Exploring the Role of Visualization in Climate Change Communication – an Audience Perspective

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Abstract

Climate change communication is a topical and relevant issue, and it is widely acknowledged that public communication about causes, impacts and action alternatives is integral to addressing the challenges of the changing climate. Climate visualization concerns the communication of climate information and data through the use of different information technologies and different modes of visual representation. In the context of climate change communication, climate visualization is highlighted as a potential way of increasing public engagement with climate change. In particular, developments within information technology have provided significant advancements that are claimed to be transformative in engaging lay audiences with issues relating to the mitigation of and adaptation to climate change. Nevertheless, there is a lack of research exploring climate visualization from an audience perspective. This thesis addresses this gap. The overarching aim is thus to explore the role of climate visualization in climate change communication from an audience perspective, focusing specifically on how lay audiences make meaning of climate change as represented in two examples of climate visualization. In addition, the thesis discusses the potential contributions and/or limitations of climate visualization from a communication perspective.

Based on a social semiotic theoretical framework, this thesis employs focus group interviews to study participants’ meaning-making related to two cases of climate visualization: a dome theatre movie developed for Swedish high school students with the aim of encouraging reflection on climate change causes, impacts and mitigation alternatives, and a web-based tool for climate change adaptation developed to assist Nordic homeowners in adapting to the local impacts of climate change.

The results of this thesis show that climate visualization can help audiences concretize otherwise abstract aspects of climate change, and that the localized focus can make climate change appear more personally relevant and interesting for targeted audiences. Nevertheless, despite these communicative qualities, the analyses also show that participants’ interpretations are shaped by their preconceptions of climate change as a global and distant issue to be solved by other actors, such as national governments, or through international policy negotiations. Although climate visualization can enhance a sense of proximity with climate change, the localization of climate risk can also lead to participants downplaying the significance of climate impacts. In addition, despite the intentions of inducing a sense of agency in both cases of climate visualization, participants critically negotiated messages concerning their roles as individuals in mitigating or adapting to climate change, and assigned this responsibility onto other actors. These findings show that although climate visualization presents certain communicative qualities, it is not a panacea for engaging lay audiences with climate change. This also underlines the importance of considering cultural and social aspects of the communicative event when studying and developing climate visualization tools as a means of communication.
Sammanfattning


Med utgångspunkt i ett teoretiskt ramverk som inspirerats av socialsemiotiska teorier genomfördes fokusgruppsstudier för att studera deltagarnas meningsskapande i relation till två exempel på klimatvisualisering: en film som visas i en domteater, framtagen för svenska gymnasieelever med målsättningen att uppmuntra till reflektion kring klimatförändringarnas orsaker, effekter och alternativ för utsläppsminskning, samt ett webbaserat verktyg för klimatanpassning, som utvecklats för att stödja husägare i Norden att anpassa sig till klimatförändringarnas lokala effekter.

Resultaten av denna avhandling visar att klimatvisualisering kan stödja mottagarna att konkretisera annars abstrakta aspekter av klimatförändringar och att ett lokalt fokus kan få klimatförändringarnas framstå som mer personligt relevanta och intressanta för målgruppen. Dock visar analyserna även, trots dessa kommunikativa kvaliteter, att deltagarnas tolkningar formas av deras förförståelse om klimatförändringar som ett globalt och avlägset problem som ska lösas av andra aktörer, såsom nationella regeringar, eller genom internationella politiska förhandlingar. Även om klimatvisualisering kan förstärka känslan av närhet till klimatförändringar, kan lokaliseringen av klimatriskerna även leda till att deltagare tonar ned de lokala klimatriskernas betydelse. Dessutom, trots att båda fallen av klimatvisualisering avsåg att skapa en känsla av att kunna påverka, blev ansvaret för klimatåtgärder föremål för kritisk förhandling från deltagarnas sida – de förklade ansvaret för att hantera klimatutmaningarna till andra aktörer. Dessa resultat visar att klimatvisualisering visserligen har vissa kommunikativa kvaliteter, men inte är någon patentlösning för klimatkommunikation. Detta understycker även vikten av att ta hänsyn till kulturella och sociala aspekter av den kommunikativa händelsen när man studerar och utvecklar verktyg för klimatvisualisering.
List of Appended Papers


Author’s Contribution to Papers

I. Anne Ballantyne is solely responsible for this article. Victoria Wibeck and Björn-Ola Linnér provided valuable comments on the manuscript.

II. The study and manuscript were planned collaboratively by the co-authors. Victoria Wibeck and Anne Ballantyne conducted the focus group interviews, Tina Neset facilitated the mind map exercise, and Anne Ballantyne conducted the interview with the scriptwriter. Anne Ballantyne conducted the data analysis and had the lead in writing the manuscript.

III. All authors contributed to designing the study, analyzing the data, and preparing the manuscript. Anne Ballantyne co-facilitated five out of seven focus group interviews with Erik Glaas.

IV. The study was planned collaboratively by the co-authors. Anne Ballantyne conducted the data analysis and had the lead in writing the manuscript.
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With gratitude,

Tak,

Anne
1 Introduction

Climate change communication is a topical issue, and it is widely acknowledged that public communication about causes, impacts and action alternatives is integral to addressing the challenges of the changing climate. Communication studies can help explore challenges, perceptions, strategies or meanings that inform and influence how we as individuals – and as a collective society – respond to the changing climate. Such studies are important, because although there might be increasing awareness and knowledge about climate change among individuals, humanity as a whole is not doing enough to keep within the goals of the Paris Agreement.\(^1\) This points to the continuous need to study communication about climate change and to identify means of communication that could enable individuals to make informed decisions and engage with the issue of climate change (Pidgeon & Fischhoff 2011; Clayton et al. 2015). In this context, lay audiences are seen as highly relevant and important due to the significant levels of greenhouse gas emissions associated with individual and household activities, as well as individuals’ indirect influence on political decision-making (O’Neill & Nicholson-Cole 2009; Hansen & Doyle 2011; Wolf & Moser 2011; Whitmarsh et al. 2013; IPCC 2014; Clayton et al. 2015).

Climate change communication is a rapidly expanding research field, in which the majority of studies seek to identify effective ways to communicate climate change with lay audiences, among others, and to understand public perceptions of climate change (Wibeck 2014a; Wang et al. 2018). Nevertheless, as Moser & Dilling (2007, 3) pointed out a decade ago when contemplating the question of how communication about climate change can facilitate social change: “The science of global warming is clear – why are they not listening? Why is no one doing anything?” Although claiming that no one is doing anything is an exaggeration, this problem framing is still a central driver of much research within climate change communication, where many studies focus on mapping public perceptions of climate change in different parts of the world, identifying factors that influence such perceptions, and developing communication strategies to change, guide or inspire perceptions, attitudes or behaviours of different groups of publics. This research agenda is important, because knowledge about different aspects of climate change communication influences our ability to respond effectively to climate change as a society (Clayton et al. 2015).

\(^1\) For instance, data from the International Energy Agency shows that, globally, emissions grew by 1.4% in 2017 (IEA 2018).
Although an intuitive response to mobilizing publics in addressing climate change could be to simply provide more and better education and information about the science of climate change, such approaches to communication have been criticized for being too simplistic, as knowledge is not the only factor that influences perceptions of climate change (cf. Nerlich et al. 2010; Pidgeon & Fischhoff 2011; Hart & Nisbet 2012; Buys et al. 2014). The underlying supposition that informs this response has been termed the ‘information deficit model’ of science communication (Sturgis & Allum 2004; Nisbet & Scheufele 2009), assuming that inaction and low levels of concern are simply caused by a lack of scientific knowledge. This approach has been widely criticized for reducing science communication to an act of transmitting information and knowledge to the public with the expectation of raising knowledge levels and changing attitudes and ultimately behaviour. Instead, scholars point to engagement as an essential aspect and approach to public communication about climate change (Lorenzoni et al. 2007; Spence & Pidgeon 2010; Whitmarsh et al. 2013; Corner et al. 2014; Moser 2014; Pidgeon et al. 2014; Wibeck 2014a). Engagement in this context is defined as “a personal state of connection” with climate change issues, and a key notion is that knowledge and awareness of climate change do not automatically translate into engagement (Lorenzoni et al. 2007, 446; see also Whitmarsh et al. 2013). Hence, public engagement could be defined as people’s interpretations of and responses to climate change, and is thus based on how people assign meaning and significance to climate change in relation to their own lives (Whitmarsh et al. 2013). Thus, a central question in this context concerns the role of communication in facilitating public engagement with climate change.

Addressing the issue of public engagement, the climate change communication literature has identified a vast array of challenges relating to the communication of climate change. For instance, studies point to public perceptions of climate change as a global and complex phenomenon (Hulme 2010a, 2010b; Jasanoff 2010), and lay people find it difficult to understand and relate to climate change because they perceive the issue as an abstract, uncertain, or distant problem that impacts other parts of the world or a distant future (Lorenzoni & Pidgeon 2006; Spence et al. 2012). In addition, public debates about climate change are sometimes characterized by controversy, scepticism and many divergent voices and stakes, resulting in limited engagement and action of individuals, who either struggle to make sense of climate change or simply lose interest or a sense of relevance (Lorenzoni et al. 2007; Stoknes 2014). As a result, lay people can find it difficult to relate to and navigate the landscape of climate change, which pinpoints the very challenge of climate change communication (Whitmarsh et al. 2013).

Climate visualization is frequently presented as a potential solution to these challenges (e.g. Nicholson-Cole 2005; Sheppard 2005, 2012; O’Neill et al. 2013; Lieske et al. 2014; Sheppard 2015; Herring et al. 2017). In particular, technological advancements in climate visualization are claimed to be transformative in engaging lay audiences with issues relating to the mitigation of and adaptation to climate change (Nocke et al. 2008; Shaw et al. 2009; Sheppard et al. 2011;
Schneider 2012; Sheppard et al. 2013; Bohman et al. 2015; Neset et al. 2016b; Herring et al. 2017). In the scholarly literature, dynamic digital formats of visualization are frequently emphasized as forms of communication that allow users to engage in the exploration of data or information (cf. Bohman et al. 2015). Furthermore, digital means of climate visualization could make climate change impacts stand out as visible and more concrete and encourage people to reflect upon, for example, future impacts and individual and social responsibilities (Smith & Joffe 2012; Lieske et al. 2014; Wibeck 2014a). In a pioneer study on the use of visualization for public communication of climate change, Nicholson-Cole (2005) argues that visual representations hold promising potential for conveying strong messages of climate change, condensing complex information, and communicating new information about climate science. As such, climate visualization is emphasized as a potential way of increasing public engagement with climate change to enhance learning, stimulate dialogue and address challenges related to or causing disengagement, such as a global and distant framing of the issue (Nicholson-Cole 2005; O’Neill & Hulme 2009; Moser 2010; Wibeck et al. 2013).

While previous research on climate change communication has predominantly focused on examining or mapping the general public’s perceptions of and attitudes towards climate change along with identifying challenges to climate change communication, calls have been made for more case- and audience-specific research that takes into consideration the context-dependent nature of communication (Moser 2010; Whitmarsh & Lorenzoni 2010; Wibeck 2014a). In addition, several studies point to a gap in the climate change communication literature concerning analyses of audiences’ interpretations and perceptions of different forms of visual communication (Shaw et al. 2009; Sheppard et al. 2011; Hansen & Machin 2013; Wibeck et al. 2013; Wibeck 2014a; Hansen 2015a; Lovett et al. 2015; Hart & Feldman 2016; Metag et al. 2016; Neset et al. 2016b; Wang et al. 2018).

Audience reception studies are relevant, because they can enhance our understandings of the social world and the reasons, motivations, constraints and implications of social change (Carey 2009; Cooren 2012). Related to the context of climate change, Hulme (2009, 28) argues that “the idea of climate exists as much in the human mind and in the matrices of cultural practices as it exists as an independent and physical category”. This argument underpins the importance of studying the ways in which we construct the idea of climate change, implying that social reality evolves out of our communicative actions (cf. Fuglsang & Olsen 2004; Moses & Knutsen 2012), and our constructions of climate change influence related actions and intentions at individual and societal levels. In this light, public engagement with climate change is an important step towards ensuring climate change as a societal priority, and we thus need to know more about the constitutive effects of (visual) communication in different social and cultural contexts. Against this background, in this thesis, I study communicative aspects of climate visualization, specifically focusing on lay audiences.
1.1 Aim and Research Questions

The overarching aim of this thesis is to explore roles of visualization in climate change communication from an audience perspective. In particular, the thesis focuses on ‘lay audiences’, referring to non-expert, non-scientific audiences. The empirical basis for investigating this aim is two cases of climate visualization, developed for specific lay target audiences. The aim of this thesis is operationalized through the following research questions:

1. How do the targeted lay audiences make meaning of climate change by means of the two cases of climate visualization?

2. How is climate change constituted in the meeting between the targeted audiences and the two cases of climate visualization?

3. In the context of climate change communication, what are the potential contributions and/or limitations of climate visualization as a means of communication with lay audiences?

These research questions focus on the meeting between audience and visualization medium, with the aim of exploring audiences’ meaning-making processes that take place among participants in social settings. Meaning-making is, thus, defined as an interactional and social process, rather than a strictly cognitive process (cf. Linell 2009).

This thesis intends to make a novel contribution to the climate visualization and climate change communication literature, by conducting two studies of climate visualization from an audience perspective. Through focus group methodology, I conduct two audience-specific studies to analyse targeted audiences’ meaning-making of climate change by means of climate visualization. In doing so, I address calls in the scholarly literature for audience-specific studies and studies on the (constitutive) effects of climate visualization. Based on this stance, study 1 investigates how Swedish high school students make meaning of climate change and visual representations of climate change in the dome theatre movie ‘A Warmer World’, developed specifically with this particular target audience in mind. Through visual representations of climate science, the movie aims to provide a starting point for discussion and reflection about climate change causes, impacts and mitigation alternatives. In addition, the movie intends to induce a sense of agency among the student audiences by raising awareness that also can translate into taking action to address climate change. Hence, central messages of the movie concerned explaining scientific aspects related to climate causes and impacts, and also to provide action alternatives for individuals.

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2 The definition of meaning is developed in chapter 3.
Study 2 centres around a web-based tool for climate change adaptation, VisAdapt™, which was developed to assist Nordic homeowners in adapting to the local impacts of climate change. Addressing the communication challenge of geographical distance, emphasized in the climate change communication literature (e.g. Mead et al. 2012; Spence et al. 2012; Whitmarsh et al. 2013; Evans et al. 2014; Wibeck 2014b), the interactive functionality of VisAdapt™ enables users to zoom in and explore regional climate scenarios and risks as well as related adaptation measures relevant to them as homeowners in a particular geographical area.

Essentially, the advantages of this empirical focus lie in the ability to conduct an in-depth and comprehensive exploration of two cases of novel climate change communication. Importantly, studying specific communication situations allows for analyses of audiences’ meaning-making of visual representations and hence descriptions of complexities and contextual factors relating to the reception situation.

1.2 Structure

This thesis is structured around six chapters. Following the introduction in chapter 1, the second chapter focuses on outlining key aspects and research trends in the fields of climate visualization, science communication and climate change communication. Together, these three related fields form the research background that informs the scope of this thesis. In chapter 3, I outline the theoretical framework, using social semiotics and multimodal communication as theoretical entry points to develop a conceptualization of meaning as a central aspect of communication. The theoretical framework is used as a foundation for the methodology, which is presented and discussed in chapter 4. In this chapter, I discuss the methodological considerations concerning my choice of empirical materials and the focus group methodology. Chapter 5 presents and summarizes the findings of the two empirical studies, which are also presented in papers II-IV. Chapter 6 concludes the thesis with a discussion of the results in relation to the literature on climate change communication and climate visualization, and with reflections on the role of climate visualization in climate change communication.
2 Background and Research Framework

2.1 Climate Visualization

Visualization in this thesis concerns data representation that aims to improve our understanding of complex or large datasets and communicate information to lay audiences or decision-makers (cf. Bishop et al. 2013). This form of visualization centres on ways in which “computer technology can facilitate the process of ‘making data visible’ in real time in order to strengthen knowledge” (Kraak 2003, 391). In line with this definition, climate visualization research typically draws on techniques from the fields of information visualization, geographic visualization and landscape visualization to create visual representations and develop tools with the aim of analyzing and communicating climate change data and information to diverse audiences through digital formats (cf. Sheppard et al. 2011; Neset et al. 2016a). Landscape visualization is typically defined in relation to methods that show the impacts of future climate change on a local scale in a realistic manner (Brown et al. 2006; Burch et al. 2010; Shaw et al. 2011; Sheppard et al. 2011, 2012; O’Neill & Smith 2014; Schroth et al. 2014; Lovett et al. 2015; Sheppard 2015). Geographic visualization (or geovisualization) makes use of geospatial data and maps to visually represent aspects of, for example, climate change (Lieske 2012; Bishop et al. 2013; Bohman et al. 2015; Neset et al. 2016a), and information or data visualization more broadly concerns the visual representation of complex and large datasets of various kind (Kraak, 2003; Tominski et al. 2011; Schneider 2012; Spence 2014; Newell et al. 2016; Herring et al. 2017; Johansson et al. 2017).

Importantly, in this scholarly context, the term visualization encompasses the human activity of forming mental models, of imagining or making sense of something (Spence 2014; O’Neill & Smith 2014). Visual representation of data is thus the communication means that support or influence this process of gaining insights. This definition essentially means that visualization is a human process, and as such not per definition related to technology or information graphics, as data representation can take many forms and make use of different modes of communication. However, Spence (2014) argues that information technology can enhance the capacity to analyse and convey large and complex data sets in a more efficient manner.

In this thesis, I focus on climate visualization as a dimension of climate change communication targeting lay audiences with an empirical focus on two examples of climate visualization that use techniques from the fields of information visualization and geographic visualization. The following section presents these two related research areas, followed by an overview of the research context of climate visualization as a means of communication with lay audiences.
2.1.1 Information Visualization and Geographic Visualization

Information visualization plays an important role in science, serving both analytical and communication purposes (Tuft 1990; Bucher & Niemann 2012; Grainger et al. 2016). In general terms, visualization of scientific data and information is described as a multifaceted field that involves the development, production and communication of science with the use of “imagery, schemes, graphical representations and computer renderings” (Pauwels 2006a, 1), and is closely linked to the field of information visualization, which is described by Tuft (1990) in the following words:

To envision information – and what bright and splendid visions can result – is to work at the intersection of image, word, number, art. The instruments are those of writing and typography, of managing large data sets and statistical analysis, of line and layout and color. And the standards of quality are those derived from visual principles that tell us how to put the right mark in the right place (Tuft 1990, 9).

In this quote, Tuft neatly summaries the scope and challenges of information visualization as an endeavour to translate large and complex datasets into visual representations through the use of different modes of communication, for instance images, numbers and words. In line with this view, Spence (2014) conceptualizes information visualization as a process of making data available to a user through representation and presentation, with representation referring to the translation of data or information into a visual illustration and presentation being defined as the communication of the visual representation to a lay audience.

Geographic visualization (or geovisualization) refers to the integration of different visualization approaches such as “scientific computing, cartography, image analysis, information visualization, exploratory data analysis, and geographic information systems to provide theory, methods and tools for visual exploration” (MacEachren & Kraak 2001, 3; see also Opach & Rød 2013; Lieske 2014; Grainger et al. 2016), and is as such related to information visualization. Drawing on the cartographic research tradition, the term geographic visualization is, however, used to define a method and research area that makes use of geospatial data to facilitate knowledge construction and help users gain new insights (MacEachren & Kraak, 2001; Kraak 2003; MacEachren et al. 2004; Nöllenburg 2007). More specifically, Kraak (2003, 398) defines geographic visualization as:

(...) the use of visual geospatial displays to explore data and through that exploration to generate hypotheses, develop problem solutions and construct knowledge. It is obvious that this is facilitated by an interactive and dynamic environment, where the user has access to the data via graphic representations.

Maps and graphics are the key modes of representation in geographic visualization, where they are used to stimulate visualization (in terms of imagination) of patterns and relationships of
geospatial data (Kraak 2003; see also Nöllenburg 2007). McKendry & Machlis (2009, 220) argue that “maps have power to inform or misinform, clarify or confuse through the use or misuse of design principles” and therefore that they are an important mode of communicating climate change information to lay audiences. Hence, central aspects of geographic visualization include the structuring and scaling of geospatial data, the graphical representation of data, and the development of user interfaces that allow for flexibility in data exploration (MacEachren & Kraak 2001; McKendry & Machlis 2009; Lieske 2012; Bishop et al. 2013; Neset et al. 2016a). The technological advancements over the past two decades have had a significant impact on the development and use of tools utilizing geographic visualization techniques. Maps and representations of geospatial data have become faster and easier to develop using computing technology. On the user side, maps have become dynamic portals of geospatial data that users can explore from computers, tablets or smartphones (MacEachren & Taylor 2013). Geographic visualization is thus conceptualized as a means to support users – be they scientists, decision-makers, students or lay audiences – in gaining an understanding of data and concepts on multidimensional scales (Nöllenburg 2007).

2.1.2 Lay Audiences in Climate Visualization

The development of visualization techniques and tools of climate data and information has received greater attention over the past two decades, because of the increasingly large and complex datasets relating to climate change, and because of the growing number of users of climate data and information in scientific communities and the public (Overpeck et al. 2011). Historically, the use of visual representations of scientific data or information was not intended for lay audiences, and visuals mainly served as illustrations, in the form of, for example, graphs and tables, communicated through scientific outlets in the confined context of science communities (Rodrigues Estrada & Davis 2015; Grainger et al. 2016). With the development of more advanced information and media technologies, the ability to create visual representations as a means to communicate science in various manners and to a broader range of audiences, including lay audiences, has improved considerably (Trumbo 2000; Snyder 2014; Rose 2016).

In the context of climate change communication, visualization serves several purposes. It is used as a means for researchers to analyse climate data, but also as an increasingly salient element in climate communication and decision support using different modes of representation to visualize scientific data and information (Nocke et al. 2008; Salter et al. 2009; Johansson et al. 2010, Sheppard 2012; Harold et al. 2016; Neset et al. 2016b). In this context, aspects concerning data selection, translation, and visual representation are highlighted as crucial in the development of meaningful visual representations as mediators of climate science, and a key challenge concerns the design of visual representations of often complex and multidimensional climate data that intuitively appeal to different user groups (Nocke et al. 2008; Johansson et al. 2010; Overpeck et al. 2011; Alder & Hostetler 2015; Sheppard 2015; Grainger et al. 2016; Johansson et al. 2017).
According to Overpeck et al. (2011) this enhanced focus on making climate data accessible to new user groups, who do not possess expert knowledge about climate change or how to interpret climate data, has led to a stronger emphasis on the role of the user and how to represent data in meaningful and useful manners in the development of visual representations of such data. Research points to the issue that, in a context of communication with lay audiences, traditional graphic representations of climate change are generally perceived as abstract and difficult for people to make sense of and relate to (Sheppard 2012; Covi & Kain 2016). Different user groups make use of different meaning-making strategies, and this is particularly salient when comparing expert and non-expert user groups, where scientists, because of their training and experience, have different prerequisites for interpreting information graphics than do lay audiences (Harold et al. 2016). Hence, ‘meaningful’ is context- and audience-dependent, underlining the importance of including considerations regarding the audience in the development of visual representations and visualization tools. Considering these challenges, a central dilemma concerning the development of data and information visualization for lay audiences is how to represent aspects of climate change, designing visual representations that lay audiences can relate to and comprehend without oversimplifying climate data (Schneider 2012; Grainger et al. 2016; Harold et al. 2016). Schneider (2012, 192) describes this issue as the challenge of bringing “the findings of climate change science on a cultural and social level” and argues for the need for interdisciplinary research efforts to address this issue and make visual representations of climate change more accessible and relevant to lay audiences.

