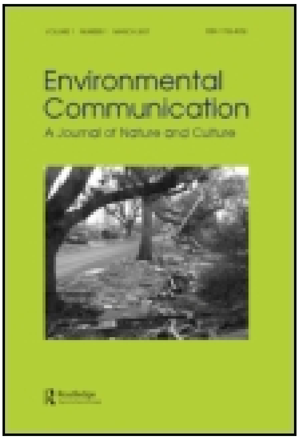

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Climate in the News: How Differences in Media Discourse Between the US and UK Reflect National Priorities

Brigitte Nerlich, Richard Forsyth & David Clarke

Studies dealing with media coverage of climate change have increased steadily over the last decade or so, alongside the media coverage of climate change itself. This article aims to contribute to this growing literature on two levels: to deepen understanding of distinctive patterns of language use across nations speaking a common language and to demonstrate the usefulness of a new approach for finding such patterns. Articles in The (London) Times and the New York Times, published between 2000 and 2009, were analyzed using methods related to computational linguistics. Results show that the US seemingly still constructs climate change as a problem, whereas the UK focuses on finding solutions for the (established) problem of climate change. This linguistic and conceptual gap may hamper mutual understanding and the crafting of global climate change mitigation policies.

Keywords: Climate Change; Media; Computational Linguistics; United States; United Kingdom; Carbon

Introduction

Studies dealing with media coverage of climate change have increased steadily over the last decade or so, alongside the media coverage of climate change itself.[1] Academic articles have examined issues around media coverage of climate change globally (Boykoff, 2008a; Mansfield, 2007; Shanahan, 2009) as well as in particular countries, such as the Unites States (Antilla, 2005; Boykoff, 2007b; Boykoff & Boykoff, 2007; Trumbo, 1996) and the United Kingdom (Boykoff, 2007a, 2008b; Carvalho, 2005; Carvalho & Burgess, 2005; Doulton & Brown, 2009; Höppner, 2010). Some

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attempts have been made to compare reactions to climate change issues in the United States (US) and the United Kingdom (UK) in particular (see Antilla, 2010; Boykoff & Rajan, 2007; Grundmann & Krishnamurthy, 2010).

This article aims to contribute to this growing literature in two ways: (1) to enhance our understanding of distinctive patterns of language use across nations speaking a common language, and (2) to demonstrate the usefulness of computational linguistics for finding such patterns. With *carbon* as a search term, inter-term interval analysis and analysis of short subsequences of words (*n*/*m* grams) were used to find overall patterns of usage as well as distinctive phraseological choices in two national newspapers, *The (London) Times* (LT) and the *New York Times* (NYT), between 2000 and 2009. The focus was on discovering subtle linguistic similarities and differences in press coverage of climate change which might be indicative of deeper ideological differences between the US and the UK, such as those discussed by Boykoff and Rajan (2007). Overall, the article intends to contribute detailed linguistic observation to the growing field of environmental communication and media studies (Anderson, 2009; Cox, 2009) as well as to be methodologically innovative in this field.

The issue at the core of this article tends to be referred to increasingly as *climate change*, but can also be written and talked about under labels such as *global warming*, *greenhouse effect* or by using lesser-known terms such as *climate modification*, *climate instability*, *climate collapse, climate crisis,* or *climate catastrophe*. The relative frequency and change in usage of some of these terms when used in books written in English can now be easily visualized using Google's new Ngram viewer (http://ngrams.googlelabs.com/info; Michel et al., 2011).

Our article employs a quantitative, computational linguistic, approach to finding more delicate patterns in climate change communication. It intentionally avoids any of the terms aforementioned, using instead a search term, *carbon*, that relates both to one of the causes of climate change debated by science and society (the rise in what has come to be called *carbon*, in the sense of *carbon dioxide*) and to one of the many solutions proposed to mitigate it (the reduction of carbon in the sense of *carbon dioxide emissions*).[2]

Although the earth's climate has changed and fluctuated for millions of years, concerns about the contributions that humans make to climate change in terms of, for example, increased carbon (dioxide) emissions, only emerged relatively recently, less than two centuries ago (Boykoff & Rajan, 2007). During the last century, concerns about what is called anthropogenic climate change have come and gone, but gathered pace since the late 1980s, when climate change science began to intersect with politics and media coverage (Bolin, 2007; Boykoff & Rajan, 2007). In this article, we want to find out whether patterns in media coverage (in this case press coverage) may reveal some distinctive patterns in national political priorities in "two nations divided by a common language" (a saying generally attributed to George Bernard Shaw): the US and the UK.

Studying media coverage with relation to climate change is important, as most people become aware of issues relating to climate change (where causes and impacts are multifaceted, complex and, to some extent, invisible) mainly through the media.

The media, in turn, can impose frames for understanding and can influence policy agendas (see Dearing & Rogers, 1996; Reese, Gandy, & Grant, 2003). We focus here on so-called broadsheet print media, as they "are responsive to scientific and social learning, to changing political agendas and contexts, and to the communicative strategies" of national and international agencies (Carvalho & Burgess, 2005, p. 1467).

There are many and quite deep political and economic issues that separate the US and the UK and these differences can influence the way that climate change is communicated, perceived and regulated. Some of these have been studied in detail in Boykoff and Rajan (2007). They stress that

> interests of carbon-based industries in both countries have exerted asymmetrical power over public policy. However, the extent to which these factors have gained influence differs. Its long history, the power of traditional cultural institutions and a more constrained physical geography arguably have shaped public perception in the UK towards preservation of the environment. Conversely, an emphasis on economic freedom through liberal democracies, and stronger personal consumption patterns have influenced the actions and expectations of US citizens (...). These attitudes towards the environment and energy consumption have manifested different political actions: the UK has ratified the Kyoto Protocol, which calls for a reduction in carbon dioxide emissions, whereas the USA, the world's biggest producer of carbon dioxide, has so far refused to do likewise. (Boykoff & Rajan, 2007, p. 208)

A second cultural trait that influences public attitudes to climate change in the US and the UK is a deeply entrenched scepticism toward scientific claims of an environmental decline. This scepticism seems to be much more entrenched in the US than the UK, especially since the "climategate" scandal in 2009 (see Carrington, 2011; Hoffman, 2011; Leiserowitz, Maibach, Roser-Renouf, Smith, & Dawson, forthcoming; Nerlich, 2010).

