Metaphors in texts about climate change

Alice Deignan
University of Leeds (UK)
a.h.deignan@education.leeds.ac.uk

Abstract

This article discusses the use of metaphors and metonyms in texts about climate change in different registers, with a particular focus on the information given to young people, and what they understand about the topic. It begins by considering the role of metaphorical thinking and language in science, and reviews some of the work on scientific metaphor in expert and popular genres. The article analyses the different functions of metaphors in two texts about anthropogenic climate change from different genres, arguing that in the popular text analysed metaphors tend to have the function of entertaining and dramatizing, and introducing and concluding (interpersonal and textual), as opposed to their informational (ideational) function in the research article that was analysed. I then discuss a corpus and discourse analysis of young people's talk about climate change. The young people's use of figurative language is compared with that of researchers and educationalists. The analysis finds that, consistent with work on scientific popularisations, written texts for non-specialists tend to "open up" in Knudsen's (2003) terms experts' metaphors, extending them creatively. I found that on occasion this seems to lead to, or reflect, misunderstandings of the underlying science. I also find that young people reference Arctic and Antarctic animals as symbols of the problem of climate change.

Keywords: metaphor, science, climate change, education, schools.

Resumen

Las metáforas en los textos sobre el cambio climático

Este artículo discute el uso de las metáforas y metonimias en los textos sobre el cambio climático en diferentes registros, con un interés especial en la información proporcionada a la gente joven, y en lo que ellos entienden sobre el tema. El artículo comienza considerando el papel del razonamiento metafórico y del lenguaje en la ciencia y revisa el trabajo de las metáforas científicas en los géneros

expertos y populares. El artículo analiza las diferentes funciones de las metáforas en dos texos sobre el cambio climático antropogénico en diferentes géneros y defiende que en los textos populares analizados las metáforas tienden a realizar la función de entretenimiento y dramatización así como de introducción y conclusión (interpersonal y textual), en contraposición con la función informacional (ideacional) del artículo de investigación que se analizó. A continuación llevo a cabo el examen de un análisis de corpus y del discurso de la gente joven sobre el cambio climático. La comparación del lenguaje figurativo de estos con el de los investigadores y de los expertos en educación demuestra que, como se recoge en la investigación sobre la popularización del discurso científico, los textos escritos para los no especialistas tienden a "abrir", en términos de Knudsen (2003), las metáforas de los expertos, extendiéndolas de forma creativa. Descubrí que en ocasiones esto parece conducir a, o reflejar, interpretaciones erróneas de la ciencia subyacente. También observo que la gente joven se refiere a los animales árticos y antárticos como símbolos del problema del cambio climático.

Palabras clave: metáfora, ciencia, cambio climático, educación, escuelas.

1. Introduction

This article describes a set of corpus and discourse analytic studies of figurative language used in writing and talk about climate change. Climate change is a current and urgent issue; 2015 and 2016 were the two warmest years on record (Met Office press release, 2017), and large numbers of animal and bird species are already negatively affected (Pacifici et al., 2017). Levels of carbon dioxide in the atmosphere were below 300 parts per million (ppm) for over 400,000 years, until 1950. In 2013 the figure passed 400 ppm, and at the time of writing the figure is 406 ppm (NASA website, 2017). Within the scientific community, there is widespread agreement that climate change is happening, and is due to human activity (Boykoff, 2011). Climate change can only be slowed, if at all, by dramatic modifications to lifestyle and consumption. Young people born in the 1990s and in this century will probably live to see some major impacts of climate change, yet this same group of people are under an unprecedented pressure to consume, from the media, their peers and advertisers. This is a behaviour which is directly in conflict with the need to reduce carbon dioxide emissions, but young people are unlikely to draw this conclusion without targeted information about climate change and its causes.

Non-scientists generally, and perhaps especially young people, do not usually read specialist scientific writing on climate change, but rather get

information through school and educational materials, and from popular science writing. As Boykoff writes,

> People typically do not start their day with a morning cup of coffee and the latest peer-reviewed journal article. Instead, citizens turn to mass media— television, newspapers, radio, internet and blogs— to link formal science and policy with their everyday lives. (2011: 53)

The research described in this article looks at how metaphors frame climate science in non-specialist pedagogic and popular texts. I also examine some of the metaphors used by school students in interviews about climate change. This is intended as a contribution to finding out what non-specialists, especially young people, are told about climate change, how this is framed through metaphor, and, in turn, how they express their understanding of it. I begin with a discussion of previous research on how metaphors are used in texts written for scientists and in texts written for the non-scientific public.

2. Metaphor and doing science

Metaphor use in science has much in common with what we know about metaphor in language and thought generally. Metaphorical language pervades the discourse of science, and, like metaphors in non-technical genres, scientific metaphors often "highlight and hide" (Lakoff & Johnson, 1980: 13) aspects of their topic. A few metaphors in science "frame our way of thinking" (Cuddington, 2001: 464); that is, they form a backdrop to scientific thought and discussion and thus are more powerful than highly visible metaphors. An example of this is the BALANCE metaphor, which is also frequent in other specialised registers such as Law and Politics (Sanchez, 2011). In the natural sciences, the metaphor could be phrased as (GOOD) NATURAL SYSTEMS ARE IN BALANCE. In everyday language, the metaphor is realised in brand names of products such as pet foods and vitamin tablets, which claim to restore the body's balance. The metaphor is seen in educational materials where it is claimed that predators and their prey live in balance, and it also underlies some specialist scientific discourse.

