Routledge
Taylor & Francis Group

Journal of Environmental Planning and Management

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/cjep20

Erroneous thinking on climate change

Mari Myllylä & Pertti Saariluoma

To cite this article: Mari Myllylä & Pertti Saariluoma (30 Aug 2024): Erroneous thinking on climate change, Journal of Environmental Planning and Management, DOI: 10.1080/09640568.2024.2389158

To link to this article: https://doi.org/10.1080/09640568.2024.2389158

Published online: 30 Aug 2024.

Journal of Environmental Planning and Management, 2024
https://doi.org/10.1080/09640568.2024.2389158

Routledge
Taylor & Francis Group

Erroneous thinking on climate change

Mari Myllylä* and Pertti Saariluoma

Faculty of Information Technology, University of Jyväskylä, Jyväskylä, Finland

(*Received 5 December 2023; final version received 1 August 2024*)

The ultimate source of the ongoing human-induced climate change must be found within the thinking that guides actions. This human aspect goes outside the laws of natural science. Human thinking as a cause of anthropogenic or industrial climate change is still an under-researched topic. Here, we focus on how humans think about climate change. We use a content-based analysis of the mind to analyze comments in a Finnish online forum, Suomi24. Our immediate findings are that people have errors in reviewing knowledge and constructing information in their mental representations. Discussions are colored by illusions, false claims, incorrect interpretations, mistakes, and opinions to deny facts. Understanding erroneous thinking is crucial, as it helps to identify ways to correct risky thinking and to understand why people do what they do. Ultimately, erroneous thinking is the root cause of the modern climate crisis.

Keywords: climate change thinking; erroneous thinking; mental content; content-based analysis of mind

1. Introduction

The ongoing human-induced climate change is a conceptually and theoretically challenging multidisciplinary problem and finding effective tools to meet its consequences is vital. The present climate change did not exist before the birth of industrial society. Its speed has also increased with the development of that society and especially due to the use of fossil fuels (IPCC (Intergovernmental Panel on Climate Change) 2023a, 2023b). Consequently, the ultimate reason for the climate crisis must be searched for in human individual and institutional actions. The explanation for actions is in human information processing and especially in thinking. Human deeds are consequences of their thinking. Although they are not always able to do what they think, everything they have done, they have thought. Despite this, little attention has been paid by researchers to human thinking on climate, which is the root cause of climate problems.

Science searches for causes and reasons because knowledge of them enables researchers to look for solutions that help to mitigate the negative effects of the phenomenon in question. Knowing that the carburetor broke because water turned into ice and expanded made it possible to solve the problem by using glycol to change the freezing temperature (Hempel and Oppenheim 1948). Finding the reason for the broken carburetor made it possible to eliminate the harm.

*Corresponding author. Email: mari.t.myllyla@jyu.fi

The above is a classic example of scientific explanation and its functions in design thinking. Its logic is clear, which may call attention away from one of its highly interesting aspects, which is the relationship between human action and mind and a natural phenomenon. Hempel and Oppenheim (1948) did not pay attention to the human aspect of their example, although it was obvious (Saariluoma, Cañas, and Leikas 2016). People looked for an explanation, and people discovered it as well as the means to eliminate the harm. Harm, of course, is also a human phenomenon. If animal minds are not counted, harm or finding some issues harmful have had hardly any relevance. In the example given above, it seems to make sense not only to think of it as a carburetor problem but also as a human research issue.

Traditionally, human research and natural science have been separate ways of rational thinking. Snow (1959) spoke of two cultures. Brentano ([1924] 1955) and Dilthey (1970), for example, adopted the idea of Geist from Kant ([1781] 1976) and other German idealists and developed *Geistenwissenschaften* or human research on very different grounds from natural science. Positivism pursued the unity of science and, at the same time, hermeneutics and phenomenology sought to establish new grounds for human research (Heidegger [1926] 1992; Husserl [1913] 2004; Radnitsky 1968; Stegmüller 1969).

The explanations of human actions differ from natural scientific explanations (Saariluoma, Cañas, and Leikas 2016; Von Wright 1971). Natural phenomena are causal, which means that the explanatory ground is something that happened before the phenomenon to be explained. For example, the climate becomes warmer after the increase in fossil emissions. However, explaining human actions is different.

Nature follows deterministic laws but, as in the analysis presented, human actions organize a specific combination of the laws of nature. However, the action also has its human side, which is essential to analyzing the event as a whole. If a person throws a stone at the head of another person, as in the case of David and Goliath in the biblical story, the issue has two sides: naturalistic and human. The trajectory of the stone follows the laws of nature, but David's thinking happens in his mind and follows the laws of human mental processes. Thus, the analysis of events having a hard scientific core must often be joined with human research grounded on analysis of what happened in reality outside of the laws of nature.

People are intentional (Brentano [1924] 1955; Von Wright 1971). Their actions are pursued toward some definite goal. They construct a representation of the situation in their mind, set a goal, and pursue that goal. It is quite possible that the way to the goal is open when the goal has been set, and therefore, no causal link can explain what people do. The explanation is to be found in some future situation (Von Wright 1971).

It is also human to err. One reason is the selectivity of human thinking. People need not search for all the alternative action paths, but they can concentrate on the relevant ones (Newell and Simon 1972; Saariluoma 1995; Saariluoma, Cañas, and Leikas 2016). The selection process enables people to live in an infinitely complex world, since they can represent it in a rational manner. They can represent the information that makes sense when thinking and guiding their actions.

Selective information processing is a necessary precondition for rational information content, but it is at the same time a source of human error. The things people see as essential are not necessarily the ones that are essential. It is also common for people to misinterpret the information they acquire and, consequently, they construct biased mental representations of situations. For thousands of years people saw how masts became visible before their ships on the horizon, but they did not find a correct

interpretation for this perceived information (Hanson 1958). Thus, both paying attention to irrelevant states of affairs and misinterpreting the facts can lead to serious errors or erroneous thinking (de Groot 1965; Evans 2013; Kahneman 2011; Newell and Simon 1972; Pohl 2017; Tversky and Kahneman 1974; Van Eemeren and Grootendorst 2004; Wason 1968).

Thinking is often organized around thought models, which are information schemas around which people structure the construction of the information content of their mental representations (Chase and Simon 1973; Myllylä and Saariluoma 2022; Saariluoma 1995). The mind integrates situation-specific information, which is partly perceivable but often has non-perceivable content elements (Myllylä and Saariluoma 2022; Saariluoma 1995). It is not always evident that people are thinking correctly, which is a cause for concern. In mental representations, it is possible to have incorrect elements. Such elements have been termed as cognitive illusions (Pohl 2017), cognitive biases (Kahneman 2011), or fallacies (Van Eemeren and Grootendorst 2004). Fallacies refer to illusory argumentation, biases to systematically disfocused thoughts, and, finally, cognitive illusions to systematic thought errors. These conceptual classes are not necessarily sharply differentiable but can refer to similar phenomena in discourse.

