LETTER

doi:10.1415/naturezg1995

The appropriately structural discourse of engineers and scientists

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The science and engineering discourse community, like every other, has developed distinct communication modes and conventions. These rational and pragmatic academics, managers and researchers correspond in ways applicable to their specific position, but commonalities exist. One of the prevailing and by far the most structured medium for idea exchange is the peer-reviewed academic journal, wherein this community relays discoveries and novel applications of previous discoveries. In this study, we will extract the attributes of this population's communication found to be most important and most evident. Here we show the importance of structure with respect to content breakdown in a bound print volume, as a whole, as well as the lower level construction of an original research report. By way of in-depth analysis of one volume[1] of a prolific journal and in particular one letter 'Robots that can adapt like animals', these structural qualities are contextualized. In addition we will use statements that the journal makes to authors, as a guide for standards of the industry as a whole. We also use generalizations made from this data as well as correspondence with practitioners in the field[2] to make claims of greater context and relevance.

The discourse of scientists and engineers is quite advanced, so advanced, that they have developed extremely efficient methods to convey dense information, much like a compressed file containing more information than its size conveys. One of the paths to examine the communication of this group is to study how the organization and structure of content streamlines the transfer of information.

The international journal 'Nature' is "published weekly, with original, groundbreaking research spanning all of the scientific disciplines"[4]. It is considered a 'high-impact journal' and it consistently scores well within the top 1% of published scientific journals, being number 10 with an impact factor of 38.6 in 2013[5]. Additionally, other journals under the Nature Publishing Group umbrella score similarly high – attesting to the prowess of its primary journal. Its performance is even more meaningful when one considers that it publishes content for 'all of the scientific disciplines', rather than for one distinct audience – like the leading 'CA: A Cancer Journal for Clinicians'. It is also significant that 'Nature' publishes for many disciplines because its editors and writing staff must tailor the means of communication for a broad academic audience.

It is for these reasons that this study was conducted on an issue of the weekly 'Nature' publication. It is also worthy of note that this specific publication has an exclusive section designated to the review of the recent progress in the fields of machine intelligence and robotics, which may influence some of the sub-audiences.

The top level hierarchy of the journal content is as follows: 'This Week', 'News in Focus', 'Comment', 'Careers', 'Specials', and 'Research'. Special attention is paid to the last category, 'Research', as this is the section that contains "Nature's main formats for original research" – articles and letters[6]. See Figure 1 for the representation of these sections.

Briefly 'This Week' (7 pages) covers scientific content that is pertinent to a larger audience and in a way that even non-scientists would understand and find interesting. It is meant to draw readers in and it occasionally refers readers to complete research communications that occur, chronologically, later in the publication. This section is in turn is broken down into 'Editorials', 'World View', 'Research Highlights' and 'Seven Days'. The distinct organization within these subsections is not addressed in this study.

The next section 'News in Focus' (13 pages) is also written for a broader audience, it however develops each short writing more fully. It is broken down into the subsections of 'News' and 'Features'. The 'News' component touches far-reaching topics, with one article under each of the following themes: 'International Law', 'Drug Development', 'Climate Change', 'Public Health' and 'Synthetic 'Windpipes'. Each weekly publication's respective 'News' subsection has publication specific themes that are relevant either to the social environment at the time or a particularly important scientific finding. As the name implies, 'Features' are eye-catching articles about an attractive topic. For example, the titles for this publication's 'Features' were, 'Laser Weapons Get Real' (with a picture from the film 'Star Wars' on the cover page) and 'Clever Fish'. 'News in Focus' offers readers an involved view of a variety of topics. It is written with such language that scientists in other disciplines would both be able to comprehend and apply knowledge gained from reading it.

