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Localizing Climate Change: Nordic Homeowners' Interpretations of Visual Representations for Climate Adaptation

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ABSTRACT

In recent years, effort has been put into developing various forms of climate visualization to create opportunities for people to explore and learn about local climate change risks and adaptation options. However, how target audiences make sense of such climate visualization has rarely been studied from a communication perspective. This paper analyzes how Nordic homeowners made sense of a specific climate visualization tool, the VisAdapt™ tool. Involving 35 homeowners from three cities in 15 group test sessions, this study analyzes the interpretive strategies participants applied to make sense of and assess the relevance of the visualized data. The study demonstrates that participants employed a set of interpretive strategies relating to personal experience and well-known places to make sense of the information presented, and that critical negotiation of content played an important role in how participants interpreted the content.

Keywords: Climate visualization; Climate adaptation; Lay audiences; Visual communication; Meaning

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1. INTRODUCTION

Climate change communication is a rapidly expanding research field, mainly converging on the goal of identifying communication strategies to promote sustainable development, mitigate greenhouse gas (GHG) emissions, and reduce climate impacts (Moser, 2014; Wibeck, 2014). Such communication efforts are challenging because of the complex, intangible, distant, and invisible nature of climate change, which makes it abstract and difficult for non-scientific audiences to conceptualize and relate to (Lorenzoni et al., 2007; Spence et al., 2012). In response to these challenges, climate visualization has been put forward as a potential means to concretize and localize abstract, distant, and complex aspects of climate change, serving as a starting point for reflection, engagement, and dialogue (Ballantyne et al., 2016; Smith & Joffe, 2013). In previous studies, climate visualization has for example been applied as means to envision complex changes to assess how to make them understandable and relevant for non-experts on the local level (e.g. Fleming et al., 2015; Sheppard 2015; Burch et al., 2010; Shaw et al., 2009). With references made to such research, we have argued elsewhere for the importance of framing climate change “as a phenomenon personally relevant to the target audience” and of the significance that “communication on risks and impacts resonates with local practices, values, concerns, and previous experiences” (Glaas et al., 2017:3). Meanwhile, it is similarly important to recognize that proximizing climate change in time and space is far from a panacea for climate change communication. Climate communicators and researchers thus need to carefully analyze variations in audience reactions to such approaches (Brügger et al., 2015).

We refer to climate visualization as an applied research area relating to the analysis and communication of climate change-related data by means of visual representations frequently included in digital platforms that allow for interactive exploration. Although visual aspects are essential elements of climate visualization, such communication is typically multimodal, because it integrates various communicative modes, such as images, linguistic text, sound, and music, into a unified whole (van Leeuwen, 2011).

Hulme (2009, p. 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.” Thus, we need to explore and understand the ways in which we construct and communicate the idea of climate change. Noting that visuals are frequently conceptualized as an immediate form of communication that transcends linguistic and cultural barriers, 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 emphasized conceptually or methodologically in visual

studies (Rose, 2016). Likewise, studies that evaluate climate visualization from an audience perspective are scarce, prompting calls for further research into user perspectives and how such modes of communication help construct the idea of climate change (Hansen & Machin, 2013; Schroth et al., 2014; Wibeck et al., 2013; Neset et al., 2016).

This study takes on this challenge by analyzing how a specific target audience (i.e., Nordic homeowners) interprets visual and text-based climate change information mediated through the web-based climate visualization tool VisAdapt™. The tool provides examples of visual representations of climate change trends and risks, and supplies an overview of concrete adaptation options suitable for homeowners. The overall aim of this paper is to advance our understanding of communication for climate adaptation purposes by analyzing a case of climate visualization from an audience perspective. The paper analyzes the interpretive strategies applied by study participants to make sense of and assess the relevance of the visualized data.

This study makes two main contributions to the environmental communication literature in general and the climate change communication literature in particular. First, the paper presents an in-depth analysis of interpretive processes in action. This analysis seeks to explore the actual consumption site (cf. Hansen & Machin, 2013) of a climate visualization case, contributing a user perspective to the literature. Second, the paper addresses a current limitation of climate change communication research. To date, this research field has predominantly explored responses to mitigation, paying less attention to the audiences' interpretations, understandings, and engagement with climate change adaptation "in terms of meanings, significance to their daily lives and to the wider community" (Whitmarsh et al., 2013, p. 19). Humanity is increasingly facing the impacts of climate change, which necessitates that communication relating to climate adaptation be put on the research agenda (Moser, 2014). In a literature review, Moser (2014) advocates communication regarding climate adaptation to help stakeholders appraise risks and explain uncertainties relating to climate change. In this context, communication is seen as important in facilitating the implementation of adaptation measures (Glaas et al., 2015a). This paper provides insights into how such communication unfolds in encounters between homeowners trying out a web-based platform for interactive climate visualization. This was done through analyzing 15 audio-recorded test sessions in which targeted users from Denmark, Norway, and Sweden in groups of two or three were asked to "think aloud" while interacting with VisAdapt™.