1.1. Human thinking and mental content

Thinking guides human actions. It also enables people to find new lines of action and to find new ways to achieve their action goals. Therefore, understanding thinking is key to explaining why people plan and act in particular ways (Ho, Saxe, and Cushman 2022; Saariluoma, Cañas, and Leikas 2016). Especially informative is the analysis of the information content of mental representations or, in brief, mental content (Allport 1980; Fodor 1992; Myllylä and Saariluoma 2022; Newell and Simon 1972). People do not just think, they think of something specific and the specific is expressed in mental content. If the properties of relevant mental content are used to explain what people do, the approach can be called content-based mental research, content-based psychology, or content-based cognitive science (Myllylä and Saariluoma 2022; Saariluoma 1995).

The core concept of content-based analysis of human thinking is mental representation. People create in their minds descriptions of their ongoing actions, goals, and physical and social environments. These descriptions can be called mental representations of the situation (Allport 1980; Fodor 1992; Newell and Simon 1972). Apperception is the process in which situation- and action-relevant pieces of information, e.g. mental models, are combined into information contents of active mental representations guiding human action (Johnson-Laird 2008; Kant [1781] 1976; Myllylä and Saariluoma 2022; Saariluoma 1995, 2001). It is good to notice here, that our focus is not in the capacity required by mental models (Johnson-Laird and Byrne 1991), but in their information or mental content. Thinking is thus a process that constructs and modifies the information content in mental representations. At the beginning of a thought process, one cannot know how to achieve the goal of an action, but in the course of the modification of current representation, one can find a solution (Köhler [1917] 1957; Newell and Simon 1972).

Lifelong experiences and some basic biological systems have made it possible for people to have thought models in apperception utilized when encoding active mental

representations. Inbuilt and information content-wise specialized neural tracts, such as the ones specialized in encoding specific colors (Zeki 1993) or object locations, comprise the lowest information levels in mental models (Lindsay and Norman [1972] 2013). Biologically embedded instinctual programs give outlines for action tendencies (Eibel-Eibesfeldt 1989). However, experiences and learning give concrete information content to the thought models in human minds.

Within cognitive psychology, various representational concepts have been developed, including schemas, mental or thought models (Johnson-Laird 1983, 2008), plans (Miller *et al*. 1960; Schanck and Abelson 1977), mental maps (Tobler 1976), concepts, and associative or neural networks (Kohonen 1977). In the way we conceptualize mental representations, the term mental representation is reserved for information in the mind that describes the representation of an ongoing action and relevant related information. The other terms from mental models and schemas to associative networks we see as long-term memory information. The line between active and stored information is not clear, as many actions can take not only days or weeks but years. Thus, actions are not only active but also stored in memory over a period of time. Also, as Ericsson and Kintsch (1995) showed, active representations have parts in working memory as well as in long-term memory. However, from our point of view, what is essential is the information content of representations.

Content-based analysis of thinking can be applied to investigating various types of practical actions, since understanding the content of thoughts can help to explain why people behave in certain ways. A good example is content-based analysis of climate thinking. Climate change is undoubtedly one of the foremost problems of mankind (World Economic Forum 2022). The phenomenon has its geophysical and chemical roots, but it is caused by human thinking, and the risks and harms it causes should be eliminated by human thinking (see e.g. Hulkkonen 2023; Jamieson 2014). At the end of the day, ordinary people decide how they think about climate change. If thinking in this matter is not operating correctly and reliably, it is a source of social risk. Therefore, the analysis of the mental content of climate change thinking becomes relevant.

2. Methods

Today, social media is important on a practical level when people form their opinions. Internet and social media online forums can also be an alternative source of information for some people (Harju 2018; Seuri *et al*. 2021; Zwaan 2022). Qualitative methods such as observations, interviews, discourse, and social media analyses, or ethnographic analyses can offer information about how people think when they think about climate change and its effects on living (Denzin and Lincoln 1994).

2.1. Participants and procedure

To investigate climate change thinking, we analyzed data from a popular Finnish online social networking website called Suomi24 (Vaahensalo 2018), where the content of discussions presented at the paragraph level is stored in the Suomi24 Sentences Corpus 2018–2020 open data repository (City Digital Group 2021). It does not contain any personal data and it is publicly available in the Kielipankki [Language bank], Korp service. According to the Finnish National Board on Research Integrity TENK

(Finnish National Board on Research Integrity) (2019) guidelines, research that is based on registry such as Kielipankki material does not require an ethical review statement from the ethics committee. The Corpus is restricted with CC-BY-NC license which makes it available for academic, non-commercial use.

Active users of the Suomi24 forum have been described as middle-aged men, who live in the city alone or with their partners, and a third are retired (Harju 2018). Suomi24 has over 11 million threads (City Digital Group 2022) and at the end of the last decade it was estimated to have over 2 million monthly users (Reinikainen 2019). However, according to Statistics Finland (2020), in 2020 Suomi24 was followed by a modest 3% of the total population.

We searched content with a keyword "ilmastonmuutos" (climate change) in discussions written only in the year 2020. This resulted in 3,816 messages being retrieved. Data were saved in Microsoft Word™.

2.2. Materials and methods

We carried out a qualitative content-based analysis (Krippendorf 2019; Myllylä, Cañas Delgado, and Saariluoma 2023; Myllylä and Saariluoma 2022) of the data following the principles of the heterophenomenological approach (Dennett 2017). Thus, empirical third-person perspectives about mental contents are directly based on the content of the first-person perspective in protocols (Ericsson and Simon 1993).

The analysis proceeded in two iterations. First, we read through all the messages to analyze what types of contents were present and what observations we can make out of it. Our immediate observation was that people have errors in reviewing knowledge and constructing information in their mental representations. Instead, they rely on illusions, misinformation, and denial. Misinformation can be defined as misleading or false information, such as erroneous opinions which are created and spread, regardless of whether deceit was intentional or not (Saariluoma and Maksimainen 2012). We focused on this topic. We then classified the related contents under different themes.

Our other findings arising from the same corpus material, which focus on denialism and conspiracy thinking, have been discussed in more detail elsewhere (Myllylä, Cañas Delgado, and Saariluoma 2023). This time we wanted to abstract how people's thinking is faulty from the point of view of information criticism.

3. Results

We categorized content about erroneous thinking and thought models regarding reviewing knowledge and information criticism in six themes: (1) errors in criterion of knowledge, (2) errors in criterion of truth, (3) errors in relationships and compatibilities of facts, (4) errors in assessing future impacts in practice, (5) errors in assessing different factors, causes and scales, and (6) errors in understanding the nature of scientific reasoning. Due to licensing restrictions, we have omitted all direct quotes.

3.1. Errors in criterion of knowledge

One important starting point for information criticism is the basic structure of knowledge and knowing. It has long been believed that knowledge is a justified true belief (de Grefte 2023; Hilpinen 1970; Cooper and Hutchinson 1997). This is called the

classic concept of knowledge. For this concept to apply, (1) one must believe that the matter exists in some way, (2) the matter must be true, and (3) the matter must be well justified. If someone does not believe it, of course they cannot know it. If, on the other hand, it is not true, it cannot be knowledge either. Finally, the person must have a good argument that the matter is true.

