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Scientific Knowledge versus Encyclopaedic Knowledge: Which Aspects of Science to Present inside Encyclopaedias?

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Introduction

The general public regularly turns to encyclopaedias in the search for knowledge (e.g. Collison 1964; Kister 1986; Katz 1991) to the extent that encyclopaedias are typically perceived as "the ultimate reference". The public not only expects encyclopaedias to have answers on everything but also considers these answers as the unquestionable truth. Concerns, however, can be raised regarding this ideal perception of encyclopaedias since the knowledge presented within these works comes from a process which is far from perfect (e.g. Popper 1963; Latour 1987; Ziman 1998). After all, science advances from identifying gaps in existing knowledge or from the questioning and refuting past theories. The methods adopted to answer research questions can be fraught with technical limitations, human mistakes and other uncontrollable parameters. Then, the findings obtained can be incomplete or contradictory. Finally, it takes a complex process of validation within the scientific community before these findings can reach the status of established facts which are ultimately incorporated into the corpus of scientific knowledge. Consequently, there are always parts of scientific knowledge which are still uncertain or controversial, hence questionable.

The conflict between the two types of knowledge causes a conundrum for encyclopaedia authors. On the one hand, there is the definitive nature of encyclopaedic knowledge as expected or perceived by the general public whereas, on the other hand, there is the tentative nature of scientific knowledge as dictated by the realities of scientific process. There seems to be no empirical research on this issue yet; hence the current paper which investigates the extent to which encyclopaedias should reflect the tentative nature of scientific knowledge, if at all.

In order to explore these conflicting aspects of knowledge, this paper starts with a review of the literature on the perceived role of encyclopaedias in science communication and considers past encyclopaedia editors' recommendations regarding the best ways to present science. After an overview of the methodology adopted for the survey conducted with contemporary encyclopaedia authors and a description of the participating authors, a detailed account of these authors' views on the nature of scientific knowledge and on the presentation of scientific knowledge within encyclopaedias is provided. Additionally, the authors' comments on the type of information to be included in encyclopaedia articles, as well as on the role of encyclopaedias, are discussed, together with the intended impacts on the readers. Through a comparison of the views of contemporary authors with the recommendations found in the literature, this paper makes further recommendations for future studies in this emergent field.

The Recommendations from the literature

Scholarship with in-depth reflections on how to develop encyclopaedias are relatively scarce — particularly those written by people with extended experience working in the industry. Regarding the presentation of science within encyclopaedias in general and the

type of information to be included in particular, brief mentions are sometimes found in papers which focus on other aspects of encyclopaedias. For example, Robert McHenry offered some relevant reflections in his interview with the *Educom Review* (1997) describing his perspectives on the future of *Encyclopaedia Britannica*. Another example is the article written by Featherstone and Vern (2006) where the general tendencies of past encyclopaedias to impose an international version of knowledge are criticised in order to give more room for the preservation of local knowledge. Exceptionally, an entire issue of the *American Behavioral Scientist* — the first issue of Volume 6 — was dedicated to the definition of the "ideal" modern encyclopaedia. Although this special issue was published fifty years ago, its content is pertinent here because it offers a very clear snapshot of the vision of various editors from prestigious encyclopaedias. Moreover, many of the views expressed in this issue are reiterated in subsequent papers.

The editors who wrote in the *American Behavioral Scientist* generally agreed that encyclopaedias should reflect the nature of the scientific process; yet the type of information to be provided varied depending on the editors' understanding of the role of encyclopaedias. Starting with the paper by Livio C. Stecchini (1962), it is reported that most encyclopaedias tend to present the most established knowledge which reflects the consensus within the scientific community. Stecchini however believed that, for an effective education, the public needs to learn that

> the truth of things as well as the things themselves, are changing entities, unfolding themselves throughout a process of differentiation, elimination and repair (Stecchini 1962, p.5).

Stecchini therefore advocated that the historical evolution of scientific knowledge and the views of the various factions debating this knowledge should be presented. Similarly, W. T. Couch (1962)

deplored that science is generally not presented as "historical" rather as "bodies of principles or laws known at the time", a situation which prevents the public learning from recurring patterns and past mistakes. Couch further argued that knowing the history of facts and ideas allows the public to assess the relative importance of these latter (by knowing how wide the acceptance is within the scientific community and how long there has been a consensus, for instance). Another editor who claimed that education should prevail within encyclopaedias was Charles Van Doren. According to him, the objective is not to provide piles of factual information, but rather a comprehensive synthesis of a topic which, if needed for a general understanding, can include a historical overview, an analysis of the scientific methods used, and a discussion of the convergent and controversial findings. The provision of a synthetic article was also seen as very important by Francis X. Sutton (1962); yet, this synthesis was not expected to be comprehensive as encyclopaedias should only be considered as starting points in the search for knowledge. Sutton also deplored that many of the encyclopaedia authors who had a strong sense of the growing and changing nature of knowledge often presumed that encyclopaedias were 'not the sort of object that readily accords with such sentiments' (Sutton 1962, p.29). Sutton added, however, that on selected topics (those still poor in established scientific facts, for instance) some authors conceded that encyclopaedias could offer a valuable display of the advance of science, become a historical marker and offer a tool for the assessment of science.