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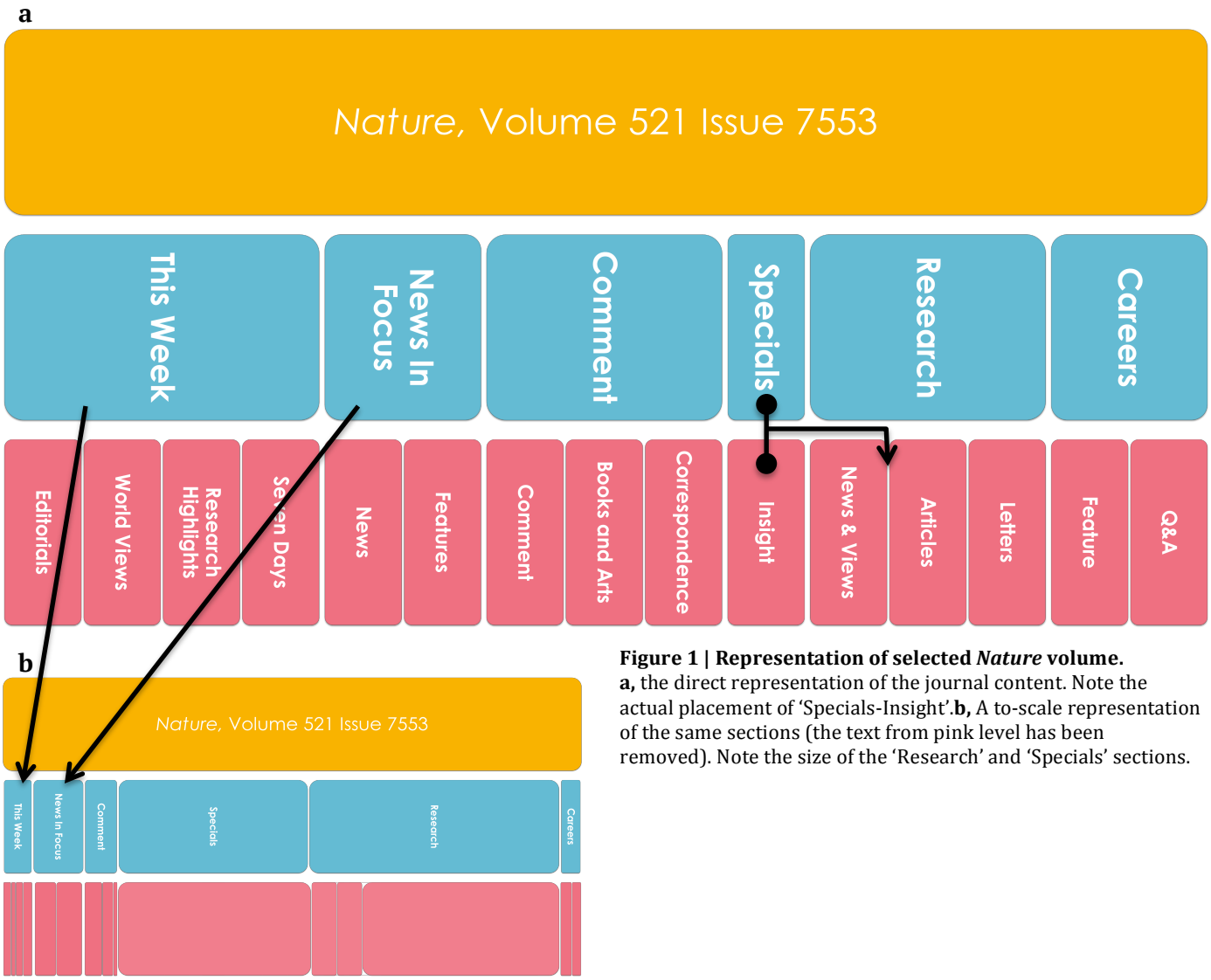

Figure 1 | Representation of selected *Nature* volume. **a,** the direct representation of the journal content. Note the actual placement of 'Specials-Insight'.**b,** A to-scale representation of the same sections (the text from pink level has been removed). Note the size of the 'Research' and 'Specials' sections.

'Comment' (9 pages) is slightly more specific and informative, with the first section sub-headed 'Comment' (to reduce confusion refer to Figure 1a). Here scientists, researchers, and engineers from academia reach out to their colleagues with a short note. This issue, containing the portion dedicated to machine intelligence, appropriately has a comment section with the heading, 'Ethics of Artificial Intelligence', where "Four leading researchers share their concerns for reducing societal risks from intelligent machines". It is written colloquially, but obviously targets the specific audience interested in machine intelligence. The subsection, 'Books & Arts' contains reviews of seven books, two of these in greater depth. In the last subsection, 'Correspondence', nature publishes communications, mostly e-mails, from readers to the magazine. Here content varies from personal viewpoints on previous findings published in nature, to criticisms of the same. The purpose of 'Comment' is then to personify the journal issue, and allow readers to feel a sort-of empathy for 'Nature'.

The section 'Specials – Insight' (54 pages) considers the progress of machine intelligence and robotics. The term machine intelligence is often considered synonymous with its subsidiary, artificial intelligence (A.I.), but by nature is a broader subject. It begins with two articles on machine intelligence, followed by an article covering a more specific case of A.I., then two articles on robotics; finally it concludes with an article that covers the application of these fields to a larger audience. This final review article, 'From evolutionary computation to the evolution of things' relays the importance of machine learning and how it has solved problems in fields to which it is not strictly related[7]. This gives the review section meaningful closure.

