Argumentative practices and patterns in debating climate change on Twitter

Purpose: The purpose of the paper is to investigate practices of argumentation on Twitter discussions about climate change.

Design/methodology/approach: Conversational threads were collected from the Twitter API. Fundamental concepts from argumentation theory and linking practices were operationalised through a coding schema for content analysis. Tweets were analysed in the context of the discussions and coded according to their argumentative approach, interaction type and argumentation stage. Linked and embedded sources were analysed in order to find how they were used in arguments, the plausibility and soundness of the message, the consistency and trustworthiness of the linked source and its adequacy with the target audience.

Findings: Among the interactions between arguers, we found five typical practices and several patterns involving the dynamics of the conversations, the strategy of the argumentation, and the linking practices. Although the rhetorical approach was prominent, agreement was rarely achieved. The arguers used a variety of sources to justify or support their positions, often embedding non-textual content. These linking practices, together with the strategy adopted and the topics discussed, suggest the involvement of a multiple audience engaged in discussing *ad lib* scientific artefacts, topics and outputs.

Originality: While Twitter has been the focus for many research papers, the conversational threads have been given little attention so far. With the Twitter API making conversations more accessible for research, this paper does not only give insight into multiple audience group argumentation dynamics, but also provides a method to study the conversations from an argumentation theory perspective.

Keywords: argumentation practices, argumentation patterns, argumentation theory, linking practices, climate change, Twitter conversations

Article classification: Research paper.

1. Introduction

Social media data makes it possible to analyse dissemination and discussion of scientific artefacts. Studying Twitter conversations referring to scientific artefacts gains insights into the choice and usage of artefacts as part of arguments, and the reactions to arguments based on scientific sources. In order to increase not just the overall understanding of science, but also a more constructive and collaborative

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dialogue between scientists and the general public, it is relevant to define how the scientific artefacts are used in conversations, and more specifically in argumentation. Twitter is a public arena on which different groups meet in a wide range of interactions (Yardi and Boyd, 2010). When members of a group interact with each other, the opinions of the group tend to shift more towards the direction it was already leaning, but convincing arguments representing new ideas may also lead to a group shifting towards those ideas (Sunstein, 2002). Our question is then what happens if an acceptable argument is exposed to and replied to by opponents in a conversational context? While Lorentzen (2021) found some examples of bridging participants establishing some kind of middle ground, polarisation may also increase if people are exposed to opposing viewpoints (e.g. Bail *et al*., 2018).

For information scholars and professionals, Twitter is a platform that is important to understand. The platform "puts scientific research into circulation" and "amplifies news, and is a channel for news distribution" (Niederer, 2019, p. 111), and as such may play an important role in disseminating research findings. With straightforward access to large quantities of data through its API, studying Twitter at a macro-level with automatic tools may be an attractive choice for researchers. Niederer, however, warns about only using a computational analysis as it may be misleading, with a close reading of the content needed for correct interpretation (2019, p. 103). In this article, we move beyond the macro-level to focus on how conversations are played out from the perspective of argumentation theory. The article builds on previous research on understanding the conversations on the platform, rather than the patterns of relationships and the contents of tweets analysed outside their contexts. The purpose is to investigate argumentative approaches and the usage of scientific artefacts in Twitter conversations. Specifically, our aim is to understand the conversations through a series of typical patterns and practices of argumentation.

As a case of study, we selected five conversational threads about climate change, including 1,697 interactions. The choice of climate change as topic is motivated by two main reasons. Firstly, it is arguably of public interest and secondly, it shows clear signs of a political divide on Twitter (e.g. Jang and Hart, 2015). As such, it may also be considered to be played out as a controversy (Marres and Moats, 2015), where communication networks display antagonising groups (Chen *et al*., 2020). Pearce *et al*. (2019) suggest that an increasing amount of research focused on the dynamics within and between groups discussing climate change is needed for two main reasons. The first one is to investigate the role of social media in relation to trust. The second one is to investigate critically into climate imaginary circulated within social media users. Furthermore, they called for analyses of the usage of non-textual elements. Considering this, we selected threads with a higher density of sources, including embedded charts as well as links to scientific articles. Our research questions are:

- What kind of argumentative approach and strategy do arguers use when discussing climate change on Twitter?
- What kind of web-based artefacts are referred-to and how do arguers use them?
- What can be learned from these practices in order to facilitate discussion of scientific topics on Twitter?

To assess the soundness of the argument in the context of the conversation, we developed a coding scheme based on argumentation theory, which was applied to discussions about climate change. The argumentation analysis allows for studying the tweets in relation to the conversational contexts in which they exist, as replies to other tweets in the discussions. Using content analysis based on argumentation theory, the paper contributes with knowledge about real time multiple audience argumentation dynamics and the argumentative use of scientific artefacts on social media. This builds understanding of how conversations evolve through different argumentative stages, and how research is discussed on the platform.

2. Theoretical background

Social media platforms make it possible for a mass audience to engage and participate in debates. Public and private spheres converge to share, exchange, and access information. In order to assess strengths and limitations of these digital tools, it is necessary to understand how communication is usually conducted in such spaces (Housley *et al*., 2018). Approaching conversations *argumentatively* helps in this process, as it allows for a deeper observation of statements and their soundness (van Eemeren *et al*., 1997). Argumentation is defined as "a communicative and interactional act complex aimed at resolving a difference of opinion with the addressee by putting forward a constellation of propositions for which the arguer can be held accountable in order to make the standpoint at issue acceptable to a rational judge who judges reasonably" (van Eemeren, 2018, p. 3). Argumentation involves stages, where the *confrontation stage* represents the meeting of different opinions, the *opening stage* refers to defining starting points, the *argumentation stage* is the actual discussion, and the *concluding stage* represents the ending of the discussion (van Eemeren, 2018, p. 36).