Jacques Barzun (1962), Harry S. Ashmore (1962), and David L. Sills (1962) took a slightly different approach by insisting that encyclopaedias were primarily a work of reference and secondarily an educational tool to promote understanding. Both Barzun and Ashmore claimed that the content provided should not only answer questions

from the general public but should also allow the scientific community to assess the value of existing encyclopaedia articles. In both case, the idea is to avoid offending readers with too simplistic content. Among the information which should accompany scientific facts, Barzun listed brief descriptions of the method of enquiry and clear delimitations of the status of knowledge. In addition, Sills added the need for an analytical and conceptual coverage — defined as 'ways to think about a topic' (Sills 1962, pp.31-32) — and the provision of selected bibliographies where encyclopaedia users could find more extensive coverage and current data. Then, noting the increased inter-disciplinary nature of the social sciences, Sills recommended that encyclopaedias should reflect that reality. Clearly, such an approach to science communication supports the idea that encyclopaedias are 'a continuing link between the [scientific] and lay worlds' (Ashmore 1962, p.15).

Regarding the presentation of knowledge that is still debated within the scientific community in particular, Barzun (1962, p.10) suggested that, in order to avoid partisanship, 'articles must conclude with a section in which the surviving issues are stated and the chief rival views summarised.' At the same time, encyclopaedia authors should avoid 'lukewarm assertions of opposite ideas at head and tail' but communicate one clear view on the topic at hand (Barzun 1962, p.10). Here Ashmore slightly disagreed with Barzun as he claimed that although most effort should be done to represent all sides with the strictest impartiality, sometimes, the easiest way to deal with scientific controversies is to 'leave them out altogether' (Ashmore 1962, p.17).

For Carl F. Stover (1962), the focus was on the use of encyclopaedias as tools to preserve the intellectual heritage of the past in order to guide the actions of present and future generations. So, beyond a memorative role, encyclopaedias should be responsive to the gradual changes in knowledge and culture. Stover strongly warned

against 'undue conservatism and historicism' whereby only facts which are safe and certain beyond question should be presented (Stover 1962, p.36). Moreover, with the spread of rationality within modern societies, the limits of knowledge should be readily acknowledged and encyclopaedias should be written in a way that 'partial truths reveal their distortions, their incompleteness, their missing parts, the places in which there is just plain ignorance' (Stover 1962, p.37). Finally, it is from such knowledge that encyclopaedias are expected to provide insights into potential trends of thought which may or may not be confirmed in the future.

The Survey Conducted with Contemporary Encyclopaedia Authors

There are many branches of science which are rapidly evolving and which have innumerable scientific uncertainties and controversies. The study presented in this paper focuses on the communication of climate change because of the importance of this science in modern societies. Both the general public and the policy makers need help to deal with the fragmentary and contradictory information on climate change that the media and the scientific community are bombarding them with; hence the need for an appropriate communication of this science within encyclopaedias.

The opinions of encyclopaedia authors involved in the writing of articles on climate change topics were surveyed. A combination of a purposive and convenience sampling was adopted in the selection of encyclopaedias targeted for this study. I chose titles which were published in 2008 — exactly one year after the publication of the highly talked-about *Fourth Assessment Report* from the Intergovernmental Panel on Climate Change. I made sure that encyclopaedias of diverse format were sampled. Ultimately, the following five encyclopaedias were targeted: the *Encyclopaedia of Global*

Warming and Climate Change; The Oxford Companion to Global Change; the *Encyclopaedia of Earth; Encyclopaedia Britannica;* and *Wikipedia*. For the first two titles, all authors were considered as potential participants whereas, for the other three titles, the choice was narrowed down (Table 1). In the case of the *Encyclopaedia of Earth*, only authors of articles within *The Climate Change Collection* were targeted. In the case of *Encyclopaedia Britannica*, only authors of articles on climate change were targeted. In the case of *Wikipedia*, considering the extremely high number of authors and their unknown level of expertise, only the most active one who contributed to articles within the *Global Warming Category*, the *Climate Change Category*, and the *Index of Climate Change Articles* were targeted. Such a choice was made possible from the statistical data available under the Page History associated with each *Wikipedia* article.