2. CLIMATE CHANGE COMMUNICATION AND THE ROLE OF VISUALIZATION

The integration of visual representations and text in the composition and layout of the web-based platform, VisAdapt™, exemplifies multimodal communication. However, having visual representations as central elements, the theoretical framing and research design of this study draws in particular on literature on visual communication. The paper is situated in one of the four sites that Rose (2016) describes as the focus of visual communication research, i.e., the site of *audienceing*. This site concentrates on the reception and audience interpretations of visuals, in contrast to the sites of *production*, *the image*, and *circulation*. Building a more comprehensive understanding of visual communication entails looking beyond the visual as an object and also studying how visual elements are interpreted by targeted users (Hansen & Machin, 2013; Rose, 2016). In doing so, this study is inspired by a social semiotic approach to communication. Specific to the context of visual and multimodal communication, several scholars emphasize semiotics as a theoretical entry point for studying communication from a meaning perspective (e.g., Kress, 2010; van Leeuwen, 2005). Van Leeuwen (2005) argues that the focus of this semiotic approach to communication has moved from the sign itself to exploring how people produce and interpret images. Correspondingly, Moriarty (1996) emphasizes that the value of a semiotic perspective on communication lies in its attention to and conceptualization of interpretation and, in particular, interpretive processes, contending that semiotics builds an understanding of not only visual interpretation, but also communication in general. In drawing on a semiotic-inspired approach, the present paper acknowledges meaning as central to communication. In this view, meaning is not defined as something inherent in a sign, as in more traditional approaches to semiotics, but instead as something that develops and evolves in the nexus between context, sign, and readers (cf. Kress, 2010). Conceptualizing meaning and interpretations as social constructs emphasizes the significance of studying how people's interpretations evolve in a social setting and points to the need for audience- and context-specific studies of communication with a particular focus on audience interpretations, an approach that we take here.

In addressing the challenges specific to the context of climate change communication, visualization is stressed because of its potential to illustrate complex or abstract aspects of climate science by exposing otherwise invisible causes and effects of climate change, making the issue appear more concrete (Ballantyne et al., 2016; Smith & Joffe, 2013). Climate visualization includes various interactive features that can be offered by visualization tools, enabling users to explore content they find relevant or interesting. For instance, perceived geographical and temporal distance from specific

climate change effects is emphasized as a significant communication challenge (Lorenzoni et al., 2007; Stoknes, 2014), because humans are generally prone to prioritizing short-term consequences relevant to their immediate context. However, the typical framing of climate change as a global issue makes it difficult for people to prioritize climate action (O'Neill & Nicholson-Cole, 2009; Spence et al., 2012). In response to these challenges, place attachment and place identity are therefore emphasized as “promising paths forward in communicating climate change impacts and adaptation” (Moser, 2014, p. 348). The literature suggests that the interactive potential of visualization technologies could address this by enabling users to zoom in on, for example, expected climate impacts in their local area and, in doing so, induce a greater sense of relevance and engagement (Bohman et al., 2015; Schneider, 2012; Schroth et al., 2014; Wibeck et al., 2013). More specifically, Schweizer et al. (2013, p. 59) recommend the development of “integrated place-based activities such as climate camps, citizen science programs, and mobile and website tools that are locally relevant, empowering, and engaging for diverse audiences.” It is worth noting, however, that there are also increasing calls in the climate change communication literature for more empirical research regarding to what extent proximizing – i.e. emphasizing climate impacts which are “close in space and time” (Brügger et al., 2015:1031) - influences audience interpretations of and willingness to take action on climate change. So far, empirical studies have shown mixed results and highlighted the complexity embedded in using proximizing as a strategy for engaging publics in climate change mitigation and adaptation (e.g. Brügger et al., 2015, Singh et al., 2017).