A simplified roulette winner example can illustrate what knowledge is about. Suppose Person A has a big win in roulette and says he knew it would happen. In this case, on the basis of the above criteria, it can be claimed that Person A knew he would win if: (1) He believed he would win. Placing a chip, of course, guarantees that he believes he will win. If he also wins, the matter is true and meets (2) the second information criterion. The last criterion (3) is problematic, because it is difficult to find a good reason why the roulette number can be predicted. However, in the case of a roulette spin influenced by magnets, for example, the outcome of which can be predicted, and the person being aware of it, he would have a good reason for his initial claim.

The same classical information criteria can be applied to climate discourse. It is possible to look at climate opinions through the criteria of information and think about the extent to which knowledge-based societal debates really are. For example, some Suomi24 debaters believe that it is not possible to state with certainty the role of humans as the current cause of climate change (1). According to them, the matter has not been scientifically studied by appropriate expertise (2), but speculation is based mainly on interpretative presuppositions, unexplored hypotheses, or "climate faith" (3). Some debaters may have thought that the results of human research were one-sided, biased, and unreliable (2), as the researchers and related research were either unprofessional or manipulated in the interests of politicians, businessmen, or the mainstream media (3), illustrating an underlying conspiracy thought model. However, the examples described above are in no way true, at least in the light of today's scientific facts, and, thus, do not meet the criteria for knowledge.

In reality, the contribution of humans to ongoing climate change has undoubtedly been shown to be significant, based on comprehensive, high-quality, and impartial research accepted by the scientific community (IPCC (Intergovernmental Panel on Climate Change) 2023a, 2023b; United Nations 2019; World Economic Forum 2022). In contrast, the few published studies that deny mainstream climate science have contained critical flaws and errors, such as inaccurately insisting cooling or low climate sensitivity, using unsuitable statistical methods or misunderstanding physics (Cook 2020).

3.2. Errors in criterion of truth

One of the key criteria in classical information analysis is truth. This usually means that a true claim matches up to the reality (Niiniluoto 1999). For example, it is true that the average global temperature has risen. On the basis of statistical monitoring, it can also be elicited that the statement corresponds to how things are. An overview of measurement statistics describing changes in various physical phenomena, such as an increase in the global surface temperature, sea level altitude, or the carbon cycle, can be found, for instance, in the report of Working Group I of the Intergovernmental Panel on Climate Change (IPCC (Intergovernmental Panel on Climate Change) 2023a). The report summarizes the results of more than 14,000 peer-reviewed studies, which

were re-evaluated by a panel of 234 experts. In addition, 517 other experts were involved in compiling the report.

The correspondence between truth and state of affairs is the most important criterion of truth (David 2022; Niiniluoto 1999). Claims that do not correspond to the truth are false and untrue. As a result, the latter cannot be taken as a basis for information. For example, it was quite common in Suomi24 to claim that it has not been possible to measure climate change, particularly temperature changes, for a long enough period, so no convincing conclusions can be drawn from the effects of human activity on climate change. Some believed that previous modeling and predictions of climate change had been proven to be incorrect, or that the changes predicted in them had been drastically exaggerated.

In reality, climate change has been extensively studied over a very long period (IPCC (Intergovernmental Panel on Climate Change) 2023a). Developments related to climate change have largely followed previous forecasts, if not advanced even more strongly (IPCC (Intergovernmental Panel on Climate Change) 2023a, 2023b). As the understanding of, for instance, climate sensitivity advances, and the amount of observational data and the computing power of computers increases, climate models and the predictions derived from them have become increasingly comprehensive and accurate (IPCC (Intergovernmental Panel on Climate Change) 2023a, 2023b; Ruosteenoja and Jylhä 2021; but see also Simpson *et al*. 2021; Urban *et al*. 2016).

3.3. Errors in relationships and compatibilities of facts

The truth of the matter can also be established on the basis of other facts. In this case, there is usually talk of compatibility of truths (Niiniluoto 1999; Young 2018). Such a network of truths usually improves reliability. However, if there are mistakes in the interrelated system of truths, in its data or how it is understood, it can lower the credibility of the claim or take the base away from it altogether.

Climate and weather are complex concepts. Terms can be confused and oversimplified. People may imagine false cause-and-effect relationships and make incorrect interpretations of reality and the climate system, which was also found in Suomi24 discussions. Cold and snowy weather in winter may be mistaken as proof that climate change is not happening. Similarly, severe summer heat can be viewed, erroneously, as a direct sign of global warming. However, the local climate is not about individual weather observations but the average of 30-year weather statistics for a wider area (IPCC (Intergovernmental Panel on Climate Change) 2023a; Ruosteenoja and Jylhä 2021). With the current climate change, average temperatures have risen globally and extreme high temperature incidences have increased. Some of the heat has also been transferred to the oceans (Cheng *et al*. 2023; IPCC (Intergovernmental Panel on Climate Change) 2023a, 2023b; World Meteorological Organization 2022).

Another example of errors in compatibility of truths in Suomi24 was to associate the public debate on climate change with previous historical, similar debates. For example, since the societal worries and fears of running out of oil that followed the oil crisis of the 1970s did not materialize, climate change and the debate about it must be a similar exaggeration or "sham." Although the debate on the oil crisis of the 1970s and on climate change today may give rise to similar emotions and thoughts, they are not compatible as phenomena in terms of their facts—that is, they cannot be compared to make reliable claims about climate change. Underlying the global energy crisis of

the 1970s was the Egyptian–Syrian war against Israel, which led to the oil embargo situation where Arab oil-producing countries began to restrict oil distribution to the West (Garavini 2011). In 1973, an energy-saving program was also published in Finland (Kasanen 1997).

3.4. Errors in assessing future impacts in practice

Attention can also be paid to the so-called pragmatic theory of truth (Capps 2023; Peirce [1931] 1958). In this case, it is a question of some claim being proved useful in practice. In technology design, for example, this is an important way of thinking. If a technical tool is of practical use, the underlying way of thinking can be considered true. Although climate analysis sometimes relies on practical benefits, it is often questionable whether the benefits are only illusory.

Some Suomi24 discussants considered climate change as a useful phenomenon, especially in Finland. An example argument was that plants and agriculture can benefit from a warmer climate and more carbon dioxide in the air. Because global warming was viewed as natural, useful, and beneficial to life, predictions about its negative future implications were denied or downplayed as untrue or overexaggerated.

In Finland, climate change can have both positive and negative consequences (Ruosteenoja and Jylhä 2021; Venäläinen *et al*. 2020), which, however, cannot be directly compared to each other. For instance, the growing season in Finland has already lengthened (Peltonen-Sainio and Jauhiainen 2020), and the growth of agricultural plants and forests is predicted to increase in Nordic countries in the future (Ruosteenoja and Jylhä 2021; Venäläinen *et al*. 2020). However, several potential negative impacts can be listed (Ruosteenoja and Jylhä 2021). Milder and rainier winters will increase windstorms, heavier snow loading, and floods, while high temperatures during the spring and summer—interrupted by increasing heavy rains—can bring droughts, forest fires, erosion and nutrient loading of water bodies, insect pests, and pathogens (Tuomenvirta *et al*. 2018; Venäläinen *et al*. 2020). On the global level, climate change causes significantly more harm than benefits for both humans and nature (IPCC (Intergovernmental Panel on Climate Change) 2023a, 2023b). Local effects in other parts of the world will also indirectly affect the lives of Finns (Tuomenvirta *et al*. 2018).