Given these different political backgrounds (and the above is only a snapshot of these), we wanted to investigate in more detail how the word *carbon* is used in the US and the UK and what this may reveal about how climate change is conceptualized in these two nations. Finding these linguistic signatures of climate change discourses in the US and the UK is vital, as how we talk about an issue determines what we do about it (or not). Moreover, how we talk and think about an issue is influenced substantially by the media coverage devoted to it (Antilla, 2010; McCombs, 1972). Climate change is a global issue. So, if nations (sharing a language) talk, at least in the press, about it in quite different ways, this signals potential difficulties ahead in finding global solutions.

We chose two national quality or elite newspapers of similar standing and reputation to gain access to the way climate change is discussed on two sides of the Atlantic, in the UK and the US: the NYT and LT. The NYT is generally seen to be a liberal newspaper and the LT as moderately centre-right (see Carvalho & Burgess, 2005; Rasmussen Reports, 2007). Both newspapers have a long publishing history, have well-educated and influential readerships, and are agenda setting (see

McCombs, 1972). The results achieved through our study of these two elite newspapers can provide pointers for how the two nations grapple with climate change issues, but they can obviously not tell the full story.

Data and Methods

Data

The data examined in this project were obtained by using the search term *carbon* to retrieve articles from the LT and the NYT held in the Lexis Nexis (LexisR) database, originally published in the years 2000, 2002, 2004, 2006, 2007, 2008, and 2009.[3] Lexis Nexis provides access to searchable content from 20,000 + global news and other sources.

As the resulting collection contained a number of duplicated and near-duplicate articles, a de-duplication process was applied whereby duplicates and near duplicates were removed, resulting in the exclusion of 782 articles from the original corpus. After de-duplication, the size of the document collection is shown in Table 1.

Thus, the available corpus comprises a total of 9,821 documents containing 7,904,191 word tokens altogether. The number of articles rises to a peak in 2007 for both newspapers and then declines a little, although the number of words is slightly higher for the LT in 2009 than in 2007. There are more articles from the LT than the NYT, but more words overall from the NYT, reflecting the fact that articles in the latter tend to be somewhat longer.

We decided not to clean our corpus by filtering out texts containing such apparently irrelevant phrases as *carbon copy*, *carbon dating*, *carbon fiber/fibre*, *carbon monoxide* and the like, to avoid biasing our findings by what we expected to find. In this respect our philosophy is, as far as possible, to "let the data speak for themselves" even if it means accepting a certain level of noise in the corpus.

Methods

Most research devoted to the analysis of climate change in the traditional mass media uses various types and mixtures of (mainly quantitative) content analysis and

Table 1. Overview of corpus.

	London			New York		
Year	Texts	Word tokens	Median text length	Texts	Word tokens	Median text length
2000	284	183,919	553.5	334	346,928	871.5
2002	291	216,216	565	384	370,579	832.5
2004	318	206,103	576.5	377	386,684	819
2006	933	551,619	521	598	588,528	816
2007	1,344	838,893	554	1000	930,681	817
2008	1,037	676,082	554	900	922,597	835.5
2009	1,171	893,757	596	850	791,605	828
Overall	5,378	3,566,589	558	4443	4,337,602	828

(qualitative) discourse analysis (including frame analysis, metaphor analysis and so on) (for an overview, see Doulton & Brown, 2009). More recently, some researchers have begun to use corpus linguistics as well (Grundmann & Krishnamurthy, 2010). The work by Grundmann and Krishnamurthy is of particular relevance in this context, as they also used Lexis Nexis. However, they searched this database in a different way, using, for the US and the UK, search terms such as *climate change*, *global warming*, and *greenhouse effect*. They then analyzed the emerging corpora using WordSmith Tools, a widely used corpus analysis program that allows users to construct "word frequency lists and collocation lists (collocation is a linguistic phenomenon, indicative of the phraseological tendencies of all languages, whereby the choice of one word tends to favor the co-selection of other words, its collocates, within close proximity in a text)" (Grundmann & Krishnamurthy, 2010, p. 129). To this type of research we wanted to add a new methodological perspective derived from computational linguistics.

The rationale guiding our approach to analyzing these data is based on the simple and obvious fact that human language is inescapably a sequential phenomenon. Phonemes, words, phrases and other linguistic phenomena are generated and interpreted in a temporal sequence. A "blind Venetian," for example, is not the same as a "Venetian blind." Nevertheless, a large number of the techniques employed in the fields of information retrieval and computational linguistics effectively ignore the overwhelmingly serial nature of language and treat each text unit as an unordered collection of word frequencies—the so-called "bag-of-words" approach. Going beyond this, our analyses attempt to exploit the sequential nature of text by employing two methods that take account of the serial placement of linguistic elements.

The first method uses inter-term intervals as data to be processed by the Multi-Dimensional Scaling (MDS) technique to produce mappings (both planar and hierarchical) that give a visual representation of the inter-term relationships within a set of texts. MDS is a statistical technique for exploratory data analysis that can be applied to a matrix of inter-item dissimilarities (or similarities, after simple pre-processing) (see Kruskal & Wish, 1978). It aims to provide a concise visual representation of the implicit structure within the dissimilarity matrix in terms of a small number of quasi-spatial dimensions, thus making this structure available for visual inspection. There are numerous variant computational techniques for achieving this goal. The method we employ was first described by Sammon (1969). Sammon's method is an iterative optimization procedure that attempts to minimize the value of a "stress" function which measures the divergence between the original inter-item dissimilarities and the distances between the items in the resulting low-dimensional space.