In digital spaces, discussions are characterised by polylogue rather than dialogue (e.g. Goodwin, 2020), with a multiple audience (e.g. Palmieri and Mazzali-Lurati, 2016), and they are partially shaped and regulated by the platform (Herring and Androutsopoulos, 2015; Niederer, 2019). What makes an argument good or bad often depends on the perspective by which it is considered. The evaluation process becomes more difficult given that there are three different scholarly approaches to argumentation. The focus in the *rhetorical* approach is on persuasion, in the *dialectical* approach on procedures, methods and

rules, and in the *logical* approach on premises, conclusions, and their logical soundness (Ehninger and Brockriede, 2008). The first two approaches make use of *indirect evaluation*, considering the intended audience as arbiter. In the latter approach, *direct evaluation* is preferred, putting oneself as intended audience and asking whether the argument is convincing or not. These approaches can all be placed under the umbrella concept *argumentation theory* (van Eemeren, 2018, p. 3). Goodwin (2020, p. 159) argues for a system-level study of controversies at macro-scale, where attention is turned to "what happens when large numbers of arguers are making arguments on a loosely defined and perhaps changing topic over long periods of time", which arguably applies to Twitter. When studying complex interactions such as those in social media where the audience is multiple, conversations difficult to follow, and topics potentially ambiguous, it makes sense to combine these approaches, because arguments that are persuasive are mixed with logical arguments, whilst certain, perhaps unwritten, rules apply within the communities involved. When approaching argumentation theory in online interaction, it is essential to consider that arguments are built upon shared premises, which are acceptable by the target audience. In light of this, some concepts become particularly relevant for studying argumentation practices in social media, such as the relevance of the argument in relation to the typology of the target audience. How in such a digital environment does the audience engage in a scientific topic? By showing reasons (logical demonstration) and providing evidence (giving proof); by using credibility-based persuasion, where not evidence, but a person's behaviour or authority is the matter of the discussion; by emotional persuasion, where strong sentiments drive the arguers' choice, or finally by just expressing an opinion, without any evidence supporting it? We define these different ways of engaging in debate as *argumentative approaches*.

A controversy is characterised by the attempt to persuade the opponent (Dascal, 2008). This is in contrast to a discussion, in which the goal is to discover the truth, and a dispute, where winning is the final purpose. From this, it follows that a discussion ends with solution where consensus is reached because the arguers have a shared purpose (reaching truths), a controversy ends with resolution as the counterpart is persuaded through arguments and, finally, a dispute ends with dissolution with positions not being moved. It can be argued that a scientific conversation aims for discovering the truth through proof, but because an objective truth is difficult to establish, it is arguably more common that it resembles a controversy where argumentation is used in attempts to persuade the opponent. Resolution or abandonment can be more frequent than arriving at consensus, if the discussion is among scientists who belong to the same domain (Toulmin, 2003) when the position itself has not become ideological.

It is not essential how a debate or conversation ends when it comes to argumentation as underlined by Freeman (2002). An argument does not need to have winners and losers because the authentic spirit of argumentation consists essentially of giving reasons and evidence for claims.

Persuasion, however, is the main purpose of rhetorical argumentation and, according to Aristotle, it depends either on the character of the speaker, or on the emotional state of the audience, or on the argument itself (Rapp, 2010). In the first case, the speaker has to be credible, in the second, emotions need to be triggered to change the audience's judgments, and in the latter, the arguers must demonstrate the claim through reasoning or evidence.

On Twitter, there are different aspects that influence the credibility of the speaker such as, for example, popularity and authority. Furthermore, emotive language is used to obtain consensus (Macagno, 2014) and different kinds of external sources are linked to the conversations (e.g. Nelhans and Lorentzen, 2016), which can influence the validity of a claim (Toulmin, 2003). In such virtual spaces, a linked source may be the only counterargument used without any further comment. The use of sources, and therefore their reliability, becomes of great importance in online argumentation, because it can be also used for backing or as a rebuttal, in order to defend the advocated position and to persuade the audience. Sharing external sources could also express common interests, goals or experiences, shared premises or beliefs (e.g. Pilerot, 2012). This is also in consonance with the considerations about inter-textual reference strategy developed by Herring and Androutsopoulos (2015). On one hand, the use of external sources increases difficulty in active participation in a discussion because it requires that the audience involved has the proper education needed to distinguish between reliable sources and junk news (Corner, 2017; Venturini, 2019). On the other hand, providing reliable and authoritative sources for backings and rebuttals improves the strength of the argument and its credibility. The typology of the linking practices adopted in argumentation allows for identifying in-group discussion and the presence of non-like-minded by studying the reaction to it. This makes it also possible to assess the level of expertise of the audience and to adapt the communication strategy accordingly. The type of link, if not chosen having a multiple audience in mind, could narrow the audience to domain experts, making public participation less active and the argument credible and persuasive just for a specialised audience. The analysis of the linked and embedded sources in their conversational contexts, the argumentative approach used with the sources, and reactions from non-like-minded allow for deepening the understanding of the interaction between participants.