With the advances within information technology, visual representations of climate change are now more frequently developed and presented through digital platforms and formats that allow for interactive exploration of climate change data by modifying the visual representations and data in direct response to user navigation (Lovett et al. 2015). Bohman et al. (2015, 2196) describe this as an “upcoming research field, which moves beyond traditional realms of science communication and strives for data exploration and decision support that meets the demands of different user groups”. Applying interactive features in climate visualization tools is particularly advantageous, as it invites users to choose and explore locations or data they find relevant or interesting rather than telling them what to look at. Hence, studies on climate visualization suggest integrating interactive features in visualization tools as a way forward in facilitating public engagement with climate change issues (Mahaffy et al. 2013; Schrotz 2014; Warren-Kretzschmar & von Haaren 2014; Bohman et al. 2015; Lovett et al. 2015; Rød et al. 2015). For instance, this perspective is supported by a study of the use of 3D visualization in participatory processes of landscape planning, where Lovett et al. (2015) argue that landscape visualization can facilitate information exchange and enable users to use their own interests as entry points to explore locations they find interesting and relevant. This, in turn, helps facilitating participatory processes and supports information exchange among the participants. In this sense, enabling active participation through exploration of data, interactive climate
visualization could function as a device for ‘individualization’ of the content and thereby actively engage people in the communication process (Bohman et al. 2015; Rød et al. 2015).

Another aspect of interactive functionality of climate visualization tools is the possibility of localizing content, for example, through the use of dynamic maps and displays. This is a particularly salient aspect in the climate visualization literature, as it addresses a significant challenge which is frequently emphasized in this literature; perceived distance. The climate change communication literature presents geographical and temporal distance as an explanation for public disengagement with climate change issues (Lorenzoni et al. 2007; O’Neill & Nicholson-Cole 2009; Spence et al. 2012; Clarke et al. 2018). Climate visualization is frequently highlighted as a means to address the challenge of perceived distance by using visual representations to illustrate, for instance, future – and hence distant – causes and effects of climate change and thereby make an invisible aspect of climate change visible (Dockerty et al. 2006; Schneider 2012; Sheppard 2012; Schroth et al. 2014; Sheppard 2015). For instance, Sheppard et al. (2011) present a conceptual framework focusing on public engagement with climate change facilitated by ‘future visioning’ of local climate change. The authors argue that the ability to show the future impacts of climate change on local landscapes by applying 3D landscape visualization could increase local salience and create a sense of community and engagement (see also Salter et al. 2009; Sheppard 2015). In addition, several authors argue that adding an element of “everyday” relevance in terms of time and space and by incorporating the local factor into climate messages by the use of interactive features could enable a stronger focus on, for example, audiences’ local geographical area and induce a stronger sense of relevance (Schneider 2012; Wibeck et al. 2013; Retchless 2014; Schroth et al. 2014; Herring et al. 2017). Supporting this stance, in a review of the scientific literature on geographic visualization used for vulnerability mapping, Preston et al. (2011) also point to the advantages of using vulnerability mapping in participatory research and development processes. The authors highlight the possibility of applying interactive features of vulnerability maps in facilitating local planning processes and as a means of representing spatial information regarding climate change, including social vulnerability and local impacts. However, the authors emphasize that the assumptions of the powers of geographic visualization in educating the public about climate change should be examined critically, because maps can be interpreted in different ways by different audiences and sometimes lead to ‘false’ conclusions. Consequently, the increasing interest in and demand for geospatial information related to climate change also points to a need for an increased focus on communicative aspects of geographic visualization tools including the use and interpretive processes in future research and development efforts (ibid.).

In general, the literature on climate visualization has a strong focus on the potentials of new and advanced information technologies as means to communicate climate change and overcome some of the communication challenges outlined in the literature. Such a research focus is rooted in a problem-solving agenda that assumes that better (visual) communication will lead to more
public engagement and action. The majority of research on climate visualization focuses predominantly on the design and development phase of visualization tools, i.e. the development of new technologies for creating visual representations or the use or development of new types of visualization tools to be used for public communication (Bishop et al. 2013; Grainger et al. 2016). Studies that emphasize the development phase focus, for instance, on how to create visual representations of specific aspects of climate change, such as adaptive capacity (de Almeida et al. 2016), local risks (Dockerty et al. 2006; Lieske et al. 2014), and future impacts of climate change (Sheppard et al. 2011; Gronewold et al. 2013). Despite the strong focus on developing visual representations, there are also studies that include a focus on the user side of climate visualization tools and visual representations. Such studies focus on mapping, for instance, publics’ knowledge levels, perceived information needs and risk perception, and discuss the implications of the results in relation to climate change communication (Nicholson-Cole 2005; Shaw et al. 2009; Petit et al. 2012; Opach & Rød 2013; Schroth et al. 2014; Covi & Kain 2016; Newell et al. 2016). Nevertheless, only a few studies have an exclusive or main focus on audiences’ perspectives related to climate visualization (Spiegelhalter et al. 2011; Wibeck et al. 2013; Lovett et al. 2015; Neset et al. 2016b).

The scholarly literature focusing on climate visualization with lay audiences focuses on different types of visuals. In addition to the research fields already discussed, this strand of literature also encompasses analyses of photographs and images in environmental campaigns (Doyle 2007; 2011; Manzo 2010a), studies of media images and how such images contribute to the public framing of climate change (Lester & Cottle 2009; Höijer 2010; Hansen 2011; Olausson 2011; O’Neill et al. 2013; Hart & Feldman 2016; Metag et al. 2016), analyses and effects studies of movies or iconic representations of climate change (O’Neill & Nicholson-Cole 2009; Manzo 2010b; Nolan 2010; Howell 2011; O’Neill & Smith 2014); and studies of art depicting climate change (Hohl 2011; Curtis et al. 2012; Nurmis 2016). A common denominator in these studies is the assumption of the “power of visuals”, as visual representations or images are seen as contributing to the construction of public knowledge, insights, framing or opinions about climate change. To further explore the proposed communicative qualities of climate visualization, several scholars voice the need for further research into audience perspectives of climate visualization and visual communication in general (Holsanova 2012; Hansen & Machin 2013; Wibeck 2014a; Hansen 2015a; Hart & Feldman 2016; Metag et al. 2016). With this thesis, I intend to contribute an audience perspective to the climate visualization literature, as audience-oriented research could advance our understanding of how climate visualization contributes to shaping and constituting the social and cultural meanings of climate change (Moser 2010; O’Neill & Smith 2014) and how it affects perceptions of problems, goals and action alternatives among different target groups, including laypeople (Wibeck et al. 2013).
2.2 Science Communication

The previous section outlined research trends and perspectives related to the field of climate visualization, focusing specifically on aspects of climate visualization associated with the communication of climate data and information to lay audiences. This perspective relates to the field of science communication in more general terms, and this section will briefly outline theoretical considerations concerning the communication of science to the public. Essentially, science communication concerns the relationship between experts and different publics, holding knowledge as a central concept in this relationship (Hetland 2011). An increasingly central aspect in science communication is the public engagement perspective, which is typically presented in opposition to the ‘information deficit model’ of science communication (Bauer et al. 2007; Bucchi 2009; Schäefer 2009; Kouper 2010; Spence & Pidgeon 2010; Hetland 2014).

As noted in chapter 1, the ‘information deficit model’ is rooted in the assumption that a lack of scientific knowledge is the main reason for public scepticism towards science (Sturgis & Allum 2004; Nisbet & Scheufele 2009; Nerlich et al. 2010; Ahteensuu 2012; Hart & Nisbet 2012; Buys et al. 2014). Based on a one-way asymmetric communication perspective, this view assumes that “increased communication and awareness about scientific issues will move public opinion toward the scientific consensus” (Hart & Nisbet 2012, 701-702; see also Schäefer 2009; Hetland 2014). Closely tied to the transmission approach to communication, which assumes a linear transmission of information from sender to receiver (Carey 2009; Fiske 2011), the information deficit model has been much disputed in the scientific community, as it is criticized for failing to encompass the interactive and context-dependent nature of communication. Accordingly, rather than defining science communication as a vehicle for transporting scientific information to the public with the purpose of influencing public minds and attitudes towards science, the public engagement approach acknowledges close links between science and society and holds public participation as a key term (Schäefer 2009; Kouper 2010; Whitmarsh et al. 2013).

Questioning the basic assumptions of the information deficit model of science communication, Hart and Nisbet (2012) point to the importance of exploring audience predispositions, such as ideological belief or social identity as central aspects of science communication, as these are seen to influence people’s interpretations of science. This is founded in results from studies suggesting that rather than knowledge deficits, political and ideological divisions can explain public engagement or disengagement with the scientific consensus of scientific issues (Druckman & Bolsen 2011; Hart & Nisbet 2012). From a more normative perspective, Hetland (2011) argues for the need to develop technologies to facilitate collaborations between experts and publics, by allowing for co-exploration of scientific content and thus more actively involving and engaging publics in science communication. As discussed, climate visualization tools are often conceptualized as potentially effective means to engage publics, for instance, by using interactive features to enable users to explore content they find relevant and interesting.
Accordingly, Bucchi (2013) argues that science communication scholarship should approach communication as a process of interaction, rather than transformation of information from one mind to another. In this view, communication is conceptualized as a two-way process, which enables publics to become more involved in science communication, for instance, by providing feedback to researchers, or to participate in the research process (Ahteensuu 2012; Hetland 2014). Here, participation refers to the notion of science communication as something that takes place between different groups of people, for example scientists and publics, presuming that everybody can contribute to the process of deliberating and discussing science (Trench 2008; Hetland 2014). Supporting this view, Fischhoff (2013, 14033) argues:

(…) because science communication seeks to inform decision making, it must begin by listening to its audience, to identify the decisions that its members face – and therefore the information that they need.

Actively engaging members of the public in dialogue about environmental issues is thus seen as a fruitful way of involving people and creating shared understandings between different parties (Johnson 2012; Krauss & von Storch 2012; Pisarski & Ashworth 2013). This inclusive approach offers the potential to gain insights into how such issues are constructed in social contexts and could allow lay people to influence, for example, decision processes through active participation (Harvey et al. 2012). In addition, studies suggest that such participatory processes can enhance participants’ feelings of ownership and engagement (Khan et al. 2012; Pisarski & Ashworth 2013; Rad et al. 2015). As such, the participation or engagement perspective is conceptualized as a way to democratize science by highlighting the legitimacy of different knowledge spheres in science and policy (cf. Nowotny et al. 2001). However, Lövbrand et al. (2011) argue that it is doubtful that studies of science and technology offer enough support to legitimize deliberative governance on empirical rather than normative grounds.

2.3 Climate Change Communication

Science communication concerns the relationship between publics and science, enhancing public engagement as a central aspect in nurturing this relationship. The public engagement perspective to science has influenced strands of research within climate change communication. Here, public engagement with climate change is defined as “a personal state of connection with the issue of climate change (…) concurrently comprising cognitive, affective and behavioural aspects” (Lorenzoni et al. 2007, 446). This entails that an important objective in science communication is for individuals to engage with climate change in a meaningful manner and, importantly, that awareness and concern do not automatically translate into engagement. Rather, the public engagement approach acknowledges the influence of cultural and social factors in individuals’ interpretations of science, and science communication should thus take such factors into consideration when aiming to engage publics with science (Lorenzoni et al. 2007; O’Neill & Hulme 2009; Whitmarsh et al. 2013).
Discussing the intersections between science communication and environmental communication, including climate change communication, Davis et al. (2018) argue that the fields of science communication and environmental communication share a focus on managing or creating a dialogue with members of the public. However, research agendas within environmental communication and climate change communication are inherently persuasive, because environmental communication as a scholarly field is rooted in an ambition to solve environmental problems through communication (see also Lindenfeld et al. 2012; Cox 2013). The problem-solving agenda also functions as a driver of much research in the context of climate change communication. Climate change communication is a rapidly expanding research field with a strong focus on the role of – and how to communicate climate change with – ‘lay audiences’ and with an increasing focus on public engagement as a communicative means and objective (Wolf & Moser 2011; Whitmarsh et al. 2013; Wibeck 2014a). Previous literature reviews have documented trends and foci within the field of climate change communication. Table 1 presents an overview of literature reviews focusing on aspects of climate change communication, and briefly outlines research aims and key findings.

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3 The table lists review articles that were included in the literature review I conducted at the end of 2014. For more information about the search criteria for the review, please refer to Paper I.
<table>
<thead>
<tr>
<th>Authors</th>
<th>Research aim (as stated)</th>
<th>Key findings (as stated)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lorenzoni &amp; Pidgeon (2006)</td>
<td>To review how publics in Europe and the USA perceive climate change.</td>
<td>Most laypeople in Britain perceive climate change as a threat to others, more vulnerable and/or future generations.</td>
</tr>
<tr>
<td>Moser (2010)</td>
<td>To synthesize what is known and unknown about how to communicate about climate change.</td>
<td>Climate change communication is becoming a research field in its own right. Scholarly work on climate change communication has not developed from the field of communication studies. Recommends that scientists become more familiar with studies on communication.</td>
</tr>
<tr>
<td>Nerlich et al. (2010)</td>
<td>To review and situate the field of climate change communication within theories of science communication.</td>
<td>It is important for communicators of climate change to understand their audiences and the situation of communication. Look beyond transmission models of communication.</td>
</tr>
<tr>
<td>Wolf &amp; Moser (2011)</td>
<td>To synthesize and fine-scale insights from studies on individual understandings of climate change.</td>
<td>The majority of studies have examined public perceptions of climate change using quantitative data drawn from large samples. People are not &quot;blank slates&quot; receiving information, but messages are always interpreted against pre-existing worldviews.</td>
</tr>
<tr>
<td>Schäfer (2012)</td>
<td>To review the literature on the role of online and social media in climate change communication.</td>
<td>Climate change communication has become an important research field and the media play an important role in the production, reproduction and transformation of meanings of climate change.</td>
</tr>
<tr>
<td>Whitmarsh et al. (2013)</td>
<td>To examine the interaction between climate change and diverse publics with a focus on public engagement.</td>
<td>The authors present a typology of public engagement with climate change. Public education should be based on analyses of individuals’ existing knowledge, concerns and abilities.</td>
</tr>
<tr>
<td>Corner et al. (2014)</td>
<td>To review the literature on the role of human and cultural values in public engagement with climate change.</td>
<td>Important to engage the public in climate change. Self-transcendent and altruistic values are predictive of individuals’ engagement with climate change.</td>
</tr>
<tr>
<td>Moser (2014)</td>
<td>To review the literature on communicating climate change adaptation.</td>
<td>The role of adaptation concerns assistance in risk appraisal and explaining and visualizing uncertainties.</td>
</tr>
<tr>
<td>O’Neill &amp; Smith (2014)</td>
<td>To review the research area of public engagement with imagery of climate change.</td>
<td>Visual representations of climate change can help people to imagine future impacts of climate change. Images of climate change in newspapers and television influence our everyday perceptions of climate change.</td>
</tr>
<tr>
<td>Wibeck (2014a)</td>
<td>To develop key messages for the theory and practice of environmental education, with a focus on non-formal education.</td>
<td>Studies of public understanding of climate change tend to rely on the deficit information model. Public engagement focuses on an active public that takes part in the learning process. Framing is important in engaging a lay audience.</td>
</tr>
</tbody>
</table>

Table 1: Overview of literature review articles on climate change communication published between 2006 and 2014.
The work of this thesis has contributed a review to the existing literature, focusing on mapping and discussing climate change communication from a theoretical communication perspective. Inspired by the historic development of communication theory, I conducted a literature review of the climate change communication literature. The analyses and discussions related to the review are presented in Paper I. In this section, I will briefly outline my findings with respect to different approaches and perspectives in the climate change communication literature.

The literature on climate change communication encompasses a range of different perspectives. Based on the literature review and analysis, I identified five different categories of scientific publications that revolve around the topic of communicating climate change.\(^4\) Studies on climate change communication include a comprehensive category of research articles that focus on public understanding of climate change. These types of articles aim at mapping public perceptions of climate change, measuring awareness, attitudes or knowledge levels among the public, or identifying factors that could influence public behaviour and perception of climate change (e.g. Lorenzoni & Pidgeon 2006; Poortinga et al. 2011; Carlton & Jacobsen 2013). Generally, these types of articles seek to provide overviews of how different publics perceive climate change and how their perceptions are linked to attitudes and behaviour. Such studies typically serve the aim of establishing an understanding of communication challenges and point to potential ways to address such challenges.

A second category of articles relates to public understanding of climate change but focuses on mass media coverage of climate change (e.g. Höijer 2010; Ryghaug et al. 2011; Asplund et al. 2013; Jaspal & Nerlich 2014; Olausson & Berglez 2014; Unger 2014). Characteristically, such studies tend to analyse media framings or discourses and offer commentaries on the media landscape related to climate change. The majority of studies within this category focus on the text separately from sender and receiver and presume a strong correlation between media coverage and public perceptions of and attitudes towards climate change.

The third category, strategic communication, accounts for the largest share of publications included in the review. Studies within this category typically assume a normative position and discuss ‘how to communicate climate change’. The strategic outlook of this type of article is typically rooted in theories, models and tools inspired by social marketing campaign planning, audience segmentation and marketing, and various message and content strategies (e.g. Akerlof et al. 2011; Maibach et al. 2011; Moser 2014). Articles in this category tend to take characteristics of communication challenges or barriers to climate change as their point of departure, and are guided by motivations to present solutions or ways to overcome these challenges. The strategic focus often infers an instrumental approach to communication, where

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\(^4\) Please see Paper I for a more detailed discussion of these categories, as only a brief overview is provided here.
many articles focus on how to obtain a certain effect through the use of different communication or content strategies.

A fourth category of climate change communication papers focuses on communication effects as a result of specific communication activities (e.g. Nerlich & Koteyko 2009; Nolan 2010; Hibberd & Nguyen 2013). There is, however, a wide spread in how effect is conceptualized in these articles. Some articles conduct text analysis to discuss the strengths or shortcomings of different message strategies, some seek to document communicative effects on public awareness, knowledge, perception and behaviour, and others concentrate on audience reception of messages. The literature review reveals a divide between studies oriented towards traditional effects research focusing on measuring the direct effects of communication activities and studies acknowledging meanings and interpretations as key aspects of communication. This divide links to the fifth category of publications, which encompasses conceptual and theoretical articles (e.g. Nerlich et al. 2010; Whitmarsh et al. 2013; Wibeck 2014a). Here, the majority of articles assume a theoretical communication perspective centred on audience interpretations of messages, arguing for a shift in focus from linear and information-centric models of communication to models that take into account the complexity and context-dependent nature of communication.

2.3.1 Communication Challenges

Reviewing the climate change communication literature reveals a research field motivated by a focus on challenges that hamper communication efforts with lay audiences. In the scholarly literature, challenges are used to describe circumstances relating to the issue or context of climate change or to characteristics relating to public perceptions of climate change. These challenges are typically used as a starting point for discussing, for example, communication strategies or facilitating factors. Table 2 provides an overview of the challenges most frequently referred to in the literature along with a few key references that provide a clear summary of the argument. For the sake of contextualizing these communication challenges, I have divided them into four categories relating to the nature of the challenge: characteristics of climate change, the science of climate change, the framings of climate change, and public attitudes to and perceptions of climate change. Naturally, this is an artificial classification as many of the challenges listed and described below are interrelated. For instance, the fact that climate change is often constructed as a global, disastrous threat (framing of climate change) has been proven to influence public perception of climate change. The global problem nature is often perceived as overwhelmingly extensive, making it difficult for individuals to relate to climate change, because people fail to see how their actions could make any difference at all.

The majority of studies on climate change communication and climate visualization take addressing some of these challenges as their point of departure; however, as also argued in Paper 1, not all challenges are communication challenges. They might refer to or describe conditions that complicate or influence communication efforts, but they cannot all be solved by communication. For example, seeing that climate change is characterized as a ‘wicked problem’
(cf. Hulme 2009), with many different stakeholders and voices involved, could be seen as conditions that shape the context of climate change communication rather than issues to be solved or addressed by communication. On a similar note, the intangible and complex aspects of climate change cannot be altered; however, these conditions have been shown to influence lay people’s perceptions of climate change as a phenomenon that is difficult to make sense of or relate to. Thus, the role for communication in this context could be to frame climate change as a more relevant issue.

The challenges relating to public attitudes towards and perceptions of climate change show a range of issues frequently used to provide guidance in the field of climate change communication. The scholarly literature and research on climate change communication and communicative aspects of climate visualization are largely characterized by a normative outlook, converging around the purpose of addressing communication challenges or barriers to climate engagement (Lindenfeld et al. 2012; Davis et al. 2018). Acknowledging this disciplinary self-understanding as important and relevant, the normative outlook, nevertheless, frequently results in a position that either assumes a simplistic and transmission-oriented view of communication or omits communication as a theoretical construct from the scholarly debate (cf. Paper 1). This relates to a conversation in the related field of environmental communication initiated by Cox (2007), in which he portrays environmental communication as a field with a strong normative approach to communication with the explicit purpose of solving environmental crises (see also Peterson et al. 2007; Schwarze 2007; Davis et al. 2018). An important argument in this debate asserts that a normative or strategic aim does not necessarily have to exclude the theoretical conversation from the scholarly literature, as such reflections could provide insights into the constitutive powers of communication and what these mean for environmental or climate change communication in society (Cox 2007; Schwarze 2007; Lindenfeld et al. 2014).

With this thesis, I seek to integrate the strategic problem-solving perspective with a critical ambition of studying the constitutive role of climate visualization in climate change communication. In this thesis, ‘the role of climate visualization’ refers to and recognizes the importance of engaging lay audiences with climate change, while at the same time also pursuing a more critical objective of exploring the constitutive role of climate visualization in society. As suggested by Cox (2007), these two ambitions can co-exist. Importantly, however, the strategic perspective does not necessarily imply a transmission-oriented view of communication. For the purposes of this thesis, this view essentially means that I focus on what happens in the meeting between audiences and visualization media and how climate change is constructed in this meeting. Insights based on such analyses could contribute to the more strategic aspects of the scholarly literature, by providing an in-depth perspective of meaning-making in practice and illuminating aspects related to the social constraints in meaning-making processes.
<table>
<thead>
<tr>
<th>Challenge</th>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Characteristics of climate change</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wicked problem</td>
<td>Climate change is characterized by a complex problem nature with no obvious solution.</td>
<td>O’Neill &amp; Hulme (2009) Bellamy &amp; Hulme (2011)</td>
</tr>
<tr>
<td>Intangible, invisible</td>
<td>Climate change is intangible and invisible, which makes it abstract and difficult to understand and relate to.</td>
<td>O’Neill et al. (2013) Nicholson-Cole (2005)</td>
</tr>
<tr>
<td><strong>The science of climate change</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scientific illiteracy</td>
<td>Gap between scientific reality and public understanding of climate change. It is argued that the public lacks basic knowledge about climate science, which leads to problems understanding the implications of scientific results.</td>
<td>Jang (2013) Lejano et al. (2013) Evans et al. (2014)</td>
</tr>
<tr>
<td>Scientific uncertainty</td>
<td>Uncertainty in e.g. climate scenarios is often mistaken for a lack of consensus or scientific evidence of climate change.</td>
<td>Lorenzoni et al. (2007) Spence &amp; Pidgeon (2010) Patt &amp; Weber (2014)</td>
</tr>
<tr>
<td>Confusion</td>
<td>Misconceptions between e.g. ozone depletion and greenhouse gas emissions, or confusion between climate and weather. Public belief and concern about climate change often vary in line with local temperatures that are actual and perceived.</td>
<td>Lorenzoni et al. (2005) Pidgeon &amp; Fischhoff (2011) Capstick &amp; Pidgeon (2014) Nerlich &amp; Jaspal (2014)</td>
</tr>
<tr>
<td>Perceived lack of scientific consensus</td>
<td>Despite increasing scientific consensus about anthropogenic climate change, there is still a tendency among the public to question the level of scientific consensus.</td>
<td>Lowe et al. (2006) Buys et al. (2014)</td>
</tr>
<tr>
<td><strong>Framings of climate change</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Global threat</td>
<td>Climate change is perceived (and often framed) as a global threat but not a personal threat, which can lead to a low sense of relevance at a personal level.</td>
<td>Nicholson-Cole (2005) Moser (2006) Mead et al. (2012)</td>
</tr>
<tr>
<td>Decline in media coverage</td>
<td>The perceived news value of climate change is declining, which affects public awareness of and concern about climate change.</td>
<td>Whitmarsh et al. (2013) Smith &amp; Leiserowitz (2014)</td>
</tr>
<tr>
<td>Imbalanced view</td>
<td>The mass media often presents an imbalanced view of scientific evidence, emphasizing the ‘news’ angle. The media often highlights contention in order to create drama.</td>
<td>Campbell (2011) Bailey et al. (2014)</td>
</tr>
<tr>
<td>Disaster framings</td>
<td>Disaster framings, for example by the mass media, can result in feelings of powerlessness and helplessness.</td>
<td>Campbell (2011) Fleming et al. (2014) Jaspal &amp; Nerlich (2014)</td>
</tr>
</tbody>
</table>
Multiple interests
Political posturing. Many voices and different stakes clutter the public
debate. Competing voices and various stakeholders can lead to
confusion and disinterest among the general public.