People have adapted to environmental changes in the past by inventing, for example, new technologies (Masson-Delmotte *et al*. 2012). However, the historical conditions cannot be directly compared to the current or future situations. People's interactions between human-made and natural systems and effects on the environment change, which also creates new types of risks (IPCC (Intergovernmental Panel on Climate Change) 2023b; Masson-Delmotte *et al*. 2012; Simpson *et al*. 2021).

3.5. Errors in assessing different factors, causes, and scales

Several Suomi24 interlocutors argued that climate change can be explained solely by natural or non-human factors (such as variations in solar radiation, changes in the Earth's orbit, and volcanic activity), or that human contribution is at most negligible and insignificant. However, the current climate change phenomenon is primarily due to human activity, especially in the last hundred years, when people have been

producing significant amounts of greenhouse gas emissions (IPCC (Intergovernmental Panel on Climate Change) 2023a).

The speed and intensity of current climate change are clearly in a different category from that caused by natural factors alone (IPCC (Intergovernmental Panel on Climate Change) 2023a). Arguably, the varying temporal and spatial scales of human influence and natural factors, their differences and consequences, are difficult for many people to imagine and comprehend.

3.6. Errors in understanding the nature of scientific reasoning

It is an indisputable fact that humans have caused the current climate change, and only urgent human action can curb and adapt to it (Ahteensuu 2020; IPCC (Intergovernmental Panel on Climate Change) 2023a, 2023b; World Meteorological Organization 2022). It is important to understand that this is not just one opinion, or that there could be several "other truths" or different perspectives. There can be several opinions, but only an argument that corresponds to reality and is based on facts can be true.

An opinion differs from knowledge in that an opinion or belief need not be true. Experience has shown that actions based on mistakes lead very easily to accidents, crises, triggered risks, and other significant inconveniences in people's lives. For this reason, it is important that climate thinking and knowledge is built on facts. This knowledge-based mindset can be criticized on the grounds that knowledge is not absolute. Some Suomi24 comments illustrated this type of an unfounded "all-or-nothing-logic". However, it is impossible for a climate change researcher to present "100% of the facts about climate change" because this is contrary to the nature of scientific knowledge.

However, if a scientific claim is incorrect, it does not follow that all other claims are incorrect or that any other opinion will become factual. The core mechanism of science is self-correcting. Scientific data is constantly tested and, as a result, erroneous claims can be eliminated. In the long run, self-correcting scientific reasoning is becoming increasingly accurate (Niiniluoto 1999; see also IPCC (Intergovernmental Panel on Climate Change) 2023b, 41). Untested opinions, despite being untrue, can persist for hundreds of years.

4. Discussion

The immediate causes of climate change are natural in the scientific sense, but its root cause must be sought in human activity and, above all, in the thinking that guides human activity. For this reason, it is good to look at human climate change thinking.

To form reliable representations of the world it is essential that thoughts correspond to the states of affairs they concern. Lay thinking does not pay systematic attention to its correctness, but it still guides what people do. Science differs from lay thinking as it has invested much effort in increasing its reliability (Niiniluoto 1999). One of the great scientific problems of the twentieth century has been to increase the reliability of scientific knowledge (Bunge 1967; Nagel 1961; Saariluoma 1997). Science is not infallible, but it is still the most reliable way to look at natural phenomena from the development of technology to social and medical issues because of the

critique of information (Bunge 1967; Nagel 1961; Saariluoma 1997). According to our observations, in public debate people are not able to review knowledge reliably.

As Jamieson (2014, 103) notes: "Climate change must be thought rather than sensed, and we are not very good at thinking." The role of erroneous or irrelevant thinking and risky thought models is obvious. Our data illustrates that human representations of climate change can be seriously misconstrued. One example is the inability to review information, knowledge, and knowing correctly. On the other hand, our results indicate that typically people have skewed ideas about the causes, consequences, scales, and significance of climate change in real life.

Erroneous thinking about the climate change can involve poorer scientific knowledge and analytical thinking style, as well as several different cognitive biases. Examples are having ontological confusions "that misattribute properties of one type of thing to another" (Lindeman, Svedholm-Häkkinen, and Riekki 2023, 116), optimism bias where positive impacts of climate change are overestimated while negative information is being neglected (Beattie *et al*. 2017), and confirmation bias, where people are inclined to seek and uncritically accept information, even about improbable phenomena, if it is likely to be compatible with their existing beliefs (Kahneman 2011).

It is difficult for human cognition to pay attention and integrate information, make statistical predictions, and weight the possible causalities, benefits, and risks of climate change (Baron 2006; Kahneman, Sibony, and Sunstein 2021). Climate change becomes even more difficult to think about correctly when it involves factors that are non-perceivable or exceed the everyday human life scale in their spatial and temporal dimensions and complexity. Wrongly constructed mental models and biased cognition (Beattie *et al*. 2017) are shown in erroneous thinking, such as having epistemically suspect beliefs which are incoherent with scientific evidence (Lindeman, Svedholm-Häkkinen, and Riekki 2023), invalid reasoning in argument fallacies (Van Eemeren and Grootendorst 2004), and making errors of judgment (Kahneman 2011; Kahneman, Sibony, and Sunstein 2021).

Due to errors and misconstructions of mental information content, people can set erroneous goals for their actions regarding climate change (Molden, Bayes, and Druckman 2022). They might even deny the phenomenon and use common denialist claims such that global warming is not real, or its impacts are not so serious, humans are not the cause of global warming, solutions to climate change will not work, or that the climate science and experts are unreliable (Cook 2020; Myllylä, Cañas Delgado, and Saariluoma 2023.

Further, climate change denialism can negatively influence people's actions to mitigate climate change (Gifford, Lacroix, and Chen 2018). Erroneous goals and denialism also make it more difficult for other people to react to climate change. Particularly in open societies, which are characterized by freedom of expression, civilized citizens, their abilities to rational and scientific thinking and their responsibilities for the well-being of a democratic society (Popper 1950), the opinions of denialists are important on a political level (Cook 2017). Political decisions are one form of social action. Thus, it is important to make it easier for people to understand the threat and set goals for their actions that make sense by thinking about how much climate change will affect mankind.

Our focus in this article has been on the information content of thought models in erroneous thinking on climate change. The construction and qualities of erroneous thinking can be peeled back like the layers of an onion. The details can be abstracted to open the general schematic structure of a particular thought model. The method is

familiar from phenomenological studies (Husserl [1913] 2004). Research can abstract one level at a time.

Understanding climate change thinking is relevant for the people whose task it is to convey information about the social and natural risks of climate change. They can target information at critical points in the information space. They can argue that it is worth taking actions and choosing alternatives that support the mitigation of climate change.