The second method uses short subsequences as distinctive features in seeking significant contrasts in the phraseological choices between texts from two different sources within a corpus. The method based on examining inter-term intervals finds words which are closely or remotely co-located in the corpora. The method based on subsequences extracts loosely related sequences of words which are distinctive for a given corpus, for a given time and which may change over time. Both methods together provide insights into the general distribution of words or concepts in the two corpora, individually or combined, but also reveal what is distinctive for one corpus compared to the other.

Inter-Term Interval Maps. Our first method is a mapping procedure based on inter-term intervals, i.e., the distances measured in number of intervening word-tokens, between terms in the texts. The overall procedure can be described in terms of four steps, as follows:

1. Select a vocabulary.
2. Estimate the 50th percentile distance between each pair of terms in the vocabulary by examination of a particular corpus. The 50th percentile corresponds to the median distance between terms and is therefore an average. In this context it is the most natural way of summarizing in a single number the relationship between those terms.
3. Apply MDS to reduce the inter-term interval matrix to a small number of dimensions. Our policy was to accept the solution with the smallest number of dimensions that gave a stress level of 0.1 or less, indicating, in effect, that at least 90% of the information in the original matrix was preserved in the lower-dimensional representation. In the examples quoted in this article, this always resulted in a 2-dimensional solution.
4. Plot the positions of the terms in this low-dimensional space as a scatter plot to elucidate inter-term relationships; as well as performing a clustering of the terms in the same space to produce a dendrogram as an alternative way of displaying the inter-term relationships.

In the present study, the vocabulary was selected by first finding the strongly associated collocates of the word *carbon* in the LT and the NYT subcorpora separately, which turned out, in both cases, to occur in the top 22 by rank. These were selected, and then certain derived forms (such as *reducing* from *reduce*) were added as equivalents. The resulting vocabulary consisted of 28 items, which are listed below (see Results-Inter-Term Interval Mapping).

To compute inter-term intervals, a bespoke program was written in Python. Two ways of measuring inter-term intervals were implemented, of which only one was used in the present study. From a statistical point of view, distances between words have two characteristics that make them difficult to process: (1) very skewed distributions with high variances; (2) prevalence of "censored" observations, in that document length is often shorter than typical distance from one term to another. For example, if term A is found at position 500 of a 600-token document, and no occurrence of term B is found between position 500 and the end of the document, we know that the A–B interval must be at least 100 tokens, but do not have an actual distance. The program would record this example as a censored interval of 100. This is analogous to the situation in longitudinal studies where a participant in a study drops out or the study ends before a terminal event (such as death or failure of a piece of equipment). We, therefore, used a method developed to deal with sets of partly censored observations, namely the Kaplan–Meier product-limit estimator (Kaplan & Meier, 1958), to compute average inter-term intervals. Thus, all the mappings in what follows are based on the 50th percentile distance as calculated by the Kaplan–Meier estimator. Our rationale for using inter-term intervals is that they provide indices which are more informative about semantic associations than individual word or term frequencies.

Our reason for employing MDS is simply that, as long as a low-dimensional solution can be found, it is a way of summarizing a collection of complex interrelationships and presenting that summary to the human perceptual system with the highest bandwidth, namely the visual system. The version of MDS used in this study was Sammon's semi-metric scaling procedure (Sammon, 1969) as implemented in the R package (www.r-project-org). The clustering procedure used was Ward's method (Ward, 1963), also as implemented in R.

Scatter plots and dendrograms were also produced with the R system (see Results below).

Contrastive Subsequences. Our second method is based on what Sinclair (1991) calls the "idiom principle," namely, the tendency for speakers and writers, as well as listeners and readers, to work with chunks of language rather than isolated words. In linguistics, a variety of terms have been used to refer to the results of such chunking, such as "collocations," "concgrams," "flexigrams," "lexical bundles," "multi-word expressions," "prefabricated phrases," "skipgrams," among others (Cheng, Greaves, & Warren, 2006). All are generalizations of the basic notion of an *n*-gram, which refers to a sequence of *n* tokens. However, different authors have generalized this concept in slightly distinct ways, and thus the meanings of these terms overlap in a somewhat confusing manner. As the terminology for such multi-element linguistic units is not yet standardized, we will refer in this document to *n*/*m*-grams. An *n*/*m*-gram is defined as a group of *n* tokens occurring within a segment of *m* tokens, where $m \geq n$.

For example, the ordered 3/7-gram "you want to," is a series of 3 tokens that can be found in the following 7-token segments, among others[4]: "if you don't want to be rich," "apparently you all want to make a . . .," "don't you even want to see it," and "unless you want me to throw you . . ." Conversely, the segment "I don't know" contains 3 order 2/3-grams as follows: "I don't," "I know," "don't know." An *n*/*m*-gram may be ordered or unordered. In the latter case the *n* tokens are a subset of the *m* tokens in the full segment; in the former case they are a subsequence. In this investigation, only ordered *n*/*m*-grams were considered.

A program was written in Python to search for ordered *n*/*m*-grams that distinguished between the two sources of text in our corpus, using the likelihood-ratio G-squared statistic (see Dunning, 1993) as the measure of distinctiveness. Results from this program are provided below. G-squared (G2) is a measure of discrepancy between observed and expected frequency counts defined by the formula $G^2 = 2\Sigma(O_{ij}\ln(O_{ij}/E_{ij}))$, where O_{ij} stands for observed frequency and E_{ij} for expected frequency of item *i* in category *j*. This measure is often called the *log-likelihood ratio* by corpus linguists, though statisticians refer to it as the *log-likelihood-ratio goodness-of-fit statistic*, or G-squared for short. With large samples, its distribution is well approximated by the Chi-squared distribution. We have used it as an index of distinctiveness because Dunning (1993) showed that its behavior was more robust in situations with small or highly uneven cell counts than the conventional Chi-squared formula, a finding echoed by Kilgarriff (1996). In the examples quoted in this paper, expected frequencies were computed by assuming equal rates in both subcorpora.