According to Tromble (2019), it is essential for the interpretation of digital data to have robust heuristic models, including for example forms of communication or types of expression. For our purposes, we consider argumentation as a form of communication, following certain rules and having an architecture independent of a given topic, partially shaped by the *technicities* of the platform. Taking into account the technicities of the platform entails that one must pay attention to how the platform emphasises, filters and orders content (Niederer, 2019, p. 18). For example, the act complex on Twitter includes replies directed

primarily to the speaker, but also potentially available to anyone else. This entails that the argument is not only a question about reasoning, but also about the ability to master the medium. We operationalise the concept as a model adapted to the technicities of the platform to interpret conversations in which participants aim to give reasons for their positions. Hence, we aim to understand Twitter argumentation given the example of climate change, but not necessarily limited to the topic.

3. Literature review

A review by Pearce *et al*. (2019) investigating the applied methodologies, and the most important remaining issues in the related research, shows the extent of the literature about climate change across different social media platforms. On Twitter, the authors identify three distinct approaches to the analysis of the topic: *climate change publics*, where the platform acts as a digital forum for seeking and discussing scientific issues, *climate change themes*, in which the platform is used as a source for thematic analyses, and *climate change professional communication*, focusing on how professionals use Twitter. Pearce *et al*. (2019) suggested further research on conversation dynamics within and between antagonising groups. Moreover, the authors called for qualitative analyses, studies of visual communication, and more detailed studies of public communication.

In the following, the focus is on research dissemination, discussion, argumentation, and conversation analyses on Twitter. A study of communication between climate action network NGOs indicated that geopolitical structures were also present on Twitter, although there was relatively little interaction between them (Vu *et al*., 2020). Anderson and Huntington (2017) found that incivility and sarcasm were not common in tweets about the 2013 Colorado floods, but when comments were uncivil, the tweets were more likely to be of political nature. Uncivil and sarcastic language was also related to climate change denial. By studying scientific communication through an automatic analysis of tweets beginning with an @-mention, Walter *et al*. (2019) concluded that scientists addressed politicians with a greater degree of conviction than fellow scientists. Having explored Twitter discourse and climate change survey responses, Bennett *et al*. (2021) found a significant relationship between climate talk and climate opinion, as well as regional differences regarding most discussed topics. While the analysis revealed a presence of science in the tweets, there were also regions where climate change denial dominated. Newman's (2017) analysis of tweets following the IPCC AR5 report showed that non-elite users posted a large share of the most retweeted content, and that a multitude of external sources was linked-to. Among these, mainstream media was more common, but science news, blogs and other web-only sources were frequently used. Twitter users seem to post about societal impact of climate change as well as redistributing scientific content with less technical language (Haunschild *et al*., 2019). In Niederer's

(2019) study of climate change discourses on Twitter, adaptation to climate change effects and scepticism were dominant themes. However, a closer analysis revealed that the scepticism discourse was characterised by a critical stance towards scepticism rather than a sceptical stance towards human caused climate change.

Although there are plenty of examples of research on communication on Twitter, little scientific work has so far been dedicated to the application of argumentation theory or similar in a conversational context. Both Catenaccio's (2021) and Greco and De Cock (2021) found few examples of dialogue between tweeters and companies. In the latter study, it was concluded that differences among the participants regarding definitions and premises created a misalignment in the opening stage, and a concluding stage was not reached (Greco and De Cock, 2021). Pang and Law (2017) focused on visual rhetoric based on Aristotle's conception of rhetoric in tweets tagged with #worldenvironmentday. Using quantitative content analysis, they concluded that there were significant relationships between retweet counts and tweets expressing perceived character (ethos), and tweets expressing sympathy and hope (pathos), whereas tweets expressing logic, argumentation or evidence (logos) were not frequently retweeted. Similarly, Moernaut *et al*. (2020) also identified examples of such rhetoric in their study of form and positioning strategies for persuading the audience within the climate change topic. Strategies such as delegitimising logic and reason and attempting to trigger emotional responses of the opponent were found in both groups. The authors suggested that the strategies increased polarisation rather than contributing to constructive discussions. Finally, in a theoretical piece, Goodwin (2020) demonstrated how to approach social media from argument theory perspectives. Albeit limited to tweets replying to an original tweet and not conversational threads, the approach was useful for mapping the sceptic's hypocrisy argument, giving insights into how one may combat such arguments.

The literature above is focused on partial conversations, with little attention so far been given to more complete conversations. Among the few analyses of Twitter conversations, participants of political discussions attempted to expose potential weaknesses in the arguments of the opponents in order to persuade the audience without reaching agreement (Lorentzen, 2016). In vaccination discussions, participants aimed to force their opinions onto opponents, although there were examples of participants using arguments or proof (Lorentzen, 2021). Both of these examples point to a dispute-like conversation type. In a study of scientific articles shared and discussed, Nelhans and Lorentzen (2016) found that the most common referred works were open access articles from natural sciences, and that the linking practices included self-promotion, conversation starters and as arguments. In Moernaut *et al*. (2020), external sources were promoted for giving authority to the tweet while Pang and Law (2021) saw a large share of tweets with visuals for persuasion purposes.

Different approaches to content analysis appear in the reviewed literature, such as the quantitative approach with codebooks (e.g. Anderson and Huntington, 2017; Moernaut *et al*., 2020; Pang and Law, 2017), the structured qualitative approach (e.g. Goodwin, 2020), and the unstructured qualitative method in Lorentzen (2021). In this paper, we focus on a topic that has not yet been studied with conversational threads as data. Both the content of the tweets and the sources linked-to are approached argumentatively, using quantitative content analysis based on the concept outlined in the theoretical framework. This structured approach allows for identifying and analysing argumentative patterns and practices within the topic.