Nisbet (2009)
O’Neill & Hulme (2009)

Public attitudes towards and perceptions of climate change

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Description</th>
<th>Sources</th>
</tr>
</thead>
</table>
| Distance                                            | Temporal, social, geographical distance. Humans are geared to prioritize short-term consequences, but geographically distant impacts and delayed gratification make it difficult for people to prioritize climate action. | Lorenzoni et al. (2007)
Spence et al. (2012)
Pahl et al. (2014) |
| Low concern, low sense of relevance                  | Declining concern is explained by distance, perceived lack of political action, complexity, and feelings of helplessness. Low sense of relevance relates to low perception of personal gain. Mitigation action is not perceived as compelling or urgent at an individual level. | Hart (2011)
Wolf & Moser (2011)
Stoknes (2014) |
| Low sense of responsibility                         | People externalize responsibility for climate change action by assigning it to other actors such as governments.                               | Bichard & Kazmierczak (2012)
Whitmarsh et al. (2013)
Wibeck (2014a) |
| Denial                                              | Individuals often use denial as a fear-avoidance strategy.                                                                                   | Stoknes (2014) |
| Scepticism                                          | Lay people struggle to distinguish legitimate scepticism from radical scepticism. Scepticism is rooted in people’s core values and worldviews. Scepticism typically concerns notions regarding human influence on climate. | Pidgeon & Fischhoff (2011)
Poortinga et al. (2011)
Buys et al. (2014) |
| Issue fatigue                                       | Disinterest, over-abundance of information, which leads to a decline in concern about climate change. There are other, seemingly more important and immediate concerns that outrank the issue of climate change. | Moser (2006)
Krauss & von Storch (2012)
Pidgeon (2012) |
| Ideology, cultural and social values                | Linked to energy consumption – lifestyle and consumption culture is a barrier to action. Ideology, beliefs and values influence perceptions of climate change. | Lorenzoni et al. (2007)
Fleming et al. (2014)
Wibeck (2014a) |

Table 2: Overview of climate change communication challenges as described in the scholarly literature.
3 Theoretical Framework

Communication theory is used as the theoretical entry point for this thesis, defining communication as a constitutive practice (Craig 1999; Carey 2009; Linell 2009; Fiske 2011). This view is typically associated with the interaction paradigm, which acknowledges the interactive and boundless nature of communication and focuses on meaning as a central aspect of communication (McQuail 1985; Heath & Bryant 1992; Dougherty et al. 2009; Fiske 2011). The interaction paradigm is understood in contrast to a communication paradigm that conceptualizes communication as a transmission of information that focuses on the transmission of a message from a source to a receiver (Delia 1987; Jensen & Rosengren 1990; Heath & Bryant 1992; Rogers 1997; Carey 2009; Linell 2009 Fiske 2011). Contrary to the views of the transmission paradigm that tend to focus on the cognitive abilities of the individual mind, the interaction paradigm rests on the ontological assumption that meanings cannot be transferred. Rather, all participants – sender and receiver – become co-creators of meaning. Associated with the interaction paradigm, the constitutive view fundamentally defines communication as an act of sharing, exchanging and negotiating ideas, knowledge, thoughts, reflections, feelings and anxieties, and through this dialogical act, communication participants contribute to producing, maintaining or transforming social reality (Carey 2009; Cooren 2012). In this view, communication is understood as a social and cultural process that acknowledges interpretations and meaning as key elements, in constituting social reality (Heath & Bryant 1992; Deetz 1994; Rogers 1998; Peters 1999; Nicotera 2009; Schoeneburg & Trittin 2013). Adhering to the constitutive view of communication, I study climate visualization as a process of communication. As outlined in chapter 2, key aspects in climate visualization concern the development of meaningful visual representations of data or information. Hence, in terms of communication theory, climate visualization will be explored through the lens of visual communication, and more specifically multimodal communication.

As a field of research, visual communication is used as an umbrella term labelling a multifaceted field that covers a broad and diverse range of theories and practices that share a common focus on visuals and images. As such, scholarship on visual communication relates to the fields of visual culture and visual studies that are rooted in the scientific tradition of cultural studies (Elkins 2003). However, unified around ‘the visual’, the field additionally finds inspiration from a variety of different scholarly disciplines and theoretical traditions, such as art history, aesthetics, psychology, semiotics, education and film theory (Griffin 1991; Moriarty 1997; Smith et al. 2005). For the purposes of this thesis, I draw on a strand within visual communication that defines visual communication, and communication in general, as essentially multimodal (cf. Kress & van Leeuwen, 2006; Kress, 2010; van Leeuwen 2011; Bucher & Niemann 2012; Jewitt et al. 2016; Zhao et al. 2018). Multimodality is a research domain that takes an integrative approach to the study of visual communication, and the research
carried out in this domain is informed by theories of social semiotics (Kress 2010; Adami 2017; Hodge 2017). This chapter will discuss key aspects of multimodal communication from a social semiotic perspective, which will lay the foundation for my choice of methodology.

3.1 Social Semiotics and the Multimodality of Visualization

As outlined in the previous chapter, I conceptualize visualization as processes of communication and imagination and argue that meaning is a key term in exploring such processes. Social semiotics provides a useful framework for conceptualizing and understanding how meanings evolve, develop and constitute social reality through communication. Social semiotics is conceived from traditional semiotic theory, but as the name implies, social semiotics takes as a basic premise that meaning is created, maintained and invented in ‘the social’, rather than found in a structural relationship with the sign itself (Kress 2010; van Leeuwen 2011; Kress & van Leeuwen 2006).

Kress (2010) describes the research potentials of social semiotics as a framework that allows the researcher to ask questions related to all aspects of meaning creation and the role of meaning in society. This includes the social constraints in meaning-making processes and how meaning is shaped and constituted in social settings. With this thesis, I explore the constitutive effects of climate visualization from an audience perspective. As such, social semiotics provides a theoretical platform for conceptualizing the process of visualization in a social context and for exploring audiences’ meaning-making processes. Kress (2010) outlines four core concepts that define the essence of communication in his perspective of social semiotics – a definition of communication, which I will adopt for the purposes of this thesis. Hence,

communication is multimodal
communication is meaning
communication is social action
communication is interactional

In addition to this definition, Kress (2010) stresses interpretation and representation as two core concepts in processes of communication. The following sections discuss these defining concepts of communication in relation to visualization and function as the theoretical guide for this thesis.

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5 This focus on the audience perspective will be elaborated and further discussed in section 3.2.
3.1.1 Multimodality
Communication is multimodal.

Pioneered by Gunther Kress and Theo van Leeuwen (2001; 2006), the notion of multimodality evolved as a concept that intended to move beyond the disciplinary focus on meaning-making within visual communication (Ledin & Machin 2018). Based on the grounds that different modes of communication almost always appear together rather than as separate elements, and that people seldom communicate using strictly one mode of communication, the multimodality scholarship argues for a focus on the use of different modes of communication and how these are combined for communication purposes (Jewitt et al. 2016). This approach is based on the central argument that visual communication is never just visual. Other modes of communication (or semiotic resources), such as writing, graphics, composition, colour, font and speech, are also argued to influence our interpretations, conceding that communication – visual or textual – is always multimodal. Visual representations of climate change consist of multiple modes of communication – be they maps, colours, composition or text – and are as such inherently multimodal. The different modes, and the ways in which they are combined and structured, contribute to our overall experiences and perceptions of the visual representation.

Bucher and Niemann (2012, 285) argue that “because of the co-presence of different modes, the audience is confronted with a kind of hypertextual structure of different information sources”. Hence, this broader approach to the visual acknowledges the interconnectedness of form, content, design, composition and mode, and the integration of the different modes are seen as a key aspect. The basic assumption informing this perspective is that “the whole of a multimodal ensemble is more than the sum of its parts” (Bucher & Niemann 2012, 286). This stance is supported by the argument that meaning is made with different semiotic resources, but that visual representations and other forms of visual communication are experienced and interpreted by participants as integrated wholes (Jewitt 2009; Kress 2010; van Leeuwen 2011; Jewitt et al. 2016).

In the two examples of climate visualization studied in this thesis, content, i.e. the semiotic resources used to create visual representations, and form, i.e. the technology and the medium, are seen as integrated aspects. Hence, the visual representations as presented in the dome theatre might make an impression because of the design of the visual representation itself, or because of the experience in the immersive environment – or because of a combination of the two. On a similar note, a risk map in the web application VisAdapt™ might be perceived as interesting and relevant due to the actual risk factors displayed on the map, but also because of the interactive features of VisAdapt™ that for instance enable the user to zoom in on a geographic location of particular interest. The methodological implications of the multimodal approach are that in terms of analysis, I will not attempt to separate form and content, as audiences’ meaning-making is a based on both of these aspects.
3.1.2 Meaning
Communication is meaning.

Meaning is the fundamental aspect in semiotic theory (Fiske 2011). Broadly outlined, traditional semiotics is defined as the science that studies signs and meaning systems (Eco 1986; Chandler 2007; Fiske 2011). Various traditions and theoretical strands within the field of semiotics have been used as critical methods of cultural and literary analysis focusing on innumerable variations and combinations of text and images (Manghani 2013). As such, having developed from linguistic and cultural studies, semiotics is a very comprehensive field of study that encompasses stances of theoretical as well as applied nature, but predominantly, traditional semiotics is about studying meanings and meaning systems in signs. Based on the conceptualization of meaning as a central aspect of communication, social semiotics theory is largely inspired by the works of semioticians Barthes and Halliday (van Leeuwen, 2011; Adami 2017). Barthes’ later works (cf. Barthes 1977, 2009) are accredited with widening the scope of semiotics from that of linguistic analysis to include images and other modes of cultural phenomena as well, emphasizing that images are polysemous – that they can reflect or evoke multiple meanings. Therefore, Barthes (2009) advocates the relevance of studying the integration of text and image, contending that the relationships between text and image are culturally and historically driven, thus paving the way for conceptualizing communication as multimodal (van Leeuwen 2011). Halliday (1978) is accredited with bringing the social aspect into the world of semiotics, extending that language is a product of social processes and that language meanings are enacted in social contexts and thus influence social roles, structures, and values (Adami 2017). This perspective defines the main difference between traditional semiotics and social semiotics. Traditional semiotics focuses on the structures and codes of different meaning systems, while social semiotics focuses on “participants in semiotic activity as connected and interacting in a variety of ways in concrete social contexts” (Hodge & Kress 1988, 1). Hence, communication is essentially an enactment of social processes and the multimodal sign is conceptualized as shaped, interpreted and reinterpreted by participants in every communicative event (Adami 2017).

The sign is another key term in semiotics, intrinsically linked to the concept of meaning through the process of interpretation. The nature of the sign has been the subject of much debate and scholarly attention for more than a century. In very broad terms, Eco (1976, 7) defines semiotics as concerned with “everything that can be taken as a sign”, suggesting that a sign is anything which stands for something else (Chandler 2007). In multimodal social semiotics, the sign is defined as semiotic materials or resources that have some sort of materiality, a physical presence, and are orchestrated into a whole that is experienced by the reader (Jewitt 2009; Kress, 2010; van Leeuwen, 2011; Ledin & Machin 2018). While traditional semiotics tends to focus on detecting meanings and meaning systems of simple signs in terms of mode – for instance the word “horse” or a depiction of a tree, as classic examples of Saussurean and Peircean thinking
The concept of meaning is historically rooted in a structural conception of the sign-meaning relationship accredited to Saussure’s pioneering work that equates meaning with content (cf. Chandler 2007; Fiske 2011). Often associated with critical realism or structuralism (cf. Höijer 2008), this perspective regards meaning as inherently intertwined with the text and is often related to transmission-oriented models of communication (Chandler 2007; Fiske 2011). Opposing this view, social semiotic theory is rooted in a constructivist ontology and defines meaning as a social process, emphasizing cultural and social circumstances as important aspects of meaning-making processes (ibid.). This view draws on Barthes’ notions of denotation and connotation (Barthes 1977) that describe different levels of interpretation of a given sign. Denotation refers to a broader level of consensus (but cannot be taken as a literal sign that transcends all boundaries), where connotation is more influenced by social and cultural codes and conventions (Chandler 2007).

Specifically contemplating the communicative qualities of photographs, Barthes (1977) explains the tendency of ascribing such strong communicative qualities to this particular type of visual by arguing that denotation is often taken as a natural, universal meaning of a sign, where connotation is the context-dependent process of signification. This leads to the illusion that photographs are purely denotative in that they, without filter or code, depict reality (see also Chandler 2007; Fiske 2011). This is an important point to underscore in the context of visual communication, because images are frequently described as immediate forms of communication that transcend linguistic and cultural barriers (Sturken & Cartwright 2001; Rose 2016). Consequently, the reception stage of visual communication is often neglected in research efforts, as the notion that different people might develop different interpretations of the same image is rarely underscored conceptually or methodologically in visual studies (Rose 2016). In addition, the lack of reception studies could be explained by a relatively strong focus on the act of seeing, which typically relates to studying how vision occurs and how the human brain processes stimuli such as colour or shape (Berger 1998; Rose 2016), or a focus on the camera as a mechanical eye that accurately captures the essences of reality and consequently grants viewers visual access to this reality (Sturken & Cartwright 2001; Manghani 2013). Opposing this view, the ontology of meaning as introduced by Barthes (1977) and developed by others (e.g. Kress 2010; van Leeuwen 2011; Moriarty 2011; Holsanova 2012; Jewitt et al. 2016; Ledin & Machin 2018)
emphasizes that all signs, including photographs, are polysemic, meaning that they are always open to interpretation at both denotative and connotative levels.

On a similar note, Eco (1986) metaphorically characterizes processes of interpretation as an encyclopaedia, accentuating the role of pre-existing knowledge and cultural context, because such preconceptions shape and influence the process of signification; the connotations that are formed in the mind of the reader (Moriarty 1996). The process of signification takes a step towards explaining the complexity of interpretation, pointing to meaning as a pluralistic and ever-evolving concept. Importantly in this view, interpretations are defined as a second-order system of signification, where cultural myths play a central role. In semiotic terms, myth, as developed by Barthes (2009), is defined as dominant ideologies in a given culture at a given time and are thus seen as collective representations or beliefs “that make aspects of daily life appear as if ‘natural’ and not socially and historically determined” (Manghani 2013, 12). Barthes’ contribution to semiotics and visual communication is found in this notion that although reality comes across as being natural, it is indeed constructed and the construction appears through the use of myths in processes of signification (Chandler 2007; Fiske 2011). As such, in social semiotics the fixed relationship between sign and meaning has been abandoned and meaning is seen as a result of signification and is therefore not embedded in the sign itself (Moriarty 1996; Fiske 2011; Moriarty 2011). Importantly, as stressed by Chandler (2007), it is, however, noteworthy not to conceptualize connotation in terms of ‘individual subjectivity’. Rather than personal, individual meanings, connotations are culturally and socially dependent interpretations enacted and widely recognized within cultural settings.

In relation to the two studies of climate visualization in this thesis, meaning is thus not seen as inherent in the visual representations, but constructed through audience’s interpretations. As laid out in the discussion above, the process of interpretation is influenced by the design and the different modes used to create the visual representations, as well as the audience’s preconceptions of climate change that are shaped by cultural myths of the phenomenon of climate change.

3.1.3 Social action and interaction
Communication is social action and interaction.

As already laid out, in a social semiotic perspective, the multimodal sign is always newly made in social interaction (Kress 2010; Jewitt et al. 2016). Essentially in this view, communication is an act of putting the multimodal sign that represents one’s perception of a given aspect of reality into an interrelation with other people – for example, a defined target audience. The members of the target audience – the participants or readers – draw on their available resources when interpreting the sign. This means that communication participants are agentive and actively involved in meaning-making and that in a social semiotic context, the notion of a fixed relationship between sign and meaning has been abandoned and replaced by a commitment to
explore interpretive processes through which signs become meaningful (Kress 2010). This understanding of communication corresponds with a constitutive view of communication that defines communication as a social and cultural phenomenon that acknowledges interpretations and meaning as key elements, because communicative practices play a central role in influencing or constituting our perceptions of reality (Heath & Bryant 1992; Deetz 1994; Rogers 1998; Peters 1999; Nicotera 2009; Schoeneburg & Trittin 2013). Accordingly, communication is fundamentally about sharing, exchanging and negotiating ideas, thoughts, reflections and feelings in a social context (Craig 1999).

An important question in multimodal analysis is to discover how new forms of communication function semiotically (Jewitt 2009; Ledin & Machin 2018). Asserting the constitutive powers of communication, Ledin & Machin (2018) emphasize that different signs have different canons of use and that these canons are intrinsically linked to social practices. A new use or combination of semiotic resources will essentially have to be linked to new or existing social practices. In this view, digital forms of climate visualization as studied here can be argued to offer new semiotic modes that, in turn, are enacted in (new) social contexts. The two examples of climate visualization that form the empirical foundation for this thesis represent relatively novel types of climate communication, using technologies that allow for multimodal integration of semiotic resources in the design of visual representations.

The concept of interaction is closely related to dialogue, conceptualizing communication as an inherently dialogical practice, which is seen as the very foundation for all meaning-making. This view is consistent with an interactional view of sense-making as formulated and elaborated by Marková et al. (2007) and Linell (2009). Dialogue, in this sense, is not only understood as an actual conversation or interaction between two or more people, or the ability of receivers of communication to provide feedback to the sender, which are understandings typically related to our everyday use of the term. Importantly, as neatly described by Linell (2009), dialogue also refers to interaction in a more abstract and metaphorical sense. This means that communication is always dialogical and interactional, because interpretations and meanings are formed in relation to other voices, implicit or explicit, in a social context. For example, the interpreted meanings of a text do not only depend on the sender’s communicative intentions but are created in the interaction between reader and text and the social context of the communication situation. This line of thought also infers that communication is inter-relational, underlining the social aspects of communication. Linell (2009, 30) describes this in the following way:

I would argue that dialogicality is an attribute of human sense-making, that is, the dynamic processes, actions and practices in which meanings are contextually constituted in the interactions of human beings with others and environments. So dialogicality is primarily inherent in these interactions and interrelations (Italics in original).
The interactions and social interrelations influence interpretive processes, even in one-to-one situations, simply because we as humans are integrated parts of different social systems. Hence, meanings are co-constructed in implicit or explicit dialogue with the surrounding social contexts and with the creator of the sign (ibid.). This view also stresses context, be it cultural or social, as an important aspect of communication. The term context is relatively broad and used in many ways, but it can be described as a set of circumstances that surround and frame a certain event (Helder 2011). Thus, social and cultural contexts are seen as sociological, cultural and psychological aspects relevant to the receiver (or sender) that influence the construction and interpretation of messages and are as such not restricted to aspects belonging to the external environment (ibid.).

3.1.4 Representation and interpretation
According to Kress’ (2010) definition, representation and interpretation are essential aspects of communication. Representation is closely linked to the sign and is conceptualized as the semiotic resources used to represent or materialize a given perception of reality, which is called the referent or object in semiotic terms. The sign is thus the physical appearance of the referent, motivated by the interests and intentions of the sign-maker (Jewitt 2009; Kress 2010; Rose 2016). More specifically, Kress (2010, 49) defines representation as a focus “on my interest in my engagement with the world and on my wish to give material realization to my meanings about that world”. He distinguishes representation from communication, defining communication as a wish to make the represented meanings available to others. Communication, in this view, is thus always motivated by the sign-maker’s interests and intentions and by the wish to make a representation available to others (Bucher & Niemann 2012; Adami 2017). Essentially, representation explains the link between the sign, i.e. what we see, and the referent, i.e. the scientific knowledge, idea, data or information the representation represents (Slaattelid 2016). Importantly, representations do not replicate or mirror reality; they are merely constructions of a scientific reality (Pauwels 2006b; Manghani 2013). The different forms of the referent elucidate that representation is indeed the result of a process of capturing and translating data into signs, rather than mere replications of an objective reality.

In some scholarly contexts, the notion of representation as a construction of scientific reality is a familiar refrain and is as such perhaps not a novel or surprising point to make. Nevertheless, research suggests that audiences often perceive particularly visual representations of science with the assumption that they function as mirrors of scientific truths. Perhaps even more importantly, producers of visual representations often remain unreflective of the ontological status of visual representations. In many instances, the fact that visuals per se are constructions and interpretations of a referent simply go by unnoticed (Trumbo 2006). For example, Sturken and Cartwright (2001) highlight that visuals in science communication are often conceptualized as a powerful means of communication, because scholars tend to conceptualize visual representation as an “instrument, which helps us see further than the human eye (…) providing the capacity to see ‘truths’ that are not available to the human eye” (Sturken & Cartwright 2001,
This view is rooted in a philosophy of scientific realism that assumes an unbroken chain between the sphere of science and an objective reality. The constructivist perspective that representation is an interpretation and translation rather than an equivalent to an objective world is often overlooked (Trumbo 2006; Rose 2016; Slaattelid 2016; Vaage et al. 2016).

Seeing that representation and interpretation are two key elements in multimodal communication, meaning-making can be analysed from production as well as reception perspectives (Holsanova 2012; Bucher & Niemann 2012). The reception stage of multimodal communication has, nonetheless, received much less attention in the scholarly literature, leaving the realm of interpretation of multimodal signs, as explored in the present study, largely unaddressed (Bucher & Niemann 2012).

### 3.2 Four Sites of Meaning

Investigating the question of how to study meanings in different aspects of visual communication, Rose (2016) introduces a framework for exploring the range of methodologies in visual communication research. The framework is structured around four sites related to the meaning of visual and multimodal materials: the site of production, the site of the image, the site of circulation, and the site of ‘audiencing’. The site of production refers to the producer of the visual and focuses on purpose, genre and technologies used in making the sign. The site of the image centres on the image itself and typically analyses content-related aspects such as composition and symbolic meanings. The site of circulation concerns how the image moves from the site of production to the site of reception. Particular attention is being paid here to technologies carrying the movement and how these might change the compositional qualities of the visual. Motivated by Fiske’s (2011) notion of audiencing, the fourth site concentrates on the reception and audiences’ interpretations of the image. In the context of this framework, Rose (2016) reviews and discusses which methods are best suited to examining meanings from the four different perspectives.

It is worth noting that the four sites are seen as interrelated aspects of the communicative event. In practice or for analytical purposes, it is therefore difficult and problematic to isolate one specific site, without considering the three others as influential parts of, for instance, audiences’ meaning-making. Thus, the site of production naturally influences the reception of an image, simply because aspects related to form, technologies and content are typically associated with the production of visuals. Likewise, the site of circulation, which conceptualizes the movement of an image between the site of production and the site of audiencing, is inevitably linked to both of these sites. Conceptualizing these four sites of meaning, Rose (2016) introduces three modalities used to analyse visuals at the four sites: the technological, compositional and social modalities. As applied by Rose (2016) these modalities refer – not to modes or semiotic resources as described above – but to different perspectives through which each of the four sites
of meaning can be analyzed. The technological modalities refer to visual technologies that influence “how an image is made but also how it travels and how it is displayed” (Rose 2016, 25). Compositional modalities are defined as the strategies used to design the image or visual, for example colour, organization of content and layout. The social modalities refer to the social context in which the visual is produced, seen and used. The matrix presented in Figure 1 is adapted from Rose’s (2016) framework and aims to provide an overview of the different research foci in visual and multimodal studies, as well as illustrating the scope of the present thesis in relation to other research perspectives.