A one-page survey questionnaire was emailed to the targeted authors as part of a larger PhD project. Only the results from the first part of the questionnaire (see Appendix 1) were relevant to the current paper and discussed here. Authors were first invited to provide their name and institution, to identify the encyclopaedia they had contributed to, to name one of their articles they wanted to reflect on, and to indicate their level of expertise regarding the topic of their article. The first questions enquired through multiple-choice questions about the authors' views on the nature of knowledge within the topic of their article and on the way in which that knowledge should be presented inside encyclopaedia. One open-ended question invited the authors to comment on the reasons they think knowledge should be presented in the way they suggested earlier. To follow-up on that last question, another open-ended question enquired about the objectives that the authors were trying to achieve through their article and the effect they were expecting to have on their readers. In May and June

2009, the questionnaire was emailed to the targeted encyclopaedia authors whose email addresses were obtained from the Internet (for example, from institutional websites or from personal blogs). In the case of *Wikipedia* where authors often contributed anonymously using pseudonyms, contact was achieved through the authors' Userpages (by using the integrated email function or by leaving messages on the Talkpage). The authors were given one month to return the filled questionnaire. After an initial analysis of the survey results, the preliminary report was sent to the participating authors who were then invited to make comment and to particularly get in touch if they thought their answers were overlooked or misinterpreted.

The Authors Participating in the Survey

Out of the 833 authors who contributed to the encyclopaedia articles mentioned in the previous section, 717 were contacted by email, of whom 75 responded and filled the survey questionnaire. This corresponds to a response rate of 10.46 percent. The distribution of the participating authors across the five encyclopaedias is detailed in Table 1. In comparison with the distribution of the 833 authors in targeted population, authors from the *Encyclopaedia of Global Warming and Climate Change* were over-represented whereas those from *Britannica* and *Wikipedia* were under-represented. However, this unbalance had limited affect on the final findings of the study as the responses provided by the participants did not seem to vary according to the encyclopaedia.

The participating authors came from diverse backgrounds. When asked to indicate where they worked, 53 participants entered the name of academic institutions, 10 worked for governmental agencies and research institutions, 3 worked for non-governmental organizations and private companies, 3 were independent consultants whereas 7 did not disclose information regarding their working place. Judging from the

information found on the Internet about these institutions, the most represented country was the USA (n=41 participants), followed by the UK (n=8 participants), Australia (n=6 participants), and Canada (n=4 participants). There were also participants from Germany, France, Italy, Switzerland, New Zealand, India, and Hong-Kong (one participant from each country). Finally, when the participants describe themselves in relation to the topic of the articles they had contributed to and chosen to reflect on for this study, 28 of them said they were definitely experts on the topic. By contrast, 25 participants said that they worked on the topic although they did not consider themselves as experts, whereas the remaining 19 participants said that they were only interested or passionate about it.

Encyclopaedia type	Encyclopaedia format	Encyclopaedias considered	Articles targeted	Authors targeted	Authors contacted	Authors participating
Specialised encyclopaedia	printed	*Encyclopaedia of Global Warming and Climate Change* (by SAGE)	All 733 articles	All 180 authors	164 authors	29 authors
	printed, online (oxfordreference.com)	*The Oxford Companion to Global Change* (by Oxford University Press)	All 219 articles	All 156 authors	150 authors	13 authors
	online (eoearth.org)	*Encyclopaedia of Earth* (by the Environmental Information Coalition and the National Council for Science and the Environment)	Only the 99 completed articles* from the *Climate Change Collection*	All 78 authors	77 authors	7 authors
Generic encyclopaedia	printed, electronic, online (britannica.com)	*Encyclopaedia Britannica* (by Encyclopaedia Britannica, Inc.)	Only the 27 articles* pertaining to global warming and climate change	All 55 authors of the targeted articles	38 authors	9 authors
	online (wikipedia.org)	*Wikipedia* (by Wikimedia Foundation, Inc.)	Only the 282 articles* listed under the *Global Warming Category*, the *Climate Change Category*, and the *Index of Climate Change Articles*	All 364 authors who contributed to 10 or more articles or who contributed to fewer than 10 articles but whose average contribution exceeded 10 edits per article	288 authors	17 authors
5 encyclopaedias			**1360 articles**	**833 authors**	**717 authors**	**75 authors**

* as of 31 January 2009

Table 1. Encyclopaedias, articles and authors considered in the study

Authors' Views on the Nature of Scientific Knowledge

As expected in the case of a scientific topic — more particularly in a controversial topic such as climate change — the knowledge within the articles chosen by the participating authors was considered to be highly intricate (Figure 1). More specifically, this knowledge was more often considered to be more complex with many interrelated concepts (n=49 participants) than simple and factual (n=22 participants), more evolving (n=59 participants) than stable (n=17 participants), and more tentative (n=17 participants) than absolute (n=4 participants). Similarly, this knowledge was more often considered to have multiple versions (n=16 participants) than only single one (n=4 participants).