4. Method

4.1 Data collection and sampling

We used the same dataset as in Lorentzen *et al*. (2019), collected during two weeks starting on 23 August 2018 using the Twitter Streaming API to filter tweets referring to a research artefact with a URL, and the potential follow-on conversation. This was made possible through the combination of the keywords *'dx doi org'*, *dx.doi.org*, *researchgate*, *academia.edu*, *arxiv.org* and *socarxiv.org*, and the most active participants in the conversations. With this approach, the API returns a stream of tweets including a specified keyword as well as tweets sent to and from the most active participants. From the stream, tweets referring to one of these URLs and replies to tweets in the database were collected. Finally, all tweets replied-to that had not been collected were looked up so that the conversations could be traced to their origins, if possible. The final dataset includes roughly 30,000 tweets. Because of ethical issues, we have anonymised the dataset prior to analysis, replacing usernames, user IDs and tweet IDs with numerical values. It should also be noted that a deleted tweet, a tweet from a protected account, and a tweet posted by a suspended user cannot be accessed. If such a tweet was part of the conversation, the entire conversation could not be collected. However, if a tweet was deleted after it has been returned by the API, the API notifies the client so that it can be treated. All such tweets were replaced by the text "DELETED at <timestamp>". The metadata id_str (tweet identifier) and in_reply_to_status_id_str (replied-to tweet identifier) were kept to avoid broken threads. The data collection method entails that few tweets include hashtags (only 1.7%), so the audience and the participants are likely to be part of a follower network. Hence, replies are more likely responses to tweets from their feeds rather than from the results from hashtag searches.

Conversational threads were derived from the metadata field indicating which tweet a tweet was replying to. From a set of threads with at least 30 tweets, we selected five threads referring to climate

change. The five threads varied in length and number of participants. Threads T2065 and T2310 had four participants each and comprised 37 and 88 tweets respectively. Thread T1202 included 63 tweets and eight participants, and the corresponding numbers for T359 were 51 and twelve. T2312 was far longer than the other four, involving 59 participants posting 1,458 tweets. As this thread was very long and had a complex structure, it was divided into nine subsections comprising 127 to 299 tweets based on its structural characteristics. Thus, the final set of selected threads to code included 14 conversations and sub-conversations. Three threads covered *climate change deniers* and *science* (T359, T2065, T2310) and one was about *atmospheric pressure* (T1202). Four segments of the long thread were about *emissions* and *carbon dioxide* (T2312S3, T2312S4, T2312S7, T2312S9) and two were focused on *temperature increase in the atmosphere* (T2312S2, T2312S8), with the other three segments differing from these topics (T2312S1 about *extreme weather in the arctic*, T2312S5 covering a diverse range of topics and T2312S6 having a scientific focus).

It should be stressed that a study such as this is limited to the studied platform and the technicities of the platform and its API at the time of data collection. When data were collected for this study, the chosen method was the best option to collect conversations, although vulnerable to network connection issues (as tweets are collected in real-time) and the user filter possibly not covering all participants. The new API (version 2.0) makes it easier to collect the conversational threads from a set of collected tweets. Finally, we do recognise the time-gap between data collection and analysis. However, with our intention to find out how participants argue based on resources they need for support (e.g. Goodwin, 2020), we believe that this is a minor issue. The data, regardless of time, arguably give rich insight into the audience, the types of resources shared, and the types of arguments used.

4.2 Data analysis

Because of the nature of Twitter, it is not only difficult to select the target audience but also to search for consistency of type of argument in long chains of conversational tweets. While having a specific argument in mind such as the sceptical one (Goodwin, 2020) allows for a deeper analysis of the structure of the statements, it leads necessarily to the selection of a particular segment of the conversation or a small sample of individual contributions (single tweets), inevitably losing context. To gain an understanding of the practices without losing the context of the tweets, such as the sub-conversation the tweet belongs to and the tweet replied-to, we searched for a more general argumentative approach applied to the entire conversational threads. The analysis took off from concepts from argumentation theory as we looked at what the tweet expressed, how it replied to a tweet and in what context the interaction took place. Following Niederer's (2019) recommendations, we analysed arguments not only on a macro-level,

but also on micro-level with close reading of the tweets in their networked conversational contexts. Building on previous Twitter conversation studies with similar methods (e.g. Lorentzen, 2021; Lorentzen, 2016; Nelhans and Lorentzen, 2016), we looked for argumentation types and strategies, claims and stances. Following a pilot study using open coding, we developed a codebook for categorising the content of the tweet with the attributes *tweet type*, *argumentative approach*, *interaction type* and *stage*.

The codebook was refined over a series of independent coding sessions by both authors, each evaluated with a Kappa test. After each session, we redeveloped the codebook and coded a new set of tweets, until we reached a satisfying score. The Kappa scores after the third round, in which both authors coded 185 tweets, were deemed good enough. The tweet type score was 0.73, argumentation type 0.8 and interaction type 0.75, which represents substantial agreement according to Landis and Koch (1977). Table I shows the categories and the number of instances. After coding all tweets in the selected discussions, we derived macro-level aggregated patterns from all tweet-reply pairs. We also derived the most typical sequences of tweets. The overview and the sequences were then used to identify argumentative patterns and practices for further analysis.

[insert Table I here]

We also investigated the use of external sources, including links to other web pages as well as embedded charts or other media. In total, we found 272 tweets with such sources, some of them included multiple times in different tweets. With the relatively few unique sources, we applied open coding of them, looking at type of source, usage of source and the conversational context in which it was used. As science is the background of the discussed topics, we analyse the linking practices of the users involved in the interaction to go back to their common ground (Pilerot, 2012), identifying the presence of a multiple audience (Palmieri and Mazzali-Lurati, 2016) composed by academics, activists, deniers, and other people interested in the topic. All tweets with sources were analysed in their conversational contexts with specific focus on the argumentative usage of the source, its soundness, and finally its adequacy to the discussion and its audience.