As such, climate visualization is increasingly recommended for its potential as a key element of climate change communication, but few studies investigate this potential from an audience perspective (Smith & Joffe, 2013). In addition, in a recent review, Carvalho et al. (2017) critically noted that research into public engagement with climate change is predominantly positioned within theoretical stances of social psychology focusing on communication as an instrument for changing people’s attitudes and behaviors. VisAdapt™ exemplifies a visualization tool intended to engage audiences with climate change adaptation by addressing the challenge of geographical distance through using interactive visualization technologies. Focusing on interpretive strategies and meaning as closely linked to the audience’s sense of engagement, this study explores the meeting between users and the tool at the site of audiencing.

3. BACKGROUND AND CONTEXT

Climate change is expected to have a strong influence on the magnitude of weather-related risks facing the existing building stock in the Nordic region (IPCC, 2013). This includes the intensification of

common risks, such as rot, leakage, and basement and urban flooding, related to a high-precipitation climate, as well as increasing but less-managed risks related to a warmer and more humid climate, such as mold and high indoor and outdoor temperatures (Glaas et al., 2015b). Such changes require new or updated management practices for buildings, and that appropriate adaptation measures be put in place (Gupta & Gregg, 2012).

Due to the scale-specific nature of the climate change adaptation of buildings, homeowners have been presented as key agents in implementing concrete adaptation measures (Visscher et al., 2016; Wamsler & Brink, 2015) and therefore been identified as an important target group for related climate adaptation communication. As presented in contemporary research, it is essential that homeowners consider risks which are anticipated to be intensified by climate change such as rot and mold, basement flooding and high indoor temperatures in concrete renovating or building projects (Koerth et al., 2013; Smith et al., 2013). Assuming that interactive visualization tools can provide opportunities for raising risk awareness and inspiring action in highly shifting contexts (e.g., Lujala et al., 2015), several such tools have been developed for various areas around the globe (Neset et al., 2016). The VisAdapt™ tool analyzed here is one such tool.

3.1. VisAdapt™

VisAdapt™ (www.visadapt.info) is an open access web-based visualization tool which can be used on any computer, smartphone or tablet. It is intended to support awareness of climate change risks and adaptation options, and targets Nordic homeowners as primary users. The tool includes information about anticipated climate change effects and risks facing sub-national regions and house types, as well as adaptation measures which can be implemented to avoid specific risks. VisAdapt™ was launched online in November 2014 on Nordic public national adaptation portals, and linked to via e.g. insurance companies and branch organizations' homepages such as the Swedish Homeowners Association. The data and information in the tool have been collected from meteorological institutions, national authorities, universities and research institutions, municipalities, insurance companies, and organizations in three of the five Nordic countries (i.e., Denmark, Norway, and Sweden) (Glaas et al., 2015b).

VisAdapt™ is built around three main components (Figure 1). In the left-hand panel, the user inserts his or her street address and information about the house type and material, which are used to visualize the location of the searched house and to offer a sorted selection of adaptation guidelines. In the middle panel, information is provided on anticipated climate change trends in four central climate parameters (i.e., mean temperature, mean precipitation, heat waves, and cloudbursts) for the RCP 8.5

climate scenario (based on the assumption that GHG emissions will continue to rise) over the coming 40–60 years. The middle panel also includes risk maps for flooding in all Nordic countries as well as municipal exposure indices ranking municipalities on exposure to climate change risks (currently available only for Norway). In the right-hand panel, users are provided with adaptation guidelines appropriate for the selected house type/material and sorted according to the climate parameters expected to change the most in the searched or selected area. The tool has a high level of interactivity (Neset et al., 2016) and allows the user to explore various geographic areas, climate parameters, risks, and house types/materials. Interactivity refers in this context to the functionality that information changes dynamically without any time lags according to selections made by the user, such as the insertion of a searched address or a specific risk, which creates a visible and direct interactivity (Johansson et al., 2017). Such information visualization techniques follow principles for transmission of complex and multifaceted data into more easily usable information units (e.g. Spence, 2014).

Figure 1: Design of VisAdapt™. (www.visadapt.info)

4. METHODOLOGY

This study builds on experimental test sessions that were part of a series of focus group interviews with homeowners in Denmark, Norway, and Sweden. The focus group interviews were structured in three phases. First, participants were engaged in a general discussion of climate change, their risk perceptions, and their roles and responsibilities as homeowners in adapting to climate change impacts. Second, the participants were given a brief introduction to VisAdapt™ and divided into

smaller groups of two or three people, in which they were asked to explore the tool without the presence of a moderator. Third, after the test sessions, the participants reconvened in the focus group setting to discuss their perceptions of VisAdapt™. The present analysis treats the test sessions, while analyses treating the focus group discussions are presented in Glaas et al. (2017) and Glaas et al. (2015a).