<table>
<thead>
<tr>
<th>Modalities</th>
<th>Sites</th>
<th>Production</th>
<th>Image</th>
<th>Circulation</th>
<th>Audiencing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technological</td>
<td>Technologies used to produce the visual.</td>
<td>Visual effects used to make, reproduce or display the visual.</td>
<td>The technologies that carry the visual from site of production to site of audiencing.</td>
<td>How displayed? Where? The link between technological display and seeing.</td>
<td></td>
</tr>
<tr>
<td>Compositional</td>
<td>Genre? The type of visual.</td>
<td>Visual and spatial structure and organization.</td>
<td>How changed when/if remediated?</td>
<td>Viewing positions offered? Relationship to other texts?</td>
<td></td>
</tr>
</tbody>
</table>

Figure 1: Matrix of four sites of meaning and three modalities in visual studies. Adapted from Rose (2016).

Rose’s (2016) framework is useful for the purposes of this thesis, because it provides an overview of the different aspects of meaning-making at different sites that can be used to inform methodological design, when focusing on a specific site of meaning. The work of this thesis is situated at the site of audiencing, specifically focusing on the social modalities of meaning-making. Nevertheless, aspects related to the sites of production, the image itself, and circulation will be included as important influential factors in audiences’ meaning-making.
3.3 Studying Meanings

Charting the theoretical orientation of this thesis, I have conceptualized visualization as a communicative process defined as being multimodal, social and interactional, holding meaning in relation to interpretation and representation as a central aspect. It is clear from studying the literature on social semiotics and various descriptions and accounts of meaning that meaning is an intangible, abstract and elusive concept that in general terms relates to the production and the interpretation of a polysemic, multimodal sign. From a methodological perspective, there are thus at least two important questions to ask – and answer. Firstly, wherein lies the relevance of studying meanings from an audience perspective? And secondly, how can we methodologically study how such meanings evolve? This section starts out by contemplating these two questions, which subsequently form the foundation for the research methodology of this thesis.

Following the ontology of communication and visualization, as delineated in the theoretical framework, the social semiotic approach points to the role of communication in constructing, changing and maintaining social reality. Meaning is not something that is naturally contained in an objective world, nor is it transmitted to us through different modes of communication. Meaning is created through interpretive processes and influence and is influenced by social contexts, and communication is thus seen as a constitutive component in the creation of social issues (cf. Chandler 2007; Kress 2010; Fiske 2011; Hansen 2015b; Rose 2016; Ledin & Machin 2018). Deliberating on the issue of climate change, Hulme (2009, 355) argues:

We won’t understand climate change by focusing only on its physicality. We need to understand the ways in which we talk about climate change and through which we reveal to ourselves what climate change means to us.

This points to the importance of studying how climate visualization contributes to the constitution of climate change as an issue in social contexts. Doing so will expand our knowledge about cultural significance, social practices and lay people’s engagement with the issue of climate change.

Aiming at studying meaning creation at the site of audiencing, I have found it necessary to translate the theoretical notions of meaning into a more concrete framework to inform the methodological grounds for the two empirical studies. As outlined below, I have derived five aspects of meaning from the theoretical framework of social semiotics that will inform the design of the studies. I have illustrated these points in Figure 2.
1) Following the theoretical notion of multimodality, meaning is seen as a response to both form and content of climate visualization. As such, audiences’ meaning-making processes are influenced by their perceptions of the communication experience as a whole and the use situation, along with the modes of visual representations for climate change. This also relates to Rose’s (2016) technological and compositional modalities as influential factors in meaning creation.

2) The audiences’ perceptions of the message, their understanding or framing of the message, plays an important role in their meaning-making. This concerns different levels of interpretation, as described by Barthes’ (1977) notions of denotation and connotation, and is seen as an interpretive response to the sign, the visual representation.

3) The perception of the message links to the participants’ sense of relevance, and hence the social context of the communicative event. Do members of the defined audience see themselves as a relevant audience with an information need? This is determined by the social context and the framing of the visual representation as well as the social modalities of meaning (cf. Rose 2016).

4) The social and cultural nature of meaning and communication also points to audiences’ pre-existing frames and knowledge as influential factors in meaning-making processes. As discussed, communication is always part of a social context, and interpretations are therefore influenced by the audiences’ interpretive resources, such as existing knowledge about and preconceptions of climate change.

5) The conceptualization of communication as dialogical means that the audiences’ perceptions of intent and other voices are part of the meaning-making process as well. This relates to participants’ perceptions of the sender’s intended message but could also be argued to include the sharing or negotiation of views, as interpretation occurs in relation to other voices and viewpoints in the social context.

Importantly, the five aspects of meaning-making that I have presented here are not to be seen as separate, but as overlapping elements that constitute meaning-making processes. Additionally, acknowledging the multidimensional nature of meaning, I by no means pretend to fully capture the complex essence of this phenomenon in a simplistic model. However, I find the overview and focus on five essential aspects of meaning-making important and necessary for studying meaning-making processes at the site of audience, because it allows me to translate the abstract notions of the theoretical framework into more concrete concepts that can form the foundation for a valid research design.
Figure 2: Five aspects of meaning in a multimodal, social semiotic perspective.

Meaning

- The communication experience
- Sense of relevance
- Perception of intent and other voices
- Perception of message
- Pre-existing knowledge and frames
4 Methodology

4.1 Empirical Materials

Empirically, I focus on two examples of climate visualization – a dome theatre movie and a web application – that are specifically intended as means to engage lay audiences with aspects of climate change. I have chosen the two visualization formats as the empirical grounds for the thesis, because I wish to study the constitutive effects of climate visualization, focusing specifically on the role of new and advanced visualization formats. Dome theatres and web applications represent two increasingly popular and interesting types of climate visualization; dome theatres because of the immersive environment and because they are becoming a widely used means of science communication in science centres and planetariums (Fraser et al. 2012; Wibeck et al. 2013), and web applications because they have the potential to reach large audiences and integrate interactive features that allow users to localize and co-create content (Mahaffy et al. 2013; Johansson et al. 2017). Essentially, the advantages of this empirical choice lie in the ability to conduct an in-depth exploration of two cases of novel climate visualization that are both intended for specific yet broad target audiences. In the following sections, I provide a more detailed account of the two cases of climate visualization.

4.1.1 The dome movie ‘A Warmer World’

Study 1 focuses on the dome theatre movie ‘A Warmer World’. Launched in 2011, the movie was the result of a collaboration between researchers at Linköping University, Norrköping Visualization Center C and the Swedish Meteorological and Hydrological Institute, and is an example of digital climate visualization in an immersive environment targeting a specific audience. The movie can be seen and experienced at Norrköping Visualization Center C, which is a science centre that hosts a range of different public outreach activities, such as interactive exhibitions, events and dome theatre movies, using advanced visualization technology and design to engage visitors with science6. The centre combines visualization research with public outreach activities and focuses on new ways technology and digital imagery can offer unique and captivating visitor experiences. One of the main attractions at the Visualization Center C is the dome theatre, which is currently the most technically advanced in northern Europe. It covers a total screen surface of approximately 300 square meters, providing the audience with a multisensory, immersive experience⁶.

The movie ‘A Warmer World’ is based on a series of visual representations supported by a narrative and music, and presents an overview of different aspects related to climate change causes and impacts and to the need for climate mitigation. For instance, the movie addresses questions such as ‘What is happening with the climate and why?’, ‘What can we do to influence

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⁶ http://visualiseringscenter.se/en/about-c

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Earth’s future climate?’ and ‘Why is it so difficult to reach agreement in climate negotiations?’. It builds on data from different climate scenarios regarding sea level rise and greenhouse gas (GHG) emissions associated with, for example, various food products, household energy consumption, clothing production or aviation, and it was designed to specifically target young people in Sweden (primarily upper secondary school students).

The movie is designed as a narrative with three different speakers, representing three different voices in the climate debate: a high school student, who asks questions and holds discussions with a climate researcher, and an industrial representative, introduced as the owner of several factories. The speakers take the audience through a journey of visual representations based on information graphics that present different perspectives and science-based information about climate change. Visually, the movie consists of a series of visual representations of climate data, addressing issues relating to, for instance, the greenhouse effect, causes and impacts of climate change, and different mitigation strategies that can be taken at an individual level. The visual representations are accompanied by the three speakers and music – there are, as such, no elements of photographic reality or “real-life” images in the movie. Nor are any of the three speakers visible.

Figure 3 shows examples of visual representations from the movie. The three globes (Image C) represent three different ways of accounting for the responsibility of GHG emissions: 1) total current emissions per country (based on 2007 data), 2) cumulative historical emissions since the 1860s, and 3) emissions per capita per country. The different ways of calculating emissions influence how responsibility is assigned. For instance, scenario 1 has a greater emphasis on the USA and China, whereas scenario 3 significantly reduces the responsibility of China. This particular representation is used to contextualize the international climate change negotiations, as the speakers compare and discuss the differences in the three different ways of distributing responsibility, thus aiming to show why it is difficult to reach international agreements. The movie also explains the concept of tipping points (Image D), and discusses population density (Image E) and different scenarios of global warming (Image B). In addition, the movie stresses personal actions that can be taken to reduce climate impact, for example energy and food consumption (Image A), clothing production, and air travel (Image F).

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7 http://visualiseringscenter.se/en/film/warmer-world
8 Swedish upper secondary education (gymnasium) is a three-year programme offered to students who have completed nine years of compulsory schooling. Upper secondary education in Sweden provides the foundation for “further studies, and for personal development and active participation in the life of society” (source: http://www.skolverket.se/om-skolverket/andra-sprak-och-lattlast/in-english/the-swedish-education-system/upper-secondary-school).
Figure 3: Examples of representations from the movie ‘A Warmer World’. With kind permission from Norrköping Visualization Center C.
4.1.2 The web-based application ‘VisAdapt™’

The second study focuses on a web-based tool for climate change adaptation, VisAdapt™. The VisAdapt™ study is part of a broader project involving Nordic research institutes in collaboration with Nordic insurance companies. The aim of the project was to develop a visualization tool that could help Nordic homeowners to adapt their properties to a changing climate. The development process involved workshops with the insurance companies and pilot testing of VisAdapt™ prototypes with homeowners. The tool is designed as a web-based platform that entails geographic and information visualization consisting of an interactive interface that guides users through a three-step process, in which different locations and house types can be selected and regional climate-related risks, scenarios and related adaptation measures can be explored (cf. Glaas et al. 2015a; Neset et al. 2016a; Paper III).

VisAdapt™ was launched in 2014 and is an example of a visualization tool designed to reach a large and diverse target audience: Nordic homeowners. The tool was developed in response to Nordic insurance companies experiencing a trend towards increased costs related to homeowners’ claims for payment due to weather-related damage to their properties (Glaas et al. 2015b). This trend is likely to continue, as climate change within the Nordic region is expected to cause impacts in the form of floods, landslides, heatwaves, cloudbursts and storms, which will present problems for homeowners and others, because of related damage to their properties (ibid.). In order to reduce homeowners’ vulnerability to such risks, VisAdapt™ was developed to facilitate climate adaptation among Nordic homeowners at a practical level, tying together house characteristics and regionally projected climate risks with specific adaptation guidelines (Johansson et al. 2017).

VisAdapt™ consists of three interrelated modules (see Figure 4) that allow the user to localize content by typing in an address and using Google Street View to display the house in module 1 on the left-hand side. In addition to displaying the house, the user is asked to select features of the house, such as type of roof, façade, foundation and garden topography. In the middle module, the user is able to zoom in on the geographical location of his or her house and investigate climate scenario and risk maps for that specific location as well as zooming out to explore climate vulnerability in other regions. Here, the user can explore and browse through different climate variables related to the risks specific to the selected region, for instance the projected change in the number of heatwaves or cloudbursts, or identify areas that are particularly prone to issues such as flooding. The third module on the right-hand side presents adaptation guidelines specifically based on the selected house features, geographic location and climate parameters (ibid.).

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9 The partners in developing VisAdapt™ were the Norwegian University of Science and Technology, Linköping University and Aarhus University, with the advisory board consisting of representatives from the Nordic insurance companies If, Gjensidige, Codan/Trygg-Hansa and Tryg Insurance.

10 VisAdapt™ can be accessed here: http://visadapt.info
For example, the adaptation measures could point to an increased risk of mould due to the specific house type and an increase in annual precipitation, and additionally provide measures to prevent mould from causing damage to the house.

Figure 4: VisAdapt™ representing climate scenarios for cloudbursts in central Jutland, Denmark.

4.1.3 The Site of Audiencing and Social Modalities
Revisiting the framework for studying meanings, as laid out by Rose (2016) and presented in Figure 2, the focus of this thesis, and hence this section, is the site of audiencing in relation to the two cases of climate visualization presented above. As already shown, the site of audiencing can be described and analysed in terms of three modalities: the technological, the compositional and the social. The social modality is the focus for the two studies, but the technological and the compositional modalities are also important to consider as part of this. This section will describe and compare the two cases of climate visualization in relation to the three modalities.

The two cases of climate visualization are both produced with a clear communicative intent. In addition, both visualization tools are developed with a specific target audience in mind – rather than “the public” in general. This is interesting from a communication viewpoint, because it makes the communication intentional in sharing the aim of engaging targeted users (lay audiences) with climate-related issues. Such engagement efforts are however sought through different means in the two cases of visualization.

Spence (2014) argues that user-tool interaction can be either passive or active. Passive interaction refers to simply looking at a display, and active interaction relates to users seeking information and interacting with the display. Despite the inherent paradoxical notion of ‘passive
interaction’, this points to the idea that interpretation is conceptualized as interaction as well. Essentially in this view, the meeting between user/audience and visualization tool is always conceptualized as a process of interaction.

The distinction between degrees of interaction relates to and is determined by technological and compositional modalities. While the audience of the movie is invited to sit back and enjoy the journey of the movie narrative, VisAdapt™ invites the user to explore aspects of climate change risk and adaptation that he or she finds interesting. The dome movie seeks to engage audiences primarily with climate change mitigation and uses visual representations of climate science in combination with narratives and music in the dome theatre, providing a multi-sensory experience in an immersive environment. Hence, the audience-medium interaction can here be described in terms of passive interaction. The web-based application represents a different site of audiencing in that it can be accessed and used wherever and whenever it suits the user. The intended engaging aspects of VisAdapt™ are instead the interactive features that enable users to navigate between a house profile (for example, their own house), risk and scenario maps and related adaptation measures, thus aiming to make the content seem more locally relevant to the user. As such, the use situation of VisAdapt™ can be described as active interaction.

Interactive applications such as VisAdapt™ could be described in terms of hypermediacy (cf. Bolter & Grusin 1999), which is a type of medium that uses multimodal representation characterized by fragmentation and hypertextual organization of content. The hypertextual structure of VisAdapt™ enables the user to actively select focus points that are seen as personally relevant. However, although exploration is emphasized as a primary characteristic of the tool, VisAdapt™ also contains a narrative element. The content is structured in a left-to-right logic where the three modules are interrelated and the user is prompted to start on the left-hand-side by typing in his or her home address. The user is thus guided through the tool that tells the ‘climate story’ of relevance to a particular geographical location. The main aspect of exploration is thus found in the middle module that enables the user to explore climate scenarios and risk maps for different locations in the Nordic countries.

The social modality of the site of audiencing refers to two aspects (cf. Rose 2016). Firstly, the social practice of spectating, for instance, the social act of watching a movie at the cinema or accessing a website from a laptop at home influences the meaning-making of a visual sign. This is because different use situations influence our perceptions, attention levels and interactions in connection with the visual. In addition, different use situations infer different social contexts. In the dome theatre, audiences are in a public space and social protocols mean they have limited opportunities to communicate or discuss the contents of the movie with peers or family during the movie. The use situation of VisAdapt™ differs significantly from the movie, as the website can be accessed from any computer or laptop with internet access, either alone or together with family or friends. Indeed, this means that the use situation of VisAdapt™ is much less
constrained than that of the movie, providing the opportunity to discuss the content with other people while using the tool. The second aspect refers to the social identities of the spectators. This relates to how the audiences are defined by the producer of the communication and how the audience is addressed by the messages. This relates, among other things, to the type and level of information presented, but also to the action alternatives presented to the audience. In summary, Table 3 provides an overview and comparison of the two empirical cases with respect to communicative elements.

<table>
<thead>
<tr>
<th>Communication elements</th>
<th>A Warmer World</th>
<th>VisAdapt™</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of visualization</td>
<td>Information visualization, geographic visualization, computer graphics</td>
<td>Geographic and information visualization</td>
</tr>
<tr>
<td>Target group</td>
<td>Swedish upper secondary school students</td>
<td>Nordic homeowners</td>
</tr>
<tr>
<td>Focus</td>
<td>Causes and impacts of climate change, climate change mitigation</td>
<td>Local impacts of climate change and climate change adaptation</td>
</tr>
<tr>
<td>Technology</td>
<td>Immersive environment (dome theatre)</td>
<td>Interactive navigation (website)</td>
</tr>
<tr>
<td>Form</td>
<td>Narrative</td>
<td>Exploration (and narrative)</td>
</tr>
<tr>
<td>Site of audiencing</td>
<td>Science centres</td>
<td>Private setting</td>
</tr>
<tr>
<td>Aim</td>
<td>Engagement</td>
<td>Engagement</td>
</tr>
</tbody>
</table>

Table 3: Comparison of the two cases of climate visualization in relation to communication elements.

4.2 Focus Group Interviews

Research on the social modality of the site of audiencing is related to the research practices of media reception studies that typically utilize ethnographic methods or interviews to study how media audiences interpret content. In this body of research, interviews are established as a method to explore audiences’ interpretations of media content, and provide the researcher with insights into perspectives and viewpoints of the participant (cf. Schröder 2001; Höijer 2008; Rose 2016). Inspired by this body of research, I apply focus group interviews as the main method for exploring how audiences make meaning of the two cases of climate visualization presented above.

Focus group interviews are typically defined as “a research technique that collects data through group interaction on a topic determined by the researcher” (Morgan 1996, 6), and is a recognized method to explore how people’s ideas, interpretations and understandings of a focused topic evolve in a social setting (Morgan 1997; Krueger 1998; Smithson 2000; Morgan 2010; Wibeck 2010; Ryan et al. 2014; Halkier 2016). Following the theoretical framework as outlined in the previous chapter, I acknowledge social interaction as an essential aspect of communication. In particular, the interactive nature of focus group interviews is a core characteristic and primary source of interest of the method (Wilkinson 1998; Morgan 2010; Morgan & Hoffman 2018). The emphasis is therefore not on identifying people’s individual interpretations or viewpoints, but rather on the sense-making that takes place among the participants as a result of joint
discussions in a social setting. As such, focus group interviews strive to use the dynamics of the group setting to stimulate discussion among participants and, in doing so, motivate participants to verbalize, elaborate on and develop ideas, perceptions and viewpoints during the group discussions (Kitzinger 1995; Smithson 2000; Kitzinger 2005; Marková et al. 2007; Wibeck et al. 2007; Halkier 2010; Morgan 2010; Brown 2015).

The notion of the focus group interview as a place where people’s understandings and interpretations evolve in a social setting emphasizes the significance of the interactive nature of focus group interviews as a core facet of the methodology. Interaction occurs in the group setting, when participants both question each other and explain their own viewpoints to each other (Morgan 1996). As such, the strength of focus group interviews is not merely found in exploring “what people have to say, but in providing insights into the sources of complex behaviors and motivations” (Morgan 1996, 139). Thus, the dialogical nature of focus groups allows the participants to exchange opinions and let ideas emerge and flourish in the group interaction.

With the aim of exploring audiences’ meaning-making of two cases of climate visualization and considering the conceptualization of meaning as a multidimensional construct, the focus group methodology provides a framework for allowing participants to express, explain, elaborate on and reflect upon their perceptions of visual representations (cf. Schröder 2001). Recognizing the dialogical nature of focus groups means that ideas and opinions are not necessarily pre-existing in the minds of the participants prior to the focus group discussions, but are instead dialogically constituted and constantly “negotiated, modified and transformed as they circulate in dialogue” (Marková et al. 2007, 132). This, of course, represents the risk of social control or dominating voices in the group setting, with the consequence that not all perspectives or opinions are expressed or heard (Wibeck 2010; Halkier 2016). Nevertheless, accepting a social constructivist viewpoint means that interpretations are always dialogically formed and are never pure in the sense that they exist independently of social relations in the minds of individuals. Hence, in terms of generating data, a strength of focus group interviews is found in the ability of the method to use the discussions between participants as constituting the data (Wilkinson 1998; Morgan 2010; Brown 2015). The stories, anecdotes and viewpoints voiced by participants in a focus group setting provide insights into “multiple meanings and the richness of their social world” by allowing participants to express and develop context-based reflections regarding the topic of discussion (Ryan et al. 2014, 331).
In a discussion on the challenging aspects of audience research focusing on an audience’s meaning-making, Höijer (2008) proposes that:

(…) in research on interpretations, readings, attitudes, intentions, emotions, or reactions, we are looking for something that is not materialized ‘out there’, like a film or television programme or newspaper article. Instead, we start by constructing a body of material that we suppose reflects the phenomenon we want to study (Höijer 2008, 277).

The focus group methodology is based on a social constructivist assumption that meaning is socially constructed through social interaction – including talk. As emphasized in the quote, studying meanings and interpretations essentially means studying something that is not visible, not tangible, and has no physical shape. Utilizing focus group interviews, means that language or talk is seen as the locus, or vessel, of meaning, as the discussions or conversations in the focus groups essentially constitute the research data. In social semiotic terms, language is seen as a viable way to analyse meanings related to social processes resulting from different reality perspectives (Hodge 2017).

The social constructivist outlook highlights that any knowledge-generating activity is determined by perspective and, in turn, that knowledge in itself becomes a social construction that is formed in the interaction between researcher, empirical material and context (Moses & Knutsen 2012). Brinkmann & Kvale (2015) use the metaphors of the ‘interviewer as a miner’ and the ‘interviewer as a traveler’ to distinguish between two different epistemological conceptions of interviewing, generally associated with positivist and constructivist scientific philosophies, respectively. Accordingly, the mining metaphor conceptualizes the research process as an endeavour to “dig nuggets of knowledge out of a subject’s experiences” (ibid., 57). The interviewer as a traveller, on the other hand, is “on a journey to a distant country that leads to a tale to be told upon returning home” (ibid.). These metaphors contrast the idea of knowledge as a mirror of reality with a conception of knowledge that sees the interview as a social construction, where the results are influenced, retold and interpreted by the interviewer.

Seeing interpretation as a basic characteristic of research necessarily points to the need to fully abandon the idea of a direct mirroring or link between different knowledge relationships in empirical research. Linell (2009, 29) articulates this from a communicative perspective and argues that “the analyst’s reconstructions are not merely copies of participants’ constructions, but they are building the latter, recontextualising them (…)”. In this view, the researcher contributes to the construction of a social reality, the research process and the research results. Importantly, in this sense, interpretations are seen as an inherent condition and part of research activities, and the empirical material is thus not regarded as value-neutral or raw, but instead as a construction of the empirical condition (Alvesson & Sköldberg 2000; Holstein & Gubrium 2011). Rejecting the idea of an independent social reality that can be objectively perceived does not mean that empirical research cannot provide interesting or useful insights. On the contrary,
different interpretations of empirical material mean that we have to accept ambiguity as an inherent aspect of social science research that could point to new insights, theories, pathways, arguments and ways of thinking (cf. Fleming & Howden 2016).