5. Findings

Table II shows an aggregated view of the communication patterns. The connections between the categories are represented as replies to tweets, where rows represent the replying tweet categories and columns the replied-to tweet categories (e.g., there were 101 R3 replies to R1 tweets). Considering the interactions in all threads, we found that the dominant argumentative approach was rhetorical, with a prevalence of persuasion through demonstration (R3) and credibility based persuasion (R1). Similar to

Moernaut *et al*. (2020), attempts to delegitimise was common, although we saw few examples of triggering emotional response. Whereas Pang and Law (2017) saw that retweet counts were often associated with emotional or credibility based arguments, our results indicate that it is more common with replies to arguments based on demonstration or proof. This type of argument attracted more than twice as many replies as the second most common replied-to type (R1). Given that retweeting and engaging in debate are different activities, this indicates that arguments based on proof are more likely to spark discussions and the other two rhetorical types more likely to be disseminated. R3 arguments were most often replied-to with a similar kind of argument. There were also many instances of credibility-based replies to these, and logical arguments focused on the validity of premises in the argument (L). Most of the arguments were based on either proof, credibility, emotions or logic. Hence, opinions without any kind of evidence were not common. Opinions were most common as responses to arguments with proof.

[insert Table II here]

Disagreements were far more common than agreements, mirroring results from Lorentzen (2016). When agreement was reached, it was more often as a reply to an R3 than other argument types. Among the replies to agreements, we found 45 credibility-based tweets (R1), many of them questioning credibility of speaker, source or argument, but also supporting tweets questioning credibility of opponents. Furthermore, we saw 48 instances of persuasions through demonstration or proof (R3), of which 18 supported the agreement and 26 objected to the argument. We conclude from this that even after agreement was reached, the discussion did not end as opponents replied with counter-arguments. Disagreements and counter-arguments were more often followed by a reply with demonstration or proof (196 and 300 respectively), and credibility-based arguments (141, 184). Of the latter type, there were few examples of supporting the disagreement or counter-argument, but in most cases, the replies questioned the credibility of the speaker. The most common interaction types to these two were tweets of the same type, i.e. further disagreements (212 cases) and counter-arguments (377). In tweets following emotional rhetoric (R2), both disagreements and counter-arguments were common, but there were also examples of agreement following this type of argument. These agreements typically followed as response to tweets with non-scientific visuals.

Statement with source and *Statement without source* were the most used tweet-types in reply to questions and other statements with or without sources, while the expression of an opinion was marginal. Statements with and without sources were often replied to by R1 and R3. The use of sources was twice as often met with disagreement than agreement and three times as often with a counter-argument. When sources were used in tweets, the reply was more often of the type R3 or questioning of credibility with few instances of supporting credibility. The practice of moving goalposts seen by Lorentzen (2021) was not

common. Finally, R3 and R1 were the most used argument type and the more reacted-to. Opinions and emotional persuasions (R2) were overall marginal. The use of the counter-argument in response to R1 and R3 was slightly superior compared to the expression of simple disagreement. Most of the interactions were in the argumentation stage and the confrontation stage. With few exceptions, there was a notable absence of opening and concluding stages.

5.1 The practices and the patterns

The various ways the participants use arguments in the context of the examined conversations are here denoted *argumentative practices*. The *argumentative patterns* are the argumentation dynamics and strategies (deliberate or not) that these practices allow us to identify. From the discussions, we have identified five different practices and several patterns that cover much of the argumentative exchanges. These have some different characteristics.

Practice 1 - T359. In practice 1, tweets make use of linked or embedded sources. In this practice, the argumentation type R3 and interaction type counter-argument dominate. The following tree of exchanges represents a typical example of the practice, where the codes follow the order *tweet type*, *argumentative approach*, *interaction type*, and *stage*:

1. SO, R3, N/A, Opening

2. StS, R3, CA, Argumentation

2.1. StS, R1, TC, Argumentation

2.1.1. StS, R3, CA, Argumentation

2.2. StS, R3, CA, Argumentation

2.2.1. StS, R3, CA, Argumentation

2.2.1.1. StS, R1, D, Argumentation

2.3. Oth, R1, D, Argumentation

2.4. Deleted tweet

2.4.1. StS, R3, CA, Argumentation

2.4.1.1. StS, R3, A, Argumentation

In the example, the discussion bifurcates in a few directions, notably ending with disagreement in one case (2.2.1.1) and agreement in another (2.4.1.1). There is a repeating pattern here, where R3 is equally used from both the arguing parts, while R1 is used by deniers of human caused climate change. In this interaction, the *confrontation* and *concluding* stages are absent. There are examples of concluding comments elsewhere in the thread that indicate that participants lose interest in the discussion, perhaps because of lack of clear starting points, also seen in Greco and De Cock (2021). If we look at the tweet type, we see the repetition of the sequence **StS → StS** (Statement with source). From the linking practices, it seems that the participants are interested in science and education, but the sources are mainly blogs and social media and not scientific peer-reviewed journals. The main usage is *providing source for justifying premises, claims or conclusions* rather than *providing source for justifying rebuttal*. The general tone used is polite, with some exceptions, and the language is not technical.