Adopting a semiotic approach to communication entails studying how people's interpretations evolve in a social setting. Focus group interviews are a research method suitable for exploring how attitudes, opinions, and perceptions develop in social settings, in which discussions often encourage participants to articulate their opinions as they evolve in social contexts (Wibeck et al., 2007). Accordingly, the format of the test sessions was selected to allow and encourage participants to engage in dialogue about the tool and to articulate their opinions and views in a social context while exploring the various aspects of VisAdapt™.

In the test sessions, groups of two or three participants were asked to explore VisAdapt™ without the presence of the moderator and were encouraged to “think aloud” while exploring the visualization platform. The discussions were audio-recorded and subsequently transcribed for analysis. To assess the method, we first tested this experimental part of the method in a pilot study to ensure that the test sessions would contribute valid data for the study. Here the test sessions were observed to assess how well the audio-recordings could capture the interaction, both amongst participants and between the participants and the computer. We found that the smaller group setting functioned well for the purpose of encouraging dialogue between participants when using the tool, which could be captured well by the audio-recordings. Here a decision was taken not to video-record the sessions since this potentially could have made participants feel uncomfortable. Despite the potential bias of dominant voices, the test sessions functioned well to provide insights into participants' interpretive processes in their interactions with the tool, their immediate experiences of various features of VisAdapt™, and their opinions on content relevance.

As VisAdapt™ was specifically developed to target homeowners in the Nordic countries, we conducted test sessions with homeowners from the municipalities of Aarhus (Denmark), Norrköping (Sweden), and Trondheim (Norway). To ensure a diverse representation of participants from the target group, we strove to recruit a broad range of participants with respect to rural/urban location, age, and gender. The common denominator was that all participants from a given country should be homeowners from the same municipality. We recruited participants using extended social networks and by contacting local housing associations. In the recruitment process we did not ask specifically

about background parameters such as beliefs about climate change, previous experiences with implementation of adaptation actions or computer experience, which nevertheless were rather diverging among participants as could be observed in the recordings. As presented in the analysis below, in particular previous experiences with weather-related events appeared to be important when interpreting the information. Related to computer skills, the person that felt most confident with computers in the groups tended to steer the mouse. However, this generally did not seem to have significant impact on the discussions. All participants provided their informed consent to participate in the study. Details of the test sessions are presented in Table 1.

No	Size	Participants	Location	Date
1	3	2 men, 1 woman	Aarhus, Denmark	20 June 2013
2	2	1 man, 1 woman	Norrköping, Sweden	17 June 2014
3	2	2 men	Norrköping, Sweden	17 June 2014
4	2	2 men, 1 woman	Norrköping, Sweden	17 June 2014
5	3	2 men, 1 woman	Norrköping, Sweden	18 June 2014
6	2	1 man, 1 woman	Norrköping, Sweden	18 June 2014
7	3	2 men, 1 woman	Trondheim, Norway	3 November 2014
8	2	1 man, 1 woman	Trondheim, Norway	3 November 2014
9	3	3 men	Trondheim, Norway	4 November 2014
10	3	2 men, 1 woman	Trondheim, Norway	4 November 2014
11	2	1 man, 1 woman	Aarhus, Denmark	6 November 2014
12	2	1 man, 1 woman	Aarhus, Denmark	6 November 2014
13	2	2 women	Aarhus, Denmark	6 November 2014
14	3	3 men	Aarhus, Denmark	7 November 2014
15	2	2 men	Aarhus, Denmark	7 November 2014

Table 1: VisAdapt™ test sessions

The data analysis took the form of a thematic content analysis concentrating specifically on meaning and interpretive processes (Marková et al., 2007). We assumed an inductive strategy for data analysis with emphasis on how participants made sense of the content while interacting with the tool and each other. To accommodate this focus, the first step of analysis consisted of a broad categorization of the transcribed texts defined by shifts in topics to identify what the participants discussed in the groups. Next, we conducted a meaning condensation of the categorized text sequences that summarized the topics of discussion and, based on this, analyzed the sequences with an emphasis on identifying recurrent themes characterizing how the participants made sense of VisAdapt™. This part of the analysis concentrated on identifying recurring interpretive strategies used by the participants and

how the participants assessed the relevance of the content. Insights based on these analyses are presented below.

5. RESULTS AND ANALYSIS

A recurring interpretative strategy employed by participants in all test sessions was to draw on personal experience to reflect on the relevance of a particular element of VisAdapt™. This was a primary point of reference in all test sessions and included participants reflecting on experiences relating to their own homes, sharing anecdotes about relatives or friends, and referring to specific weather-related events in the past.