Cooper (2001) traces the origins of the BALANCE metaphor back to Greek thought. Cuddington notes that the metaphor frames nature as "a beneficent force" (2001: 463), and before Darwin, an order that was believed to have

been designed by God. She argues that the metaphor suggests an unscientific idea, which has now been superseded by the more sophisticated mathematical concept of "equilibrium", also, of course, metaphorical. In the discipline of ecology, equilibrium is a way of describing species numbers, where predators, food supply and other influences are such that the numbers of a species are stable over time. This mathematical notion has no intrinsic evaluative quality, but it can become blurred with the older BALANCE metaphor, whose positive connotations often seep into it. Both Cooper and Cuddington note that the BALANCE metaphor has suggested a constancy that does not, in reality, exist. Species numbers have always fluctuated, often to extreme degrees. Ladle and Gillson (2009) claim that for some ecologists, a FLUX OF NATURE metaphor is replacing the BALANCE OF NATURE one, but that this is not seen more widely in texts accessed by the general public.

In one of the best known discussions of the framing function of metaphors, Lakoff (1991) argued that mappings such as A NATION IS A PERSON justified, and in some cases, directly led to, specific actions in a war context. Cuddington (2001) and Ladle and Gillson (2009) make the same claim of the BALANCE OF NATURE metaphor. Cooper (2001) argues that the natural world is always undergoing change, albeit often very slowly; the BALANCE metaphor hides this, and is used to argue for conservation activities that preserve a perceived ideal state. Ladle and Gillson (2009) show, through corpus and document analysis, that the BALANCE metaphor is associated with conservation of nature and prevention of change. One example is in the US, where this approach led to attempts to prevent all forest fires "in order to prevent disturbance and thereby maintain a perceived balance" (2009: 230). Ladle and Gillson note that, over time, the result of this policy was larger, more severe fires, which caused much more serious damage than would have resulted from the smaller fires that had been prevented.

As well as framing, metaphors are often ways of developing new hypotheses in science, as described by Boyd (1993: 482). The importance of metaphor to developing scientific thought is well documented, including by scientists themselves, such as Brown (2003) and Cuddington (2001). Brown writes of metaphor:

> It is at the very core of what scientists do when they design experiments, make discoveries, formulate theories and models, and describe their results to others – in short, when they do science and communicate about it. (2003: 14)

This author traces in scientific detail the metaphors used by scientists in their developing understanding of topics such as the atom, protein folding, and the cell, arguing that metaphors shape the direction of scientific enquiry. He also argues that the metaphors that dominate and shape thought are as much a product of culture and embodiment as metaphors in other domains of life.

Scientists have also analysed how metaphors can hinder understandings of science. In an account of the history of cancer treatment written for non-scientists, Mukherjee (2010), an oncologist, writes that medical researchers' use of the war metaphor to talk and think about their research seriously slowed down advances in understanding and developing treatments. The war metaphor was politically apposite at the time and place he describes: the Cold War period in the US. Mukherjee argues that the war metaphor portrays cancer as a homogenous, identifiable enemy, leading to the mistaken conceptualisation of it as a single disease, for which a single treatment could be found. Some doctors and researchers believed, he argues, that if only the weapon – early versions of powerful chemotherapy, administered in the absence of the drugs that are now available to alleviate its terrible side effects – was delivered in high enough doses, the enemy could be conquered, over the battleground of the patient's body. It is now known that cancer takes a wide variety of forms, which have a range of different causes, and the treatments that are available and being developed differ accordingly. He argues that the misguided search for a single "magic bullet" (page 86) delayed progress on some cancers, possibly by decades.

3. Science communicated through metaphor to non-scientists

Explorations of metaphors in science communication have divided their use into, broadly, metaphors used to communicate between peers, and metaphors used to explain science to the non-scientific public, that is, for a pedagogical purpose (for example, Boyd, 1993). A repeated finding is that linguistic metaphors very quickly lose any sense of metaphoricity to scientists. Knudsen (2003) asked scientists their views about metaphorical terms in the field of DNA, and reports:

> A number of the molecular biologists I have consulted argue that, since they know exactly which chemical relations and substances are being referred to, the metaphors in question have lost any figurative quality they might have

> had. In the opinion of these scientists, no definitive difference exists between these metaphorical concepts and concepts with a mere non-figurative origin. (2003: 1252-1253)

When the same topics are written about for non-scientists, in popularisations for example, the metaphors tend to be, in Knudsen's terms, "opened up". She compared the metaphors used to talk about DNA by scientists in peer to peer communication and in popularisations. In communication between scientists in the research journal *Science*, linguistic metaphors such as *translation*, *code* and *message* quickly became established and were used "just like any other scientific concept" (2003: 1254). Knudsen shows how this TEXT metaphor was "opened up", that is, extended, explored and re-lexicalised in popularised accounts, some of which were written by the same scientists. She cites linguistic metaphors such as *read off*, *dictionary*, and *spell out* from *Scientific American*, as well as re-uses of the established scientific terms *message*, *translate* and *code*. Semino (2008) found the same process in her analysis of a scientific article about ageing, and a popularised version, which was published in the *New Scientist*. The scientists put forward the hypothesis that as an organism ages, cells become less effective at removing toxins; this is described using what Semino terms a metaphor of WASTE DISPOSAL. In the scientists' texts, the use is fairly limited, while in contrast, the popular version exploits the mapping creatively and humorously, beginning with a long description of the writer's attic, and the junk it contains (2008: 143).