Several participants provided additional comments regarding the nature of knowledge around the topic of their article. A couple of them insisted on the complexity of this knowledge. More specifically, one participant ($A40_{W}$) highlighted the inextricable combination of scientific and political questions within the article whereas another participant ($A42_{W}$) deplored that politics [and] religion are 'dressed up as science' to form — what he denounced as — 'pseudo-science pretending to be science'. Other participants commented on the tentative and evolving nature of knowledge. For instance, one participant ($A67_{W}$) talked about 'a theoretical and speculative' knowledge. Another participant ($A69_{SAGE}$) indicated that his article is in an 'emerging field of research' with the measurements 'not yet completely defined' and the knowledge 'not yet completely established.' Another participant ($A38_{W}$) explained that, 'as with most science, there is a very stable core, with deeper and more detailed understanding still evolving.' Similarly, one participant ($A48_{SAGE}$) wrote about his topic that 'the overall concept […] and some of its impacts are well understood. However, the physical

mechanisms behind it [are] much debated.' In one case, the participant ($A71_{EB}$) even indicated that that the consensus around his topic 'changes frequently'. The rest of this paper discusses which aspects of this scientific knowledge are to be presented inside encyclopaedias.

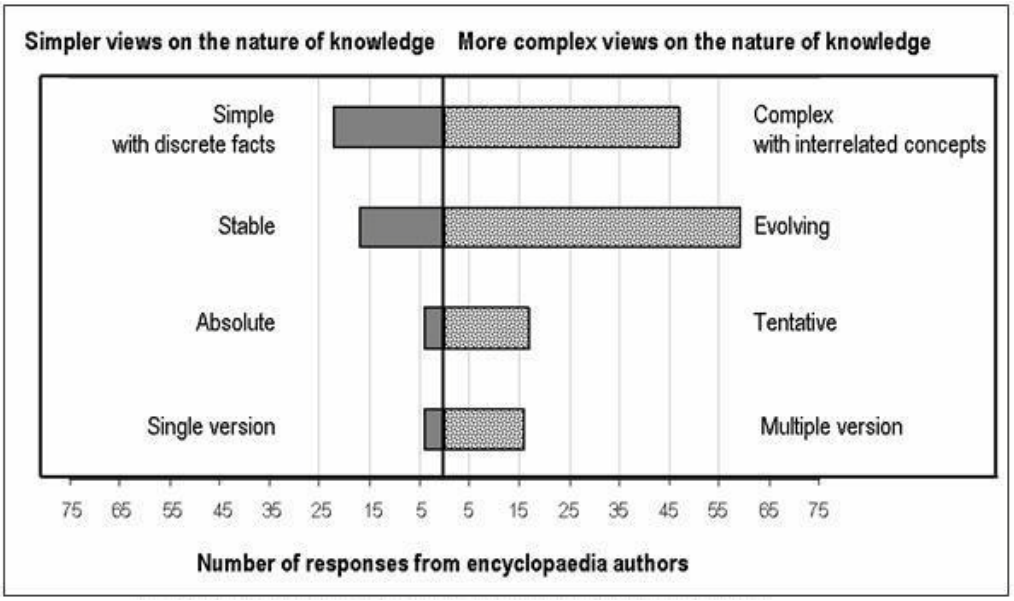

Figure 1. The authors' views on the nature of scientific knowledge

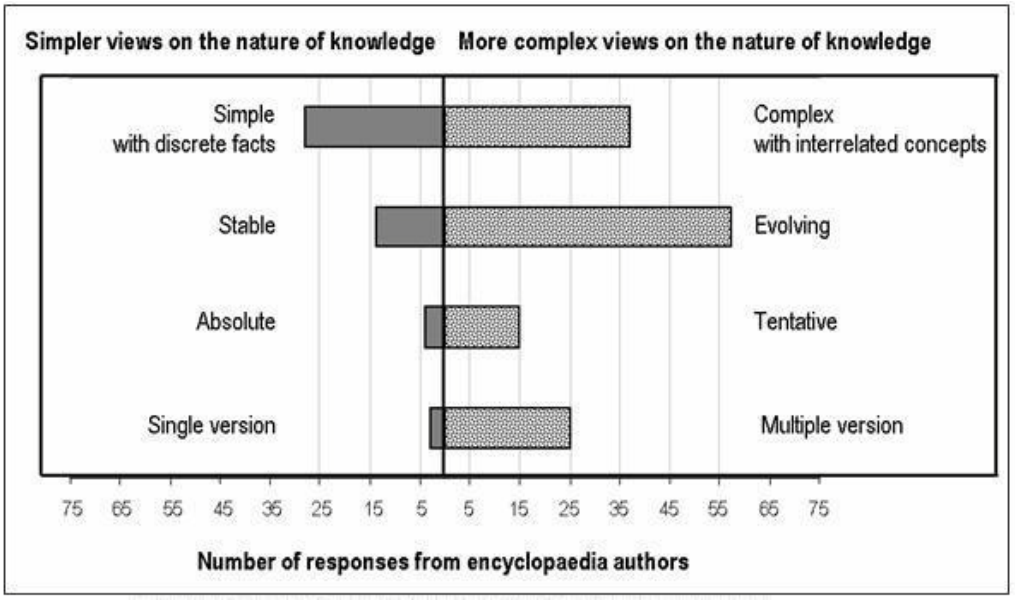

Figure 2. The authors' views on the presentation of scientific knowledge inside encyclopaedias

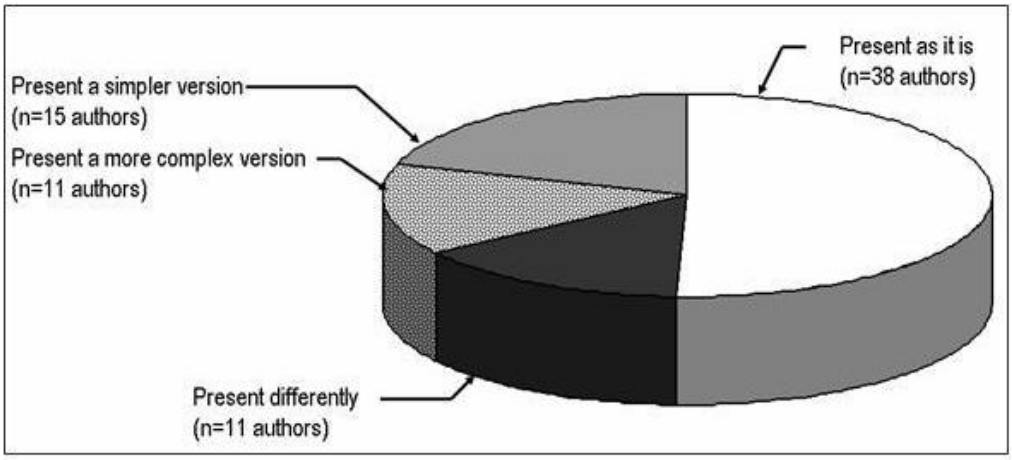

Figure 3. The change from scientific knowledge to encyclopaedic knowledge

Authors' Views on the Presentation of Scientific Knowledge inside Encyclopaedias