In particular, the participants used personal experience relating to their own homes as reference points in assessing the relevance and significance of the information about climate change scenarios and impacts relative to their own situations and, furthermore, in reflecting on adaptation measures they had already taken or could take to enhance their resilience. Such discussions were typically related to the middle panel of VisAdapt™ featuring risk and scenario maps. The participants anchored the represented data in a familiar context, i.e., their own homes, to validate the accuracy or relevance of anticipated climate change impacts. In many cases, the data representation spurred reflection on participants' homes, and sharing such reflections in the test sessions often evolved into longer spinoff dialogues, in which various weather-related challenges and potential solutions were discussed, as exemplified in the excerpt below.

4:1—Mold and rot, are you afraid of them?

4:2—Well, I don't know, I'm afraid of moisture in my basement.

4:3—As we discussed before, I think about when we renovated in 2004, we chose between a suspended and a slab foundation—this was a very current issue then.

4:1—Do you have a suspended foundation?

4:3—We had before, under half of our house, but we removed that and built a slab foundation, insulated well, and screwed on the floor, a wooden floor.

4:1—Has that worked well?

4:3—Yes, it has worked well, no moisture and therefore no rot in the floor joists and the like.

(Test session 4, authors' translation)

Here, three participants take as their starting point specific adaptation measures related to rot and mold and reflect on the relevance of taking measures against such impacts in their own homes. They subsequently shared experiences with measures they themselves had implemented. Using VisAdapt™ as a starting point, the participants reflected on a specific type of climate impact and possible related

adaptation actions, and used their own experiences as homeowners not only to assess the relevance of the VisAdapt™ information but also to contribute local and personal knowledge of the subject. Similarly, anecdotes or recollections of weather-related events were used as interpretive strategies, which primarily served the purpose of assessing the severity and significance of potential impacts and risks.

In general, interpreting in light of personal experience was an important strategy with which participants broke down regional climatic changes into locally relevant information. However, in this process, they acted rather selectively regarding the information presented and quickly dismissed visual outputs in which such links were not obvious, as illustrated in the example below, in which the participants were trying to get more detailed information from a scenario map regarding the projected changes in their local area:

12:2-Should I click there? (12:1 – mmmmm...)

12:2-I must be able to get closer in...the changes here – what will they be?

12:1 – well, uhm... nothing according to that. Well, very little. Very, very little. It's just like light, light....

(Test session 12, authors' translation)

After this exchange, when unable to see any changes in their local area, the participants moved on to a different map.

Another frequently observed sense-making strategy could be called 'localization'. Here, participants used their geographical and local knowledge as a reference point for interpreting the scenarios and risk representations in the middle panel of the tool. Participants used their geographical knowledge as a resource when interactively comparing, for example, regional differences in climate risks, but also as a driver when choosing to explore climate risks or impact scenarios in specific geographical areas—whether their own surroundings or other locations of interest. Unsurprisingly, localization was primarily used as a strategy to interpret maps in VisAdapt™, i.e., the climate scenario maps or risk maps. In doing so, participants interacted with the tool in one of two ways: 1) “zooming in”, i.e., relating the visual representation to local knowledge, and 2) “zooming out”, i.e., exploring the relevant data on their surroundings and comparing these with data on other areas.

Related to “zooming in”, in all sessions participants predominantly focused on and displayed an interest in their local areas, applying personal knowledge of the place to make sense of risk maps or climate scenario maps. An illustrative example comes from a Swedish test session, in which

participants used their local knowledge of a low-lying area to interpret the magnitude of flood risks presented by the tool:

3:1—That's Glan [i.e., a lake in Norrköping].

3:2—And the west side of Bråviken [i.e., a bay in the Baltic Sea] right? It follows Motala Ström [i.e., a river in Norrköping].

3:1—And what do we understand if we look at this view here? Can you look at Saltängen [i.e., a low-lying urban area in Norrköping]? Yes, there's a big risk over there.

3:2—This is Saltängen right? It's where they will build.

3:1—Should this represent that?

3:2—Yes, a flood area, it probably means risk of flooding, but it looks as though it follows the watercourse.

(Test session 3, authors' translation)

Exploring the risk map, the participants recognized Glan Lake in their local area, which captured their attention and stimulated interest in further exploring known landmarks and the associated climate risks, such as how the urban area Saltängen would be exposed to flooding.