Deignan et al. (2013) analysed a *New Scientist* article which presented findings about glaciers alongside the two research articles that it was based on. The terms *equilibrium* and *balance* were used in the research articles, in the expressions *equilibrium line altitude* and *surface mass balance*. These have technical meanings related to the relationship between ice melting in the summer and re-accumulating in the winter, and the point on the glacier at which these occur. The terms tend to be abbreviated to "ELA" and "SMB", which suggests that their figurative origin is lost (ibid.). The terms were used frequently in the research articles, but there were no exploitations or developments of a balance metaphor. In the *New Scientist* popularisation, the terms ELA and SMB were not used, either in full or abbreviated form. However, the writer used derived terms such as *out of equilibrium*, in

> (1) glaciers are about 25 percent *out of equilibrium* (Anathaswamy 2011: 8).

This expression is not used at all in the research articles that were analysed, nor in a wider corpus search of academic articles. It appears to have been creatively coined by the *New Scientist* writer. The writer also used the balance-related linguistic metaphor *tipping point*, in citations such as

(2) Greenland will reach a *tipping point* in about 30 years (ibid, p. 8)

an expression which again is not used at all in the source research texts. As was the case for the "junk" metaphors described by Semino, above, the metaphors used by scientists communicating with each other seem to have lost any figurative dimension they may have had, while the popular text treats them creatively.

Another difference in metaphor use between research and popular texts is function, which I illustrate with an example of two topically-related texts about climate change. In 2017, an article was published in the peer reviewed journal *Anthropocene Review*, entitled "The Anthropocene equation" (Gaffney & Steffen, 2017). The article proposed an equation to represent the rate of change to the Earth's system. The first author, Gaffney, is a science journalist, while Steffen is a chemist who has published in some of the leading scientific journals. Gaffney also published a version of the article in the *New Scientist*, entitled "Simple equation shows how humanity is trashing the planet".

There are differences between the two articles in the functions that metaphors are used for. The articles contain a number of shared metaphors that denote scientific and technical concepts; these include *drive*, *driver* (an abstract force that leads to change), *baseline* (as in *baseline data*) and *instability*. The research article also includes more specialised technical uses of metaphor, such as *feedback(s)*, *interaction*, and *forcing*, which have a denotational, or referential, function. These include the figurative expression *saw-tooth* in the following:

(3) …the Earth System of the Quaternary is typified by *saw-tooth* oscillations of glacial-interglacial cycling.

which refers to a strong up-and-down pattern of a line on a graph, to denote the same phenomenon. This use of *saw-tooth* is found in a number of texts in the Oxford English Corpus, either referring to a graph, real or imaginary, or to the screens on medical instruments to measure heart rates etc. It is common in scientific texts to find figuratively-used expressions which refer

to the appearance of a line on a graph, or representation on a diagram to stand for a trend or distribution, such as *curve*, *steep*, *climb*, *falling*, *peak* and *trajectory*, as in the following citations, all from specialist academic texts:

(4) At low levels of adoption, the supply *curve* for adopters is *steeper* than it is at higher levels of adoption (Expert corpus; see below)

(5) Each site's yearly hydrograph was categorized into one of four types (Simple, Complex, Semi-Complex I or Semi-Complex II) based upon the visual characteristics of the *climbing* limb, the *peak* flow times and the *falling* limb. (Expert corpus; see below)

(6) The graph traces the deterministic *trajectory* from an initial state when the allele is rare in both populations to when the allele has reached global fixation. (*Genetics online*, 10.06.2005)

I regard this as a metonymy from metaphor. The description of aspects of a graph using terms from the concrete semantic field of rising, falling, and in the case of *trajectory*, flying through the air, is metaphorical. The association of these features of a graph with the changing phenomenon that they represent is then metonymical.

The related popular article published in the *New Scientist* contains some metaphors that denote, in common with the research article, but also metaphors that appear to have other functions. An analysis of the following paragraph illustrates this. Metaphors identified using the Metaphor Identification Procedure (Pragglejaz, 2007) have been underlined:

(7) For the last 2.5 million years, Earth settled into a rather unusual period of potential instability as we rocked back and forth between ice ages and intervening warm periods, or interglacials. Far from living on a deeply resilient planet, we live on a planet with hair triggers. Industrialised societies are fumbling around with the controls, lulled into a false sense of security by the deceptive stability of the Holocene, the last 11,700 years. Remarkably and accidentally, we have ejected the Earth system from the interglacial envelope and are heading into unchartered waters. (page 2)

The Oxford English Corpus was used as a reference corpus to examine citations of the underlined metaphors. As expected, a number of them, such as *settled into*, *resilient* and *lulled [into a false sense of security]* are in very general use with the same denotational meanings as in this text, and do not appear

to have additional functions in the article. Of interest here, and in contrast to the metaphors identified in the research article, are the following:

> Rocked back and forth
> Hair triggers
> Fumbling around with the controls
> Ejected… envelope
> Heading into unchartered waters

These seem to have functions beyond denoting, the first of which is explanatory, or pedagogical. *Rock back and forth* in: "We rocked back and forth between ice ages…" conveys the proposition expressed in the research article in the sentence discussed above:

> (3) the Earth System of the Quaternary is typified by saw-tooth oscillations of glacial-interglacial cycling.

