

A Linguistic Approach to Information Propagation: Using BERT to Analyse the Spread of Ideas in the British Government 2000 – 2020

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Extended Abstract

This paper has two purposes – (a) to present a linguistic approach to studying information propagation based on large language models like BERT, and (b) to use this linguistic approach to understand the role of information propagation in the British government’s implementation of policies designed to increase *resilience*, *sustainability* and *wellbeing*.

Regarding (a), I argue that many of the information propagation processes currently researched using network analysis (e.g. propagation of public opinions, controversial and toxic content) have a linguistic aspect. So, the propagation of things like toxic content involves the diffusion of fundamentally linguistic objects; words, sentences, etc. Thus, questions about how the diffusion of such content is wrapped up with linguistic processes (e.g. lexical meaning change) arise. Such questions cannot be answered by only network analysis. Natural language processing is needed. Regarding (b), I note that research on information propagation is largely focused on social media networks, despite information propagation being highly relevant to other areas of social life. I focus on the role information propagation plays in changes in governance. For example, political scientists [5] have noted that since the 1980s governance in many countries (e.g. USA, UK, Australia) have undergone significant neoliberal reforms, e.g. privatisation of state assets, outsourcing of the provision of public services. The propagation of arguments via think tank networks about introducing market mechanisms into government and shrinking the state is recognised as a key factor behind neoliberalisation [1]. Understanding why changes such as neoliberalisation happen therefore requires understanding information propagation across governance organisations. Over the past 30 years there has been an increasing trend in the UK towards implementing policy based on ideas of *resilience*, *sustainability* and *wellbeing* [2]. To understand the linguistics of information propagation and its role in policy-making, I examine the propagation of these ideas across the British state’s executive division of labour (i.e. division of labour between central departments, e.g. Department of Education vs. Cabinet Office) during 2000 – 2020, focusing on the lexical meaning change involved in their propagation.

Data and Methods: To do this, I use a stratified dataset sampled from a collection of approximately 120000 British governments collected using web scrapers. Each strata of the dataset contains sentences of a central department’s documents. The dataset contains approximately 85 million tokens. I then tracked the lexical meaning change inherent in the propagation of the target vocabulary ‘resilience’, ‘resilient’, ‘sustainable’, ‘sustainability’ and ‘wellbeing’ using Lucy and Bamman’s [3] method of word sense induction (WSI) based on clustering BERT embeddings – a method with very strong performance on SemEval WSI tasks that isn’t too computationally intensive. In this method, sequences from the dataset were inputted into BERT to acquire embeddings for each token in the dataset. As BERT is pre-trained, there was no need to train it on my dataset (though future experimentation to see if fine-tuning would improve accuracy would be useful). K-means was then used to cluster

the acquired embeddings of a sample of tokens of the target vocabulary, where the centroid of each cluster is taken to represent a particular sense of a target vocabulary term. Then, token embeddings outside the sampled embeddings are matched to the centroid closest to them by cosine similarity, thus producing *sense clusters* – clusters of token embeddings which each contain tokens of a target vocabulary term that express one particular sense. Through this method, the senses expressed by each token of each target vocabulary term were automatically extracted.

Findings: After extracting senses using WSI via BERT, how the increase in the use of the target vocabulary is driven by increases in the use of particular senses of the target vocabulary, and how unique a sense is to a particular executive sector of the British government, can be analysed. Some example results of these analyses, concerning senses of ‘resilience’, are provided in the figure and table below. In Figure 1, the plot on the left shows the change in the relative frequency of ‘resilience’ across all strata. A generalised additive model (GAM) was fitted to make the overall trend clearer. The plot on the right shows changes in the relative frequencies of senses of ‘resilience’ across all strata – again with GAMs fitted. It is plain that the growth in ‘resilience’ between 2000 and 2010 is largely driven by the sense *resilience 3*. Following the work of Montariol et al. [4], an impression of the contents of a sense cluster can be given by retrieving the terms within the cluster which score the highest TF-IDF. Thus, the top 5 key terms of *resilience 3* are ‘local resilience’, ‘resilience forum’, ‘resilience forums’, ‘national resilience’, ‘london resilience’. These are all terms that relate to *resilience* as an organisational capacity of regions of the UK to manage/assess crisis response and risk, as defined in legislation in the *Civil Contingencies Act 2004*, e.g. ‘resilience forums’ refer to organisations established through the Act to manage regions’ crisis response and risk assessment. In Table 1, how unique each sense is to each executive sector is measured by the standardized adjusted residuals obtained through performing a chi-squared test on the observed frequencies of each sense in each strata. From these residuals, it is plain that *resilience 3* is especially distinctive of the Cabinet Office (‘cabinet’), while *resilience 5*, which concerns the psychological resilience of children (TF-IDF key terms: ‘pupils’, ‘school’, ‘confidence resilience’, ‘self esteem’, ‘emotional resilience’) is especially distinctive of the Department of Education (‘DE’). Using these results I argue that the propagation of ‘resilience’ throughout the government’s executive division of labour involves the generation of senses of ‘resilience’ adapted to the function of each executive sector. The implementation of policies designed to enhance *resilience* is only possible given this adaptive sense generation. Adaptive sense generation via propagation is needed to turn *resilience* into a practical, actionable policy concept.