Results

Results Using Inter-Term Interval Mapping

The vocabulary (28 items) used in collocational mapping is listed as follows:

> carbon, dioxide, emissions/emission/emit/emitted, footprint/footprints, monoxide, fibre/fiber, neutral, low, zero, reduce/reduction/reduces/reducing, tonnes/tons/ton/tonne, capture/captures, cut/cuts, copy/copies, atmosphere, offset/offsets/offsetting, permit/permits, storage, trading, levels/level, credits/credit, dating, poisoning, gases/gas, atoms/atom, trapping, heat, greenhouse.

These terms were chosen by taking the 22 most strongly associated collocates (within a window of plus/minus 8 tokens) with the word *carbon* in either the LT or the NYT corpus, 2000–2008. The word *carbon* was also added, and closely equivalent word-forms grouped together. Terms separated by slashes are treated as equivalent. To display the results of the interterm interval mapping, we initially combined the corpora. This gave an overview of the largely similar use of terms across the two. (See Figure 1 for a representation in terms of a 2D plot of Sammon MDS solution and Figure 2 in terms of a dendrogram).

However, as later analyses will show, there are also some distinctive features when one looks more closely. The NYT and the LT may speak a common language, as we will see, but they are divided by how they use it.

Looking along the dendrogram (Figure 2) from left to right, two distinct, although slightly overlapping, clusters emerge, with (carbon) *footprint* straddling, to some extent, the two clusters.[5] The first cluster on the left is composed of words mainly dealing with the causes or problems of climate change, whereas the second cluster on the right is mainly composed of words dealing with remedies or solutions. As we shall see in our *n*/*m* gram analysis, the NYT mainly focuses attention on the first, the LT mainly on the second cluster in a variety of ways.

Results Using Contrastive Subsequences

Contrasts Between London and New York. The program for finding contrastive *n*/*m*-grams was used to seek phraseological differences between the LT and NYT subcorpora (years 2000–2008) with *n*/*m* settings 2/4, 3/5 and 4/6. For each of these runs the four "seed terms" *carbon*, *CO_2*, *climate*, *warming* were used. Since the

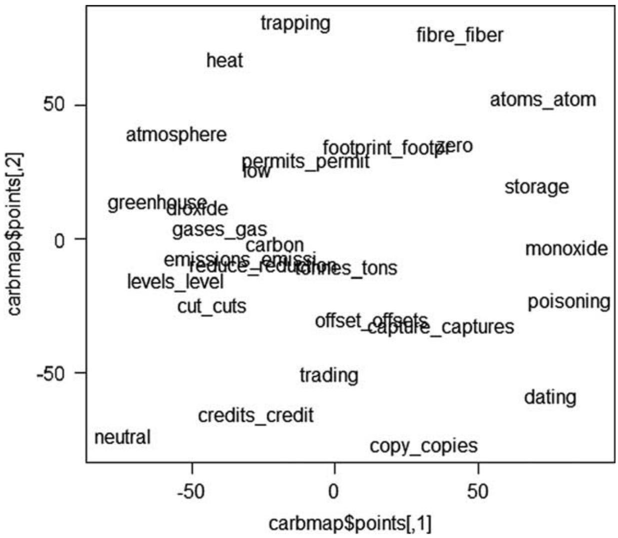

Figure 1. 2D plot of Sammon MDS solution (inter-term distance mapping) for *The* (London) *Times* and the *New York Times* combined, 2000–2008.[6] [Sammon stress = 0.0754.].

number of subsequences in a large corpus can be huge, the program only computes the distinctiveness score (G-squared) for those that contain at least one of a specified list of seed terms. We shall first study an unselected list of 2/4 grams, before turning to an examination of a selective list of 2/4 and 3/5 grams which emerge when they are listed in alphabetical order. Looking at the overall list first, differences in the discourse about carbon in the two newspapers can be illustrated by focusing on the 10 2/4-grams with the highest G-squared values, as shown in Table 2.

In this table the second column (polarity) is positive for those subsequences that have a higher rate of occurrence in the second subcorpus (the NYT) and negative for those with a higher rate in the first (the LT). We can ignore three of the subsequences—(*carbon, fibre*), (*carbon, fiber*), (*tonnes, carbon*)—which result from spelling differences between US and British English. Of the other seven, only one (*global, warming*) is more frequent in NYT than LT. Thus the 2/4-grams: (*carbon, emissions*), (*co2, emissions*), (*climate, change*), (*low, carbon*), (*zero, carbon*), (*carbon, trust*) characterize UK rather than US discourse. Apart from (*carbon, trust*), terms that refer to a UK organization, and (*climate, change*), these all form parts of expressions referring to ways of dealing with excess carbon dioxide or CO_2 in the atmosphere. This suggests that UK discourse has moved onto discussing solutions, while US discourse during this period remained concerned with the problem, i.e., whether global warming is a reality.

Another distinctive difference between the two corpora emerges when one turns to a study of more specific lists of *n*/*m* grams. In this case, we focused first on *n*/*m* grams that begin with *carbon*. Whereas the only 2/4 grams in the NYT that are related to

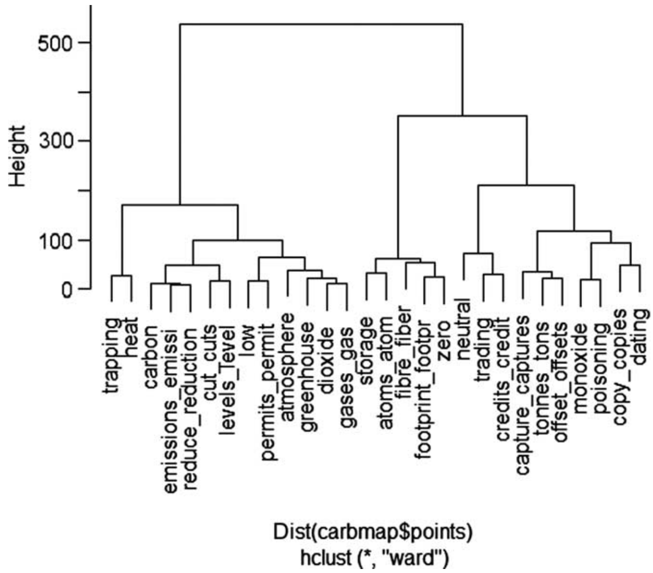

Figure 2. Dendrogram of 2D Sammon solution using combined data from *The* (London) *Times* and the *New York Times*, 2000–2008.