Investigating climate change-related thought models and the contents of thinking also opens new possibilities to explain human action. One can base an explanation of what people do on information about their mental content. One can say that people do what they think: that they, for example, are willing to give their support to political directions which deny or minimize the risks of climate change (Uscinski, Douglas, and Lewandowsky 2017). However, people do not necessarily know what they think and especially why they think as they think. Consciousness research has shown that only a tip of the knowledge required to control human actions is explicit. A vast part of the relevant information in the mind is subconscious (Chalmers 2010; de Groot 1965; Dennett 2017; Revonsuo 2010; van Gulick *et al*. 2012). Thus, analyzing how people think from the third-person perspective (Dennett 2017) is essential.

A normal model of explaining human actions or behavior is causal. Something happens and people act logically in response to the event. A stimulus is presented on a computer screen and depending on its properties, some properties of humans can be explained. Neisser (1964), for example, showed that similarities in background and target affect the speed of detection. Although this has been a very valid and contributive view of the mind, it is not the same as content-based thinking.

In philosophy, causal models of explaining human action have been seen as limited for some time (Brentano [1924] 1955; Von Wright 1971). These researchers claimed that human beings set goals for their actions and what they do now must be explained on the basis of some future state of affairs. Instead, in causal explaining, the phenomenon that explains something (explanans) emerges before the phenomenon to be explained (explanandum). For example, I am reducing my consumption of fossil fuels today to make a good life possible for future generations. Thus, the intentional explanation is conceptually different from the causal one.

We call our approach the "content-based analysis of mind" because we base our argumentation on the properties of related mental content (Myllylä and Saariluoma 2022; Saariluoma 1995, 2001). In content-based cognitive research, the idea of explaining will essentially extend the basic ideas of intentional explanation and intentional explaining, and they can be seen as a subcase of content-based explaining. Intention can refer to the future outcome of an action, as human mental content is not fixed in a physical place and time. The mind can represent things that are outside the immediate situation in the past or in the future. Thus, intentional explaining of actions refers to the future situation, which makes it understandable why people act now as they do. However, it is not only representations of the future that are essential in explaining human actions, it is also essential to pay attention to all aspects of human mental representations, as these mental contents can also shed light on human control of actual ongoing actions. Intention is just one type of explanatory mental content. It is vital, but there are many others.

Different aspects of mental content have been called to the attention of researchers, but in cognitive science no systematic approach has so far been developed to use this

source of information about the human mind in explaining human actions. This is due to historical reasons, as other problems have been in the interest of researchers. However, we see that this idea of investigating content as content will become a relevant topic in the future. Newell and Simon (1972) discussed content-oriented analysis of the mind. Allport (1980) called attention to modular neural systems, which are content-oriented. Fodor (1992) examined the philosophical bases of mental content. However, from our point of view, the crucial step is to learn to use mental content as an explanatory ground. Any properties of mental content can be used to explain human actions by means of showing that representational content and some aspects of actions are associated. Thus, the information content of representations can provide a sense-making explanation for what people do.

Content-based thinking also needs its metascience. The core question is what kinds of theoretical contexts and theoretical concepts could be used to express its outcomes. One goal of content-based thinking is to improve the clarity of public and social information processing. It would be logical to link the scientific efforts with conceptual engineering (Chalmers 2020; Eklund 2015; Floridi 2011). Thus, it would make sense to coin the notion of the conceptual model. Conceptual models are theoretical notions describing empirical reality. Empirical ideas of illusory-based thought models in the minds of people could be seen on the level of theory as conceptual models. However, apperceptive processes can also be seen as conceptual models in content-based theoretical thinking.

Conceptual models form the basic theoretical concept for theories on information content and content-based thinking. Conceptual models can also be used to express theoretical ideas in order to construct new models for acting with information. They are intimately linked with the idea of ontologies as theories of content (Chandrasekaran, Josephson, and Benjamins 1999). Content-based research works in the information space; it investigates, analyses, and designs issues relevant for the information content in social and individual information spaces. Illusory and false thought models in considering climate change are an example of an important content phenomenon.

5. Conclusions

Our investigation illustrates that human thinking is actively involved in climate problems and threats. Climate change can be considered from different scientific points of view. It is essentially change in the human natural or physical environment, and for this reason it is good to consider it by means of the concepts and methods of natural science. They give us an idea how things are. They also describe the states of affairs and mechanisms in natural scientific terms. However, natural science cannot draw the full picture.

In reality, climate problems are human problems because human suffering is the only risk. Molecules can be organized on earth in an unlimited manner and, for them, it is not significant that the temperature or water level rises. It is something that happens as logically as the sun rises. From the human perspective, things are different. If things go on following predicted paths, it will mean significant suffering for people. It is indeed possible that substantial numbers of people will die. For this reason alone, one must pay specific attention to the foundations of research and rationality used in working to tackle climate change.

What actions people are willing to take depends on their thinking. How people comprehend and have constructed their mental models regarding climate change can be studied in how they write about it (Zwaan 2022), for instance. In this paper, we have analyzed the mental content expressed in social media discussions in the Suomi24 online forum. Even though Suomi24 is followed only by a small part of the Finnish population, we think that the content of these messages related to climate change can explain why some people are still against the massive literary and research material and judge the phenomenon as non-existent or of little consequence. It is a question that can be asked in the context of content-based cognitive and mental research. The goal is to open up how people cloud their clear understanding of facts. People with poor internet reading and critical thinking skills can take the illusory claims presented above as a building block for their thinking, and the outcome can be seriously risky.

As social media spreads conceptions so effectively, illusory models can gain extensive space in the mental spaces of social groups. Thus, social media misinformation easily gains social influence and, consequently, represents a new kind of societal risk. Climate change is deceptive, as the signs of its reality are not immediately to hand. Climate-based changes in nature are slow, but they are also difficult to combat and restore. For this reason, it is essential to meet the problems of illusory thinking as quickly as possible.

It is worth pointing out that industrial climate change has hardly any other ultimate cause than human thinking with its successes and failures. Nature acts according to its own laws, but human thoughts and decisions are the root cause of industrial or anthropogenic climate change. Therefore, it is vital that scientific attention is focused on the mental processes involved.

Being able to analyze the human thinking involved in climate change issues is essential for environmental management. Especially critical in open society is to eliminate manipulative and illusory arguments from democratic discourse. Erroneous thinking is dangerous, and for this reason it is essential to investigate human illusory thinking in climate issues to manage environmental safety.

Acknowledgments

We thank the editor for their helpful comments and Robert Hanna and an anonymous referee for their important observations on the previous version of the manuscript.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by the Etairos STN project of the Academy of Finland under Grant number 327355; Business Finland through the COACH project under Grant number 3289/31/2022, operating under the umbrella of the SEEDForest ecosystem.

ORCID

Mari Myllylä http://orcid.org/0000-0002-9753-373X

Data availability statement

Data supporting the results or analyses presented in the paper can be found in: http://urn.fi/urn:nbn:fi:lb-2021101521

References

Ahteensuu, M. 2020. "Ilmastovitkuttelu ja Tieteellinen Epävarmuus" [Climate Procrastination and Scientific Uncertainty]." In *Ilmastonmuutos ja Filosofia [Climate Change and Philosophy]*, edited by S. Kyllönen and M. Oksanen, 27–45. Helsinki: Gaudeamus.