References

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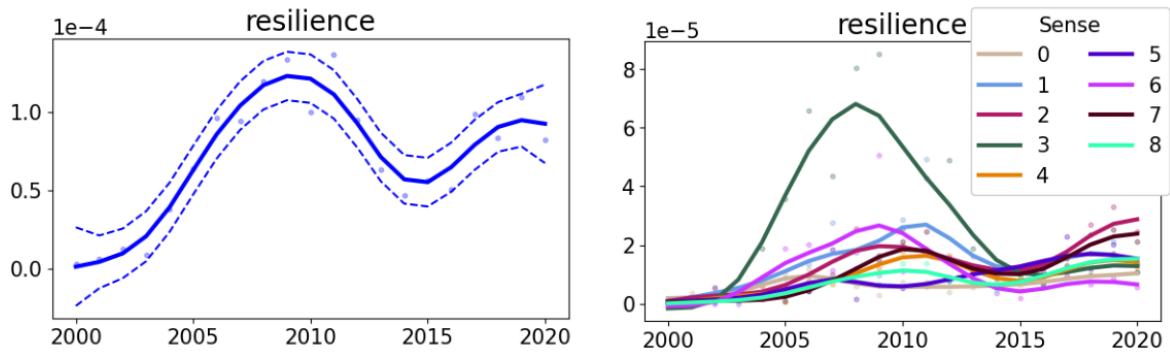


Figure 1. The plot on the left visualises the changes in the relative frequency of ‘resilience’ over time. The plot on the right visualises the changes in the relative frequencies of senses of ‘resilience’ over time.

| | DCMS | DE | DEFRA | DHSC | DWP | FCO | MOD | MOH | MOJ | cabinet | home | treasury |
|---|--------------|--------------|-------------|-------------|-------------|-------------|-------------|-------|--------------|--------------|--------------|-------------|
| 0 | 2.5 | -3.11 | -2.45 | 0.5 | 1.09 | -0.13 | 1.99 | -0.42 | 11.73 | -7.35 | 11.06 | 2.71 |
| 1 | -2.58 | -4.04 | 4.31 | 1.52 | -0.72 | -1.51 | 0.05 | 1.68 | 0.22 | -8.35 | -1.47 | -0.97 |
| 2 | 10.99 | -3.19 | -0.17 | 1.85 | -1.24 | 5.65 | 3.07 | 0.29 | 0.26 | 15.89 | 0.36 | 4.36 |
| 3 | -8.65 | -8.47 | -8.52 | -4.33 | -4.48 | -6.88 | -1.97 | 0.38 | -4.1 | 27.67 | -2.39 | -10.15 |
| 4 | 6.17 | -3.72 | 7.04 | -2.38 | 1.04 | 3.18 | -1.48 | -1.31 | -2.44 | -7.72 | -3.08 | 8.28 |
| 5 | 1.69 | 36.94 | -8.51 | 7.86 | 8.47 | -2.38 | 2.4 | -2.89 | 5.45 | -15.11 | 4.82 | -2.86 |
| 6 | -5.97 | -5.01 | -3.27 | -1.68 | -2.73 | -4.15 | -3.42 | 1.42 | -2.9 | -11.2 | -2.44 | -5.23 |
| 7 | 0.48 | -1.78 | 9.53 | -1.55 | 2.81 | 2.56 | -0.31 | -0.9 | -2.38 | 0.07 | -5.12 | 9.22 |
| 8 | -0.69 | -0.37 | 5.07 | 0.47 | -1.11 | 7.22 | 0.84 | 1.02 | -1.68 | -9.75 | 2.19 | -0.51 |

Table 1. Standardised adjusted residuals measuring how much the frequency of a sense of ‘resilience’ in a strata deviates from its expected frequency, obtained through conducting a chi-squared test. Each term in the topmost row represents a central department. Each number in the leftmost column represents a sense of ‘resilience’. The largest residual in each department is in bold.