4.2.1 Focus Group Participants

The above discussion points to the importance of considering criteria and strategies for selecting and recruiting participants for focus group interviews, as the parameters for selecting participants contribute to the framing of the social context of the interview situation (Schroeder 1994; Höijer 2008; Silverman 2011; Rose 2016). Höijer (2008) presents an overview of different perspectives on participant representation that can be used to inform selection parameters for interview participants. The central question concerns who the participants represent, and different options encompass seeing the participants as representatives of himself or herself, a social group, an institution, a national population, or the human species (Höijer 2008, 280).

For the purposes of the empirical work in this thesis, I have recruited focus group participants for both studies based on the principle of social belonging. This choice is based on the social semiotic assumption that meanings are enacted in social and cultural contexts and should therefore also be studied as such (Chandler 2007; Ledin & Machin 2018). This perspective relates to the social semiotic notion of appellation, which means that we as readers are created by the sign, because it hails us, it speaks to us (cf. Kress 2010; Rose 2016). The sign – the visual representation – constitutes a certain audience by targeting it, speaking to it from a certain cultural and social perspective and through the communicational design and message strategy creates a certain position for the target audience. Appellation is thus guided by communicative intent. Studying the constitutive effects of climate visualization, I use the intended audience, the social grouping that is addressed by the two cases of climate visualization, as the deciding factor for selection of focus group participants. This decision rests on the ontological assumption outlined in the theoretical framework that meaning is not completely situation-based and unique to each single individual (cf. Chandler 2007). Although there are individual differences influenced by, for instance personal experiences and knowledge, cultural and social ties do play a role in shaping our meaning-making processes. Höijer (2008, 281) formulates this view as a “belief in homogeneity within a culture or subculture”, seeing cultural contexts as influential in shaping social life and meanings in social contexts. The social semiotic conceptualization of meaning suggests that culture, social context and individuality play a role in shaping meanings. This perspective creates a theoretical position somewhere between a structuralist belief in general cultural structures of reality and a situationalist perspective that argues that interpretation is always situational, unique to individuals and context-dependent (Höijer 2008).

Selecting participants based on their belonging to a certain social context – in the case of this thesis, Swedish high school students and Nordic homeowners – means that certain aspects are emphasized while others are understated. My choice of letting the targeted audience be the deciding factor for selecting focus group participants means that two broad geodemographic
factors are emphasized and that the participants are recruited from the social groups of “Swedish high school students” or “Nordic homeowners”.

4.3 Research Design

Based on the theoretical and methodological notions presented above, the following sections present and discuss the research design more specifically related to the two studies of climate visualization. Overall, for the purposes of both studies, we approached the focus group interviews in a semi-structured manner allowing the participants to discuss aspects they regarded as relevant. However, to stimulate discussion in the groups and to ensure some degree of comparability in terms of structure and topics discussed, we produced interview guides with open-ended questions (see Appendix 8 for details) that sought to encourage the participants to express their own opinions and views and discuss the content using a familiar vocabulary.

More specifically, we strove to conduct the sessions with as little interference from the moderator as possible, using limited probing, as we wanted to allow the participants’ interactions to steer the direction of the study in order to let them emphasize issues of importance to them (cf. Morgan & Hoffman 2018). Therefore, the moderator primarily asked questions from the interview guide that the participants had not covered themselves, and occasionally asked clarifying questions, but otherwise let the discussions unfold as deemed relevant by the participants. The objective was therefore not to dictate an interpretive frame for the focus group interviews, but rather to create a setting conducive to the production of different perspectives and narratives that might develop during the focus group conversations (Holstein & Gubrium 2011, 158).

4.3.1 A Warmer World

This study aimed to explore how members of the target audience made meaning of the movie ‘A Warmer World’ by analysing how the participants discussed the movie content and form. To accommodate this, the study used focus group interviews as the main research method, supplemented by a digital mind map exercise and an interview with one of the scriptwriters of the movie.

The interview with the scriptwriter was used as a means to contextualize the movie and gain an understanding of considerations pertaining to the target audience and communicative aspects related to content and form. As the movie was specifically made for Swedish teenagers, we contacted a local upper secondary school and invited students (16-19 years of age) from a social science education programme to participate in the study. In this case, the students’ teacher was an important facilitating factor in recruiting participants for the study, as she agreed to arrange their participation as part of their school curriculum. Students from years 1 and 3 participated in the study and were invited to Norrköping Visualization Center C to watch the movie during school hours.
After having watched the movie, we conducted three focus group interviews that provided the empirical basis for investigating the students’ meaning-making of the movie. We formed the focus groups so that they each consisted of 5-7 students who knew each other from school (the same school class). The fact that the focus group participants were recruited from within the same school classes means that they were likely to bring established social dynamics to the focus group sessions. This could, on the one hand, present a risk of dominating voices, with a few students setting the agenda and voicing their views, and with others being ignored or feeling less inclined to participate actively in the discussions or voice contrasting views. On the other hand, the group constellation meant that the students were asked to discuss the movie in a familiar social context – a context in which they are encouraged to express views and opinions on an everyday basis, and in which they are therefore also used to discussing, disagreeing and verbalizing their views. Assisted by the teacher, we recruited participants for the focus group interviews by asking for volunteers from among the students who had been invited to watch the movie. The focus group sessions lasted approximately 60 minutes each, and were audio-recorded with permission from the participants and subsequently transcribed verbatim for analysis. Table 4 provides an overview of the focus group sessions.

<table>
<thead>
<tr>
<th>No.</th>
<th>Participants</th>
<th>Group size</th>
<th>Place</th>
<th>Date</th>
<th>Moderator/observer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>High school students 3rd year</td>
<td>7 students</td>
<td>Norrköping, Sweden</td>
<td>15 March 2012</td>
<td>VW/AGB</td>
</tr>
<tr>
<td>2</td>
<td>High school students 1st year</td>
<td>5 students</td>
<td>Linköping, Sweden</td>
<td>16 March 2012</td>
<td>VW/AGB</td>
</tr>
<tr>
<td>3</td>
<td>High school students 1st year</td>
<td>6 students</td>
<td>Linköping, Sweden</td>
<td>16 March 2012</td>
<td>VW/AGB</td>
</tr>
</tbody>
</table>

Table 4: A Warmer World: focus group sessions (source: Paper II).

Another challenge related to group dynamics and focus group interaction is the role of the moderator (Morgan 1996; Wibeck 2010). Naturally, the moderator plays an influential role in the construction of data, for example, by his or her mere presence, the way the focus group session is introduced to the participants, and the formulation of interview questions. Although focus group interviews are constructed situations that serve the purpose of research, and as such are influenced by these circumstances, the goal is to provide a setting where the participants feel comfortable discussing freely and co-developing ideas, opinions and attitudes. Therefore, the role of the moderator is to provide a relaxed setting and ensure the discussions are structured around a ‘focused subject’ (hence, ‘focus groups’, cf. Wibeck 2010), guiding the discussions in a way that is relevant to the research questions. However, at the same time, it is important that the moderator does not disrupt or influence the flow of conversation (ibid.). Hence, as a practical precaution to avoid language barriers, misunderstandings or the participants feeling insecure in the interview situation, a Swedish researcher (Victoria Wibeck) facilitated the focus group.

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11 The students signed up to participate in the focus group interviews before watching the movie.
interviews, as I understand but do not speak Swedish. I was present during the sessions, but I primarily observed and took notes, so as to not disturb the natural flow of the discussions with questions formulated in Danish.12

Using the theoretical notions of meaning as outlined in the theoretical framework as a starting point (cf. Figure 2), we designed an interview guide with questions relating to the conceptualization of meaning. The purpose of the interview guide was to ensure a focus on the participants’ meaning-making of the movie, while at the same time encouraging them to discuss the movie freely using a familiar vocabulary. The interview guide also served the purpose of ensuring some degree of compatibility across the three focus group interviews. The link between the five aspects of meaning and the questions from the interview guide can be seen in Table 5. Note that the structure of the questions in the table is random, as the table serves the purpose of illustrating the connection between meaning and the different questions. The actual interview guide can be seen in Appendix 8.1.1.

<table>
<thead>
<tr>
<th>MEANING</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>The communication experience</td>
<td>What did you think about the choice of images and figures? What did you think about the combination of the speakers and the images? What were your expectations before you came to the Visualization Centre to watch the movie?</td>
</tr>
<tr>
<td>Perception of message</td>
<td>If you were to tell a friend what the movie was about/what message was conveyed, what would you say? What are your spontaneous reflections after watching the movie? What did you think about it? What did you think while watching it?</td>
</tr>
<tr>
<td>Sense of relevance</td>
<td>Did you learn anything new? If yes, what? Was there anything from the movie that you would like to know more about? At school, how would you like to continue working with the issues brought up in the movie?</td>
</tr>
<tr>
<td>Pre-existing frames and knowledge</td>
<td>What comes to mind when I say the words “climate change”? What do you see as the most important issues related to climate change?</td>
</tr>
<tr>
<td>Perceptions of intent and other voices</td>
<td>If you were to tell a friend what the movie was about/what message was conveyed, what would you say?</td>
</tr>
</tbody>
</table>

Table 5: Link between the theoretical conceptualization of meaning and the interview questions for study 1.

The format of a movie and the dome setting meant that we could not get an impression of the participants’ instantaneous reactions to the movie while watching it. Instead, we had to ask the participants to reflect upon the movie in retrospect in the focus group sessions. This gave the disadvantage that we could not get an idea of the students’ live meaning-making of the movie.

12 A few times during the focus group sessions, I asked a follow-up question to which the participants reacted by laughing and/or silence, suggesting that it would indeed have been problematic for me to be the main facilitator of these sessions.
However, the retrospective perspective could give an indication of which aspects of the movie the students found interesting, particularly relevant and worth discussing. In fact, Halkier (2016, 10) argues that focus groups are particularly useful for studies with the aim of exploring content interpretations in social contexts, because the negotiations that take place in the focus groups regarding, for instance, how to understand the message of a movie often resemble negotiations or discussions we have with family members, friends or colleagues. Thus, we strove to stimulate reflections regarding the movie’s contents with the questions in the moderator’s guide. As an introduction to the interview, we stressed that we were not responsible for making the movie, emphasizing that the participants should feel free to voice any criticism or concern related to the movie, as we were interested in their honest opinions and viewpoints.

Specifically relating to the movie’s message and the participants’ perceptions of the message, we asked whether they liked the movie and how they would retell the movie to friends, thus aiming to encourage the participants to engage in a discussion and reflection about the movie and what messages the movie intended to convey. In addition, we intentionally did not refer specifically to any of the visual representations when asking questions, as we were interested in seeing which representations they remembered and brought up in the discussions. We chose this strategy because the participants’ recall or emphasis could be an indication of which visual representations had actually made an impression, either with respect to perceived information need, by visualizing something they did not know or had not thought about beforehand, or with respect to their perceived sense of relevance and usefulness of the movie’s messages. To explore this, we therefore asked questions of a more general nature, as we wanted to encourage the participants to reflect upon and bring up elements from the movie that they found particularly interesting or relevant. Related more specifically to the communication experience in the dome theatre, we avoided asking directly whether they liked the dome theatre experience, as such a question would probably just receive a short reply, such as “good” or “interesting”. Instead, we asked the participants “What were your expectations before you came to the Visualization Centre to watch the movie?” to have them reflect upon the communication experience in a different manner. Overall, with the research design outlined here, we strove to motivate the participants to share their perceptions of the movie, in terms of content, form, communication experience and sense of relevance.

With the purpose of exploring the targeted audiences’ general perceptions of climate change, the students took part in an online mind map exercise, where they were asked to draw mind maps of their associations with climate change. The term ‘climate change’ was inserted at the centre of the mind map chart, and the students were enabled to add any number of links and individual entries describing their associations with climate change. A total of 52 students participated in the mind map exercise. The categorization and analysis of the mind map entries provided an accumulated snapshot of how a larger group of students conceived of climate change. However, we could not know if the general idea we received from the mind map
analysis was in fact shared by the smaller group of students who participated in the focus groups. To address this, we initiated the focus group sessions by asking the participants “What comes to mind when I say the words ‘climate change’?” and “What do you see as the most important issues related to climate change?” In the analysis of the focus group transcripts, we subsequently analysed the responses and discussions related to these questions to gain an understanding of how the participants perceived the concept of climate change.

4.3.2 VisAdapt™

This study focused on the launch version of VisAdapt™ that was made public in November 2014. The study aimed to explore how members of the target audience made meaning of the VisAdapt™ content. The study takes as its starting point the concept of individuals’ adaptive capacity, which is defined as a combination of structural aspects, such as institutional systems and technology, and aspects related to individuals’ perceptions of climate risk and their own roles in adapting to or managing such risks (Engle 2011; Fleming et al. 2014). Thus, public engagement in this context is conceptualized as engaging relevant audiences in climate adaptation action.

The VisAdapt™ study was organized around focus group interviews as the main methodology, but we also incorporated test sessions as part of the method. We conducted a total of seven focus group sessions with homeowners from the towns of Aarhus (Denmark), Trondheim (Norway) and Norrköping (Sweden), as outlined in Table 6. These three locations were selected to ensure a spread in exposure to climate change risks and national policy contexts, allowing for a variation in risk assessments across the Nordic region. The first interview in Aarhus functioned as a pilot study to test the method of combining focus group interviews and test sessions, and further to develop the interview guide.

<table>
<thead>
<tr>
<th>No.</th>
<th>Participants</th>
<th>Group size</th>
<th>Place</th>
<th>Date</th>
<th>Moderators</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Homeowners, Aarhus, DK</td>
<td>3</td>
<td>Aarhus University</td>
<td>20 June 2013</td>
<td>AGB &amp; EG</td>
</tr>
<tr>
<td>2</td>
<td>Homeowners, Norrköping, SE</td>
<td>6</td>
<td>Norrköping, Sweden</td>
<td>17 June 2014</td>
<td>EG &amp; TN</td>
</tr>
<tr>
<td>3</td>
<td>Homeowners, Norrköping, SE</td>
<td>5</td>
<td>Norrköping, Sweden</td>
<td>18 June 2014</td>
<td>EG &amp; TN</td>
</tr>
<tr>
<td>4</td>
<td>Homeowners, Trondheim, NO</td>
<td>5</td>
<td>Trondheim, Norway</td>
<td>3 Nov. 2014</td>
<td>AGB &amp; EG</td>
</tr>
<tr>
<td>5</td>
<td>Homeowners, Trondheim, NO</td>
<td>8</td>
<td>Trondheim, Norway</td>
<td>4 Nov. 2014</td>
<td>AGB &amp; EG</td>
</tr>
<tr>
<td>6</td>
<td>Homeowners, Aarhus, DK</td>
<td>6</td>
<td>Aarhus, Denmark</td>
<td>6 Nov. 2014</td>
<td>AGB &amp; EG</td>
</tr>
<tr>
<td>7</td>
<td>Homeowners, Aarhus, DK</td>
<td>5</td>
<td>Aarhus, Denmark</td>
<td>7 Nov. 2014</td>
<td>AGB &amp; EG</td>
</tr>
</tbody>
</table>

Table 6: VisAdapt™: focus group sessions (source: Paper III).

The recruitment of participants for the focus group sessions was structured around two main principles: they had to be homeowners and live in one of the above-mentioned municipalities. We recruited people for two sessions in each location by contacting local housing organizations and, more effectively, by using our extended networks to establish contacts (cf. Halkier 2016). In terms of considering group dynamics, we strove to ensure a broad spectrum of participants with respect to rural/urban location within each of the three municipalities, as well as age and
gender. We did this to ensure a group constellation with different views, experiences and interests related to climate change risk and vulnerability, but the common denominator in the groups was the fact that they were all homeowners, and also shared a connection to, knowledge about and an interest in the same geographic location. The focus group sessions were each moderated by two persons from the research team, with one person (Erik Glaas) being present at all 7 sessions to ensure a degree of consistency between the focus groups interviews.

The focus group interviews were divided into three phases (see Table 7), where the participants were firstly engaged in a general discussion about climate change and their perceptions of risks and adaptive capacity. Secondly, they were given the opportunity to use VisAdapt™ in smaller groups (the test sessions), and thirdly, we returned to the traditional focus group format, where we continued the discussion about perceptions of climate change risks, adaptive capacity and roles and responsibility, and also a more general reflection about their experience with using VisAdapt™.

<table>
<thead>
<tr>
<th>Focus group interview</th>
<th>Test sessions</th>
<th>Focus group interview</th>
</tr>
</thead>
<tbody>
<tr>
<td>To explore the participants’ perceptions of climate change risks, responsibilities and adaptation.</td>
<td>To explore the participants’ interactions with and interpretations of VisAdapt™.</td>
<td>To explore the participants’ general perceptions of VisAdapt™, how they perceive the relevance of the tool, and their general perceptions of risk in relation to the VisAdapt™ experience.</td>
</tr>
<tr>
<td>5-8 participants</td>
<td>2-3 participants</td>
<td>5-8 participants</td>
</tr>
<tr>
<td>2 moderators</td>
<td>No moderator</td>
<td>2 moderators</td>
</tr>
<tr>
<td>Semi-structured</td>
<td>Unstructured</td>
<td>Semi-structured</td>
</tr>
<tr>
<td>30 minutes</td>
<td>30-45 minutes</td>
<td>30 minutes</td>
</tr>
</tbody>
</table>

Table 7: Overview of the focus group and test session structure (source: Paper IV).

Similar to the study of the dome movie, we designed an interview guide that covered aspects related to the conceptualization of meaning in the theoretical framework. The questions from the interview guide and their correspondence with aspects of meaning-making can be seen in Table 8. The interview guide can be seen in its entirety in Appendix 8.1.2.
### Table 8: Link between the theoretical conceptualization of meaning and the interview questions for study 2.

<table>
<thead>
<tr>
<th>MEANING</th>
<th>The communication experience</th>
<th>What are your spontaneous reactions to VisAdapt™ after having used it? What is your general impression of VisAdapt™? Any reflections from using the tool?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Perception of message</td>
<td>This aspect was primarily explored during the test sessions, but was also partly covered by questions related to the participants’ general impression of VisAdapt™.</td>
</tr>
<tr>
<td></td>
<td>Sense of relevance</td>
<td>How do you view your own roles in adapting your houses to extreme weather phenomena/climate change? Do you consider climate change to be relevant where you live? Why? Do you think that a visualization tool such as VisAdapt™ can help you reduce your vulnerability to climate change or help you make decisions regarding climate adaptation in relation to your house? (If yes, how? If no, what type of help/information would you need?) Any new information? Did you learn anything new? Any particularly interesting parts? Is VisAdapt™ relevant for you considering your own house? How so? How far does your responsibility go with respect to climate adaptation?</td>
</tr>
<tr>
<td></td>
<td>Pre-existing frames and knowledge</td>
<td>What comes to mind when I say the words ‘climate change’? Are there any weather- or climate-related risks you consider particularly important for society to address now or in the future? Have you thought about how such changes could affect your house? Or have you personally experienced any weather- or climate-related damage to your house? Have you personally experienced any weather- or climate-related damage? Who, in your opinion, has the main responsibility for ensuring that society adapts to climate change?</td>
</tr>
<tr>
<td></td>
<td>Perceptions of intent and other voices</td>
<td>This aspect was primarily explored during the test sessions but was also partly covered by questions related to the participants’ general impression of VisAdapt™. Have you read or heard anything about climate change or how we can adapt to climate change in the media or debates?</td>
</tr>
</tbody>
</table>

The first part served the purpose of starting off broadly, discussing the participants’ views on their roles as homeowners in relation to climate change and how they saw their roles in adapting to climate change risks. Studies on individuals’ adaptation to climate change have identified perceptions of risks and responses, including how individuals see their own role in adapting to climate change, as key challenges and emphasize the important role of communication in addressing these challenges (cf. Grothmann & Patt 2005; Blennow & Persson 2009; Adger et al. 2013). Against this background, we used the first part of the focus group sessions to discuss the participants’ general perceptions of climate change to firstly identify their perceived challenges or constraints relating to engaging in adaptation action, and secondly to use these perspectives to contextualize the participants’ interpretations of VisAdapt™. This was deemed relevant in relation to the participants’ pre-existing knowledge of and experiences with climate
change as homeowners. To this end, we started out in the same way as we did in study 1, by asking “What comes to mind when I say the words ‘climate change’?” From this broad perspective, we zoomed in to discuss aspects related more specifically to local climate risks and how the participants perceived such risks in relation to being homeowners. From the discussion about risks, we wished to discuss how the participants viewed their own role as homeowners and their adaptive capacity in relation to climate change, and especially to understand how they perceived the relevance of discussing climate change in this capacity.

In summary, the first phase of the focus group discussions served the purpose of discussing different perspectives pertaining to the participants’ perceptions of climate change, specifically focusing on their views on risk and responsibility, as these aspects have been identified as being particularly important in facilitating individuals’ adaptive capacity. From this broad outline, we moved on to the second phase, in which the participants were given a brief introduction to VisAdapt™, and were subsequently divided into smaller groups of 2-3 people and given the opportunity to familiarize themselves with VisAdapt™ without the moderators being present. When introducing VisAdapt™, we also emphasized that the participants should feel free to voice any criticism or feedback, as we were particularly interested in their opinions and views in order to improve the tool, if necessary. While exploring VisAdapt™, they were asked to “think aloud” and simply discuss features of the tool as they were navigating the different modules. The test sessions were audio-recorded with informed consent from the participants and later transcribed verbatim for analysis. Table 9 presents an overview of the test sessions.

<table>
<thead>
<tr>
<th>No.</th>
<th>Group size</th>
<th>Place</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
<td>Aarhus, Denmark</td>
<td>20 June 2013</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>Norrköping, Sweden</td>
<td>17 June 2014</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>Norrköping, Sweden</td>
<td>17 June 2014</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>Norrköping, Sweden</td>
<td>17 June 2014</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
<td>Norrköping, Sweden</td>
<td>18 June 2014</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td>Norrköping, Sweden</td>
<td>18 June 2014</td>
</tr>
<tr>
<td>7</td>
<td>3</td>
<td>Trondheim, Norway</td>
<td>3 November 2014</td>
</tr>
<tr>
<td>8</td>
<td>2</td>
<td>Trondheim, Norway</td>
<td>3 November 2014</td>
</tr>
<tr>
<td>9</td>
<td>3</td>
<td>Trondheim, Norway</td>
<td>4 November 2014</td>
</tr>
<tr>
<td>10</td>
<td>3</td>
<td>Trondheim, Norway</td>
<td>4 November 2014</td>
</tr>
<tr>
<td>11</td>
<td>2</td>
<td>Aarhus, Denmark</td>
<td>6 November 2014</td>
</tr>
<tr>
<td>12</td>
<td>2</td>
<td>Aarhus, Denmark</td>
<td>6 November 2014</td>
</tr>
<tr>
<td>13</td>
<td>2</td>
<td>Aarhus, Denmark</td>
<td>6 November 2014</td>
</tr>
<tr>
<td>14</td>
<td>3</td>
<td>Aarhus, Denmark</td>
<td>7 November 2014</td>
</tr>
<tr>
<td>15</td>
<td>2</td>
<td>Aarhus, Denmark</td>
<td>7 November 2014</td>
</tr>
</tbody>
</table>

Table 9: VisAdapt™: test sessions without moderator (source: Paper IV).

This part of the study was chosen because it allowed the participants to use VisAdapt™ and discuss the user experience while navigating the web tool. In this sense, the test sessions functioned as a continuation of the focus group discussions, albeit in a much more unstructured manner, because the participants were left to set the agenda without the influence of a moderator.
The advantages of this approach were that we would get an impression of their immediate reactions to VisAdapt\textsuperscript{TM}, such as confusion, surprise, disagreement and interest, and also of how they made sense of the tool regarding its functionality and content. In addition, the aim was that the setting of these sessions would lead to an informal discussion resembling a use situation, and that the participants would voice their immediate impressions of the tool and its content. Of course, there was the risk that the unstructured nature of the sessions would lead to participants straying off topic or simply forgetting to discuss the tool while using it. Therefore, to test the method design, we organized a pilot study in Aarhus, Denmark, to assess the usability of this setup. It turned out that although there were digressions from discussing the tool, the audio-recordings of the test session dialogues provided interesting data concerning the participants’ interactions with the tool, their sense of relevance and insights into their interpretive processes of the visual representations. In addition, the recorded discussions made it possible to follow their patterns of navigation and identify which module or representation in VisAdapt\textsuperscript{TM} they were discussing.