climate change are (*carbon*, *dioxide*) and, surprisingly, (*carbon*, *offsets*), the LT uses a much wider variety of climate related 2/4 grams around *carbon* as a hub, namely: (*carbon*, *capture*), (*carbon*, *emission(s)*), (*carbon*, *energy*), (*carbon*, *footprint*), (*carbon*, *homes*), (*carbon*, *neutral*), (*carbon*, *permits*), (*carbon*, *price*), (*carbon*, *programme*), (*carbon*, *reduction*), (*carbon*, *scheme*), (*carbon*, *trading*), and (*carbon*, *trust*).[7]

When looking along the alphabetical list of 2/4 grams one also arrives at 2/4 grams starting with the word *climate*. 2/4 grams beginning with this word are mostly from the NYT. While the LT speaks of *climate care*, the NYT speaks much more about *climate scientists*, probably as a source of authority but also as a source of conflict and dissent. Finally, when looking at 2/4 grams starting with *warming*, one can see that they are all used in the NYT, which confirms results by Grundmann and Krishnamurthy (2010)

Table 2. 10 2/4 grams sorted by highest G-squared values.

Rank	Polarity	G-squared	Frequency-1	Frequency-2	Subsequence
1	−0.9962	1,040.48	587.00	0.00	*(carbon, fibre)*
2	0.9937	775.77	0.00	730.00	*(carbon, fiber)*
3	−0.3688	774.69	3165.00	2,081.00	*(carbon, emissions)*
4	−0.8727	703.44	572.00	54.00	*(Co_2, emissions)*
5	−0.2888	619.15	3940.00	3,100.00	*(climate, change)*
6	−0.6912	549.55	715.00	185.00	*(low, carbon)*
7	0.2723	452.86	1892.00	4,720.00	*(global, warming)*
8	−0.8661	444.60	366.00	36.00	*(zero, carbon)*
9	−0.9855	431.15	250.00	1.00	*(tonnes, carbon)*
10	−0.9288	370.20	257.00	12.00	*(carbon, trust)*

that *global warming* is much more a US American term than a UK English term (this can now also be confirmed by searching Google Ngram viewer).

When widening the net and looking at 3/5 grams alphabetically, one can again find a significant difference between the NYT and the LT in their usage of *carbon* and its collocates. The NYT still appears to be grappling with the issue of *carbon dioxide* (which is rarely used elliptically as *carbon*) in relation to *heat trapping gases*, while the LT is trying to reduce carbon emissions by means of, it seems, first and foremost, *carbon capture and storage*. We shall return to the importance given to carbon capture and storage in our diachronic analyses to which we now turn.

Changes in Patterns Over Time. As well as contrasting press coverage in the LT with that in the NYT by means of *n*/*m*-grams, we wanted to see how the picture had been changing over time. A program was written to calculate rank correlations of the relative frequencies of *n*/*m*-grams in each document with its year of publication. This was run separately for the LT and NYT. Again the four core "seed terms" were used: *carbon*, *CO_2*, *climate*, *warming*.

The 10 3/5-grams most negatively and 13 most positively correlated with year of publication in the LT (2000–2009) appear in Table 3. This shows which *n*/*m* grams were most strongly declining and increasing over that period in that corpus. The second column of the table shows the (rank) correlation; the third column shows its

Table 3. Decline and increase of *n*/*m* grams in *The* (London) *Times* between 2000 and 2009.

Most strongly declining in LT			
1	−0.1211	8.88	*(climate, change, levy)*
2	−0.1105	8.10	*(carbon, copy, of)*
3	−0.1035	7.59	*(the, climate, levy)*
4	−0.1006	7.37	*(a, carbon, copy)*
5	−0.0854	6.26	*(m, carbon, d)*
6	−0.0798	5.85	*(sub, m, carbon)*
7	−0.0753	5.52	*(and, carbon, monoxide)*
8	−0.0738	5.41	*(on, carbon, steel)*
9	−0.0610	4.47	*(carbon, copies, of)*
10	−0.0536	3.93	*(carbon, steel, business)*
Most strongly increasing in LT			
1	0.1207	8.85	*(carbon, and, storage)*
2	0.1199	8.80	*(carbon, capture, storage)*
3	0.1189	8.72	*(carbon, capture, and)*
4	0.1137	8.34	*(a, low, carbon)*
5	0.1134	8.31	*(energy, and, climate)*
6	0.1108	8.12	*(energy, climate, change)*
7	0.1003	7.35	*(and, climate, change)*
8	0.0999	7.33	*(to, low, carbon)*
9	0.0990	7.26	*(of, climate, change)*
10	0.0951	6.97	*(climate, change, the)*
11	0.0940	6.89	*(on, climate, change)*
12	0.0928	6.81	*(to, climate, change)*
13	0.0907	6.65	*(low, carbon, economy)*

equivalent *z*-score. Although these correlations do not indicate strongly linear relationships, their associated *z*-scores show that they are highly statistically significant and therefore that the indicated relationships are worthy of further scrutiny.

The correlations we found show that the *n*/*m* gram (*climate*, *change*, *levy*) is on the decline in the LT, whereas *n*/*m* grams including the terms *low* or *energy* or *carbon capture and storage* are on the rise. This confirms results from another study that showed the rise of *low carbon* denoting an aspirational "form of life" in the UK (Nerlich, 2011), which can be achieved, it is argued, by using carbon capture and storage as one major solution to climate change mitigation.