Practice 2 - T1202. In practice 2, tweets do not make use of sources. This practice draws the following repeating argumentation pattern: **R1 → R3**. Here, the use of R1 is prevalent in the same category of arguers who help each other in the debate. The following sequence acts as our example of the practice:

1. St!S, R2, D, Argumentation

1.1. St!S, R3, CA, Argumentation

1.1.1. Oth, R1, TC, Argumentation

1.1.1.1. St!S, R3, D, Argumentation

1.1.1.1.1. St!S, R1, CA, Argumentation

1.1.1.1.1.1. St!S, R3, CA, Argumentation

In this case, a user who was linking evidences previously in the thread adapts to the audience by continuing arguing without sources, and then being accused of “ad hominem-argument”. Here, tweets do not include sources (St!S) and interactions are primarily disagreements and counter-arguments. The ad hominem was otherwise seen as replies to reasonable evidences and was most frequent when the argumentation involved users distrusting science, which could be interpreted as an indicator of science denial (T359, T1202, T2065, T2310, T2312S4). In contrast, when the rejection of arguments comes from academics, it is commonly expression of different shared premises or identification of fallacies (T2312).

Practice 3 and 4 - T2310 and T1202. What makes practice 3 stand out is the inclusion of agreements, which is not common in these discussions. However, some examples of a few agreeing tweets as consequence of argumentation do exist:

1. St!S, R3, TC, Argumentation

1.1. St!S, R3, A, Argumentation

1.1.1. St!S, R3, TC, Confrontation

1.1.1.1. St!S, R2, A, Confrontation

In the first case (T2310), *Agreement* is a consequence of *Topic change*, drawing the following pattern **TC → A**. It occurred at different stages of the discussion, *Argumentation* and *Confrontation*, when the topic was the impact of pasture and eating meat on climate. Here, a participant shifts the focus of the debate with an attempt to persuade using proof, in the second case also causing a new confrontation.

In T1202 we see the same practice, but with the use of emotional persuasion (R2). In our example below, a change of topic influences the interaction, but the use of emotional persuasion in the concluding stage increases its significance.

1. St!S, R2, TC, Concluding

1.1. St!S, R2, A, Concluding

1.1.1. St!S, R2, A, Concluding

1.1.1.1. StS, R2, A, Concluding

Practice 5 - T2312S5. Practice 5 includes questions, drawing the pattern **Q → St!S** and **L → R3**, where the *Logical* argument commonly consists in questioning the congruence of premises and conclusions, mirroring the Socratic use of dialogue. However, when the pattern is **Q → L** and **L → D** and not **Q → L** and **L → CA**, the logical argumentation shows no strength. The same patterns of questions answered with R3 without sources followed by new questions was found elsewhere in the thread.

1. Q, L, D, Argumentation

1.1. St!S, R3, CA, Argumentation

1.1.1. Q, L, CA, Argumentation

1.1.1.1. St!S, R3, CA, Argumentation

1.1.1.2. StS, R3, CA, Argumentation

1.1.1.2.1. Q, L, D, Argumentation

5.2 The sources and the audience

The sources used by the participants were mainly embedded charts (71 tweets) and links to scientific articles (40). Quotes from scientific articles (12) and infographics (9) were also found. The presence of scientific content is an obvious effect of the data collection method and can be contrasted with the results from Veltri and Atanasova (2017), whose study found a domination of content from news organisations. Similarities with their study include links to blogs and NGO reports of which we found nine instances each in the conversations. We also found a few examples of non-scientific artefacts such as memes in the form of pictures (10) and quotes (8), as well as links to other web pages (17), which suggests that there is a different background and level of expertise among the participants. The general purpose of these practices was providing source for justifying premises, claims or conclusions rather than providing source for justifying rebuttal, with some exceptions in T2312S7 and T2312S8. There were also cases of informing about research and questioning content.

Lorentzen (2021) identified different practices in the two main groups, where pro-vaccine participants relied on academic sources and their opponents on non-academic content. We did not see such a pattern with the few blogs linked-to. If anything, these were in the pro-community. However, we did notice that sceptics made use of charts taken out of context, and embedded sources without references as arguments. While visuals comprised a large share of the used sources in our study, they occurred in only 71 of 1,697 tweets, which can be contrasted to Pang and Law (2017) who found visuals in almost half of the tweets. Perhaps visuals are more likely to be retweeted than frequently appear in conversational tweets. Moernaut *et al*. (2020) saw various external sources used as authoritative. Here, we saw that the linked sources were overall consistent with the apparent purpose of the tweet and if considered valuable or questionable by the audience, proposed and debated several times in different stages of the argumentation and segments of the threads.

The topics, the different argumentation types and the linking practices suggest the involvement of a multiple audience, especially when the topic was about alternative forms of energy, the impact of pasture and eating meat on climate, the meaning of scientific consensus, or politics, while it was almost completely academic when methodology of research and causes of climate change were discussed. The participation of a non-academic audience in scientific context is also limited by the use of paywall publications and technical language. Although we did not search for geographical, terminological and

opinion related expressions as in Bennett *et al*. (2021), the results confirm a presence of an active community promoting climate science on Twitter. We noticed that when the discussions concerned the causes of climate change, the argumentation became more specialised and deniers more antagonised.