The metaphor *rock back and forth* draws on our everyday, bodily experience to make this accessible to a non-scientific readership (in interesting contrast with the research article use of *saw-tooth*) and therefore seems to have a pedagogical function as well as a denotational one. The paragraph as a whole summarises material that is covered over several pages and is supported by detailed references to other research studies in the research article. However, each of the other metaphors listed above both explains but also adds additional meaning to the points made in the research article. The point that human activity is having a major effect on climate, introduced in the paragraph cited above with "Far from living on a deeply resilient planet…" is introduced in the research article with the sentence:

> (8) However, an entirely new forcing is now driving change in the Earth System: human activity (H). Although H is a subset of I (internal dynamics), here we argue that the magnitude, the unique nature of the forcing in the history of the planet, and the rate have now become so profound that H deserves to be considered in its own right in the context of Earth System dynamics.

This text presents an outsider standpoint to human activity, while the popular article repeatedly writes of *we*. The human race is talked of metonymically as taking actions that a single person would: *fumbling around*, *ejecting*, *heading to unchartered waters*. Each of these actions is also metaphorical, writing of the changes wrought to the environment and other species by an

industrialised lifestyle as if they were the physical actions of an individual or small group of people. As noted above, the research article also uses metonymy, but from a graph to a phenomenon – that is, using a scientific artefact to explain a scientific phenomenon, rather than bringing the discussion into the immediate realm of the human body and human action.

The popular article also uses metaphor to move blame for the crisis away from humanity; the metaphor *hair trigger* is used, as part of a claim that the Earth is a very fragile system. This claim is not made in the research article, which instead writes of the *magnitude* of the changes produced by human activity.

In the title of the popular article: "Simple equation shows how humanity is trashing the planet", and the penultimate sentence: "The stakes could not be higher, yet critical knowledge and action needed for stability is in danger of becoming collateral damage in today's war on facts", the tendency for metaphors to have a function that encompasses entertaining, dramatizing and, sometimes, exaggerating, is seen, in expressions such as *stakes… high*, *collateral damage* and *war*. In my analysis, this has overlapped with the pedagogic function in some expressions, discussed above. Unsurprisingly, neither the pedagogic nor the entertaining function was found in the research article.

4. Science metaphors in school education

Having discussed the form and function of scientific metaphors across genres, and briefly described a number of studies, I return to the issue raised in the introduction: the communication of climate change to young people. In order to investigate this issue, a project team from Leeds and Lancaster Universities, UK, compiled three corpora, as follows:

Corpus	Contents	Tokens
Expert	Journal articles and policy documents.	509,772
Materials	Texts accessed by young people and their teachers relating to climate change.	260, 679
Interviews	Transcribed interviews with school students aged 11-16.	87,929

Table 1. Climate change corpora from different genres.

The Expert corpus has two sub-corpora of roughly equal sizes. The academic section consists of articles published in three prestigious journals in the field: *Climate Change*, *Global Environmental Change* and *Nature*. The team took advice from climate experts at Leeds and Lancaster Universities on the choice of these journals. The policy documents section consists of policy documents from the Intergovernmental Panel on Climate Change, the UK Department for Environmental, Food and Rural Affairs, Oxfam and other bodies that comment at a national or international level on climate change. The Materials corpus consists of texts such as curriculum materials, science textbooks, revision websites, popular science websites for young people, and teacher information packs. This was the last corpus to be built, and also the most complex, as many of the texts are from the internet, or from textbooks, and are multi-modal. For this project we only analysed text formally, but we noted that the use of images and sound were also often metaphorical.

The Interviews corpus consists of transcriptions of 41 focus group-style discussions between one of the project teams and groups of school students. The students all attended one of the four collaborating secondary schools in the Yorkshire region (north-east England). The schools are in different socio-economic areas; and ranged in location from Leeds city centre, through suburban to rural. All are non-selective, state (i.e. not fee-paying) schools, who have links with Leeds University through the latter's teacher training work. Students were nominated by their science teachers to take part, and were interviewed in year groups, that is, each group consisted of children from the same school year and science class. Ethical approval was granted through the relevant University of Leeds committee; all participants gave informed consent, and data were anonymised and stored securely.