A further analysis of the 3/5-grams most negatively and most positively correlated with year of publication in the NYT (2000–2009) shows that in the NYT, the use of the word *warming* in *n*/*m* grams is going down (with *monoxide* going down the fastest. However, we can disregard this as this article focuses on climate change not carbon monoxide poisoning and other issues that may be related to carbon monoxide). Conversely, use of the phrase *climate change* and the word *emission* is rising.

In addition to the correlational analysis of *n*/*m* grams, above, an alternative form of chronometric analysis was performed by comparing the inter-term interval matrices (derived from the 28-item vocabulary listed above) formed from the years 2004 and 2006 combined with those formed from the years 2008 and 2009 combined, for both the LT and the NYT. This contrasts the two available years before and after the peak year of press coverage of climate change issues in 2007.

In Tables 4 and 5, a negative value signifies distance greater in the later than the earlier sample, therefore, indicating terms that are tending to move further apart in the texts. A positive value signifies greater distance in the earlier sample, therefore indicating a pair of terms that are tending to come closer together. The 20 most negative and 20 most positive (relative) changes in distance are shown. These pairings preserve asymmetry; thus for instance (*zero*, *carbon*) and (*carbon*, *zero*) are treated separately. The following tables show the differences in distance in 2004–2006 versus 2008–2009 in the LT and the NYT.

In the LT the term *low* is moving closer together with a variety of climate related terms, such as *heat*, *greenhouse*, *trading*, *atmosphere, carbon,* and *capture and captures* are moving together the fastest with *storage*. In the NYT by contrast the word *permit* is moving closer together with a variety of other words, such as *capture* and *captures*, *trading*, and *emissions* but *low* is also moving in on some terms such as *greenhouse*, *emissions,* and *credits*. This is probably related to the controversial Waxman-Markey Bill or the American Clean Energy and Security Act 2009 which tries to establish a carbon trading or cap-and-trade system based on permits similar to that used in Europe.

Carbon Footprint, Low Carbon, and Carbon Capture and Storage. Finally, we want to take a closer look at three important *n*/*m* grams that have emerged as distinctive clusters from our analysis, namely the 3/5 grams (*the*, *carbon*, *footprint*), (*a*, *low*, *carbon*), and (*carbon*, *capture*, *storage*).

Table 4. Diverging and converging pairs of terms in *The* (London) *Times.*

Strongest divergence		
1	−0.5463556	Tonnes_tons ... dioxide
2	−0.4819791	Tonnes_tons ... greenhouse
3	−0.4764149	Levels_level ... dioxide
4	−0.4553461	Trapping ... tonnes_tons
5	−0.4503147	Offset_offsets ... emissions_emissi
6	−0.4503011	Emissions_emissi ... trading
7	−0.4480524	Permits_permit ... atmosphere
8	−0.4473384	Tonnes_tons ... trading
9	−0.4465129	Footprint_footpr ... emissions_emissi
10	−0.4449536	Capture_captures ... fibre_fiber
11	−0.4307311	Capture_captures ... dioxide
12	−0.4282446	Dating ... footprint_footpr
13	−0.4275093	Emissions_emissi ... neutral
14	−0.426614	Carbon ... neutral
15	−0.4241897	Capture_captures ... tonnes_tons
16	−0.4177671	Gases_gas ... dioxide
17	−0.4159697	Capture_captures ... greenhouse
18	−0.4093316	Emissions_emissi ... atmosphere
19	−0.4090375	Carbon ... atmosphere
20	−0.4074015	Atmosphere ... dioxide
Strongest convergence		
1	0.9005168	Capture_captures ... storage
2	0.7362383	Low ... carbon
3	0.5895738	Zero ... carbon
4	0.4357051	Poisoning ... levels_level
5	0.3688235	Poisoning ... reduce_reduction
6	0.3551429	Cut_cuts ... trading
7	0.3477779	Atmosphere ... low
8	0.3477653	Poisoning ... copy_copies
9	0.3179876	Poisoning ... low
10	0.3149393	Storage ... capture_captures
11	0.3004222	Emissions_emissi ... levels_level
12	0.3000117	Low ... trading
13	0.2959721	Storage ... emissions_emissi
14	0.2908228	Low ... copy_copies
15	0.2877179	Greenhouse ... low
16	0.2862007	Levels_level ... trading
17	0.2773893	Reduce_reduction ... trading
18	0.2746811	Trapping ... atmosphere
19	0.2731803	Monoxide ... reduce_reduction
20	0.2680763	Low ... heat

As we saw above, *carbon footprint* is a phrase used both in the UK and the US, but there are differences in use, as well as similarities. We found that the 3/5-gram (*the*, *carbon*, *footprint*) is virtually unused prior to 2006, both in the NYT and the LT. Its usage takes off in the LT subcorpus in 2006, a year earlier than in the NYT subcorpus, and remains higher in the LT than the NYT, However, there are signs that by 2009 its popularity is waning in both newspapers.

Whereas trends in the usage of *carbon footprint* are similar in the two newspapers, the use of *low carbon* and *carbon capture and storage* is very different. The *n*/*m* gram