The “zooming out” strategy was used to explore and compare various places and/or identify vulnerable places in other parts of the country on the maps, in order to explain or understand impacts and changes (or the lack thereof). For example, as illustrated by the following quotation, participants compared anticipated precipitation changes in various known places:

9:1—But Trondheim is, generally speaking, not the worst place to live in Norway either. If you look at the precipitation map over the entire country, then it's there that it's raining right now. But in some places rain will increase by more than 10 cm per year.

9:2—Skjåk, Selbu—how is it there? Tydal, Røros—same thing. Sirdal as well. [All mentioned places are in Norway.]

9:3—But is a 10-cm increase so much more then?

9:2—That depends on how it happens. If it comes down in small amounts at a time, it's not so dangerous, but if all comes down at once, you'll have big problems.

9:1—Yes, and the total number of days with cloudbursts. If you have more than an additional 15 days per year. And it's bad already.

(Test session 9, authors' translation)

Here, the participants compared their hometown—Trondheim—with other Norwegian towns in assessing whether Trondheim would be more exposed to precipitation changes relative to other areas. They established that Trondheim is likely to experience a degree of change similar to that in other areas, and discussed the extent to which this would be problematic.

Furthermore, focusing on known geographical areas, the participants negotiated the VisAdapt™ content by drawing on first-hand knowledge of, for example, local topography or infrastructure that

could potentially be used to modify the risk maps. For instance, participants would provide information about vulnerable locations frequently exposed to flooding in their local areas. In this sense, although VisAdapt™ provided information about risks and climate scenarios at a local level, the participants naturally possessed even more localized knowledge of their own neighborhoods and towns. They used this knowledge to negotiate or nuance the information displayed on the risk and scenario maps in the middle panel of the tool.

In our analysis, we also examined the extent to which participants used their existing knowledge of climate change as an interpretive resource. We found that preexisting knowledge of climate change was only seldom explicitly cited in the discussions, but appeared to be a powerful means to convince other participants when invoked, as illustrated below:

14:3—There are no big changes in this area, really ...

14:1—Two degrees is actually a lot, because the average temperature of the whole world is eight degrees.

14:2—Hmm, yes then if it is ... then two degrees is a lot.

14:1—It really is. It is something we will notice.

(Test session 14, authors' translation)

In this exchange, in which participants were looking at scenario maps representing the annual mean temperature increase, one participant concluded that the increase shown on the map was insignificant. However, this perception was negotiated by another participant (14:2), who provided knowledge of the global mean temperature, which was then used to reinterpret the temperature scenario with the conclusion that the two-degree increase would be quite significant. Interestingly, analyzing the discussions in the 15 test sessions revealed only a few instances in which participants used existing knowledge of climate change as an interpretive resource.

While preexisting knowledge of climate change was rarely raised in the discussions, participants frequently voiced confusion or irritation because of a perceived lack of reference points when they were struggling to make sense of information perceived as too technical or complex. To be able to function as a “stand-alone” feature as intended (see Section 3), the language for presenting climate change scenarios and risks in this and similar tools needs to be further assessed. The confusion by participants in this study appeared based on a perceived lack of precise knowledge, reference points, and definitions in the climate change data that participants felt hindered their understanding of the visual representations. For example, they often expressed confusion about definitions, concepts, numerical values, and scales, or felt that they lacked a baseline against which to contextualize and assess the significance of climate impacts, such as increased water levels:

6:1—Sea level rise—that you can understand—but what is the water level? What water level? It doesn't say.

6:2—It must be other waters that are not the sea, lakes and the like.

6:1—It doesn't say water "levels." And flood areas, are those small or big?

(Test session 6, authors' translation)

The perceived lack of reference points proved problematic for the participants in various ways and points to the need to more carefully consider how to present climate data to avoid misconceptions. In some groups, the way the data were presented typically led to discussion of definitions or scales and prompted VisAdapt™ searches for more information to clarify the issue. In other groups, the perceived lack of knowledge or definitions simply functioned as a barrier that caused participants to give up and move on, or to express frustration that the tool, in their view, did not provide them with adequate information. Furthermore, a lack of reference points often led participants to dismiss the visualized changes as insignificant to their local area, as illustrated in the following excerpt:

9:1—Here is the measured average temperature anyway. It looks like it will be two degrees warmer in 40–60 years.

9:2—That's not so much then ...

(Test session 9, authors' translation)

As opposed to the previous example in which one participant had preexisting knowledge he could use to contextualize a two-degree temperature increase, this quotation illustrates a much more frequent tendency: that participants often lacked reference points with which to assess the significance of the represented scenario data. In this example, the participants simply concluded that a two-degree temperature increase in 40–60 years was "not much," leaving them with an impression of climate change as nothing to worry about as homeowners because they assessed its risks and impacts as moderate.