We analysed the data in a variety of ways, for different purposes. To conduct metaphor research, I used the corpus software *Sketch Engine* (Kilgarriff et al., 2014) to perform word counts, generate concordances and identify frequent and significant collocates, cross-checking a sample of my analysis with other team members. This enabled us to compare the three corpora against each other, and also against two reference corpora, the British National Corpus and the Oxford English Corpus. I started by using the Word List function of *Sketch Engine* to obtain a list of the most frequent words in each of the three corpora. Our focus was on lexical words rather than grammatical words such as prepositions. While we acknowledge that prepositions are often metaphorically used, my initial analyses showed that this is rarely, if

ever, with meanings specific to the domain of climate science. Having obtained a word list, in order of frequency, for each of the three corpora, I concordanced each of the lexical words, or, more precisely, lemmas (i.e. all inflections of a word), starting with the most frequent. For the two larger corpora, I analysed concordances down to words that occurred 200 times per million words, that is, of mid-range frequency. In this way I analysed the concordance data for several hundred words. I then analysed concordances for all lexical words in the Interviews corpus down to a raw frequency of 5. This analysis sought to establish whether words were used with a figurative meaning or literally. To do this, I used a version of the Metaphor Identification Procedure (MIP) (Pragglejaz, 2007). MIP stipulates reading entire texts to determine context, which is clearly not practical for a corpus of this size, and not possible in any case from the starting point of the concordance line. However, the subject matter was known, and the genre of the texts was predictable, so I found that in almost all cases the 80 characters of context of a concordance line was sufficient to determine whether a word was being used literally or figuratively, and in the few remaining unclear cases, a slightly expanded window was enough.

The MIP analysis showed that the majority of frequent lexical words were used literally. The most time-consuming part of the analysis was where words were used both literally and metaphorically. This was the case especially for a set of words describing level, including *level* itself, *high*, *low*, *rise*, *fall* and similar words. These are used in the usual scientific sense, to describe and compare quantities of abstract entities, including the use described above, related metonymically to graphical representations of data. Members of this lexical set are also used literally in climate science, to talk about the sea level. For words such as these, citations of each meaning were counted carefully. A smaller number of words were always used metaphorically in the corpora: frequent examples included *impact*, *scenario*, *approach* and *balance*. The findings from previous studies, discussed above, indicated a tendency for specialist scientific metaphors to be "opened up" (Knudsen, 2003) in popularisations. Our findings were consistent with this. Our comparative analysis of the Expert and Materials corpora showed a broad picture in which, in the Expert corpus, metaphors tended to be found in technical terms or semi-technical descriptions, while in the Materials corpus they were used for overtly pedagogic purposes, often being turned into similes, and/or with the grounds for the metaphor explained. Further details about the Expert and Materials corpora are discussed in Deignan et al. (2017). I now discuss the examples of

figurative language that we identified in the corpus of interviews, comparing these, where relevant, with the other two corpora.

The Interviews corpus was analysed using corpus tools and also thematically. During the manual thematic analysis, metaphors were again marked up using the MIP procedure, and I marked up metonyms following Littlemore and Tagg's procedure (2016), which is a variant on MIP, based on work by Biernacka (2013). I found that in the Interview corpus, metaphors were sometimes used in a similar way to the other corpora. In other citations, however, they were "opened up" and extended. As shown in Table 2 below, students tended to favour metaphors whose vehicles are likely to be familiar objects in the world of an older child or young adult, such as *trap*, *bounce* and *blanket*. There was some evidence that their understandings of the target domain were inaccurate as a result of their bringing their own real-world knowledge to the interpretation of metaphors. I now discuss some specific examples of this. Table 2 gives the most frequent metaphors in the Interviews corpus. In a few cases, the same words were also used as similes; this is shown in column 4. Some of these words were also used literally, but for clarity, the figures for literal use are not given here.

Rank	Lemma	Frequency as metaphor	Frequency as simile	Figurative uses per millon words
1	go	388		4410.1
2	greenhouse	161	30	2172.2
3	way	130		1478.4
4	cap (in ice-cap)	94		1069
5	release	89		1012.1
5	trap	89		1012.1
7	lead (/li:d/)	38		432.1
8	slow	36		409.4
9	bounce	33		375.3
10	point	32		363.9
11	chain	30		341.1
12	blanket	30	5	341.1
13	rise	27		307
14	level	23		261.5
15	escape	21		238.8
15	impact	21		238.8
15	link	21		238.8
18	contribute	18		204.7
19	balance	13		147.8
20	save	11		122.3
21	low	10		111.2
21	footprint	10		111.2
22	band	5	3	90.9
23	play	7		77.8
24	barrier	4	1	66.7
24	scenario	5		66.7

Table 2. Most frequent metaphors (with similes) in the Interviews corpus.

The most frequent metaphor in the Interviews corpus was *go*, which is accounted for by citations such as the following:

(9) I think that erm, like the way we're *going* and the way the earth's changing, it's possible that like in many years' time, it might, like…

(10) …because you're burning trees which err, because of their burning, err, releases CO_2 and then those trees are *gone*.

(11) Bees are supposed to, erm they were talking about a bit of a problem with bees, and if bees *go*, then no plants will get pollinated.

(12) …some animals are *going* extinct, like polar bears, because they're losing where they live.

Despite its frequency, for a number of reasons, *go* is not the most salient metaphor in the corpus. Firstly, the use of *going to* to talk about the future was included in the figurative counts, but this is clearly not domain-specific, and might be better considered to be a grammatical use rather than lexical. Only slightly more domain specific was the frequent use of *go up/go down* to refer to temperature. Also, like many frequent words, *go* is highly polysemous, the high number of citations in fact reflecting smaller numbers of many different meanings, each of which, if counted as a separate group, would appear much lower in the frequency rankings.