6. Discussion and conclusions

Climate change is a topic of popular interest generating scientific, political and public debate. If the approach is technical and the linked source is not accessible, then the conversation would remain within a small world even if retweeted. As a less technical language increases likelihood of dissemination (Haunschild *et al*., 2019), the technical approach reduces the possibility of communication to the public, as the means used to disseminate the message narrows the audience. Because an argument starts usually with non-like-minded, arguing on social media breaks the resonance of echo chambers opening the participation to a multiple audience. In such context, giving reasons and proof to justify one's position might not be sufficient to persuade the antagonist because of lack of shared premises. This lead the audience to adopt and adapt to different strategies in order to "win" debates, as, for instance, a group of like-minded helping each other after the opponent had contested or proved falsehood of a statement or proof. Giving reasons and proof to justify one's position provides the active and the invisible audience an opportunity to learn and make choices in everyday life as seen in threads T2310, T2312S3 and T2312S9. As Yardi and Boyd (2010) found out, interactions between like-minded users strengthen the identity within the group, whereas interactions between non-like-minded seem to push groups further apart. In the examined conversations, we saw no evidence of consensus between non-like-minded. On the contrary, like-minded often make group efforts in undermining the authority of the counter-part as seen in R3 followed by R1, but this pattern is balanced by **R1 → R3**, meaning that the audience attitude is not passive to this strategy. In the first case, when an argument is backed by a source, the opponents often reject the source without giving any reason, showing the presence of an audience rejecting evidences based on data. In the second case, credibility based arguments are responded-to with a counter-argument or a source as proof, showing an audience strongly committed to evidences. Because credibility is a concept usually tied to consistency between speech and practice, it is important to clarify that when discussing scientific topics, the argument is consistent with evidence obtained through observation and experiment. Science is not a cause, even if scientific findings may have supporters or activists defending them and using them as argument. In the conversations, we encountered cases of credibility-based persuasion targeting evidences by undermining the arguer's degree of expertise, their actual knowledge of the topic, their ability to understand statistics, and the level or quality of the scientific journals or media.

Counter-arguments were far more common in the conversations than simple disagreements. The use of counter-arguments, instead of plain agreement or disagreement, suggests that participants show an interest to further the discussions. However, the goal seems to be to enforce the viewpoint onto the opponent or winning the argument, rather than arriving at consensus. The question is if the polarisation increases through this (e.g. Bail *et al*., 2018; Moernaut *et al*., 2020; Yardi and Boyd, 2010) or if a middle ground can be reached. Using accessible sources as evidences and explaining one's reasons exposes the audience to different perspectives creating bridges between positions and leading to more reasoned and effective interactions. However, when the source is an embedded chart, table or figure from a research article, it is easily taken out of context. The use of such a source as evidence may lead the audience to a false conclusion of the research, as neither the researchers' interpretation of the data nor the research method are made available to them. Moreover, climate change deniers seem to pick up on the differences of viewpoints within the scientific community, suggesting that the apparent lack of scientific agreement also is a signal of doubt that climate change is human caused. Perhaps the different communication practices among scientists depending on the target group (Walter *et al*., 2019) contribute to this. When scientists communicate with each other they adhere to a different protocol, which cannot easily be translated to a platform where audiences are multiple.

If in a conversation the use of proof or demonstration based persuasion is prevalent, rather than persuasion based on credibility or emotions, both the actual audience and the invisible one are urged to critical thinking. In evaluating the soundness of the content and the sources, the audience involved in argumentation, unknowingly and perhaps unwillingly learns something different. Moreover, where the sources are functional to the argumentation and its context, they are rarely linked with self-promotional intents as in non-conversational posts, as seen in Nelhans and Lorentzen (2016). This practice makes the scholarly efforts in communicating research more effective, allowing at the same time a richer and varied presence of evidences (Newman, 2017), suitable to the actual/target audience. However, by involving the counter-part in a sequence of tactical questions (practice 5) or pushing it not to use evidences (practice 2), participants search for an opportunity for strengthening their own position without showing signs of openness to positions other than their own. Finally, even if the discussions do not end with persuasion, resembling in some parts a dispute (Dascal, 2008), the results show that agreement can be reached through applying different and contrasting argumentative strategies such as shifting the focus or emotional persuasion. However, the pattern of counter-arguments following an agreement suggests that agreement is likely to be an expression of support from like-minded, whereas non-like-minded continue their attempts to argue, quite often with credibility-based persuasion. As argued by Moernaut *et al*. (2020), such practices lead to increased polarisation instead of constructive discussions. A prerequisite for a

constructive argumentation is the willingness to collaborate in the search for common values. Without this, arguments on social media are reduced to disputes where people win out of exhaustion.

In summary, our results offer several significant theoretical and practical contributions. Previous studies have focused on thematic analyses, professionals communication, and Twitter as a forum (Pearce, *et al*., 2019), but from our literature review it is clear that very little attention has been given to the interactions in a conversational context. What is unique for our study is the focus on the use of scientific outputs in Twitter conversations about climate change from an argumentation theory perspective, group argumentative behaviour, and usage of scientific sources and their adequacy to the audience. By doing so, we have shed light on how discussions on Twitter evolve in controversies (if participants are seeking shared values) or disputes (if there is an absence of shared values), on how scientific outputs are used as arguments, and the argumentative strategies adopted among the participants.

6.1 Implications for practices and research

From the results, it is evident that although the character of the conversations was rhetorical, neither of the two parties succeeded in convincing its opponent, even when arguments were seemingly reasonable. Convincing an opponent is probably not a realistic aim when the arguers lack common values, premises, and aspiration to find them. It is arguably more important to convince the audience rather than the opponent. In addition, the person sharing scientific findings needs to be aware of any potential ambiguity in the tweet if the intent is to reach a multiple audience.

In social media, a tweet is exposed to such an audience because of the medium. If someone posts a video showing summer temperature anomalies in the last 139 years (T2065) without an explanation about the data collection and where to find more information if needed, it might raise questions and arguments, as seen in this study. By not responding to them, researchers unintentionally undermine public trust not only in science but also in the technologies used to visualise it. The question is then if researchers should be required to detect these instances and then provide the context needed to understand the data.