Allport, D. A. 1980. "Patterns of Actions: Cognitive Mechanisms Are Content Specific." In *Cognitive Psychology: New Directions*, edited by G. Claxton, 112–153. London: Routledge and Paul Kegan.

Baron, J. 2006. "Thinking about Global Warming." *Climatic Change* 77 (1–2): 137–150. doi:10.1007/s10584-006-9049-y.

Beattie, G., M. Marselle, L. McGuire, and D. Litchfield. 2017. "Staying Over-Optimistic about the Future: Uncovering Attentional Biases to Climate Change Messages." *Semiotica* 2017 (218): 21–64. doi:10.1515/sem-2016-0074.

Brentano, F. (1924) 1955. *Psychologie Vom Empirischen Standpunkt* [Psychology from an Empirical Point of View]. Reprint. Hamburg: Felix Meiner.

Bunge, M. 1967. *Scientific Research II: The Search for Truth*. Berlin: Springer.

Capps, J. 2023. "The Pragmatic Theory of Truth." in *The Stanford Encyclopedia of Philosophy*, edited by E. N. Zalta and U. Nodelman. Summer 2023 Edition. Stanford, CA: Stanford University Press. https://plato.stanford.edu/archives/sum2023/entries/truth-pragmatic/.

Chalmers, D. J. 2010. *The Character of Consciousness*. Oxford: Oxford University Press.

Chalmers, D. J. 2020. "What is Conceptual Engineering and What Should It Be?" *Inquiry* (September): 1–18. doi:10.1080/0020174X.2020.1817141.

Chandrasekaran, B., J. R. Josephson, and V. R. Benjamins. 1999. "What Are Ontologies, and Why Do We Need Them?" *IEEE Intelligent Systems* 14 (1): 20–26. doi:10.1109/5254.747902.

Chase, W. G., and H. A. Simon. 1973. "Perception in Chess." *Cognitive Psychology* 4 (1): 55–81. doi:10.1016/0010-0285(73)90004-2.

Cheng, L., J. Abraham, K. E. Trenberth, J. Fasullo, T. Boyer, M. E. Mann, J. Zhu, *et al.* 2023. "Another Year of Record Heat for the Oceans." *Advances in Atmospheric Sciences* 40 (6): 963–974. doi:10.1007/s00376-023-2385-2.

City Digital Group. 2021. "The Suomi24 sentences corpus 2018–2020, Korp Version [text corpus]." Kielipankki. http://urn.fi/urn:nbn:fi:lb-2021101521.

City Digital Group. 2022. "Brands. Our Network of Forward-thinking People and Companies Build Entertaining Digital Services from Marketing, Ad Network & Digital Commerce to Media and Digital Restaurant Business." City Digital Group. https://www.citydigital.fi/en/brands/#suomi24.

Cook, J. 2017. "Understanding and Countering Climate Science Denial." *Journal and Proceedings of the Royal Society of New South Wales* 150 (2): 207–219. https://search.informit.org/doi/10.3316/informit.388378410941383. doi:10.5962/p.361798.

Cook, J. 2020. "Deconstructing Climate Science Denial." In *Edward Elgar Research Handbook in Communicating Climate Change*, edited by D. C. Holmes and L. M. Richardson, 62–78. Cheltenham: Edward Elgar Publishing. doi:10.4337/9781789900408.00014.

Cooper, John M., and D. S. Hutchinson. 1997. *Plato: Complete Works*. Indianapolis, IN: Hackett.

David, M. 2022. "The Correspondence Theory of Truth." In *The Stanford Encyclopedia of Philosophy*, edited by E. N. Zalta. Summer 2022 Edition. Stanford, CA: Stanford University Press. https://plato.stanford.edu/archives/sum2022/entries/truth-correspondence/.

de Grefte, J. 2023. "Knowledge as Justified True Belief." *Erkenntnis* 88 (2): 531–549. doi:10.1007/s10670-020-00365-7.

de Groot, A. D. 1965. *Thought and Choice in Chess*. Hague: Mouton.

Dennett, D. C. 2017. *From Bacteria to Bach and Back: The Evolution of Minds*. New York: W. W. Norton Company.

Denzin, N. K., and Y. S. Lincoln, eds. 1994. *Handbook of Qualitative Research*. Thousand Oaks, CA: Sage.
Dilthey, W. 1970. *Der Aufbau Der Geschichtlichen Welt in Den Geisteswissenschaften* [The Construction of Historical World in Human Research]. Frankfurt am Main: Suhrkamp.
Eibel-Eibesfeldt, I. 1989. *Human Ethology*. New York: Aldine de Guyter.
Eklund, M. 2015. "Intuitions, Conceptual Engineering, and Conceptual Fixed Points." In *The Palgrave Handbook of Philosophical Methods*, edited by C. Daly, 363–385. London: Palgrave Macmillan. doi:10.1057/9781137344557_15.
Ericsson, K. A., and W. Kintsch. 1995. "Long-Term Working Memory." *Psychological Review* 102 (2): 211–245. doi:10.1037/0033-295X.102.2.211.
Ericsson, K. A., and H. A. Simon. 1993. *Protocol Analysis: Verbal Reports as Data*. Revised ed. Cambridge, MA: MIT Press.
Evans, J. 2013. *Reasoning, Rationality and Dual Processes: Selected Works of Jonathan St B.T. Evans*. London: Psychology Press.
Floridi, L. 2011. "A Defence of Constructionism: Philosophy as Conceptual Engineering." *Metaphilosophy* 42 (3): 282–304. doi:10.1111/j.1467-9973.2011.01693.x.
Fodor, J. A. 1992. *A Theory of Content and Other Essays*. Cambridge, MA: MIT Press.
Garavini, G. 2011. "Completing Decolonization: The 1973 'Oil Shock' and the Struggle for Economic Rights." *The International History Review* 33 (3): 473–487. https://www.jstor.org/stable/23033194. doi:10.1080/07075332.2011.595593.
Gifford, R., K. Lacroix, and A. Chen. 2018. "Understanding Responses to Climate Change: Psychological Barriers to Mitigation and a New Theory of Behavioral Choice." *In Psychology and Climate Change: Human Perceptions, Impacts, and Responses*, edited by S. Clayton and C. Manning, 161–184. London: Academic Press.
Hanson, N. R. 1958. *Patterns of Discovery: An Inquiry into the Conceptual Foundations of Science*. Cambridge: Cambridge University Press.
Harju, A. 2018. "Suomi24-Keskustelut Kohtaamisten ja Törmäysten Tilana" [Suomi24 Discussions as a Space for Encounters and Collisions]." *Media & Viestintä* 41 (1): 51–74. doi:10.23983/mv.69952.
Heidegger, M. (1926) 1992. *Being and Time.* Translated by John Macquarrie and Edward Robinson. Reprint. Oxford: Blackwell.
Hempel, C. G., and P. Oppenheim. 1948. "Studies in the Logic of Explanation." *Philosophy of Science* 15 (2): 135–175. doi:10.1086/286983.
Hilpinen, R. 1970. "Knowing That One Knows and the Classical Definition of Knowledge." *Synthese* 21 (2): 109–132. http://www.jstor.org/stable/20114716. doi:10.1007/BF00413541.
Ho, M. K., R. Saxe, and F. Cushman. 2022. "Planning with Theory of Mind." *Trends in Cognitive Sciences* 26 (11): 959–971. doi:10.1016/j.tics.2022.08.003.
Hulkkonen, M. 2023. *Ilmasto-Oivalluksia. Kuinka Ihmismielen Supervoimat Valjastetaan Planeetan Parhaaksi* [Climate Insights. How to Harness the Superpowers of the Human Mind for the Good of the Planet]. Helsinki: Gaudeamus.
Husserl, E. (1913) 2004. *Ideas: General Introduction to Pure Phenomenology*. Translated by W. R. Boyce Gibson. Abingdon: Routledge.
IPCC (Intergovernmental Panel on Climate Change). 2023a. *Climate Change 2021 – The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press. doi:10.1017/9781009157896.
IPCC (Intergovernmental Panel on Climate Change). 2023b. *Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press. doi:10.1017/9781009325844.
Jamieson, D. 2014. Reason in a Dark Time. *Why the Struggle against Climate Change Failed—and What It Means for Our Future*. New York: Oxford University Press.
Johnson-Laird, P. 1983. *Mental Models: Towards a Cognitive Science of Language, Inference, and Consciousness*. Cambridge, MA: Harvard University Press.
Johnson-Laird, P. 2008. *How We Reason*. Oxford: Oxford University Press.
Johnson-Laird, P., and R. Byrne. 1991. *Deduction*. Mahwah, NJ: Erlbaum.
Kahneman, D. 2011. *Thinking, Fast and Slow*. London: Penguin Books.