Following the test sessions, all participants re-gathered in the focus group setting to discuss their experiences with VisAdapt\textsuperscript{TM}. Furthermore, we sought to continue the discussions regarding the participants’ perceptions of risk and adaptive capacity, this time in the context of VisAdapt\textsuperscript{TM}, to further elaborate on their assessment of the relevance of the tool. To this end, we started out in general terms and asked whether the participants viewed climate adaptation as an important issue in their local area and moved on to ask about their reaction to VisAdapt\textsuperscript{TM}. Having discussed different features of the VisAdapt\textsuperscript{TM} tool as well as aspects related to the use and relevance for homeowners, we concluded the focus group sessions by asking what could motivate the participants, in their capacity as homeowners, to focus more on implementing climate adaptation measures. This served the purpose of starting a more general discussion about the role and responsibility of homeowners in relation to adaptation, as well as adding their perspectives to the role of communication in facilitating adaptive capacity.

4.3.3 Thematic Content Analysis
In both studies, I have used the theoretical framework of meaning as the basis for the interview guides. However, concerning data analysis, I have taken a bottom-up, exploratory approach using thematic content analysis. This entails that I have used thematic content analysis as a way to systematize and structure the analyses, and that the main focus of analysis is on the different perspectives that are expressed during the sessions and on identifying themes of consensus or conflict surrounding these perspectives. As such, I focus primarily on what the participants express, but I also, perhaps less explicitly, include aspects relating to how interaction occur, for instance by emphasizing shifts in discussions as a result of a change of topic (Morgan 2010). Relating to this, the role of interaction as the focus of analytical approaches has been much debated in the focus group literature (cf. Wilkinson 1998; Halkier 2010; Morgan 2010; Ryan et al. 2014; Morgan & Hoffman 2018). On the one side, interaction is emphasized as a means to analyse how participants talk about a topic, and additionally, how conflict and convergence are
formed in the social setting of the focus groups. On the other side, interaction is argued to be the source of data construction, but not necessarily the primary interest of analysis. Discussing these perspectives on analysis of focus group data, Morgan (2010) argues for a stance that primarily sees interaction as the method of data production, but not necessarily the focus of analysis:

I argue that choices about the analysis and reporting of interaction in focus groups must be made within the context of the needs and goals of the overall project. In particular, saying that the interaction in focus groups produces the data is not the same as saying that the interaction itself is the data (Morgan 2010, 718).

Adopting this view, the empirical material derived from the focus group discussions is inherently interactive and dialogically constituted, as a result of the social setting (Wilkinson 1998; Marková et al. 2007). That is, the focus of my analyses is on the constitutive effects of dialogue, for instance how participants, as a result of the joint setting, ascribe meaning to visual representations of climate change, and how they construct issues of climate change in the social settings.

Overall, my method of analysis was inspired by thematic content analysis (Marková et al. 2007; Wibeck 2010). Here, I systematically read, examined and categorized and coded the interview transcripts for recurrent themes that represented different perspectives brought up in the group discussions. In general, the categorization and coding of interview transcripts is a method of analysis that aims to provide structure and an overview of the text, enabling a focus on interview sequences of particular interest and relevance to the research aim (Krueger 1998; Wibeck 2010; Halkier 2016).

Specifically, the first step in the analytical process therefore consisted of an initial structuring of the material to gain an overview of what the participants talked about in the focus groups. Here, I divided the text (transcript) into larger sequences defined by a change of topic or perspective, initiated either by the moderator or by the participants. Secondly, I labelled the text sequences according to the topic or focus of the discussions. Working through the transcripts of all the focus group sessions, I subsequently grouped these labelled sequences into categories that summarized the discussion focus. Following this general categorization, I conducted a meaning condensation (cf. Brinkmann & Kvale 2015) of the text sequences in the categories, essentially providing a short summary of each sequence. The meaning condensation served the purpose of condensing the longer text sequences into shorter statements that describe what and how the participants discussed in connection with the topic in the categories. This process allowed me to analyse the text within each category, focusing on recurrent themes derived from the meaning condensation. Table 10 exemplifies this process in relation to study 1. The analyses of the focus group and test session data from study 2 were conducted in a similar fashion.
How did the participants make meaning of "A Warmer World"?

<table>
<thead>
<tr>
<th>Text sequences</th>
<th>Categories</th>
<th>Meaning condensation</th>
<th>Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;5: But I think it explains really well, for example, how scientists work, and with these different scenarios and kind of why they don't... 4: Yes, how they think... 5: Or why they haven’t achieved anything at the conferences 4: It is easier to see it... You cannot just look at it one way, but there are different ways to look at it.&quot;</td>
<td>1) Discussions of specific visual representations from the movie.</td>
<td>The participants emphasize visual representations that helped them understand the complexity of climate change.</td>
<td>Making complexity visible</td>
</tr>
<tr>
<td>Text sequence 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Text sequence 3</td>
<td></td>
<td>The participants highlight that the movie gave them a clear idea and a better overview.</td>
<td>Clarifying and/or providing an overview</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Making climate change visible</td>
</tr>
</tbody>
</table>

Table 10: Example of data analysis from study 1.

4.3.4 Research Ethics

Research ethics concerns the moral responsibility towards research participants in all aspects of knowledge production and encompasses considerations regarding codes and consent, confidentiality and trust (Ryen 2011). I have included ethical considerations as part of the research design, especially focusing on the recruitment of participants to the focus group interviews, the information given to the participants prior to the interview, and how the focus group interviews were carried out.

The recruitment processes for participants for the focus group interviews in the two studies were approached in slightly different manners. For the dome study, the high school teacher played an important role in recruiting the students, as she agreed to distribute the mind map exercise and arrange the trip to the Visualization Centre during school hours. Hence, she recruited students to participate in the focus group interviews by asking for volunteers. The recruitment of participants for the VisAdapt™ study was approached in a different manner. We contacted participants directly, using housing associations and private networks. Here, participants were given an overview of the study in general terms, along with practical information, for example the expected duration of the interviews and that we would be serving refreshments.

In both studies, participants were given a brief introduction to the general purpose of the focus group interviews. As an introduction to the focus group interviews, we presented ourselves and the research project, thanked the participants for agreeing to participate, and explained that we were interested in hearing about their experiences of watching the movie/using the VisAdapt™ tool. We strove to ensure a welcoming and relaxed tone to make the participants feel comfortable in the interview setting. We asked for the participants’ permission to audio record...
the interviews and explained how the recordings would be used. During the focus group discussions, we tried to ensure that all participants’ views were heard and that everybody had a chance to contribute to the discussion.

For the purpose of data analysis and presentation of results, I did not include any personal information about the participants that could disclose their identities. In addition, I have sought to present results and analyses in a manner that does justice to the different perspectives brought up in the focus groups.
5 Results and Analyses

The aim of this thesis is to explore the role of climate visualization in climate change communication, specifically focusing on two cases of climate visualization targeting lay audiences. The focus of the analysis is on how meaning is made at the site of audiencing and how climate change is constructed in the meeting between audiences and the two examples of climate visualization. In this chapter, I present the results and analyses of the two studies, complementing the articles appended to this thesis (Papers II, III and IV).

5.1 Dome Theatre: A Warmer World

This study set out to explore the dome movie from the site of audiencing, focusing on how the participants ascribed meaning to the movie and how they discussed the movie’s messages in relation to their own ability to engage with climate change in their daily lives in terms of actions associated with climate change mitigation (Paper II).

As outlined in the methodology chapter, the interview guide was designed with the aim of addressing aspects related to meaning-making processes. The thematic content analysis of the interview transcripts was, however, content-driven, and categories and themes were derived from the transcripts. The categories identified in the analysis were naturally influenced by the moderators’ guide. However, it did not make sense to strictly use the five aspects of meaning as predetermined categories of analysis, because these aspects were inter-related in the focus group discussions and not possible to separate for the purpose of analysis. Instead, I used an inductive approach to content analysis, and based on topic shifts in the discussions, I derived three categories with related sub-categories and themes that provided insights into the participants’ meaning-making processes (see Table 11). The following sections will be structured according to the three main categories. The categories and sub-categories focus on what the participants discussed in the focus groups, whereas the themes refer to how they discussed the different categories.
5.1.1 General Perceptions of Climate Change

The category labelled ‘General perceptions of climate change’ focuses on the participants’ connotations of climate change as expressed through their conversations in the focus groups and the mind map exercise. The analyses of the mind maps showed that the students’ connotations with climate change were predominantly structured around climate change impacts, and also to a certain extent causes of climate change. However, notably, the category of actors, focusing on responsibility and solutions, was by far the least salient category with relatively few entries. Table 12 provides an overview of the three categories with related themes, exemplified with recurrent words or expressions from the mind map data.

13 The findings in this category are based on data from the focus group discussions as well as the mind map exercise, which the students took part in prior to watching the movie.
14 See Paper II for a detailed discussion of this theme.
The analysis of the focus group discussions relating to the participants’ general perceptions of climate change showed a similar focus on impacts, causes and responses. The subject of climate change impacts did not lead to much discussion among the participants. Rather, when referring to impacts, the participants in all three focus groups simply voiced short statements, expressions or most often just a word, and these statements were not further discussed, questioned or elaborated on in the groups. Examples of the participants’ connotations of climate change impacts include “sea level rise”, “diversity, mass animal extinction”, “flooding”, “warmer”, “shorter winters”, “natural disasters”, “the end of the world”, “more tsunami waves”, “the USA will be flooded, Manhattan”, “and then a polar bear who sits there and is sad”, “melting ice” and “sad little polar bears who have no place to live”. These statements did not provoke or instigate much discussion among the participants, which could indicate that they simply expressed views representing the consensus in the group or that they were not provocative enough to generate disagreement.

In the category of causes, the pattern was more or less the same, with participants making statements that were confirmed implicitly or explicitly by the rest of the group, but seldom further discussed. The participants’ connotations were structured around statements such as “cars, emissions”, “carbon dioxide”, “fossil fuels, driving cars”, “airplanes”, “transportation” and “overconsumption”. Aside from presenting statements, there were two examples of participants engaging in a longer discussion regarding the role of industrialization as a cause of...
climate change. However, the participants did not explicitly link industrialization to, for instance, Sweden, but kept the discussions at a more abstract level, focusing on industrialization in ‘other parts of the world’ as a cause and driver of climate change.

In the category of actors and responses, the pattern of group interaction changed, as the statements here were more detailed than the references to impacts and causes. This is illustrated by the excerpt below in a conversation relating to actors and responses:

1: Yes, what else do you think about?
4: There are so many things…
1: For example, Kyoto…
7: Yes, it’s difficult to think about anything relating to that…
4: Yes, anything concrete? (7: yes)
1: I’m also thinking about these climate conferences that regularly take place… with mass demonstrations and so on… (2: mmm)
3: The most recent was in Copenhagen and with all these damn mass demonstrations.
2: Yes, the question is if anything happens because of them… like, whether they work?
1: Yes, people normally get arrested (laughing)
3: All the time it’s just… no, we can’t, but we can, no we can’t, yes we can, no we can’t…
4: I’m thinking… yes, about these discussions, where they agree on these supposedly great solutions, but then they realize that they won’t work, or they are impossible to carry through… (3: laughing)
4: People won’t…
6: No…

(Focus group 1, author’s translation)

In this example, the participants contemplated the question from the moderator regarding perceptions of climate change, and participant 1 brought up the Kyoto Agreement. This led to a conversation involving most participants in the focus group session, where they referred to the 15th UNFCCC Conference of the Parties (COP 15), which took place in Copenhagen in 2009. From this excerpt, it seems that their perceptions of the conference were associated with mass demonstrations and a lack of political action, rather than climate change per se. The participants expressed a lack of faith that anything will happen as a result of these conferences, as politicians cannot seem to agree or implement solutions, and the conversation simply ends with a statement that “People won’t…”. This illustrates a pattern related to the category of actors and responses that the participants expressed feelings of hopelessness and powerlessness. They doubted that anything will ever happen politically to address climate change. Several times, across all the focus groups, participants expressed a concern of the problem-focused political framing of climate change, and a wish for more of a focus on solutions in the political debates in general.

The participants’ connotations of climate change were generally focused on impacts as the most salient aspect. These impacts seemed structured around abstract terms such as the greenhouse effect and recurrent references to the Arctic, polar bears and melting ice, with only few mentions
of locally relevant impacts that could directly affect the participants’ lives in Sweden. These connotations are consistent with iconography that have been found to represent public perceptions of climate change, including polar bears, melting ice and globes (Doyle 2007; Smith & Joffe 2009; Manzo 2010b; Wang 2018). Focusing on climate impacts in geographically distant locations suggests that the participants – both in the individual mind map exercise and in the focus group discussions – reinforced the construction of climate change as a distant phenomenon, which is consistent with several studies on public perceptions of climate change (e.g. Lorenzoni et al. 2007; O’Neill & Nicholson-Cole 2009; Spence et al. 2012; Pahl et al. 2014). Connotations associated with distance can also be said to characterize the participants’ perceptions of actors and responsibility, as their discussions and mind maps were structured around politics, international agreements and negotiations, and countries such as the USA and China. Although the participants across the focus groups expressed concern about climate change, climate change was not constructed as a personally relevant issue in terms of actions or ‘doing something’. Instead, the participants voiced frustration that nobody else is tackling these issues. Distance, in this sense, is thus understood in contrast to the individual, meaning that they did not mention individuals as playing a role in addressing climate change. Rather, solutions (or lack thereof) were framed in terms of international scale or assigned to other actors, such as parents or politicians.

The study participants’ connotations with climate change are interesting from a meaning perspective, because the connotations of climate change as a distant phenomenon provide insights about how climate change is enacted in this particular social context. Seeing that the social and cultural contexts influence meaning-making processes and interpretive resources, as discussed in chapter 3, the results in this section can be used to contextualize the participants’ meaning-making of the movie.

5.1.2 Interpretations of Message, Intent and Personal Relevance
The participants’ discussions relating to their interpretations of the message, including their perceptions of the intended messages, and their sense of relevance can be structured in terms of two sub-categories: discussions pertaining to specific visual representations recalled by the participants, and discussions related to the intended message of the movie in more general terms.

Interpretations of visual representations
The participants brought up and discussed visual representations that they experienced as interesting and relevant. For instance, the visual representation most frequently discussed and emphasized as particularly interesting by most participants in the focus groups was an illustration of three different ways of calculating greenhouse gas emissions. This was visualized by three globes with volume bar charts illustrating emissions as displayed in Figure 5.
In all three focus groups, the participants mentioned this visual representation as being particularly useful, because they felt it provided them with a better understanding of the complexity and rationales of international political discussions and disagreements. The extracts below from two of the focus groups illustrate how the students discussed and ascribed meaning to this particular representation:

5: But I think it explains really well, for example, how scientists work, and with these different scenarios and kind of why they don’t…
4: Yes, how they think…
5: Or why they haven’t achieved anything at the conferences.
4: It is easier to see it… you cannot just look at it one way, but there are different ways to look at it.
(Focus group 1, author’s translation and emphasis in bold)

1: The exciting thing was to see, I mean, we just saw that for instance Australia emitted more when it was per person – but you did get a better overview with these different bars that came up.
5: All the visualization was so well done, it really showed how… I mean you get something out of the figures in the books as well, on paper, but then maybe you do not understand how large scale it really is.
1: A small diagram…
5: But when they showed how much the countries emit and how it is distributed, then one could kind of really understand what it looks like, and I think that was very good.
(Focus group 2, author’s translation and emphasis in bold)
These two examples illustrate a general pattern in all three focus groups, whereby participants agreed on the communicative qualities of different visual representations, and their articulation of why they liked and remembered specific visual representations was developed jointly by two or more participants. They complemented each other’s arguments and repeatedly used words such as ‘see’, ‘show’ and ‘understand’ to explain how and why these visuals made an impression. The emphasis on seeing and showing suggests that the strength of this particular representation from the participants’ perspective was found in the graphic mode (the globes with volume bar charts) and in the comparison of the three globes representing three different ways of calculating emissions. Considering the frustrations voiced by the participants regarding their more general perceptions of climate change as an issue that is not dealt with properly in international climate negotiations could offer an explanation as to why this particular visual representation was brought up and emphasized as good, interesting and relevant in all groups. The representation of the three ways of calculating emissions offered a reason or an explanation of why it can be difficult to reach a consensus in international climate negotiations, and as such it addressed an implicit information need from the target audience.

The participants’ accentuation of the graphic mode of the visual representations was also evident in relation to discussions about other representations, for example:

1: You get a **better overview**, otherwise you only see a chart and then ignore it… here, it was much easier to see…
2: And what I always think is so cool, I have seen many charts on this, it’s that the population has increased and so has the carbon dioxide… the carbon dioxide **has just gone like this** and then the industrialization and **it just went straight up**… I really thought it did like this, and you really see how it has changed in recent times.
(Focus group 2, author’s translation and emphasis in bold)

Again, the participants in the example explained how a certain visual representation, in this case about linkages between carbon dioxide emissions and population growth, helped them gain an overview, because of the visual characteristics of the representation. Interestingly, they referred to the design of the representation (“has just gone like this” and “it just went straight up”), as this seemed to help them explain what they meant. Hence, they used characteristics of the visual representations to explain an aspect of the movie they found interesting and drew on these characteristics (e.g. a curve) as a common reference point in the discussion. The use of the word “cool”, and the emphasis on characteristics of the visual representation through the use of the word “really” could also indicate an element of surprise and explain the ‘likeability’ or recall of the representation.

Another visual representation that was also discussed in all three groups focused on emissions associated with different food products. This representation was designed by visualizing different types of food – carrots, soy beans, pasta, rice, chicken and beef – floating around the dome screen. The accumulated emissions of carbon dioxide, methane and nitrous oxide
associated with each type of food were illustrated by pie charts surrounding an icon representing the food product. The size of the pie chart illustrated the total amount of emissions associated with a specific type of food (Figure 6).

Figure 6: Representation of GHG emissions associated with different types of food.

The excerpts below illustrate an example of the participants’ conversations regarding this representation:

4: I remember that stuff about the food as well, how much carbon dioxide and stuff like that.
5: Yeah, those circles, the diagrams.
3: The steak.
4: Yeah, the steak just took over the entire screen.
1: Yeah, you had not thought about that a lot…
6: No…
2: It feels like food is the thing you think about the least… Or you can think about organic food and such, but you don’t think about what you eat and how it affects…
(Focus group 3, author’s translation)

Similar to the examples above, the participants here referred specifically to the graphic mode of the visual representation and emphasized the element of surprise, as the “steak just took over the entire screen”, inferring that emissions associated with this type of food are very high compared to carrots, for example. Although this visual representation was a rather coarse way of representing links between food types and GHG emissions, it made an impression on the
participants, because the visual design was perceived as surprising. Participants 1 and 2 (and 6) also reflected that the impact of food consumption is not something they normally think about in relation to climate change.

The excerpts included here represent a general pattern in the participants’ interpretations of the visual representations of the movie. They liked and emphasized representations that helped them gain an overview and made aspects of climate change clearer, and made a complex notion of climate change visible and tangible through the graphic design of the representations. In addition, the participants remembered and emphasized visual representations that introduced facets they had not thought about before or that surprised them in one way or another. These themes all seemed related to an overall topic of ‘concretization’, as the characteristics derived from the analysis can be seen as ways to make abstract or complex aspects of climate change more concrete and thus easier to relate to. The discussions regarding the visual representations suggest that these types of visualization concretized different aspects of climate change and helped the participants gain a better understanding of complex facets of climate change. As such, specific features enabling their meaning-making of climate change include graphic design that allows participants to see and compare aspects of climate change that are invisible or intangible.

Perceptions of intent and the movie’s messages
When asked directly about the intended message of the movie, the participants in all groups began a discussion relating to responsibility and actors. The excerpt below presents an example of participants’ reflections regarding the message of the movie:

5: I guess it’s about that we have to reduce our CO₂ emissions, because if we don’t the world will come to an end…
1: I think they pointed out that you can do a lot yourself, although it wasn’t very much… they didn’t show that much about how the greenhouse effect works, it was more like, they pulled this out with the food and how big a difference that would make, and this thing with the washing machine, or whatever… it was like all of this…
3: For example, showering…
4: Yes, to shower for five minutes, or…
1: You saw how much you can do and influence, so it isn’t just the responsibility of these big factories… you can do a lot yourself, as a private person. That’s what I thought it was about, really.
(Focus group 2, author’s translation)

In this example, the participants discussed what the movie was about, and they emphasized individual responsibility as a main message. The participants in all groups highlighted individual responsibility as a response to the question of what they thought the movie was about. When asked directly, they mentioned many different measures that individuals could take to contribute to reducing emissions, for example, “buy energy saving bulbs”, “cycle and walk more”, “buy environmentally friendly food”, “take the bus instead of driving”, “buy less stuff”,

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“switch off lamps” and “take shorter showers”. Mentioning specific mitigation measures indicates that the participants were well aware of what they as individuals could do to reduce emissions, as they also mentioned actions that were not brought up in the movie. In addition, there was also a general consensus among the participants in the focus groups that it is important to do something, to address the changing climate at an individual level. This focus on individual responsibility was, however, only brought up in relation to the prompted discussions on the movie’s messages:

6: We can’t produce cotton here, so we must buy it from other countries.
1: Yes.
3: I guess we could, but it would be very expensive.
6: Yeah…
4: Though it would almost be less climate friendly… think about how much energy it would take to warm up a greenhouse to produce cotton…
(Focus group 1, author’s translation)

5: You don’t exactly think about all the steps, when you buy something new – you don’t think: oh, how many emissions are associated with buying this…
6: No, exactly.
2: No, no, and you live like you do…
4: It feels almost distant, somehow.
5: Yes, exactly.
4: And that what you do yourself doesn’t make a difference… perhaps it does, but (laughing)… It feels a little hopeless somehow, because you hear that they can’t make up their minds, so it feels like it doesn’t matter…
(Focus group 3, author’s translation)

These excerpts illustrate a general pattern found in all the groups, whereby the participants negotiated the message regarding individual responsibility. In these discussions regarding clothing production, the participants jointly renegotiated the message from the movie that clothing production is associated with high levels of GHG emissions. They did not disagree as such with the claim from the movie, but they explained or justified why this is very difficult to change for them as individuals – and why they cannot assume this responsibility. For example, in the excerpt from focus group 1, they jointly argued that it would be much less climate friendly to produce cotton in Sweden, implying that keeping clothing production in Asia is the best solution. In the discussion from focus group 3, the participants explained that it feels distant and they questioned whether these ‘small actions’ at individual level actually make any difference at all. In this argument, they blamed the politicians for not doing anything to solve the problem (“they can’t make up their minds”) and they used this to justify why it feels difficult, and even pointless, to try to make a difference at an individual level. In particular, when discussing their own roles in more concrete terms, the participants expressed a sense that it will not make a difference anyway, for instance: “It requires that everybody does it, for it to… well, because I wouldn’t feel motivated to change when nobody else is doing it, because it wouldn’t make a difference” (focus group 1), “There are more concrete examples, but it feels like they don’t matter” (focus group 3), “It feels like it doesn’t make a difference if one person stops driving
Overall, the focus group discussions regarding individual responsibility were characterized by a sense of powerlessness and although they initially emphasized the importance of individual contributions to reducing emissions, they later renegotiated this stance and expressed that individual change feels pointless and insignificant in the bigger picture, or global scale, of climate change. Discussions of this type, in which participants expressed limited agency, understood as their capacity to make their own free choices and to influence outcomes and responsibility towards climate action, appeared in all the focus groups. Additionally, such discussions related to and evolved into arguments concerning other actors, as illustrated below:

6: Well, everybody has to do something, it can’t just be us in Sweden who do something.
5: But, but those decisions aren’t enough, it requires somehow that there are politicians who are willing to take some sort of radical decisions, and it seems like they don’t really exist.
(Focus group 1, author’s translation)

And the pressure is greatest on the grown-ups. I mean, they are the ones buying the food and driving cars and so on.
(Focus group 2, author’s translation)

4: It feels like you want to do something bigger, but you don’t know what to do, and nobody knows what to do to solve the problem.
1: I guess it’s the politicians, who…
4: Yes…
1: … make the biggest difference, really.
5: But they do too little.
1: Yes, it’s there we need a change.
5: Yeah.
2: I think that the USA should take care of it.
(Focus group 3, author’s translation)

Here, the participants assigned the responsibility of action to other actors, such as politicians, the USA and their parents. Politicians in particular were blamed for a lack of action, and there was a clear sense of frustration among the participants that politicians, at national and international levels, were unable to agree and implement action. The feeling of powerlessness and assigning responsibility to other actors could be explained by the participants’ general framing of climate change as a distant problem. Although the movie tried to put the emphasis on climate change action at a more local scale that would feel relevant to the audience, the construction of climate change as a distant issue seemingly influenced the participants’ interpretations of the movie’s messages at a connotative level. Denotatively, the participants identified the intended messages as being related to individual responsibility, but connotatively they later renegotiated the intended messages and aligned them with their general perceptions of climate change as a global issue that has to be solved at an international level.
5.1.3 The Communication Experience

The third category in the focus group interviews concerned the participants’ perceptions of the dome theatre experience. They generally expressed a positive attitude regarding the dome theatre, and the examples below illustrate how they explained this:

1: It was pretty awesome…
2: Yes it was…
4: It was fun.
5: It’s a completely different feeling than watching regular TV or cinema, because you get this embracing feeling, I think…
   (Focus group 2, author’s translation)

4: I thought it was good. And it was awesome to watch it on such a screen, like…
2: This meant that you wanted to watch it a little more…
5: Yes, exactly.
2: … compared to if it had been a regular movie in the classroom. It was much cooler to go away somewhere and see it.
4: And here on a larger screen.
   (Focus group 3, author’s translation)

In these excerpts, the participants highlighted that they liked the experience compared to watching TV or visiting a cinema and explained this by referring to the dome environment (“embracing feeling” and “larger screen”). In addition, they used words with positive connotations to describe the dome experience, for example “awesome”, “fun”, “embracing feeling” and “cool”. “Cool” in particular was a popular way of describing the dome experience, as this was mentioned several times in the focus groups, for example “It was a cool way of seeing it”, “I thought it was cool” or “It was cool when they zoomed in, at the beginning”. When asked to elaborate on their understanding of “cool”, they referred to specific visual representations or effects that somehow contributed to a better understanding or overview of an aspect of climate change: “Yes, and it was good to show the bars from different countries and such… that was interesting to see. It gave a clearer picture of it, compared to just looking at a piece of paper” (focus group 3), “The storyline and the pictures together made it good, because you understood even if you could not keep up with everything they said” (focus group 2). Hence, the “coolness” of the dome experience was related to the immersive environment, but also to the visual representations in the movie.