Nonetheless, there are points of interest in the concordance data for *go*. Citation (9) seems a realisation of a journey mapping, a use that was found a number of times. With the exception of *going to* to talk about the future and *go up/go down*, the most frequent metaphorical use of *go* was to talk about disappearance or extinction, in 24 citations, as exemplified in citations (10) and (11) above. In addition, there were 16 citations of the collocation *go extinct*, as in citation (12). A search of the British National Corpus showed 4 citations of this collocation, compared with 430 for the lemma *become* with *extinct*. In the Interviews corpus there were only 20 citations of the lemma *become* with *extinct*, i.e. in contrast with the BNC, it was slightly less frequent than *go extinct*. This is consistent with my perception that *go extinct* is a regional and relatively informal use that is over-represented in the speech of these young people.

The second most frequent metaphor in the Interviews corpus, and most frequent in the Materials corpus, is *greenhouse*. This is also used as a simile in 30 citations. As discussed in more detail by Deignan et al. (2017), *greenhouse*

is used in a highly technical sense in the Expert corpus in collocations such as *greenhouse gases*, and almost certainly has no metaphorical meaning for the readers and writers of the texts in the corpus. In contrast, in the Materials corpus, attention is drawn to the literal meaning, in citations such as

(13) In a *greenhouse*, shorter wavelength radiation from the Sun can pass through the glass. However, longer wavelength thermal radiation is trapped inside by the glass. So the *greenhouse* stays warm. Gases in the atmosphere, such as water vapour, methane and carbon dioxide, act like the glass.

In the Interviews corpus, there are a number of references to literal greenhouses, as well as metaphorical, such as:

(14) So the greenhouse effect is like a *greenhouse* when you walk in, it's warm isn't it cos it, other heat is trapped inside by the sun and then it like warms it up, and *greenhouse* gases are like, it's hard to explain like, the gases, I can't really explain it but I know like a *greenhouse*, it's almost like the same as a *greenhouse*.

There is some evidence that this leads to misunderstandings; for instance, the Interviews corpus also contains references to *glass*:

(15) at certain heights the sun is able to get into like the *glass*, then when it's inside it can't get out cos there's no, cos there's no sun to let it get through from inside. So then when you walk in it's really warm and because of that, and it's like, the earth is covered in like lots of *glass* panels but we just can't see them, because the sun's projecting into them. It doesn't, it won't come out, it'll just keep coming in and when it tries to get out, it'll just bounce off the roof and down in a continuous loop.

There are a number of such references in a number of different interviews. These, and other passages in the corpus, show that some of the students interviewed are under the erroneous impression that greenhouse gases form a thin, hard layer round the Earth analogous to panes of glass.

Another very frequent metaphor in the Interviews corpus is *trap*. This is an example of a group of metaphors that work by comparing scientific processes and entities to concrete objects and actions that would be very familiar in the everyday world of the young people interviewed, like *release* (discussed in Deignan et al., 2017) and *blanket*, discussed below. As shown

in Table 2, *trap* was the joint 5th most frequent metaphorically-used lemma in the Interviews corpus. It occurred in the Expert corpus 10 times with a metaphorical meaning. 7 of these refer to CO_2 being *trapped* inside fossil fuels or similar scientific states, while the remaining 3 citations are found in expressions such as *trapped in poverty*. In the Expert corpus, the frequency is just 19.6 per million words, contrasted with 1012.1 in the Interviews corpus. In the Materials corpus, *trap* is mostly used to talk about heat being trapped by greenhouse gases. Occasionally it is used to describe bubbles trapped in ice, which are then used to analyse the composition of air historically. In the Materials corpus, metaphorical *trap* occurs in 406 citations per million words, far more frequent than in the Expert corpus, but less than in the Interviews corpus, where it occurs 1,012.1 times per million words.

The following citations from the interviews are typical. All four of the schools used are represented.

(16) it's like the world like *trapped* in a giant greenhouse and it's just getting hotter and hotter.

(17) when the sun rays shine upon us, they get *trapped* in the atmosphere cos those gases trap them, and that heats the atmosphere up

(18) it's almost having tinfoil on the whole entire planet because it's keeping the heat in and it's not letting any other heat erm, out, so we're completely *trapped* in our own eco-system, and it's really hard to change because of all these greenhouse gases, it's *trapping* us slowly and slowly, it's making us more hot and more humid, and it's trapping us in.

(19) The earth is like the plant, and the CO_2 is making like a glass shelter around it, and it's *trapping* heat in.

It can be seen that while the metaphor is used in all three corpora, albeit with different frequency levels, it is used to talk about different entities. In the Interviews corpus, the entity which *traps* is the atmosphere, CO_2, or, occasionally, the ozone layer (several students confused what they had learned about the ozone layer and the greenhouse effect). The object of *trap* was variously the planet, heat or sunrays. Despite minor variations, there seems to be a consistent scenario in which an outer shell around the planet keeps something in, preventing escape. This is more or less consistent with the use in the Materials corpus, but the students both over-simplify the meaning and extend it. As a result, the Interviews use contains some slight

scientific inaccuracies, as seen in the above citations, for example, that the planet is trapped, rather than heat.