The 'Research' section (74 pages) leads with 'News & Views', wherein nature's writing staff lightly elaborate on the background of chosen articles and letters. Following the 'News and Views' subsection is the 'Specials', 'Insight' section (again for clarification refer to Figure 1a). While this may seem confusing out of context, within the physical publication it flows elegantly. The reason for this choice of arrangement, we assume, is because

it is not original research, like the following section, and it is appropriate that the publication should close with the core content, its letters and articles.

In the following subsections, 'Articles' and 'Letters', original research articles cover the breadth of the scientific spectrum; biology, astronomy, measurement, environment, and on. It is important to comment on the distinction 'Nature' itself places on these two forms of communication[6],

> "Articles are original reports whose conclusions represent a substantial advance in understanding of an important problem and have immediate, far-reaching implications."
>
> "Letters are short reports of original research focused on an outstanding finding whose importance means that it will be of interest to scientists in other fields."

Apart from being longer than letters, 'Articles', tend to be of greater importance or at least have some content that needs to be shared quickly, so that another member of the respective community might apply the presented information. 'Letters', on the other hand, are more broadly of use to other scientific communities, and are therefore written to a wider readership. Another interesting sub-note on this distinction is the difference between how each of these types of writings are prefaced – either with a summary for articles (which tend to be comparatively long with a suggested 500 words, after an 150 word abstract) – or a targeted brief – for letters (suggested 200 words)[6].

Lastly, the short 'Careers' section (5 pages) closes up the print volume. It starts with a 'Feature' article revealing and describing a unique researcher in the field. 'Q&A' follows, with answers to questions young researchers might be interested in – from the lead investigator of a prestigious lab. The last writing in this issue is an excerpt from 'Dying for Dummies (2020)', which facetiously describes what death might involve in the future. This section, like 'News & Views', gives the journal issue some personality.

In sum, from exploring the structure of the issue as a whole we find discrete elements that aid in understanding the content or guiding the reader to the appropriate articles and sections. We also see the emphasis the editor and journal place on the original research and technical reviews through the shear relative size of their sections compared to the others (see Figure 1b). Next, we will see how the editor and journal address their authors

From the document 'For Authors – Final Submissions', a guide for authors whose manuscript has already been accepted, we draw several conclusions. For one, although 'Nature' has the final say on what is published it highly respects authors opinions and guidance. Regarding the formatting specifically, the editor takes advice on essential layout features and "value<s> clear instructions from authors to help us layout their figures"[9]. 'Nature' also acknowledges its wide readership, and has its subeditors "ensure that it is intelligible"[9], with respect to not only the language used but also to figures and graphics. And lastly, a small but important detail is the role of the corresponding author. The corresponding author has key responsibility to ensure the manuscript comes out as expected by all involved parties but also has small but very significant recognition with respect to the article – provided he/she is recognized as such.

Another important document that covers standards in the industry is 'For Authors – Manuscript Formatting Guide'. This guide gives a detailed outline to authors of how their articles and letters should be formatted – for the first submission to the editor. One item it makes mention of, that couples with the