Assessing the communication experience also revealed an entertainment theme in the students’ discussions. Some stated that they had expected to experience 3D effects similar to 3D movies they had seen at the cinema, whereas others said that they would have liked to see “real” pictures of, for example, weather-related disasters or more drama in combination with the other visuals. Perhaps this can be explained by the setting of the communication experience. The visit to the dome theatre initially connoted entertainment to the participants. However, as a positive attribution when discussing the movie content and narrative, they highlighted that the movie
actually provided them with “deeper knowledge” and a “better understanding” of aspects of climate change.

5.2 Web-based Visualization: VisAdapt™

This section provides an overview and discussion of the results and analyses from the VisAdapt™ study (Papers III & IV), with a specific focus on the study participants’ meaning-making of VisAdapt™. This study differs from the dome movie study in terms of method, because the web-based nature of the VisAdapt™ tool allowed the exploration of meaning-making in a live setting, where the test sessions focused on the participants’ instantaneous reactions and thoughts regarding the VisAdapt™ content. Table 13 provides an overview of the different categories and themes constituting the participants’ meaning-making of VisAdapt™. The category ‘Interpretations of content’ is primarily based on the test sessions, while the categories ‘General perceptions of climate change’ and ‘Sense of relevance and communication experience’ are based on the focus group discussions.

<table>
<thead>
<tr>
<th>Category</th>
<th>Sub-categories</th>
<th>Themes</th>
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<tbody>
<tr>
<td>General perceptions of climate change</td>
<td>Distant impacts</td>
<td>Global impacts</td>
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<td></td>
<td></td>
<td>Future impacts</td>
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<td></td>
<td>Local impacts</td>
<td>Low risk assessment</td>
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<td></td>
<td>(when prompted)</td>
<td>Low level of concern</td>
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<td></td>
<td>Responsibility for adaptation</td>
<td>Weather-related issues (not CC) are homeowners’ responsibility</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Adaptation is somebody else’s responsibility</td>
</tr>
<tr>
<td>Interpretations of content</td>
<td>Personal experience</td>
<td>Own home</td>
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<td></td>
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<td>Anecdote</td>
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<td>Weather</td>
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<td>Localization</td>
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<td></td>
<td>(confusion)</td>
<td>Local knowledge</td>
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<td></td>
<td>Lack of reference points</td>
<td>Information too technical</td>
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<td></td>
<td>(confusion)</td>
<td>Lack of definitions</td>
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<td></td>
<td>Critical negotiation</td>
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<td>Disagreement</td>
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<td>Lack of relevance</td>
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<td>Sense of relevance and communication experience</td>
<td>Responsibility and actors</td>
<td>Concretization of adaptation</td>
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<td>Low estimation of risk at a local level</td>
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<td></td>
<td>VisAdapt™</td>
<td>Engaging and interesting (local focus)</td>
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<td></td>
<td></td>
<td>Raises awareness of adaptation</td>
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<td></td>
<td></td>
<td>Common sense (nothing new)</td>
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Table 13: Summary of data analysis from study 2.
5.2.1 General Perceptions of Climate Change

The participants’ connotations of climate change were primarily structured around climate change impacts. When asked about their associations with climate change at the beginning of the focus group interviews, participants in all the focus groups brought up issues regarding climate change impacts on a global scale, for example, relating to over-population, migration, natural disasters in geographically distant places, impacts on oceans or animal life, climate refugees, loss of biological diversity, and catastrophes in more general terms. There was a tendency in all focus groups to only discuss local impacts of climate change when prompted by the moderator. In addition, the discussions tended to change rather quickly from a local to a global perspective, suggesting that climate change was indeed constructed as a global issue in these social contexts.

When asked more specifically about climate change in relation to their daily lives as homeowners, participants in all groups had a good idea of climate change impacts associated with their local area. Concrete examples such as changing coastal areas, heavy precipitation and recent storms were mentioned, as illustrated in the excerpts below:

I think we should count on more precipitation. I think mould will grow on wooden houses – it will be an escalating problem.
(Focus group 2, author’s translation)

The problem is first and foremost more precipitation. It just gets more concentrated, so we get more at once. So the hill won’t be able to absorb it and then it goes bad. Just look at what happened in Helga in Western Norway…
(Focus group 5, author’s translation)

5: Well, my first thought was also water… because if we look at it as homeowners, it is also water, I’m thinking about…
3: Well, I’m thinking, in the immediate future… that we will have more violent storms.
(Focus group 6, author’s translation)

In addition, although the participants, when prompted, mentioned several impacts associated with climate change at a local level, there was a general tendency that they did not seem concerned about the local risks. This tendency is illustrated in the excerpts below:

But I don’t really know if it is such a big problem as portrayed in many media outlets. I think it is much, much worse when I see a tornado in the USA – I’m thinking that could be caused by climate change – I mean, if we had something like that here, I really think that the Danish population would wake up.
(Focus group 1, author’s translation)

All sorts of extreme weather, increased precipitation, wind, storms and even heat, I guess, but I don’t know how relevant that is here.
(Focus group 2, author’s translation).
If there is a storm every ten years, a Gudrun… nobody got injured, but it felled a lot of forest, which is not really serious compared to what is going on in the rest of the world…

(Focus group 3, author’s translation).

2: I have had my roof destroyed a couple of times…
I: In a storm, or…?
2: Yes, I mean with roof tiles coming off, and so on.
6: I have also lost a couple of roof tiles, but my roof is from 1928, so that’s okay.

(Focus group 6, author’s translation)

As illustrated in these excerpts, the participants expressed a low sense of risk when discussing local impacts of climate change, either because climate change was framed as much more severe in other geographic locations, or because specific impacts and consequences, such as a storm (Gudrun) and losing a couple of roof tiles, were not seen as particularly problematic. The general impressions across the focus group when prompting a local focus was that climate change was constructed as a low risk phenomenon related to manageable weather events.

In some of the groups, the time horizon of climate change was brought up when discussing impacts at a local level. For instance, one participant argued “I don’t think it is something that will happen from one day to the next. No matter what happens we will have time to get used to it…” (focus group 6). In other groups, participants argued that climate change will happen in the future, for example in 80 years’ time and that it is not an immediate threat or concern. Such statements show that some participants’ connotations of climate change concerned time, especially focusing on future impacts of climate change. In this sense, the participants constructed climate change as a temporally distant issue, implying that in relation to their role as homeowners, climate change was not enacted as personally relevant or problematic. The construction of climate change as a distant phenomenon in terms of time has also been documented in other studies (e.g. Spence et al. 2012; Pahl et al. 2014). This framing of climate change points to a central challenge in climate change communication, because reinforcing the idea that climate change happens in the future makes it difficult for people to prioritize action related to mitigation of or adaptation to climate change, because of other seemingly more immediate concerns (Krauss & von Storch 2012; Pidgeon 2012).

Focusing on interview sequences relating to participants’ perceptions of responses and responsibility in relation to adaptation, the participants in all seven groups discussed the balance between individual homeowners, local or national governments, and insurance companies in assigning responsibility for adapting to climate change impacts. The excerpts below represent examples of discussions relating specifically to the responsibility of homeowners:
It is more or less normal maintenance of the house. The better you maintain it, the better it will resist what’s coming from above and the storms...
(Focus group 7, author’s translation)

To make sure that the trees are not too close to the house and stuff like that. Of course, not to an extreme degree, but you think about it because we have had some fierce storms.
(Focus group 6, author’s translation)

I feel it’s the responsibility of homeowners. It is us who must make maintenance plans and ensure that we have taken what is coming into account.
(Focus group 5, author’s translation)

As illustrated here, when discussing the role of homeowners, participants framed the responsibility as day-to-day maintenance of their private properties. In general, such maintenance responsibilities were related to practical problems or obstacles (sometimes linked to weather phenomena), rather than direct impacts of climate change. Notably, only a few presented concrete examples of adaptation measures they had taken in relation to their own homes. The discussions upheld a separation between actions associated with the management of weather-related impacts – which were regarded as self-evident – and actions associated with climate change impacts – which were seen as abstract and sometimes irrelevant on a local scale. Associated with this was an observation regarding the participants’ understanding of adaptation as a concept. In several groups, when asked directly about adaptation measures, the participants picked up topics related to mitigation strategies, such as reducing domestic energy consumption or installing solar panels. This suggests that climate adaptation was not a salient topic for the participants, and what the moderators defined as adaptation measures were seen as common sense for the participants, and as such not related to climate change and not relevant in this context. Focusing explicitly on adaptation, and as such not on daily maintenance and climate mitigation, the participants across the focus groups generally held other actors, for example, municipalities and insurance companies, responsible for managing climate change adaptation.

5.2.2 Interpretations of Content
The analysis of participants’ interpretations of VisAdapt™ was based on two sets of data: the test sessions in smaller groups, and the second parts of the focus group interviews (cf. Table 7). The analysis of the test session dialogues identified different interpretive resources the participants used to make sense of the VisAdapt™ content: personal experience, localization, confusion and critical negotiation. These four aspects of the participants’ meaning-making will be discussed below.

Personal experience
Relating to personal experiences as an interpretive strategy, a general pattern across the test sessions showed that participants shared and drew on information or experiences relating to their own homes when using VisAdapt™. Examples of this are illustrated in the excerpt below:
Well, we live right at Moholt, and there it is relatively flat, but if it rains a lot, it will come down right there. We have experienced problems with this earlier, because someone who had built their house there had built it a few centimetres too low – real bummer – and then the water came into the house.

(Session 8, author’s translation)

Just because on a normal summer’s day, it is 50 degrees, so if there is a heatwave... It is really... I have it covered with 250 millimetres all over now, and I have made such an... ehm, styrofoam box to cover the loft hatch... but I’m not really sure what to do about the summer time. Put a fan up...?

(Session 12, author’s translation)

In these examples, the participants specifically used their own experiences to assess the relevance of proposed climate risks – increased precipitation and heatwaves – in relation to their local area and their own homes. As illustrated by the excerpts, they ascribed meaning to the VisAdapt™ risk maps by translating what the risks would mean for them as homeowners, and based on this translation, they assessed the relevance of the information in relation to their own situation. Bringing up their own homes as points of comparison, the participants tended to engage in longer conversations about different house features, how to address certain impacts, or whether the proposed impacts were deemed relevant to their situations. Other strategies relating to personal experience were the use of anecdotes and weather-related experiences. When using anecdotes, participants typically shared a story about the experiences of a relative or friend to explain or contextualize content. Drawing on weather-related experiences, participants referred to specific weather-related events in the past, such as last summer’s heatwaves or a severe storm, to assess the severity or significance of potential impacts illustrated in VisAdapt™. In this way, their recollection of past weather events served as an anchor point to assist their sense-making and establish the significance of proposed climate risks. This way of using personal experiences of weather is consistent with Olausson’s (2011) findings, showing how focus group participants draw on personal experiences of weather when making sense of climate change, suggesting that personal experience as an interpretive resource plays an important role in lay audiences’ meaning-making of climate change.

Localization

Localization was another frequently applied strategy for interpreting the VisAdapt™ information, especially in relation to interpreting the risk and scenario maps in the second module of the tool. The excerpt below illustrates a general tendency across the test sessions whereby the participants used knowledge about their local areas as an important interpretive strategy:
As seen in this conversation between two participants looking at a risk map displaying flood zones in their municipality (Aarhus, Denmark), their recognition of local landmarks – a local stream and the motorway – triggered attention and interest. In this example, the participants were not sure how to read the map, but they drew on knowledge about topographic features in the area to question or make sense of the visualized risks. It was a general trend in all the test sessions that zooming in on their local area induced a sense of interest. In addition, as also shown in the example above, they used their local knowledge to either question anticipated risks or figure out how to read the maps. Localization was also used as a “zoom out” strategy to explore other areas of interest and, in doing so, compare with data from their local areas. For example, participants from one of the Norwegian sessions compared anticipated levels of precipitation in Trondheim with other more vulnerable areas in Norway and used this to reflect on the severity of local impacts.

The technological modalities that allowed the user to see his or her own home via Google Street View and subsequently explore risks associated with different locations on the maps were generally well received by the participants. The risk and scenario maps in particular inspired the participants to discuss climate risks in their own town or neighbourhood as well as their personal experiences of severe weather events. The two types of interpretive strategies presented here – personal experience and localization – were by far the most dominant in the test sessions. Interestingly, this shows that participants used themselves, their own homes and knowledge about their neighbourhoods much more than they drew on knowledge about climate change in general. This is perhaps not surprising, as the features of the VisAdapt™ tool focused on the user’s own home as a starting point for using the tool (see Figure 7). Hence, the technological modalities that enabled a more localized focus influenced the social modalities – the use situation – as the participants in general found the local perspectives engaging and interesting.
Furthermore, the interactive features of the risk and scenario maps (see Figure 8) enabled users to explore different geographical areas in terms of specific climate risks or climate scenarios. The dynamic features of the maps that allowed users to focus on areas of interest triggered the participants’ attention, and in most of the test sessions participants spent a lot of time exploring different geographic areas that were known to them. The use of pre-existing knowledge of climate change in general was only explicitly used a couple of times across all the test sessions and was generally not an interpretive resource the participants used in their meaning-making.
Lack of reference points

The analysis of the test session transcripts also illustrated how the participants handled situations in which they did not understand the information in VisAdapt™ or felt confused or unsure about how to read a map, for instance. Such situations were frequently brought up if participants felt they lacked reference points to understand the data or to assess the significance of a risk scenario. The excerpts below illustrate examples of this type of conversation:

3: Yes, and then you can click here. Days… it seems informative, but what do they mean by ‘days’? Days with cloudbursts? And what do they mean by cloudbursts?
2: Exactly, but if you stop there, because it said something on the backside, there…
(Session 5, author’s translation)

1: Yes, a water level, I think… Sea-level rise, you can understand, but what is water level? Which water level? It doesn’t say…
2: It must be that which is not the sea, but lakes and such.
1: It is not clear what water levels mean. And the flood zone, is that big or small?
(Session 6, author’s translation)
The examples here illustrate situations in which participants did not know how to interpret the maps, because they felt unsure about definitions of concepts or scales related to the maps. This perceived lack of reference points meant that the participants struggled to contextualize the information and, based on this, assess the significance of the climate impacts. The lack of reference points also led to situations where participants underestimated the risks and impacts of climate change. For instance, contemplating scenario maps led participants in one of the sessions to conclude that “From 7-9 degrees. This means that it will be a little warmer and precipitation increases a little, but that’s not much, really.” (session 13), and others to deduct “This is definitely the annual mean temperatures. It looks like it’s going to be 2 degrees warmer in 40-60 years. That’s not much.” (session 9). In these examples, the lack of reference points to contextualize the information meant that participants underestimated climate risks and impacts in their local areas.

Critical negotiation

A final aspect related to the participants’ meaning-making of the VisAdapt™ content relates to their critical negotiation of information. This was predominantly seen in relation to the proposed adaptation measures in module three. In several instances, participants voiced highly critical stances towards the information, for example:

1: The temperature can be reduced by using a white roof.
2: How do they know that I don’t have a white roof?
1: You haven’t selected what colour to have on your roof.
2: And I don’t know if we would paint our roof white. And ‘[indoor temperature] can be reduced by blocking sunlight from entering the windows’
1: That might be problematic. You may need building permits to do that.
(Test session 5, author’s translation)

2: …To prevent the walls from tipping over.
1: That’s a weird comment. A wall would withstand high wind speeds… walls don’t tip over in Sweden…
(Session 6, author’s translation)

As seen here, the participants disagreed with the proposed adaptation measures in VisAdapt™, which were suggested in relation to the selected house features, local area and risk scenarios. There was a tendency across the test sessions to critically negotiate these guidelines, by either arguing against the proposed action as seen in the excerpts above, or by voicing counter-arguments. The analysis suggested that participants made use of this negotiation strategy when the information was perceived as either irrelevant to their own situation as homeowners, or too mundane and common-sensical. Such perceptions typically led to participants simply dismissing adaptation guidelines. One explanation of the frequent use of critical negotiation in relation to adaptation measures could be that weather and climate change generated different connotations for the participants. As discussed, the analyses of the participants’ general perceptions of climate change showed that climate change was constructed as a global issue.
with severe and catastrophic impacts. Weather, on the other hand, tended to be associated with local, manageable events. Hence, in this light, the information in the third module could be perceived as misaligned with the participants’ connotations of climate change as a phenomenon with disastrous impacts, suggesting that the participants expected a different set of action alternatives related to climate change than simply cutting down trees or clearing gutters.

Another explanation for the occurrences of critical negotiation as a meaning-making strategy could also be that participants associated climate change with mitigation rather than adaptation (cf. Paper III). As such, in the initial discussions in the focus group interviews, the participants were keen to discuss mitigation alternatives and, although asked about examples of adaptation actions that were relevant for them as homeowners, there was a tendency to discuss mitigation of climate change impacts instead. This suggests that perhaps adaptation was not a salient aspect of climate change for the participants. This has also been discussed in the broader literature on climate change communication, where media coverage of climate change tends to focus on mitigation rather than adaptation (Moser 2014; Gurwitt et al. 2017).

5.2.3 Communication Experience and Sense of Relevance

VisAdapt™: Concretizing and localizing climate change impacts

Returning from the test sessions to the focus group setting, participants were encouraged to reflect upon and discuss their perceptions of VisAdapt™. Here, the participants generally highlighted local aspects, such as the housebuilder and the zoom functions of the risk and scenario maps, as interesting, relevant, motivating and engaging. In all the focus groups, using VisAdapt™ as a starting point, participants also engaged in discussions on local climate risks as illustrated by the excerpt below:

3: I think that water levels and rain, those must be the absolute – in Denmark – biggest problems, right? Because of our flat topography.
2: I think, we don’t have problems with drought, really, I mean we don’t have that.
5: Perhaps that is one of the strange things about those climate changes. Because in some places it will rain a lot more and in other places there will be droughts…
3: Yes, yes.
5: So it goes both ways. Perhaps, geographically in Denmark, we don’t have drought issues, but while it has been a really wet summer, there are actually areas in Jutland where it hasn’t rained at all. So we see that after all. On a smaller scale.
3: But there is a big difference of how much it rains in Denmark. I mean, there is almost a factor 2 difference. From West Jutland and over here. And on Samsø – it never rains there.
1: No, it is as if those cloudbursts cause it to rain here – and keep the others rain-free, right?
4: It comes locally…

(Focus group 7, author’s translation)
As seen here, the participants in this group discussed the topography in Denmark and related this to climate risks such as precipitation, flooding and drought. Characteristically, the focus group participants used VisAdapt™ – in particular the visual representations of climate change risks in module 2 – as a starting point for discussing concrete climate risks and vulnerability in relation to their local areas. For instance, examples of locally relevant risks such as heavy rainfall and cloudbursts, heat waves and storms were frequently brought up, but also specific types of risks of relevance to homeowners, such as leading storm water from the building, problems with rain pipes, drainage and sewerage, were much discussed. This illustrates a general pattern across the focus group discussions that, in the context of VisAdapt™, climate change risks were perceived as concrete and locally anchored. Furthermore, there was a general consensus in the focus groups that the link to their own house made it easier to imagine impacts or relate to the information, for example, the risk or scenario maps. In these discussions, participants frequently referred to their own local areas or homes – “my own basement” or “the neighbour’s house”. In most focus groups, participants emphasized that the visual elements in VisAdapt™ made climate change more concrete and easier to relate to. Nevertheless, the localization features also seemed to create expectations of very downscaled information – sometimes down to individual house level, which in turn led to participants criticizing the information in VisAdapt™ as being too generic. In addition, while the local aspect seemed to induce a sense of relevance and interest, some participants mentioned that the time perspective of 40-60 years made it feel less relevant and urgent.

Although the participants’ reflections on VisAdapt™ led to discussions of climate risks and impacts as locally anchored, some participants also expressed a low sense of concern relating to climate risks in their local areas. For example, the change in precipitation as represented in VisAdapt™ was seen as relatively low, as illustrated below:

I thought that the changes would generally be greater, and it’s maybe a bit scary that you find out that it’s not so bad, because then you may be less worried than before.
(Focus group 2, author’s translation)

Hence, some participants emphasized that they had not been able to detect much change in the VisAdapt™ risk scenarios, and peaks of extreme weather events would be more relevant to convey than annual averages.