In several instances across the test sessions, participants critically negotiated, disagreed with, or dismissed information presented, as illustrated in the quotations below:

5:1—The temperature can be reduced by using a white roof.

5:2—How do they know that I don't have a white roof?

5:1—You haven't selected what color to have on your roof.

5:2—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."

5:1—That might be problematic. You may need building permits to do that.

(Test session 5, authors' translation)

6:2—"To prevent the walls from tipping over"

6:1—That's a weird comment. A wall would withstand high wind speeds—walls don't tip over in Sweden.

(Test session 6, authors' translation)

While in the former quotation the participants problematized the proposed adaptation guidelines referring to the need to get a building permit and associated issues, the latter quotation illustrates a recurrent tendency in some test sessions to create critical or skeptical distance from the guidelines by questioning the relevance of implementing some of them. This key finding indicates that participants used critical negotiation as a way to dismiss adaptation guidelines either because they failed to see their relevance or simply because they disagreed with them. This type of negotiation was typically based on participants' assessments of what made sense in relation to their homes or their knowledge of specific conditions in their local areas. In addition, critical negotiation also occurred in relation to the participants' perceptions of the featured information as too mundane, too commonsensical:

12:2—Adaptation ...

12:1—Yeah, hmmm ...

12:2—"Select paint that can withstand moisture and breathe," yes! (12:1: Yeah) "Windows, façade," yes, "remove snow lying along the façade," yes.

12:1—But you do these things already, right?!

...

12:1—There is nothing new for me here at all!

12:2—All these things, we know already. We're already doing them.

(Test session 12, authors' translation)

In this excerpt, when browsing through the adaptation guidelines in the third panel of VisAdapt™, the participants concluded that the tool did not present them with any new information, but instead featured guidelines deemed common knowledge by the homeowners. This type of critical negotiation occurred in several discussions during the test sessions, in which participants were highly critical of the information presented and disagreed with or dismissed it as either irrelevant or self-evident.

Critical negotiation was particularly salient when participants were discussing adaptation guidelines and used this interpretive strategy to question their validity and/or relevance. In general, across the test sessions, the adaptation guidelines were either simply accepted as relevant, sound advice and therefore related to the participants' own homes, or critically questioned and dismissed. In the latter instances, which occurred in 8 of the 15 test sessions, the climate change data as represented in

VisAdapt™ seemed misaligned with the participants' perceptions of climate change as a phenomenon having severe and dramatic impacts that would require much more complex responses than simply cleaning gutters, removing snow, or painting roofs. This notion could further be linked to the more dominant presence of climate mitigation in the public discourse, in which climate change has frequently been described as a distant and highly complex phenomenon (Wibeck, 2014; Whitmarsh et al., 2013). As the climate communication literature has not focused on adaptation to a large extent, this can be noted as a question, which would require further attention (cf. Moser, 2014).

6. DISCUSSION AND CONCLUSIONS

Charting directions for future environmental research, Hansen (2015) advocates research into the signification processes of visual environmental communication, to “advance further in terms of accounting for how visuals—despite their seemingly self-explanatory photographic window-on-the-world quality—are invariably ‘made to mean’ or signify in particular ways” (Hansen, 2015, p. 387). In this study, we empirically explored such processes of signification by analyzing how a case of interactive climate visualization to support adaptation was “made to mean” at the “site of audiencing” (cf. Rose, 2016).

The study illustrates how participants in all test sessions used personal experience and localization in their interpretive strategies. Our analyses demonstrate that perceived spatial proximity attracted attention and interest among users, largely in line with what previous literature has recommended for climate change communication (e.g., Bohman et al., 2015; Schneider, 2012; Schroth et al., 2014). The use of these interpretive strategies encouraged locally and personally anchored discussions of and reflections on climate change impacts, risks, and adaptation measures. In itself, this is perhaps not surprising, as VisAdapt™ prompts users to enter their own addresses and use the geographic locations and features of their houses as a starting point for exploring climate risks and scenarios. However, aside from taking an interest because of the local focus, participants negotiated or dismissed content in various ways. This is noteworthy, because they used experiences from their own homes and knowledge of their local areas in constructing and negotiating the meanings, significance, and relevance of the VisAdapt™ content and information. In this respect, participants called the concept of expertise into question (cf. Blok et al., 2008), as they drew on their ‘lay expertise’ (Brossard & Lewenstein, 2009) to evaluate the relevance of adaptation guidelines. For example, by relating expert knowledge collected from government agencies and research institutions to specific homes, the guidelines seemed easy to dismiss because the participants to some extent perceived themselves as experts in that domain. Some participants may well have possessed deeper knowledge about

adaptation due to their occupation or location. Nevertheless, this did not appear as important for their interpretation of the guidelines, as all stakeholders took a role as homeowners rather than adaptation experts. However, since we in our analysis did not focus on mapping e.g. demographic differences or occupation, we cannot here draw more detailed conclusions on the importance of such variables on the interpretation of adaptation guidelines.