Kahneman, D., O. Sibony, and C. R. Sunstein. 2021. *Noise: A Flaw in Human Judgment*. London: William Collins.
Kant, I. (1781) 1976. *Kritik Der Reinen Vernunft [The Critique of Pure Reason]*. Hamburg: Felix Meiner.
Kasanen, P. 1997. "Kuluttaja Energiansäästäjänä Ympäristön Takia—Tutkimusta ja Haasteita" [The Consumer and Environmentally Motivated Energy Conservation—Research and Challenges]." *Liiketaloudellinen Aikakauskirja* 1: 32–47. http://lta.lib.aalto.fi/1997/1/lta_1997_01_a3.pdf.
Köhler, W. (1917) 1957. *The Mentality of Apes*. Translated from the 2nd rev. ed. by Ella Winter. London: Penguin Books.
Kohonen, T. 1977. *Associative Memory: A System-Theoretical Approach*. Berlin: Springer.
Krippendorf, K. 2019. *Content Analysis: An Introduction to Its Methodology*. 4th ed. Los Angeles, CA: SAGE.
Lindeman, M., A. M. Svedholm-Häkkinen, and T. J. J. Riekki. 2023. "Searching for the Cognitive Basis of Anti-Vaccination Attitudes." *Thinking & Reasoning* 29 (1): 111–136. doi:10.1080/13546783.2022.2046158.
Lindsay, P. H., and D. A. Norman. (1972) 2013. *Human Information Processing: An Introduction to Psychology*. New York: Academic Press.
Masson-Delmotte, V., D. Swingedouw, A. Landais, M.-S. Seidenkrantz, E. Gauthier, V. Bichet, C. Massa, *et al.* 2012. "Greenland Climate Change: From the past to the Future." *WIREs Climate Change* 3 (5): 427–449. doi:10.1002/wcc.186.
Miller, G. A., E. Galanter, K. H. Pribram. 1960. "The Integration of Plans." In *Plans and the Structure of Behavior*, edited by G. A. Miller, E. Galanter, and K. H. Pribram, 95–102. London: Holt, Rinehart and Winston. doi:10.1037/10039-007.
Molden, D. C., R. Bayes, and J. N. Druckman. 2022. "A Motivational Systems Approach to Investigating Opinions on Climate Change." *Thinking & Reasoning* 28 (3): 396–427. doi:10.1080/13546783.2021.1982003.
Myllylä, M., J. J. Cañas Delgado, and P. Saariluoma. 2023. "On Conspiracy Thought Models in Thinking Climate Change." *European Journal of Sustainable Development* 12 (3): 15. doi:10.14207/ejsd.2023.v12n3p15.
Myllylä, M., and P. Saariluoma. 2022. "Expertise and Becoming Conscious of Something." *New Ideas in Psychology* 64: 100916. doi:10.1016/j.newideapsych.2021.100916.
Nagel, E. 1961. *The Structure of Science: Problems in the Logic of Scientific Explanation*. London: Routledge & Kegan Paul.
Neisser, U. 1964. "Visual Search." *Scientific American* 210 (6): 94–102. doi:10.1038/scientificamerican0664-94.
Newell, A., and H. A. Simon. 1972. *Human Problem Solving*. Englewood Cliffs, NJ: Prentice-Hall.
Niiniluoto, I. 1999. *Critical Scientific Realism*. Oxford: Oxford University Press.
Peirce, C. S. (1931) 1958. *Collected Papers*. Reprint, Cambridge, MA: Belknap Press of Harvard University Press.
Peltonen-Sainio, P., and L. Jauhiainen. 2020. "Large Zonal and Temporal Shifts in Crops and Cultivars Coincide with Warmer Growing Seasons in Finland." *Regional Environmental Change* 20 (3): 89. doi:10.1007/s10113-020-01682-x.
Pohl, R. F. 2017. "Cognitive Illusions." In *Cognitive Illusions: Intriguing Phenomena in Thinking, Judgment and Memory*, edited by R. F. Pohl, 3–22. 2nd ed. London: Psychology Press. doi:10.4324/9781315696935.
Popper, K. R. 1950. *The Open Society and Its Enemies*. Princeton, NJ: Princeton University Press.
Radnitsky, G. 1968. *Contemporary Schools of Metascience*. Göteborg: Akademieförlaget.
Reinikainen, P. 2019. "Suomi24 Takaisin Kotimaiseen Omistukseen, Ilkka Lavas Lupaa Kehittää Treffipalvelua: 'Moni Hakee Syvällisempää Keskustelua.'" [Suomi24 Back in Finnish Ownership, Ilkka Lavas Promises to Develop the Dating Service: 'Many People Are Looking for a Deeper Discussion']. Yrittäjät. https://www.yrittajat.fi/uutiset/suomi24-takaisin-kotimaiseen-omistukseen-ilkka-lavas-lupaa-kehittaa-treffipalvelua-moni-hakee-syvallisempaa-keskustelua.
Revonsuo, A. 2010. *Consciousness: The Science of Subjectivity*. New York: Psychology Press.
Ruosteenoja, K., and K. Jylhä. 2021. "Projected Climate Change in Finland during the 21st Century Calculated from CMIP6 Model Simulations." *Geophysica* 56 (1): 39–69. https://www.geophysica.fi/pdf/geophysica_2021_56_1_039_ruosteenoja.pdf.