When the participating authors were asked in which way they thought the scientific knowledge on the topic of their chosen article should be presented inside encyclopaedia, they generally indicated that this knowledge was also expected to appear intricate (Figure 2). It should be presented more as complex with interrelated concepts (n=37 participants), evolving (n=57 participants), tentative (n=15 participants), with multiple versions and perspectives (n=25 participants) rather than simple with discrete facts (n=28 participants), stable (n=14 participants), absolute (n=4 participants) and in a single version with a single perspective (n=3 participants). One of the participants ($A67_{W}$) also commented that encyclopaedic knowledge should be 'theoretical and speculative' whereas another participant ($A4_{OUP}$) insisted on its nature as 'a logic synthesis.'

Unlike the various editors mentioned in the literature review, however, the participating authors did not always consider that the nature of scientific knowledge should be presented "as it is" (Figure 3). In fact, only 38 participants — 51 per cent of them — provided

unchanging answers when assessing the nature of scientific knowledge and when talking about the presentation of this knowledge inside encyclopaedias. Here, as many as 26 participants were dealing with topics which were considered neither simple, stable, absolute, nor presented in a single version, thereby indicating that encyclopaedia authors did not shy away from complexity within their articles. By contrast, 15 participants — 20 per cent of them — considered the topic of their article to be too complex with interrelated concepts and/or with evolving knowledge and wanted encyclopaedias to present a simplified version of this knowledge. Surprisingly, 11 participants (15 per cent) took the exact opposite approach and preferred to present various versions of scientific knowledge with more complex and interrelated concepts, or to present scientific knowledge as more evolving and more tentative than it was in reality. Finally, the remaining 11 participants wanted to write their article in a way which cannot directly be compared with their perception of the nature of scientific knowledge. For example, once the nature of knowledge on a specific topic was considered as complex with interrelated concepts; yet the participant ($A32_{SAGE}$) wanted this knowledge to be presented as simple with discrete facts, stable but available in multiple versions.