Table 5. Diverging and converging pairs of terms in the *New York Times.*

Strongest divergence		
1	−0.7082289	Poisoning ... monoxide
2	−0.682776	Monoxide ... monoxide
3	−0.674928	Footprint_footpr ... offset_offsets
4	−0.64823	Footprint_footpr ... dioxide
5	−0.6352699	Offset_offsets ... dioxide
6	−0.5267875	Neutral ... offset_offsets
7	−0.5083612	Offset_offsets ... neutral
8	−0.5025335	Footprint_footpr ... emissions_emissi
9	−0.472844	Offset_offsets ... greenhouse
10	−0.4662803	Trading ... credits_credit
11	−0.4621110	Atoms_atom ... atoms_atom
12	−0.4572947	Neutral ... dioxide
13	−0.450772	Footprint_footpr ... Carbon
14	−0.445228	Cut_cuts ... dioxide
15	−0.4439741	Neutral ... tones_tons
16	−0.4394638	Footprint_footpr ... reduce_reduction
17	−0.4285145	Footprint_footpr ... neutral
18	−0.424431	Footprint_footpr ... greenhouse
19	−0.4171461	Dating ... dating
20	−0.4152171	Monoxide ... carbon
Strongest convergence		
1	0.6095358	Permits_permit ... emissions_emissi
2	0.5396138	Heat ... reduce_reduction
3	0.5351064	Levels_level ... emissions_emissi
4	0.4893782	Credits_credit ... low
5	0.4875511	Fibre_fiber ... levels_level
6	0.4818382	Low ... reduce_reduction
7	0.4442089	Trading ... permits_permit
8	0.4365331	Low ... emissions_emissi
9	0.4357922	Permits_permit ... permits_permit
10	0.4282768	Storage ... emissions_emissi
11	0.4275236	Poisoning ... reduce_reduction
12	0.3996658	Capture_captures ... capture_captures
13	0.395465	Emissions_emissi ... low
14	0.3840283	Capture_captures ... permits_permit
15	0.377356	Gases_gas ... low
16	0.3770614	Greenhouse ... low
17	0.3764188	Zero ... levels_level
18	0.3707261	Poisoning ... greenhouse
19	0.3697691	Capture_captures ... footprint_footpr
20	0.3660494	Zero ... low

(*a*, *low*, carbon) has a much higher and rising currency in the LT compared to the NYT, as shown in Figure 3. The same is the case for (*carbon*, *capture*, *storage*) (see Figure 4), which is a technical fix to reduce carbon emissions by capturing carbon from power plants and so on and sequestering or storing it underground in depleted oil fields, aquifers and so on. Although this type of climate change mitigation strategy is also used in the US (mostly under the heading of *carbon capture and sequestration*), in the UK this solution has had pronounced political backing as part of turning the UK into a “low carbon economy” and as part of a drive to find (semantically vague

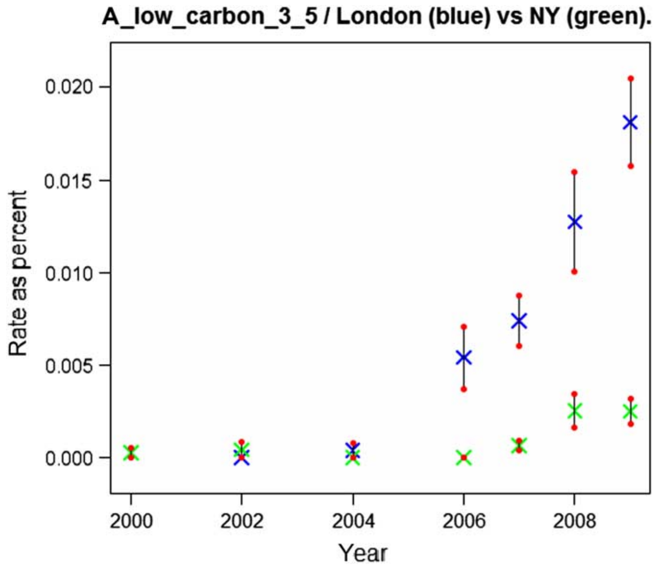

Figure 3. (Colour online) Comparative rise of *low carbon* in *The* (London) *Times* and *The New York Times.*

but politically attractive) "low carbon solutions" to climate change mitigation (see Nerlich, 2011). To give just a few examples: In April 2009, the then Labor government announced its budget under the heading the "world's first carbon budget"; in May 2010, the Queen's Speech focused, in part, on the "low carbon economy"; in March 2010, Yorkshire and Humberside were selected as a "Carbon Capture and Storage Low Carbon Economic Area"; and in May 2010, when David Cameron came to power as Tory Prime Minister, he said in his first major speech: "Let's make Humberside lead the world in carbon capture and storage."

Discussion and Conclusions

As we pointed out in the Introduction, there is an increasing volume of articles devoted to studying climate change communication and media coverage of climate change issues across the globe. These tend to employ press coverage as the material and content analysis as method, using *climate change* or *global warming* as search terms. They also tend to use various types of discourse analysis and, in some instances, corpus linguistics, as methods. Our study differs from such previous work in some important respects. For our analysis, two corpora were derived from Lexis Nexis, using the search term *carbon* to extract articles from the NYT and the LT. To study these corpora, we used a novel approach that allowed us to map relationships between words or concepts based on measuring inter-term intervals on the one hand and to examine contrasts in phrasal choices based on analyzing short subsequences or *n*/*m* grams on the other. This enabled us to compare the two corpora in detail and to track subtle changes in the use of words and phrases over time.

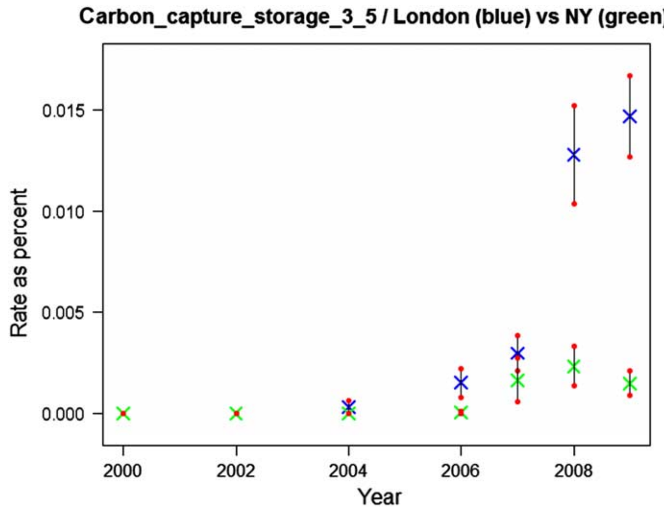

Figure 4. Comparative rise of use of *carbon capture* (and) storage in *The* (London) *Times* and *The New York Times.*

Our study of inter-term intervals revealed that the US and the UK newspaper seemed to be speaking the same "carbon language" with relation to climate change, at least on the surface. We also found that two bundles of concepts or issues preoccupied the US and the UK newspapers, with the measuring of carbon footprints linking the two bundles. One conceptual bundle focused mainly on exploring the problem of climate change, the other focused on the main on finding solutions. When using the study of *n*/*m* grams for our contrastive analysis, we discovered that there were interesting linguistic differences in the way the LT and the NYT discussed climate change (involving carbon), differences that were related to these two conceptual bundles found in the inter-term interval analysis. Whereas the NYT focused mainly on describing the problem posed by carbon dioxide emissions with respect to heating the atmosphere or increasing greenhouse gases, the LT was much more focused on finding solutions to climate change, such as carbon capture and storage for example or building zero carbon housing. In the US coverage, climate change was still mainly problematized as a threat, while in the UK coverage the threat was seen as a fact calling for political action. The NYT assumed that readers did not yet know enough about climate change, while in the LT readers were supposed to know about it and were told about various solutions.