The students' use of *blanket* shows the same tendencies. Figurative *blanket* is not found in the Expert corpus. It is found in the Materials corpus 31 times, equivalent to 118.9 times per million words, in contrast with a frequency of 341 times per million words in the Interviews corpus. In the Materials corpus, only 6 citations are metaphorical, with the remaining 26 citations being similes, in citations such as:

(20) Methane, together with other greenhouse gases like carbon dioxide contribute to global warming by acting like a *blanket* surrounding the whole planet.

The proportion of similes to metaphors is almost the exact reverse in the Interviews corpus, with 30 metaphors and 5 similes. Examples of each are:

(21) When the weather's getting warmer and it's like a *blanket* of carbon dioxide around the earth. And it's caused by carbon dioxide from cars and methane, and factories.

(22) …some gases like are stopping the erm heat, sun from bouncing, because when it shines in onto the earth, it comes down, but then the *blanket* of pollution and greenhouse gases would just stop the heat from coming back through so then it'll get really hot.

(In the Interviews data, it was sometimes difficult to distinguish simile from metaphor because of a tendency for the students to use *like* as a very frequent discourse marker, and not necessarily a marker of simile. I relied on my experience of working with this age group to help me disambiguate these uses). In a number of citations in the Interviews corpus, there is some extension of the metaphor, as in the following citation, where a student talks about not being able to *take off* the *blanket*.

(23) …a giant blanket around the earth, keeping it warm and even too warm, and we can't take that *blanket* off.

Here, as for *greenhouse*, the students have brought extended meaning to a metaphor that they have encountered in pedagogical materials. The students seemed to have noted a metaphor that resonated with their everyday experience, and that they used it with much greater frequency than it is found

in the other corpora, perhaps because of this resonance. Further, they tend to reinterpret the metaphorical use, bringing their experience to it and extending it creatively, thus bringing in slight inaccuracies.

Some of the metaphors used by the students did not occur in the other two corpora, or not with the same meaning. This was the case for *bounce*, *band* and *barrier*, as used in the following citations from the Interviews corpus.

(24) …there's lots of CO_2 coming like out of cars and things, and it's *bounced* its erm, some of the warmth is *bouncing* back onto the earth, it's like erm, it's warming up places that erm, like places like Antarctica where like polar bears live and things.

(25) …there's like a *band* around the world and it like lets some of the CO_2 out.

(26) It's like bad air that we create, it's getting trapped, erm, and it's like a *barrier* for the sun so things are heating up a lot quicker, especially the earth.

As for the examples previously discussed, the literal referents of all of these metaphors would be familiar to students from their everyday lives. They may represent the students' attempts to make sense of the diagrams that feature in many websites and textbooks, in which greenhouse gases are represented as a discrete layer around the planet (a *band* or *barrier*), deflecting heat (which *bounces* back to earth). As for the previous metaphors, this leads to some over-simplification of the science.

5. Symbols of climate change for students

In my manual analysis of the Interviews corpus, I also attempted to identify the central images and entities that students use to refer to the wider problem of climate change. As would be expected, the image of the polar bear is highly salient to the school students, and they referred to this animal in 35 of the 41 interviews. Polar bears were referred to especially when students were asked what climate change is and what the main effects are. Responses to these questions included:

(27) Err, climate change, it's mostly happening in the ice-caps and it's destroying all the habitats of the *polar bears*, and they're running out of space to hunt the food and look after the cubs.

(28) Erm like in the Arctic, with *polar bears* all the ice-caps are all melting so they're like migrating a bit South to different countries and erm, it's causing like havoc in little villages around.

(29) It's erm, it can cause the ice-caps to melt I think and erm, which can cause sea-levels to rise. Erm, flooding in areas, erm, some animals are going extinct, like *polar bears*, because they're losing where they live.

Students in three of the four schools also mentioned penguins, the second most frequent animal to be mentioned after polar bears. [*Polar*] *bears* is the most significant collocate of *penguin*, because they are often mentioned together, as in the following point about the effect of climate change, made by a 14 year old student:

(30) It can affect like anything that is adapted to that environment sort of thing. Like *polar bears* and *penguins*.

When asked to say how she would explain climate change and its effects to a younger pupil, one 12-year-old female student said the following:

(31) imagine you got a *penguin* and that penguin lives on Antarctica on a like massive sheet of ice which can melt easily as the temperatures go up… because it's getting warm and the ice is melting, and let's say it's getting warm, the ice is melting and there's a seal over here trying to eat the penguin but can't go on land, well can't move from land that well, but then the ice is gradually getting shorter and shorter, and then the seal has more water to move in, and then because of us, the ice is gone, and the penguin has to swim, but it can't swim forever, it can't hold its breath forever, and then the seal eats the penguin.

Students produced various narratives of this kind, describing how the habitats and lives of polar bears, penguins and seals were threatened, and the food chain was disrupted. In general, animals tended to be mentioned before people as victims of climate change, and seem to act as symbols of the problem.