Authors' Views on the Type of Information to be Included inside Encyclopaedias

At different places within the filled questionnaires, some participants made some clear statements regarding the type of information to be included inside encyclopaedias. Because of constraints in space within encyclopaedias, these participants often mentioned that the information to present has to be carefully selected. Ten participants indicated that the focus should be on basic facts — also referred to as 'the key elements' ($A9_{OUP}$) or 'the essential facts' ($A56_{OUP}$).

The popularity among the general public is sometimes taken into consideration in the choice of information to present. Two participants made sure to cover 'the points increasingly talked about' ($A19_{EOE}$) whereas three authors admitted that they intentionally emphasised less known points. In the last case, one participant ($A36_{W}$) particularly made sure to highlight 'important but relatively poorly understood [points].' By contrast, four other participants insisted that both popular and less popular points have to be covered inside encyclopaedia articles, even if not necessarily in an equal fashion. Similarly, participants also seemed to pay particular attention in the currency of the information to include in their articles: they 'looked for the most recent non technical articles and reports' ($A69_{SAGE}$), they 'endeavoured to bring new results from the state of the art in the field' ($A46_{W}$), they tried 'to spread the recent news' ($A75_{W}$), etc.

There were four participants who mentioned the need to supplement the facts provided with some contextual information. One participant in particular ($A24_{SAGE}$) selected facts relative to the reality of the local and the larger scale and added 'the context in which those facts must be interpreted'. Three participants ($A16_{EOE}$, $A27_{EB}$, $A68_{OUP}$) explicitly said that providing a historical background was particularly important for the definition of the context of a specific topic. Their approach was, however, different from providing a historical evolution of science as discussed by Stecchini, Couch and Van Doren. Indeed, none of the participating authors seemed to think that going through the history of facts and ideas was appropriate for their encyclopaedia articles, except — maybe — in the case of the participants who indicated that 'we are still learning about the topic, it is a young field of study' ($A21_{SAGE}$).and that

'knowledge is not yet completely established […] this is an emerging field of research' ($A69_{SAGE}$).

The importance of presenting the mainstream views — also defined as 'the data that is most founded and has the greatest support amongst scientists' ($A32_{SAGE}$) or 'the most up-to-date information that was the least controversial' ($A48_{SAGE}$) — was mentioned a couple of times. Yet, not all participants thought that encyclopaedias should be limited to these, particularly in the case of topics with scientific controversies. For instance, one participant wrote:

> The article has to, as far as possible, reflect the mainstream view on the subject, note any significant minority views, and inform the non-technical reader of the relative strengths of these cases ($A41_{W}$).

This presentation of 'the relative strengths of [various] cases' — a key task in what was often referred to as 'a balanced coverage' — was lengthily discussed during the survey. Actually, the participating authors often provided very specific instructions on how to proceed, such as the reference to 'competent scientific authorities' ($A73_{W}$) and other 'reliable sources' ($A74_{W}$) including the scientific literature.

Regarding the representation of the inter-disciplinary aspect of science, two participants seemed to follow Sill's views. Although the first participant ($A62_{SAGE}$) acknowledged that he wrote his article mostly from the discipline he is best acquainted with, he also tried to 'highlight that there are other ways of approaching the topic.' The other participant ($A64_{SAGE}$) even claimed that his main goal was to write an article 'that will identify to the readers the various disciplines that combine to enhance our understanding of [the topic].'

Finally, in line with Stover's recommendations, three participants deliberately tried to push the limits of existing knowledge for future outlooks. Indeed, one participant ($A25_{EB}$) tried

'to interpret systematically collected observational data' whereas another participant ($A58_{SAGE}$) attempted 'to summarize and specify the known… and to offer informed speculation on where the situation is heading.' Similarly, the last participant ($A24_{SAGE}$) tried to discuss the 'possible/probable consequences of [specific aspects of climate change].'

It should be noted that there were other types of information recommended in previous literature which seemed to be totally ignored by the authors surveyed here. Although the existence of scientific uncertainties and controversies were widely acknowledged and regularly mentioned by encyclopaedia authors in their articles, there is no mention of past errors — which may prevent society learning from these latter as discussed by Stover. None of the participants provided an introduction to 'the process of differentiation, elimination and repair' followed by science in general — as mentioned by Stechinni. But even when discussing specific topics, participants also appeared reluctant to talk about the methods of enquiry followed by researchers — as recommended by Ashmore — or to guide the reader towards understanding 'how to think about' these topics — as recommended by Sills.