Engaging in arguments using scientific publications as counter-argument or as proof sustaining one's position, is an effective strategy if the publication is accessible and the audience knows how science proceeds and understands its language, i.e. among peers. However, in absence of shared premises, this practice can start a wearing process where the opposite part shares a publication that states the contrary or that is an exception in respect to the one posted by you. Among academics, such an argument may be seen as insignificant. However, in a multiple audience, the argument may increase uncertainty about scientific consensus. It is important for advocates of science to clarify that differences in viewpoints among scientists do not necessarily indicate a lack of consensus, especially regarding the topic of climate change.

Communicating and discussing science with a multiple audience in social media require both effort and responsibility. It is probably more effective to quote a misinterpretation of a scientific finding (taken out of context) as a quote retweet with an appropriate hashtag, rather than just replying to the tweet. This practice exposes the topic of the discussion to a different audience than the original one, opening up for different points of view and possibly more balanced and reasonable contributions.

6.2 Limitations

The approach has given us insight in how a multiple audience interacts when arguing about climate change in relation to shared scientific artefacts. It allows for evaluating plausibility and soundness of the message and its consistency with the linked sources by taking a rhetorical perspective. While data were collected to cover as much of the conversations as possible, it is not without its limitations. Twitter activity is event-driven in the sense that its users respond to what happens at the time of tweeting. Therefore, this two-week sample does not represent Twitter discussions of climate change in general as it is limited to some of the climate change discussions that took place at a given time and on one platform only. Moreover, the practice of quoting a tweet in a conversation to redistribute it requires more investigations outside the scope of this paper. Mixing quotes with replies does indeed make the conversation analysis more complex, but the data collection method allows such data to be collected. If the tweet does not match keywords or is a reply to collected tweets, the tweet may be collected if it is a quote of a collected tweet.

We also want to stress that this type of study does not capture intentions and motivation for participating. Analyses of arguments could be combined with surveys focused on such aspects (e.g. Bail *et al*., 2018; Pang, 2018), for example using the conceptual framework for linking social media activity to civic engagement presented by Pang, Qin and Ji (2021). With indications of a relationship between younger people's usage of social media and civic engagement (e.g. Pang, 2018; Pang *et al*., 2021), a focus on this group should be especially relevant when studying certain aspects of Twitter participation and civic engagement, such as *Fridays for Future*.

With these limitations in mind, the study has given insights into the patterns and practices of argumentation, and demonstrated a method for networked content analysis of tweets in the context of a conversation. Given that Twitter has made collecting conversations easier with the new API, we expect more attention to be given to the conversations on the platform. Hence, we call for more research on the different uses of arguments and academic sources in the context of digital discussions to build knowledge about the public understanding and perception of science.

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Table I: Codes, explanations and number of instances.

	Code	Explanation	Tweets
Tweet type	St!S	Statement without source	827
	StS	Statement with source	242
	Q	Question	219
	C	Chained tweet	150
	SO	Source only	21
	RS	Requesting source	13
	Oth	Other	214
	Copy	Copy of previous tweet	9
	Del	Deleted tweet	2
Argumentative approach	R1	Rhetorical 1, credibility based persuasion	439
	R2	Rhetorical 2, emotional persuasion	188
	R3	Rhetorical 3, persuasion through demonstration or giving proof	663
	L	Logical	237
	O	Opinion, statement without support	168
	Del	Deleted tweet	2
Interaction type	A	Agreement (supporting)	206
	D	Disagreement (not supporting)	526
	CA	Counter-argument	664
	N	Neutral	130
	TC	Topic change (including moving goal posts)	72
	N/A		97
	Del	Deleted tweet	2

Table II: Relationships between tweet types, argumentative approaches and interaction types based on replies. Rows represent the number of replies to a given category. Note: the least common types (deleted tweet, copy of tweet), the "Other" tweet type and the "N/A" interaction type are excluded.

		Replied-to category															
			Tweet type						Argumentative approach					Interaction type				
			SO	**RS**	**StS**	**St!S**	**C**	**Q**	**R1**	**R2**	**R3**	**L**	**O**	**A**	**D**	**CA**	**N**	**TC**
Replying category	TT	**SO**	0	2	2	8	1	5	4	0	9	5	1	2	3	10	3	1
		RS	0	0	0	10	0	1	2	1	6	2	2	4	1	5	0	2
		StS	6	6	49	120	17	34	61	23	97	45	15	27	72	106	18	9
		St!S	5	7	115	444	60	147	170	112	332	163	48	86	265	327	71	50
		C	0	2	25	60	51	6	19	8	85	27	11	8	40	85	9	6
		Q	2	0	39	118	12	28	42	20	112	25	20	23	53	109	16	7
	AA	**R1**	2	6	79	223	31	50	144	56	149	66	24	45	141	184	23	26
		R2	0	1	31	109	13	24	43	53	63	21	7	40	53	69	10	11
		R3	9	9	95	328	68	120	101	52	337	126	43	48	196	300	58	33
		L	4	1	33	124	28	31	36	15	107	62	17	21	59	114	25	10
		O	2	1	24	63	19	30	32	8	69	27	32	24	36	58	27	8
	IT	**A**	1	1	38	104	13	32	47	33	88	27	11	73	36	63	14	17
		D	5	6	80	301	47	50	124	68	217	92	25	42	212	203	32	25
		CA	7	6	113	347	67	96	138	62	308	127	29	34	190	377	24	23
		N	2	5	10	23	7	54	18	12	43	30	25	14	25	20	56	9
		TC	1	0	9	32	16	8	12	6	38	10	6	10	8	34	8	11