6. Conclusion

In this article, I have argued that scientific metaphors are never neutral. Like metaphors in other genres and register, they have entailments which can be

ideological and influence behaviour. This was the case for example, for the "balance of nature" metaphor. Scientific metaphors have different functions in different text types, popularisations tending to use metaphor for explanatory, dramatization and entertainment purposes. Educational materials for young people use metaphor as a pedagogic device, and often spell this out with simile. The findings of this study were consistent with work by writers such as Knudsen (2003) and Semino (2008) in showing that texts written for non-specialists tended to open up scientific metaphors. This study also attempted to find out how the users of such texts, young people, reproduced these metaphors. It has found that they further extended and opened them up, bringing their own concrete experience to their interpretation, and that they brought their own metaphors to their attempts to explain their understandings.

Acknowledgements

The research into young people's understandings of climate change described here is part of a larger project called "Translating Science for Young People", funded by the Arts and Humanities Research Council, UK (grant number AH/M003809/1). I am grateful to the other investigators Elena Semino (Lancaster University) and Indira Banner (Leeds University), to the Research Fellow, Shirley-Anne Paul (Leeds University), who conducted the interviews, to the young people who took part in the interviews, and to their science teachers.

Article history:
Received 16 May 2017
Received in revised form 17 September 2017
Accepted 17 September 2017

References

Anathaswamy, A. (2011). "Last chance to hold Greenland back from tipping Point." *New Scientist* 2794: 8-9.

Biernacka, E. (2013). *The Role of Metonymy in Political Discourse*. PhD thesis, The Open University.

Boykoff, M.T. (2011). *Who Speaks for the Climate? Making Sense of Media Reporting on Climate Change*. Cambridge: Cambridge University Press.

Boyd, R. (1993). "Metaphor and theory change: What's 'metaphor' a metaphor for?" in A. Ortony (ed.), *Metaphor and Thought*, 481-532. Cambridge: Cambridge University Press.

Brown, T. (2003). *Making Truth: Metaphor in Science*. Illinois: University of Illinois Press.

Cooper, G. (2001). "Must there be a balance of nature?" *Biology and Philosophy* 16: 481-506.

Cuddington, K. (2001). "The 'balance of nature' metaphor and equilibrium in population ecology". *Biology and Philosophy* 16: 463-479.

Deignan, A., J. Littlemore & E. Semino (2013). *Figurative Language, Genre and Register*. Cambridge: Cambridge University Press.

Deignan, A., E. Semino, & S-A. S. Paul. (2017). "Metaphors of climate science in three genres: Research articles, educational texts, and secondary school student talk". *Applied Linguistics*.

Gaffney, O. & W. Steffen (2017). "The anthropocene equation". *The Anthropocene Review*: 1-9.

Kilgarriff, A., V. Baisa, J. Bŭsta, M. Jacubček, V. Kovř, J. Michelfeit, P. Rychlý & V. Suchomel (2014). "The Sketchengine, ten years on". *Lexicography* 1: 7-36. URL: www.thesketchengine.co.uk [05/06/2017]

Ladle, R. & L. Gillson (2009). "The (im)balance of nature: A public perception time-lag". *Public Understanding of Science* 18: 229-242.

Lakoff, G. (1991). "Metaphor and War: The metaphorical system used to justify war in the gulf". URL: https://georgelakoff.files.wordpress.com/2011/04/metaphor-and-war-the-metaphor-system-used-to-justify-war-in-the-gulf-lakoff-1991.pdf [05/06/2017]

Littlemore, J. & C. Tagg (2016). "Metonymy and text messaging: A framework for understanding creative uses of metonymy". *Applied Linguistics* 16:1-28.

The Met Office (2017). "2016: One of the warmest two years on record". Web blog post. URL: http://www.metoffice.gov.uk/news/releases/2017/2016-record-breaking-year-for-global-temperature [05/06/2017]

Mukherjee, S. (2010). *The Emperor of All Maladies: A Biography of Cancer*. New York, HarperCollins.

NASA (2017). "Climate change: How do we know?" Web blog post. *Global Climate Change. Vital Signs of the Planet*. URL: https://climate.nasa.gov/evidence/ [05/06/2017]

Pacifici, M., P., Visconti, S. H. M., Butchart, J. E. M., Watson, F. M. Cassola & C. Rondinini (2017). "Species' traits influenced their response to recent climate change". *Nature Climate Change* 7: 205-208

Praggljaz Group (2007). "MIP: A method for identifying metaphorically used words in discourse". *Metaphor and Symbol* 22: 1-39.

Sanchez, J. (2011). "The trouble with 'balance' metaphors". Web blog post. URL: http://www.juliansanchez.com/2011/02/04/the-trouble-with-balance-metaphors/ [05/06/2017]

Semino, E. (2008) *Metaphor in Discourse*. Cambridge: Cambridge University Press.

Alice Deignan is a Professor of Applied Linguistics in the School of Education, University of Leeds, UK. She works with corpora to investigate lexical meaning, especially focussing on metaphor and metonymy. She is interested in cross-register variation, and its implications for non-expert language users such as young people and language learners. She is author of *Metaphor and Corpus Linguistics* (2005, John Benjamins) and co-author of *Figurative Language, Genre and Register* (2013, CUP with Jeannette Littlemore and Elena Semino).