Above findings have implications for climate change communication and climate visualization initiatives in a number of ways. Related to visual outputs, to avoid confusion and misconceptions related to the technical language of climate projections, future climate visualization targeting lay audiences would benefit from rethinking the way future climate is presented. Linking visualization, by exemplifying e.g. how a flooding or heat wave can play out locally would likely be a fruitful way of conceptualizing complex phenomena which in this study seemed to create barriers to fully engage with information presented (for more discussion about lessons learned about visual outputs and interactivity in climate visualization, see Glaas et al., 2017 and Johansson et al., 2017).

Related to the localization of climate change in communication, several studies have pointed to the need to reframe climate change as a local instead of a global issue as a way to reduce people's perceived distance from climate change and make it more personally relevant and engaging (Evans et al., 2014; Sheppard et al., 2011; Schroth et al., 2014). In our study, the participants' critical negotiation of localized content suggests that although a local focus is likely to engage audience interest and attention, it will not necessarily awake concern about local climate change impacts. In some instances, the local focus instead led to the assessment of climate risks and impacts as rather low. In addition, localizing information seemed to make the information appear less reliable in some respects. In line with Brügger et al. (2015) and Singh et al. (2017), we argue that the complex audience reactions to communication that proximizes climate change in time and space warrant further analysis. We therefore argue that additional research into the global-local dichotomy of climate change from an audience perspective is needed, exploring how audiences ascribe meaning to and assess the relevance of climate change from global versus local perspectives.

The participants' critical negotiation of content and their limited use of prior knowledge of climate change as an interpretive resource is noteworthy considering the geographic context of the study. The Eurobarometer (2014) special report on climate change that surveys EU citizens' perceptions of and attitudes toward climate change concluded that, of EU citizens, Swedes and Danes are the most likely to think of climate change as one of the most serious problems facing the world. In addition, respondents from Sweden and Denmark were the most likely to mention personal responsibility as a

way to address the changing climate. Nonetheless, the participants in this study often remained critical or skeptical in negotiating the meaning and relevance assigned to the information. Against this background, the designation of homeowners as a target group of a communication initiative may not be aligned with their perceived information need or risk perception. A possible explanation for this is that the adaptation focus of the tool is not aligned with the participants' perceptions of climate change as a global issue with dramatic, even catastrophic, impacts and consequences.

How the participants ascribed meaning to the VisAdapt™ content illuminates the limitations of traditional transmission-oriented approaches to communication that have long been criticized by communication theorists (Carvalho et al., 2017; Craig, 1999), but that several authors argue still inform many climate change communication initiatives (Ballantyne, 2016; Cone et al., 2013; Fleming et al., 2014; Lindenfeld et al., 2012). Our analyses illustrated how meanings and interpretations of climate change were negotiated at—rather than transferred to—the site of audiencing, as participants drew on knowledge of their local areas and weather-related impacts as well as personal experience when making sense of the VisAdapt™ content. In this process, the interactivity of the tool allowing the user to localize and 'zoom out' played a significant role for the dialogue. This suggests that a traditional conceptualization of communication and visualization as means of transferring engagement or knowledge could be constraining rather than motivating, because people critically negotiate content and information and because they may not see themselves as a relevant target group. The analysis of interpretive strategies identified how participants took insights into vulnerable locations in their local areas as their points of departure, and used this knowledge to negotiate and reflect on presented information about climate change impacts, local risks, and adaptation measures relevant to them as homeowners. This points to the potential of conceptualizing audiences as co-authors in climate change communication, engaging people in interactive data exploration and dialogue about climate change at a local level, using their insights, experience, and local knowledge as starting points for discussing and identifying, for example, relevant adaptation action. We argue that it could be useful to allow users to interact with other users of the tool through, for example, providing a discussion forum or allowing users to add information or pictures about their own adaptation experiences to encourage further interest in the issue and to localize information from the bottom up, providing more voices addressing various ways forward.

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