Authors' Views on the Role of Encyclopaedias

While answering the survey questionnaire — particularly questions 3 and 4 (see Appendix 1) — many participating authors discussed their views on the roles that encyclopaedias play for the general public and for the community of researchers. Here, some participants identified more than one role played by encyclopaedias.

Here, encyclopaedias were primarily viewed as reference works. Indeed, providing information to the public appeared to be the main concern for as many as 51 participants. Encyclopaedias were explicitly defined as 'a compendium of knowledge' ($A66_{EOE}$), 'a

reference in a large printed, permanent format that is nevertheless just a snapshot of knowledge' ($A58_{SAGE}$) or 'a place where people could get a quick outline of [various hypotheses]' ($A39_{W}$). In their answers, participants used expressions such as 'introduce' (e.g. $A9_{OUP}$), 'communicate' (e.g. $A5_{OUP}$), 'describe' (e.g. $A2_{SAGE}$), 'present' (e.g. $A30_{EB}$), 'report on' (e.g. $A12_{W}$), 'inform on' (e.g. $A61_{EOE}$), 'tell about' (e.g. $A54_{EB}$), 'lay out the facts on' (e.g. $A42_{W}$) 'provide information on' (e.g. $A35_{W}$), or 'pass along the knowledge of' (e.g. $A62_{SAGE}$) specific aspects of the topic covered in the articles of their choice. Yet, at least in some fields of climate change, it is sometimes recognised that encyclopaedias may have 'no convenient / certain answer to provide the readers' ($A13_{SAGE}$). Moreover, there were a few times when participants admitted using their articles to advocate specific positions within the climate change debate. See for example the following quotes:

> I want people to know that more is known about climate change than many people believe and the effects of climate change are tangible ($A15_{SAGE}$);
> I was hoping readers would understand that climate change IS already having an impact ($A58_{SAGE}$);
> [I wanted to] make it clear that many 'sceptics' rely, implicitly or explicitly, on conspiracy-theoretic reasoning. I hope readers will recognise this and apply real scepticism to alleged 'sceptics' ($A37_{W}$).

The role of encyclopaedias as educational materials was mentioned secondarily. At least 21 participants used the verb 'understand' — as in the expression 'I want the reader to understand…' — or the noun 'understanding' — as in 'I want the reader to get an understanding of…' There were also seven cases where encyclopaedias were clearly expected to provide a comprehensive synthesis or — in the words of the participants — 'an overview' (e.g. $A66_{EOE}$), 'a summary' (e.g. $A65_{OUP}$), 'a synopsis' (e.g. $A59_{SAGE}$) or 'a snapshot' ($A2_{SAGE}$) of

specific topics. Finally, the educational value of encyclopaedias was also hinted when one participant ($A63_{SAGE}$) claimed that encyclopaedias 'should be a taster for people, not the "last word" ' or when another participant ($A28_{W}$) talked about them as texts that should provide 'a general background on subjects with references for in-depth reading.' Four participants expressed the desire to dispel myths and misconceptions among the general public (e.g. $A13_{SAGE)}$ and to establish 'the truth' (e.g. $A42_{W}$). There were also participants who condemned and counter-acted erroneous information communicated by politicians (e.g. $A72_{W}$), by the corporate world (e.g. $A44_{W}$) and by the media (e.g. e.g. $A38_{W}$). The quotes from the author below also illustrate this last point:

> The fact that present uncertainty is not as great as often portrayed in popular media and that any controversy is perhaps more political than scientific is what we wanted our encyclopedia article to capture ($A58_{SAGE}$).

Finally, the educational role of encyclopaedia also includes the development of the critical thinking of the readers which should be able 'to look at the issue of climate change objectively rather than react emotionally under the influence of popular press' ($A15_{SAGE}$), to critically analyse the information provided (e.g. $A6_{SAGE}$), to seek alternative ways of investigating the topic (e.g. $A62_{SAGE}$), and even to continue researching the topic beyond encyclopaedia articles (e.g. $A30_{EB}$).

Regarding the use of encyclopaedias to define future actions, the case of the research community and the case of society in general were discussed in different terms. In the case of researchers, encyclopaedias could be used to provide 'starting points' ($A16_{EOE}$) or a 'course of direction for future research' ($A66_{EOE}$) as mentioned by three participants. In the case of society in general, a handful of

participants recognized the use of encyclopaedias to promote societal changes by encouraging the readers into action. For instance, participants tried 'to engage others in the plight of these small island nations whose future is at risk due largely to the actions of others' ($A29_{SAGE}$) or 'to act to prevent climate change' ($A45_{EOE}$). In the case of policy-makers in particular, encyclopaedias could be used 'to promote a deeper and more critical view on these [approaches]… for a better usage of those at policy-making level' ($A6_{SAGE}$) and 'for informed policy choices' ($A40_{W}$).