Saariluoma, P. 1995. *Chess Players' Thinking: A Cognitive Psychological Approach*. London: Routledge.
Saariluoma, P. 1997. *Foundational Analysis: Presuppositions in Experimental Psychology*. London: Routledge.
Saariluoma, P. 2001. "*Moderni Kognitiotiede* [Modern Cognitive Science]." In *Moderni Kognitiotiede [Modern Cognitive Science]*, edited by P. Saariluoma, M. Kamppinen, and A. Hautamäki, 26–50. Helsinki: Gaudeamus.
Saariluoma, P., J. Cañas, and J. Leikas. 2016. *Designing for Life: A Human Perspective on Technology Development*. London: Palgrave Macmillan.
Saariluoma, P., and J. Maksimainen. 2012. "Intentional Disinformation and Freedom of Expression." *International Review of Social Sciences and Humanities* 3 (2): 9–20.
Schanck, R. C., and R. B. Abelson. 1977. *Scripts, Plans, Goals, and Understanding*. Mahwah, NJ: Erlbaum.
Seuri, O., H. P. Ikäheimo, A. Vihma, and J. Hartikainen. 2021. " "Media and the Information Environment: There is No Such Thing as Nordic Exceptionalism." In *The Political Analyst's Field Guide to Finland*, edited by K. Ilmonen and P. Moilanen, 103–125. Jyväskylä: University of Jyväskylä. doi:10.17011/jyureports/2021/10.
Simpson, N. P., K. J. Mach, A. Constable, J. Hess, R. Hogarth, M. Howden, J. Lawrence, *et al.* 2021. "A Framework for Complex Climate Change Risk Assessment." *One Earth* 4 (4): 489–501. doi:10.1016/j.oneear.2021.03.005.
Snow, C. P. 1959. *The Two Cultures and the Scientific Revolution*. Cambridge: Cambridge University Press.
Statistics Finland. 2020. "Väestön Tieto-ja Viestintätekniikan Käyttö 2020" [The Population's Use of Information and Communication Technology 2020]. Tiede, Teknologia ja Tietoyhteiskunta 2020. Helsinki: Statistics Finland. https://stat.fi/til/sutivi/2020/sutivi_2020_2020-11-10_fi.pdf.
Stegmüller, W. 1969. *Hauptströmungen Der Gegenwartsphilosophie: Eine Kritische Einführung [Main Traditions of Modern Philosophy]*. Stuttgart: Kröner.
TENK (Finnish National Board on Research Integrity). 2019. The Ethical Principles of Research with Human Participants and Ethical Review in the Human Sciences in Finland. *Finnish National Board on Research Integrity TENK Guidelines 2019*. 2nd, revised ed. Helsinki: Publications of the Finnish National Board on Research Integrity TENK. https://tenk.fi/sites/default/files/2021-01/Ethical_review_in_human_sciences_2020.pdf.
Tobler, W. R. 1976. "The Geometry of Mental Maps." In *Spatial Choice and Spatial Behavior*, edited by R. Golledge and G. Ruston, 69–81. Columbus: Ohio State University Press.
Tuomenvirta, H., R. Haavisto, M. Hildén, T. Lanki, S. Luhtala, P. Meriläinen, K. Mäkinen, *et al.* 2018. Weather and Climate Risks in Finland: National Assessment. *Publications of the Governments Analysis, Assessment and Research Activities 43/2018*. Helsinki: Prime Minister's Office.
Tversky, A., and D. Kahneman. 1974. "Judgment under Uncertainty: Heuristics and Biases." *Science* 185 (4157): 1124–1131. doi:10.1126/science.185.4157.1124.
United Nations. 2019. *Global Sustainable Development Report 2019: The Future Is Now—Science for Achieving Sustainable Development*. New York, NY: United Nations. https://sdgs.un.org/sites/default/files/2020-07/24797GSDR_report_2019.pdf.
Urban, M. C., G. Bocedi, A. P. Hendry, J.-B. Mihoub, G. Pe'er, A. Singer, J. R. Bridle, *et al.* 2016. "Improving the Forecast for Biodiversity under Climate Change." *Science* 353 (6304): Article aad8466. doi:10.1126/science.aad8466.
Uscinski, J. E., K. Douglas, and S. Lewandowsky. 2017. "Climate Change Conspiracy Theories." Oxford Research Encyclopedias, Climate Science, September 27, 2017. doi:10.1093/acrefore/9780190228620.013.328.
Vaahensalo, E. 2018. "Keskustelufoorumit mediainhokkeina – Suositut suomenkieliset keskustelufoorumit mediassa." [Discussion forums as media dislikes—Popular Finnish-language discussion forums in the media.] Wider Screen 21 (3): 2013–2018. http://widerscreen.fi/numerot/2018-3/keskustelufoorumit-mediainhokkeina-suositut-suomenkieliset-keskustelufoorumit-mediassa.
Van Eemeren, F. H., and R. Grootendorst. 2004. *A Systematic Theory of Argumentation: The Pragma-Dialectical Approach*. New York: Cambridge University Press.

Van Gulick, R., E. Margolis, and R. Samuels. 2012. "Consciousness and Cognition." In *The Oxford Handbook of Philosophy of Cognitive Science*, edited by S. P. Stich, 19–40. New York, NY: Oxford Handbooks. doi:10.1093/oxfordhb/9780195309799.013.0002.

Venäläinen, A., I. Lehtonen, M. Laapas, K. Ruosteenoja, O.-P. Tikkanen, H. Viiri, V.-P. Ikonen, *et al.* 2020. "Climate Change Induces Multiple Risks to Boreal Forests and Forestry in Finland: A Literature Review." *Global Change Biology* 26 (8): 4178–4196. doi:10.1111/gcb.15183.

Von Wright, G. H. 1971. *Explanation and Understanding*. Ithaka, NY: Cornell University Press.

Wason, P. C. 1968. "Reasoning about a Rule." *The Quarterly Journal of Experimental Psychology* 20 (3): 273–281. doi:10.1080/14640746808400161.

World Economic Forum. 2022. *The global risks report 2022*. 17th ed. World Economic Forum. https://wef.ch/risks22.

World Meteorological Organization. 2022. *United in Science 2022: A Multi-Organization High-Level Compilation of the Most Recent Science Related to Climate Change, Impacts and Responses*. World Meteorological Organization (WMO), United Nations Environment Programme (UNEP), Intergovernmental Panel on Climate Change (IPCC), World Meteorological Organization (WMO), United Nations Office for Disaster Risk Reduction (UNDRR), Global Carbon Project (GCP), UK Met Office. https://public.wmo.int/en/resources/united_in_science.

Young, J. O. 2018. "The Coherence Theory of Truth." In *The Stanford Encyclopedia of Philosophy* (Fall 2018 Edition), edited by E. N. Zalta. Stanford, CA: Stanford University. https://plato.stanford.edu/archives/fall2018/entries/truth-coherence/.

Zeki, S. 1993. *A Vision of the Brain*. Oxford: Blackwell.

Zwaan, R. A. 2022. "Conspiracy Thinking as Situation Model Construction." *Current Opinion in Psychology* 47: 101413. doi:10.1016/j.copsyc.2022.101413.