Another feature of language use that distinguishes the NYT from the LT was that the solutions discussed in the UK were framed by using the word *carbon* in more creative ways in a variety of *n*/*m* grams than in the NYT. There was talk of *carbon programmes* and *carbon schemes* and a debate about the *carbon price* was reported on. This type of linguistic creativity (see Koteyko, 2010) was very much absent from the NYT coverage (see examples listed above). Another difference was that when discussing solutions to climate change, the LT focused on two issues: the low carbon economy and using carbon capture and storage to achieve it. There is little scope here to discuss the ideology underlying this focus, but it seems to be a very distinctive feature of UK climate change discourse.

By revealing such differences, our study makes a novel contribution to the existing literature, especially two articles, one by Boykoff (2007a), dealing with US/UK issues, and one by Grundmann and Krishnamurthy (2010), focusing on quantitative aspects of media coverage. Boykoff's article notes that:

> The US federal and UK governments, for example, have both been important actors in international climate negotiations but have played very different roles, the US being branded a foot-dragger, whereas the UK has portrayed itself as a champion of domestic action and international cooperations. (Boykoff, 2007a, p. 471)

Our analysis shows that the NYT and LT have contributed to this type of positioning.

The article by Grundmann and Krishnamurthy (2010), based on corpus linguistics, compared media reactions to climate change in the US, the UK, and other European countries like France and German, using terms such as *greenhouse effect*, *global warming* and *climate change* to search the Lexis Nexis database between 1980 and 2007. Two of their findings merit discussion.

First, they found that the "US discourse is very much dominated by a scientific frame" (Grundmann & Krishnamurthy, 2010, p. 143). This is confirmed by our findings showing that the US, at least the NYT, is still grappling with climate change as a (settled or contentious) scientific problem or issue (in rather complex ways, which have been studied by other authors in more detail, see for example Leiserowitz, 2010; Zhao, Leiserowitz, Maibach, & Roser-Renouf, forthcoming).

Second, they noted the US used *global warming* to dramatize the issue of climate change and used it in conjunction with words such as *threat* and *reduce*, whereas "in the UK words such as *action*, *threat* and *combat* are associated with global warming and climate change alike" (Grundmann & Krishnamurthy, 2010, pp. 143–144). The more action and solution oriented framing of climate change also emerged from our analysis. These results and ours appear to overlap with older findings by Trumbo (1996) that show that scientists tend to emphasise problems and causes, while politicians and special interests tend emphasise judgments and remedies. But more qualitative research on our corpora is necessary to confirm this.

In the conclusion to their article, Grundmann and Krishnamurthy (2010) call for more research into identifying "agency, discourse participants, subtopics, and change over time and across countries" (p. 145). Our article, using methods derived from computational linguistics, has contributed to filling some of these lacunae, but more extensive quantitative and qualitative research is needed not only for the US and the UK but also for India, Australia or Canada for example. All these nations share a common language, but might be divided in how they use it to discuss climate change and how they frame policies related to climate change mitigation. Our study was also limited by only focusing on two national newspapers and should be extended to larger corpora. We have however demonstrated that the algorithms we developed to search the LT and the NYT have the potential to be extended to other corpora.

As Boykoff (2007a) has pointed out, different country contexts can engender "varying media representational practices" (p. 481). This may in turn contribute "to divergent priorities in global climate policy and politics" (Boykoff, 2007a, p. 481). Our research has found the linguistic signatures that characterize these divergent political and cultural priorities. The subtle linguistic and conceptual differences dividing two nations speaking a common language should not be ignored, as they do not only indicate divergent political priorities, but pose genuine obstacles to negotiating global and international climate change mitigation policies.

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Notes

[1] For continuous updates on articles appearing in the field see http://www.climatechangecommunication.org/ and http://agwobserver.wordpress.com/2010/10/04/papers-on-media-and-climate-change/ (for a site that constantly monitors media coverage, see Boykoff & Mansfield, online; for one of the most recent contributions on the issue, see Boykoff & Smith, 2010)

[2] On the many uses of the word *carbon* in so-called lexical (carbon) compounds, see Nerlich and Koteyko (2009a, b), Koteyko, Thelwall, and Nerlich (2010), and Koteyko (2010).

[3] Previous research by Nerlich and colleagues (see Koteyko et al., 2010) has shown that the word *carbon* only began to be used extensively in debates about climate change around 2006. We therefore initially used two-year intervals before going for yearly extraction of data after 2006.

[4] Notice that the *n* constituent tokens do not have to be found consecutively for the *n*/*m*-gram to match. (Specimen matches from fiction by Iris Murdoch.)

[5] For a more detailed analysis of *carbon footprint* and other lexical "carbon compounds", see Koteyko et al. (2010) and Nerlich and Koteyko (2009a, 2009b).

[6] It should be noted that because the MDS procedure requires symmetric or near-symmetric distance matrices the underlying inter-term intervals are averaged before submission to the scaling procedure. Thus, intervals I–J and J–I become equal. Consequently any asymmetries (e.g., between *carbon … trading* and *trading … carbon*) are in effect smoothed out by this analysis.

[7] For studies of this type of lexical creativity see Koteyko et al. (2010).

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