Parameters influencing the communication of science inside encyclopaedias

During this survey, neither the type and format of encyclopaedia, nor the profile and expertise of encyclopaedia authors appeared to have any influence on the approach adopted for the communication of science. I, however, suppose that on-going changes in modern encyclopaedia making — particularly the advances in online publishing — could be influential. For instance, because online encyclopaedias generally have more space than the printed ones, it is possible that more scientific information can be included there. Also, because of the increasing number of non-expert authors contributing to user-generated projects such as *Wikipedia*, it is possible that gradually more effort will be dedicated to the accumulation of facts rather than to the in-depth discussion of scientific processes. Even if my suppositions are correct, the changes in encyclopaedia making are probably only slowly influenced by the industry; hence the non-conclusive findings during this survey.

Compared to the findings from previous literature, the correlation between the presentation of scientific knowledge, the choice of the type of information to be included within encyclopaedia articles, and the perceived role of encyclopaedias

appeared less clear from the findings of the survey. It is however possible that, as discussed by Barzun, the participating authors were influenced by their perception of their readers — the level of readership, the information needs, etc. This last point is hinted when participants stated that they took into consideration local and global contexts as well as the popularity of existing information when selecting content for their articles. Yet the survey did not provide enough data to further corroborate this point. It is equally possible that the communication of science within encyclopaedias was dictated by some editorial policies within specific encyclopaedias or by the writing style of individual authors, however testing these parameters goes beyond the scope of this exploratory study.

Conclusion

Although previous literature clearly indicated that encyclopaedias should present science with all its complexity and sometimes questionable aspects — thereby contradicting the general public's perception of the nature of encyclopaedias — this survey with contemporary authors offers a more intricate picture of encyclopaedia development. The participating authors adopted a wide range of approaches to the presentation of scientific knowledge within encyclopaedias and to the choice of scientific information to include in their articles. These participants also identified many more roles for encyclopaedias than ever described before.

From an educational point of view, these changes in encyclopaedia making could have both advantages and disadvantages. For instance, the presentation of a simplified version of scientific knowledge could succeed in introducing a new topic to the novice information seeker but could fail to develop the critical thinking of the advanced learner and could even antagonise the experts in the area. Also, there could be topics where the general public does not

need to know the details of science building. Exception could however be made in the case of topics at the heart of public policies where a critical understanding of scientific facts is required because of their impact on key areas for society such as health, economy and development. Considering these points, it might be more effective for science communicators to increase the effort towards the development of specialised encyclopaedias, which could be tailored to a very specific audience and to the type of topics covered. In fact, the publication of specialised encyclopaedias online could be even more effective because of the relative flexibility in the amount of space available, a point that science communicators should readily take advantage of.

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Appendix: Excerpt from the Survey Questionnaire Used

- Your name:
- Your institution:
- For which encyclopaedia(s) have you written articles on climate change?
- Please choose ONE of YOUR articles on climate change to reflect on and specify:
- How would you describe yourself in relation to the topic of this article**?**
  (Tick as many as apply)

☐ I am interested/passionate about this topic
☐ I have worked on this
☐ I am an expert on this

1. How would you evaluate the nature of knowledge in the topic of the article mentioned above? *(Tick as many as apply)*

☐ It can be considered as simple and discrete facts
☐ It can be considered as complex and interrelated concepts

☐ It can be considered as stable knowledge
☐ It can be considered as evolving knowledge

☐ It can be considered as absolute knowledge
☐ It can be considered as tentative knowledge

☐ There is one version of knowledge
☐ There are various versions of knowledge ☐ Other *(Specify)*:

2. How do you think that knowledge needs to be presented in the encyclopaedia article? *(Tick as many as apply)*

☐ It needs to be presented as simple and discrete facts
☐ It needs to be presented as complex and interrelated concepts

☐ It needs to be presented as stable knowledge
☐ It needs to be presented as evolving knowledge

☐ It needs to be presented as absolute knowledge
☐ It needs to be presented as tentative knowledge

☐ Only one version of knowledge needs to be presented
☐ Various versions of knowledge need to be presented ☐ Other *(Specify)*:

***3. Why* do you think knowledge in encyclopaedia article should be presented in that way?**

4. What were you trying to achieve through your article and what effect do you hope it will have on your readers?