', 'slack', 'sluggish', 'laggard', 'creeping', 'leisurely', 'plodding'
- Small - Big; 'large', 'great', 'big', 'greater', 'high', 'wide', 'major', 'grownup', 'hulk', 'small', 'little', 'petite', 'diminutive', 'short', 'trifling', 'petty'
- Smooth - rough or not smooth; 'rough', 'uneven', 'rugged', 'coarse', 'corny', 'grainy', 'harsh', 'ragged', 'shaggy', 'smooth', 'plain', 'even', 'glib', 'sleek', 'slick', 'polished', 'clean', 'fluent'
- Ugly - Beautiful; 'beautiful', 'handsome', 'fine', 'gallant', 'goodly', 'likely', 'lovely', 'personable', 'sheen', 'homely', 'ugly', 'mean', 'plain', 'charmless'