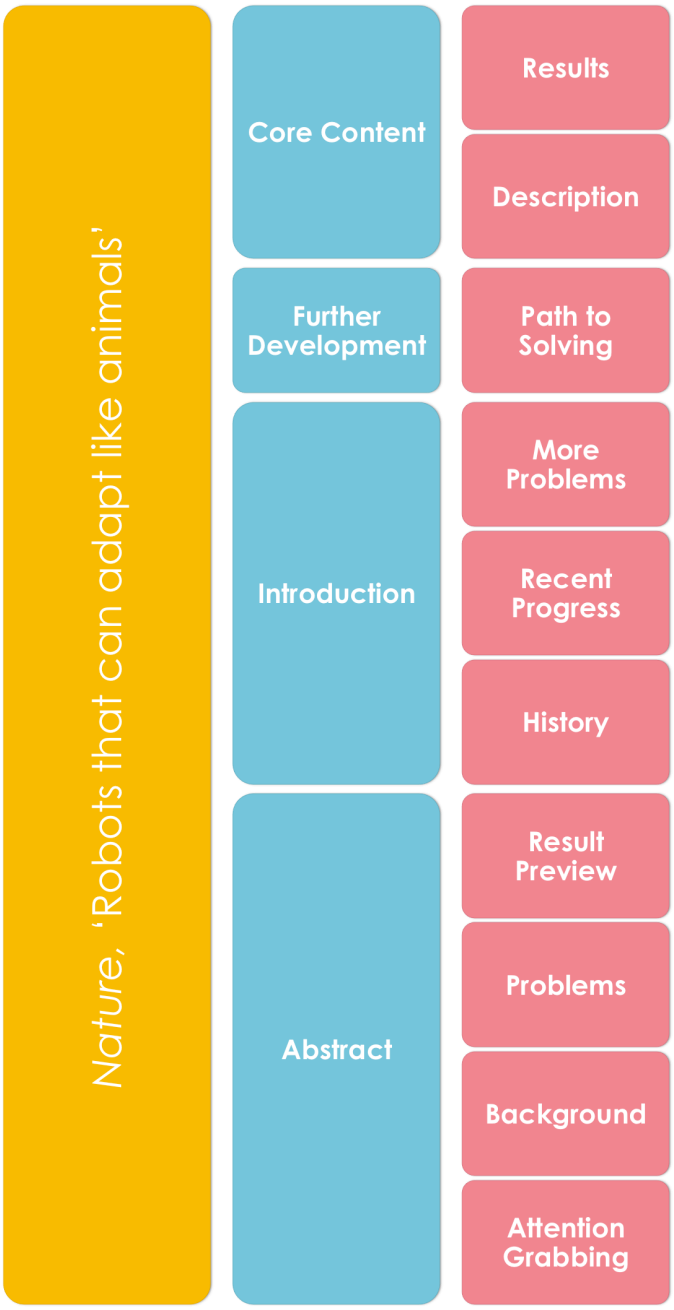

Figure 2 | Analogous representation of the chosen journal 'Letter'. Notice how the introductory content has more subdivision and a wider audience than the later sections, even though it expresses this content in fewer words.

previous articles, is that the 'Nature' is international and that it covers all of the sciences, highlighting that readers may not be native English speakers. Aside from set word counts and other details, it also makes specific points about the Methods section and its contents, "The methods section…should contain all elements necessary to allow interpretation and replication of the results"[6]. The journal's credibility rests on the author's credibility – because of this 'Nature' ensures that readers trust that experimenters carried out research appropriately. The last point drawn from this communication is what 'Nature' accepts as references, apart from the standard, published, peer-reviewed journal article, it also lists "published conference abstracts, numbered patents and preprints on recognized servers" as credible content[6]. These sources of information can also be established as formal communication within the discourse community.

Now, we will apply the structural breakdown methodology to the studied 'Letter'. If we look at 'Robots that can adapt like animals', we see an analogously similar structure to the issue as a whole[8]. The report starts with an easy-to-read and attention grabbing abstract. This summary gives some background to the subject matter, and then presents the problem that the research works to solve. After, it briefly discusses the relevant results and the relevance of the results to larger problems or other fields.

An extensive background follows this abstract; the background covers a brief history, recent progress and some of the problems the field still faces. It also includes references to interesting tangents. We find this section comparable to 'This Week' and 'News in Focus' in the way that it grabs readers' attention with interesting cases and non-technical verbiage.

Next, the report addresses, briefly, how the previously mentioned problems are solved. We find this equivalent to 'News & Views' (of the journal issue). In a similar fashion, the article presents key findings that urge the reader to continue reading – or perhaps peek further in the article for equations or diagrams related to those findings.

The article proceeds with the core content that backs up the authors' initial claims. This includes an in-depth description of the algorithm presented, with relevant symbolic figures that aid in the reader's understanding of the content. Next, the article sums the results and states how they can be applied more broadly, which highlights their importance. As with most of the 'Letters' and 'Articles', the report ends with some areas for further research. We find these elements, which rightly make up the majority of the article, analogous to the 'Specials-Insight' and 'Research' sections due to the specialized subject matter and far-reaching findings.

For a more comprehensive comparison of the studied issue and the presented 'Letter', we have included an analogous figure that represents the structural breakdown of the studied article (see Figure 2).

As a whole we have found that structure of content is very important for comprehension of communicated technical material. We have seen this throughout the selected journal, article and even in the standards 'Nature' explicitly sets for its authors. We also drew parallels between how the specific breakdown of content spans from a larger compilation of information to an original research report.

Received 14 October 2015; accepted (A+) 16 October 2015.

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Supplementary Information is available in the online version of the paper.

Acknowledgements We thank Northeastern University, Suzanne Richard, and Nancy Hong and especially John Gavin for feedback and discussions.

Author Contributions Zane Gavin designed the study, performed the experiments and analyzed the results, and also wrote the paper.

Author Information Reprints and permissions information is available at zanecgavin.github.io. The authors declare no competing financial interests. Readers are welcome to comment on the online version of the paper. Correspondence and requests for materials should be addressed to Z.C.G.. (gavin.z@husky.neu.edu).

Methods Diagrams were constructed in powerpoint. Analysis was conducted in Excel. This paper was modeled after 'Robots that can adapt like animals'.