Actors and responsibility
In the focus group discussions, the participants generally emphasized the importance of striking a balance between individual and societal responsibility. However, most participants stressed that homeowners need to take responsibility for their own properties. Especially when discussing adaptation at an individual level, participants referred specifically to the adaptation measures from VisAdapt™’s third module. Consistent with the results from the test sessions, most participants referred to these measures as common sense. Still, the focus group discussions
at this point were characterized by a concrete approach to individual adaptation and adaptive capacity, focusing on how to handle specific climate change impacts, such as water leakages and protecting suspended foundations from mould. Hence, when discussing the responsibility for adaptation in the context of VisAdapt™ as compared to discussing climate change in more general terms in the first part of the focus group interview, the participants put much more emphasis on individual responsibility and their discussions were centred around concrete measures and personal experiences. Although perceived as being common sense and sometimes too mundane, the adaptation measures presented in VisAdapt™ seemed to have clarified what adaptation could mean for homeowners in the Nordic region, as expressed by a participant from one of the Norwegian groups:

This is a tool that might make us more aware that we must clear out our drains and ensure that we have waterproofed walls and a watertight roof. That’s fairly self-evident. But it directs attention towards it, so the tool makes us aware that we must do something.

(Focus group 5, author’s translation)

Summing up, the localization features of VisAdapt™ – the housebuilder and the zoom functions on the risk and scenario maps – initially induced a sense of relevance, interest and attention. Additionally, the local focus inspired participants to discuss climate change risks and impacts from a local perspective in a very concrete manner. The analysis of the participants’ perceptions of responses and responsibility in relation to their sense-making of VisAdapt™ illustrates that the focus on concrete adaptation measures in the tool inspired participants to discuss adaptation more specifically in relation to their own homes and their local areas. Thus, although perceived as self-evident and something one automatically does as a homeowner, the linking of local climate risks and scenarios with specific adaptation measures seemed to induce a sense of agency with climate change adaptation. Hence, prompted by VisAdapt™, the participants constituted climate change as being personally relevant in relation to their roles as homeowners. Yet, the localization of climate risks also left some participants with a lower estimation of risk and climate impacts at a local level.
6 Discussion and Conclusions

With this thesis, I set out to explore the roles of visualization in climate change communication from an audience perspective. This aim has been operationalized through three research questions, asking firstly, how targeted lay audiences make meaning of climate change by means of the two cases of climate visualization, and secondly how climate change is constituted in the meeting between the targeted audiences and the cases of climate visualization. The third research question focuses on potential contributions and/or limitations of climate visualization as a means of communication with lay audiences.

The constitutive view of communication and theories of social semiotics have served as theoretical entry points for addressing the aim and research questions. The thesis’ central analytical focus is how the target groups make meaning of climate change in the meeting with visualization media. Because of differences in the communication situations in the two cases of visualization, meaning-making processes were analysed in different ways. In the case of VisAdapt™, I used focus group interviews in combination with the test sessions as a method for exploring the participants’ live interpretations and interactions with the tool. The audio recordings of their conversations and ‘think aloud’ sessions constitute the empirical material used to analyse their meaning-making. This method could not be applied to the movie case, as the dome theatre setting did not allow for ‘live’ exploration of meaning-making. Instead, I used the focus group interviews to encourage the participants to reflect upon the movie’s messages, visual representations and communication experience in retrospect. Having two different cases of climate visualization as the empirical foundation allowed for a broader analysis of the roles of visualization in climate change communication, which will be discussed below.

6.1 Climate Change as a Global Issue

Addressing the first research question, both studies analysed the participants’ connotations with climate change in general as a part of their meaning-making processes. The findings suggest that the participants in both studies discussed climate change as a global issue with severe impacts. In light of the global perspective, impacts were described in terms of either dramatic consequences, such as the end of the world, or geographically distant consequences in, for instance, the Arctic. Impacts of climate change were by and large the most salient theme in these discussions, while causes of climate change and responsibility for addressing climate change were discussed only peripherally. In both studies, when the theme of responsibility was brought up, discussions mostly concerned actors on international scales, and predominantly politicians or public authorities were assigned the responsibility of addressing the changing climate in terms of either mitigation or adaptation. Hence, climate change was constructed as a distant phenomenon in terms of space, responsibility and – in the VisAdapt™ study – also time.
The construction of climate change as a global issue is well-documented in the literature, where studies on public perceptions point to psychological distance as a barrier to engaging lay audiences with climate change (Lorenzoni & Pidgeon 2006; Wolf & Moser 2011; Mead et al. 2012; Spence et al. 2012; Stoknes 2014). Discussing the construction of climate change as a global issue, Hulme (2010a, 2010b) offers insights on the scientific narrative of global climate change. He argues that the scientific construction of climate change as a global phenomenon, enacted through, for instance, the global temperature index, global climate models and the use of the term global warming, means that the climate as a social construct has become detached from local meanings related to weather and personal experiences (see also Jasanoff 2010). In a recent review of the literature on public engagement with climate imagery, Wang et al. (2018) discuss the influence of visual imagery on public perceptions of climate change. Synthesizing findings from studies on climate iconography (e.g. Doyle 2007; Manzo 2010a; Schäfer & Schlichting 2014), the authors argue that visuals in different communicative contexts play an important role in the social construction of climate change as a globally distant issue, and they point to the importance of studying the implications of the psychological distance with climate change.

Although limited in scope, the results of this thesis show how the global-local dichotomy influenced the ways in which the participants made meaning of and constructed the issue of climate change. Hence, different aspects pertaining to these perspectives will be discussed in the following sections.

6.1.1 Critical Negotiation
An interesting finding relating to the first research question is the participants’ use of critical negotiation as part of their meaning-making. Both VisAdapt™ and the movie ‘A Warmer World’ focus on individual engagement and responsibility related to climate adaptation and mitigation, respectively. Related to the theme of responsibility, results from both studies identify critical negotiation as a recurrent meaning-making strategy. A possible way of explaining this critical negotiation could be the participants’ connotations of climate change as a global and distant phenomenon.

As laid out in the theoretical framework, preconceptions are seen as an inherent aspect of meaning-making and recognizing them as such could explain the participants’ use of critical negotiation as a meaning-making strategy. Climate change as a global, distant phenomenon with severe impacts can seem incompatible with individual responsibility and simple daily actions. This view was partly expressed by some of the participants in the dome movie study, where a theme of powerlessness and helplessness, at times, dominated the discussions. Participants contested the stance that they, as individuals, should assume responsibility in mitigating climate change, by renegotiating the basic premises of the suggested actions, and by assigning responsibility to other actors. Seeing that the participants in this study were teenagers, it is
perhaps an expected outcome that they would expect their parents or politicians to deal with the climate crisis. Nevertheless, in light of the conversations regarding the movie’s messages, where the participants demonstrated knowledge about mitigation at household and individual levels, their efforts to distance themselves from the responsibility as laid out in the movie is a significant finding.

In the VisAdapt™ study, critical negotiation of content frequently occurred in relation to the third module in the tool that presents measures homeowners can take to adapt their property to climate change. Here, the participants distanced themselves from the content by either explicitly disagreeing with the adaptation measures and thus presenting an alternative perspective, or simply dismissing the advice for being too mundane or simply irrelevant to their situation. Nevertheless, although sometimes dismissed as common sense, the analysis also showed that participants’ discussions regarding specific adaptation measures made climate adaptation seem more relevant and concrete to them. This enhanced focus on individual responsibility needs, however, to be seen in the context of the participants’ capacity as homeowners, because they are used to assuming responsibility for the day-to-day maintenance of their houses. In this perspective, it might not be considered a great leap to accept responsibility for protecting their property against climate change impacts. The explicit links between climate risks and adaptation measures could also explain the enhanced focus on individual responsibility, as this link along with the local perspective made local climate change impacts appear more tangible and thus easier to relate to.

Although drawn from two different communication situations and target groups, these findings are interesting because they point to similar patterns of meaning construction in the two studies and can, thus, provide insights into the relationship between representation and interpretation in climate visualization. The two cases of climate visualization studied here are examples of targeted communication, which means that the multimodal representations in the movie and the web-based application were developed with particular target audiences in mind and with a specific purpose – to engage audiences with climate change and enhance their sense of individual responsibility. In both studies, however, examples of critical negotiation showed that the participants renegotiated representations of climate change to align with their perceived reality of climate change. This means that although the two cases of visualization addressed the audiences as individuals with responsibility and agency, not all participants defined themselves in this manner and they instead renegotiated the conveyed messages to align with their perceptions of individual responsibility. These findings contribute an audience perspective to the literature on individualisation of responsibility (cf. Berglez et al. 2009; Olausson 2011; Uggl 2015; Soneryd & Uggl 2015; Uggl 2017) by elucidating how participants make meaning of messages concerning individual responsibility. The findings of this thesis indicate that the critical negotiation of meanings was influenced by participants’ already existing perceptions of climate change, suggesting that global framings influence people’s
understandings of their own role in addressing climate change. Notably, studies of how Swedish media report on climate change point to a shift in media focus from climate change as a global issue to be solved in the context of international politics to focusing on national and individual responsibility for mitigating emissions (Berglez et al. 2009; Olausson 2011). The results of this thesis suggest that media framings of the individualization of responsibility did not influence the participants' connotations of climate change.

6.1.2 Local Manifestations of Climate Change
The second research question focuses on how climate change is constituted in the meeting between the targeted audiences and the cases of climate visualization. In the literature on climate change communication, the framing of climate change as a global phenomenon has been found to constitute climate change as a personally distant issue, influencing people’s sense of efficacy (Lorenzoni et al. 2007; O’Neill & Nicholson-Cole 2009; Spence et al. 2012; Pahl et al. 2014). Climate change as a global issue is maintained and reinforced communicatively in social contexts, for instance through media coverage, climate and environmental campaigns, and also through science communication (Wang et al. 2018). Studies on media framings of climate change suggest that public perceptions of climate change are influenced by media coverage containing iconic metaphors and images showing, for example, polar bears and the Arctic, as well as issues related to sea-level rise in the geographic South (e.g. Manzo 2010a). Such media framings are linked to and informed by the scientific perspectives of climate change as a global phenomenon, and media coverage and images thus contribute to the construction of global climate change (Ryghaug et al. 2011; Eskjær 2013).

From a public engagement perspective, the problem with the distant framing of climate change is twofold. Firstly, the global scale can lead to feelings of helplessness and powerlessness, because the magnitude of the problem can seem overwhelming and pointless to address at an individual level (Nerlich & Jaspal 2014). Secondly, seeing climate change as a distant issue makes it difficult for people to address and prioritize because of other, seemingly more immediate concerns (Stoknes 2014). Although people might connect with the issue of climate change in an emotional manner, because they feel sorry for a struggling polar bear, this feeling seldom translates into action. In the scholarly literature, climate visualization is highlighted as a means to offer an alternative framing to the global construction of climate change by offering more localized perspectives of, for instance, climate change impacts. In particular, interactive features have been emphasized as a way to engage audiences with climate change by enabling them to explore areas and risks they find relevant and interesting (Sheppard et al. 2011; Schroth et al. 2014; Bohman et al. 2015; Sheppard 2015).

VisAdapt™ is an example of such a tool. It aims to engage homeowners with climate change adaptation through the use of multimodal representations encompassing maps, colour, text, icons, photographic images and compositional modalities (cf. Rose 2016). With a left-to-right
structuring of content, VisAdapt™ aims to guide the user from his or her own home as the starting point, to explore risk and scenario maps for the regional area of the house location, and to provide specific adaptation measures associated with the type of house, location and types of risk. The analysis of the participants’ meaning-making of the VisAdapt™ content suggests that they found the tool interesting and engaging, and the localization features seemed to establish climate adaptation as a more salient and concrete issue for the participants in their roles as homeowners. As such, in the meeting between VisAdapt™ and the participants, climate adaptation was co-constructed as a local and more personally relevant issue. However, although enhancing audiences’ sense of proximity with climate change, the localization of climate risks also led some participants to downplay the significance of local climate risks. This is an important perspective to add to the discussion, since it points to the complexity of interpretive processes. The VisAdapt™ study suggests that the technological and compositional modalities used in the tool can contribute to changing the conversation about climate change to a more local focus of personal relevance for the user. However, the results also indicate that the focus on local risks and concrete adaptation measures could contribute to constituting climate change as an issue of low concern or low risk.

This finding contributes to the scholarly discussion of the global-local dichotomy of climate change (cf. Hulme 2010a; Hulme 2010b; Jasanoff 2010) that argues for a need to link the global with the local to reinforce cultural and personal meanings of climate change. The VisAdapt™ study demonstrates the importance of personal experience and localization as central interpretive strategies, as participants primarily used these two strategies to make sense of content in VisAdapt™. This shows that weather manifestations and related experiences are meaningful and engaging perspectives through which climate change can be discussed. However, as evident in the study, weather and climate change may connote two different things, and coupling them could reduce people’s concern about climate change in general. Thus, there is a need for future research to explore further how climate change as a global issue can be coupled with climate change (or weather) as a local issue in a meaningful manner.

6.1.3 Concretizing the Abstract
Related to the second research question is also the construction of climate change as a more concrete phenomenon in the meeting between participants and the cases of climate visualization. A common denominator in the two studies was that the participants’ general associations with climate change were structured around global impacts. In the initial phase of the focus group interviews in both studies, participants tended to either omit local climate impacts from their discussions, as was typically the case in the dome movie study, or to only briefly refer to local impacts before returning to the global perspective again, as was frequently seen in the VisAdapt™ study. This supports earlier findings in the literature that climate change is often perceived as a complex, intangible and abstract issue (cf. Nicholson-Cole 2005; Lorenzoni & Pidgeon 2006; Moser 2006; O’Neill & Hulme 2009; Hulme 2009; Nisbet 2009; O’Neill et al. 2013).
The results suggest, however, that the participants in both studies emphasized aspects related to ‘concretization’ in their meaning-making of the content as a positive attribute of climate visualization. For instance, the dome theatre study showed that participants emphasized visual representations they felt made complex aspects of climate change visible, clarified connections, provided an overview, or made climate change tangible. In this respect, they underscored the visual representations as means to help them see changes, correlations or comparisons through modes of information graphics using, for example, size and colour to compare or contrast aspects of climate change. Likewise, in the VisAdapt™ study, participants’ discussions about climate adaptation became much more concrete when discussed in the context of the risk and scenarios maps that represent climate impacts related to, for example, sea-level rise. Participants generally referred to these maps as interesting and relevant, and the visual representations of climate change impacts made the issue appear more personally relevant to the participants. Hence, insights from the two studies show that the visual mode was generally emphasized as a communicative quality, because of the ability to provide an instant overview of a complex issue of climate change. In particular, compositional modalities associated with information graphics or maps that made use of colours or shapes to represent, for instance, a change, a contrast, differences or comparisons were highlighted by the participants as helping them to concretize otherwise abstract or complex aspects of climate change.

6.2 The Role of Climate Visualization – an Audience Perspective

In the literature review (Paper I) of the field of climate change communication, I found that the normative or strategic focus is seldom coupled with a theoretical conversation or considerations of communication, as advocated by Cox (2007) and others (Schwarze 2007; Davis et al. 2018). The analysis of the communication approaches in climate change communication research shows that the field is highly fragmented with respect to how communication is defined and conceptualized. Although there are studies that argue for the influence of ideologies, values and beliefs on people’s perceptions of climate change and draw on a conceptualization of communication rooted in cultural theory and the interaction paradigm (e.g. Bellamy & Hulme 2011; Poortinga et al. 2011; Whitmarsh et al. 2013; Capstick & Pidgeon 2014; Corner et al. 2014; Wibeck et al. 2014b), the literature analysis demonstrated that many studies of climate change communication find inspiration in more transmission-oriented approaches to communication. Although studies with the aim of advancing theoretical frameworks or conceptual models for climate change communication typically argue for a dismissal of the transmission paradigm, such arguments have not dispersed to the entire field of climate change communication. Hence, communication perspectives associated with linear and top-down approaches are still frequently applied in this context and theoretical reflections on the ontology of communication are rarely addressed or discussed.
I argue (cf. Paper I) that assuming a transmission-oriented approach to communication is problematic, because it ignores the formative role of communication in constituting social reality, by approaching communication as a simplistic act that can be managed and controlled by a sender. Such a view has implications for communication studies, as it overestimates the role of the sender and underestimates the contextual and social aspects of communication, and thus neglects the complexity of meaning creation and power relations in communication. The ontological distinction between diverging conceptions of communication matters, because theoretical notions of communication per se become part of a constitutive influence on reality (Craig 2007).

I have argued for the relevance of integrating the strategic position with the critical ambition of exploring the role of climate visualization as a means of communication with lay audiences. This strategic perspective is associated with the third research question: What are the potential contributions and/or limitations of climate visualization in climate change communication? Contemplating the role of media in society, Bolter and Grusin (1999) introduce the concept of remediation. The authors question the ‘newness’ of new media and argue that new media are simply “refashioning the established media and reinventing themselves in the quest for immediacy” (Bolter & Grusin 1999, 254). Following this perspective, an important question concerns the ‘newness’ of the two examples of climate visualization analysed in this thesis. The newness of the types of visualization studied relate to digital technologies that change or define the communication situation. From an audience perspective, do these digital forms of climate visualization have anything new to offer? Or are they simply remediated versions of ‘old’ media? The results of this thesis have provided insights into these questions. In summary, as discussed in this and the previous chapter, the results of this thesis point to five different roles for climate visualization in climate change communication from an audience perspective.

1) **Co-creation:** In the VisAdapt™ tool, the ‘newness’ consists of dynamic features that interrelate content in the tool and allow for localization of content. In this way, users become co-creators of the narrative through their exploration of the tool. Co-creation also took place at an interpretive level, where participants critically negotiated, and thus co-created, messages of the two cases of climate visualization.

2) **Concretization:** Aspects pertaining to the communication experience were integrated as elements in audiences’ meaning-making. Relating to this, key results propose that climate visualization has a role to play in constituting climate change as a more concrete phenomenon. In particular, compelling graphic representations that provided an overview helped the participants concretize aspects of climate change.
3) **Localization:** The results of the VisAdapt™ study identify localization as a role for climate visualization. In this study, participants co-constructed climate change as a local and more personally relevant issue in the context of VisAdapt™ and participants frequently made use of personal experiences and knowledge about local areas to make sense of the content.

4) **Sense of relevance:** The analyses show that visual representations that address a perceived information need, and localize or concretize climate change were emphasized by the participants as relevant and interesting. Hence, climate visualization has a role to play in making climate change appear more personally relevant.

5) **Engagement:** The results show that visualization tools that enable localization of climate change risks and impacts can stimulate interest and attention and as such can be used as an entry point for discussing climate change in more general terms. This means that climate visualization as explored here has a role to play in engaging audiences with climate change.

The studies also point to certain limitations concerning the constitutive powers of climate visualization, as the participants did not construct climate change as an issue related to individual responsibility in their meaning-making. Rather, they critically negotiated the messages of individual responsibility, using their connotations of climate change as a global, and distant, phenomenon to reassign the responsibility to other actors. On a related note, although localization of climate change through visual means can be a way to induce a sense of relevance among audiences and draw attention to individual action alternatives, the local focus has also been found to affect audiences’ risk appraisal, because the impacts of climate change at a local level – in the Nordic region – do not correspond with their general perceptions of climate change as a disastrous phenomenon with severe impacts. In conclusion, the two cases of climate visualization studied here show that although climate visualization has an overarching role to play in constituting climate change as a local and concrete phenomenon and in engaging lay audiences with climate change, we might also have to modify our expectations of these ‘new’ types of media.

An important reason for choosing an audience perspective originates from the social semiotic framework that defines meanings as constructed in social and cultural contexts, and consequently that aspects of reality that we might perceive as obvious or natural are constructed through communication (Chandler 2007). This means that communication is intrinsically linked to social and cultural practices and therefore contributes to constituting social reality (Ledin & Machin 2018). The results of the two empirical studies in this thesis show that communication is a much more complex and dynamic process than simply a matter of stimulus and response. Theoretical perspectives that conceptualize communication as a mere transmission of information from one mind to another prove too limited to understand these processes. Studying the site of audiencing underlines that audiences’ meaning-making is influenced by their existing
perceptions of climate change as a global and distant phenomenon. Exploring the roles of visualization in climate change communication from an audience perspective, this thesis shows that there are several roles for visualization in addressing challenges of climate change communication and engaging lay audiences with climate change. However, the results also show that climate visualization alone cannot constitute climate change as an issue of, for instance, individual responsibility, as audiences draw on preconceptions of climate change inspired by other sources of information in co-creating narratives of the changing climate.
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8 Appendices

8.1 Moderator Guides

8.1.1 Study 1: A Warmer World

Moderator’s guide

- What comes to mind when I say the words “climate change”? What do you see as the most important issues related to climate change?
  (Vad tänker ni på när jag säger ordet ”klimatförändring”? Vilka är de viktigaste frågorna som hänger ihop med klimatfrågan?)

- What are your spontaneous reflections after watching the movie? What did you think about it? What did you think while watching it?
  (Vilka är era spontana reflektioner efter att ha sett filmen? Vad tyckte ni om den? Vad kände ni när ni såg den?)

- What did you think about the choice of images and figures? What did you think about the combination of the speakers and the images?
  (Vad tyckte ni om valet av bilder och figurer? Hur fangerade talet tillsammans medbilderna?)

- If you were to tell a friend what the movie was about/what message was conveyed, what would you say?
  (Om ni skulle återge för en kompis vad filmen handlade om/vilka budskap som framfördes, vad skulle ni säga då?)

- What were your expectations before you came to the Visualization Centre to watch the movie?
  (Vilka förväntningar hade ni inför att se klimatfilmen på Visualiseringscentret?)

- Did you learn anything new? If yes, what? Was there anything from the movie that you would like to know more about?
  (Lärde ni er något nytt? I så fall vad? Finns det någonting ni skulle vilja veta mer om?)

- At school, how would you like to continue working with the issues brought up in the movie?
  (Hur skulle ni vilja jobba vidare i skolan med de frågor som filmen väckte?)

- What (if anything) would you change if you were asked to create the mind maps again?
  (Vad (om något) skulle ni ändra om ni nu skulle fylla i mindmapen igen?)
8.1.2 Study 2: VisAdapt™

The focus group interviews are divided into three parts:
1) The homeowners’ general perceptions of climate change, risk, responsibility and adaptation.
2) Exploration of VisAdapt™ in smaller groups.
3) Homeowners’ perceptions of the content and form of VisAdapt™, how they perceive the relevance of the tool and their perceptions of risk.

Moderator’s guide

Part 1
- What comes to mind when I say the words ‘climate change’?
  - Are there any weather- or climate-related risks you consider particularly important for society to address now or in the future?
  - Have you thought about how such changes could affect your house? Or have you personally experienced any weather- or climate-related damage to your house?
  - Have you personally experienced any weather- or climate-related damage?
- How do you view your own roles in adapting your houses to extreme weather phenomena/climate change?
  - And have you thought about climate change from this perspective? How?
  - Have you thought about any specific measures?
- Who, in your opinion, has the main responsibility for ensuring that society adapts to climate change?
  - Who should pay for the damage in the first place?
  - What should the role of insurance companies be?
  - What should the role of municipalities and public authorities be?
  - How can society create incentives to make homeowners adapt to climate change?

Part 2
- Short introduction to VisAdapt™.
- Participants are divided into groups of two or three and have 30 minutes to explore and use VisAdapt™.

Part 3
- Do you consider climate change to be relevant where you live? Why?
- What are your spontaneous reactions to VisAdapt™ after having used it?
- Do you think that a visualization tool such as VisAdapt™ can help you reduce your vulnerability to climate change or help you make decisions regarding climate adaptation in relation to your house? (If yes, how? If no, what type of help/information would you need?)
• What is your general impression of VisAdapt™?
  o Any reflections from using the tool?
  o Any new information? Did you learn anything new?
  o Any particularly interesting parts?
  o Is VisAdapt™ relevant for you considering your own house? How so?
• Have you read or heard anything about climate change or how we can adapt to climate change in the media or debates?
• How far does your responsibility go with respect to climate adaptation?
• What would make you put even more effort into adapting your home to climate change?
Papers

The papers associated with this thesis have been removed for copyright reasons. For more details about these see:

http://urn.kb.se/resolve?urn=urn:nbn:se:liu:diva-147726