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Visualizing climate change: an exploratory study of the effectiveness of artistic information visualizations

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Artists creatively use scientific data in artistic information visualizations (AIVs) to address climate change. Yet, it is unclear how effective they are in making viewers consider climate change as important. To assess their reception, this research studies and compares AIVs in relation to four additional visual forms, which are common in the communication of climate change (information visualizations, news photos, digital art visuals and cartoons). Qualitative research consisting of a short survey, q-sort and semi-structured interviews was employed. Some AIVs were judged clearer and more agreed with than other AIVs, suggesting that a less abstract AIV style might be more suitable. In comparison to the other visual forms, the artistic information visualizations were the least effective in making viewers consider climate change as important. It appears that artists' free choice of data focus and artistic styles faces limits when depicting a complex topic such as climate change. A need for clarity or accompanying descriptions to the visualizations, at least when targeted at the general public without art training, might be necessary. The study did not show distrust in art's involvement in the climate change discourse.

Keywords: visual arts; climate change; environmental communication; artistic information visualizations; public engagement

Introduction

The communication of anthropogenic climate change has experienced a steady increase in volume since the beginning of the twenty-first century (Hagen, Middel, and Pijawka 2015; Moser 2016). In Western Europe, the general public is largely *aware* of the problem of climate change (Hagen, Middel, and Pijawka 2015; Steentjes et al. 2017). However, the question arises: how can the general public be effectively engaged *beyond awareness*? One possibility is to create visualizations that depict

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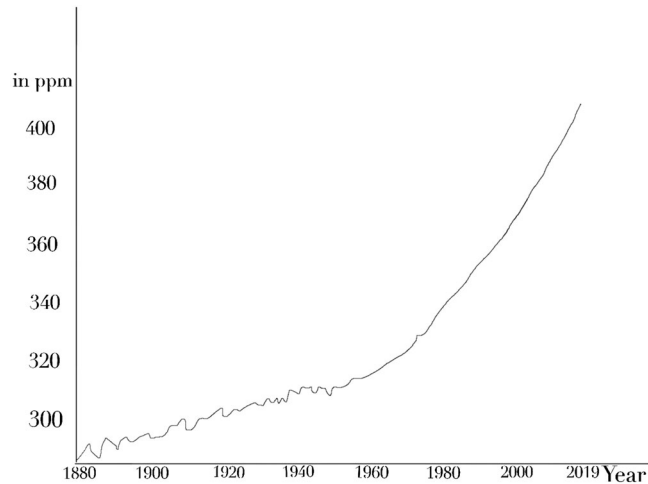


Figure 1. Information visualization showing the atmospheric concentration of carbon dioxide (CO₂). Modified figure from open-access data *Our World in Data*, based on data from National Oceanic and Atmospheric Administration, Creative Commons BY license, no endorsement clause.

climate change as an *important* topic, i.e. to create a sense of issue salience (Nicholson-Cole 2004; O'Neill et al. 2013).

Information visualizations, which are data-based representations, are frequently used by environmental organizations to visualize the multifaceted issue of climate change in a fact-based way (see Figure 1) (Herring et al. 2016; Johansson, Neset, and Linnér 2010). While environmental organizations have an obvious stake in rendering climate change an important topic, artists might be perceived to be less connected to this issue. However, climate change artists are increasingly interested in creating a sense of urgency and mobilizing individuals to achieve positive change (Hagen, Middel, and Pijawka 2015; Nurmis 2016; O'Neill and Smith 2014).

Artists started to create artistic modifications of information visualizations, so-called *artistic information visualizations* (AIVs) to creatively contribute to the augmentation of visualizations in an increasingly rationalist world. AIVs' core contribution lies in their unique ability for artistic freedom, and boundary-less capability to show *novel* data-based visuals in times of information overload (Moere and Purchase 2011). For instance, they show graphical lines about temperature, fossil fuel and sea level rise as an artistic work in a painterly, creative way (see Figure 2).

While the use of information visualizations in climate change communication has been researched (Herring et al. 2016; Johansson, Neset, and Linnér 2010; Tominski, Donges, and Nocke 2011), art's communicative role in addressing environmental issues has remained understudied (Dunaway 2009; Miles 2014; O'Neill and Smith 2014). The concept of

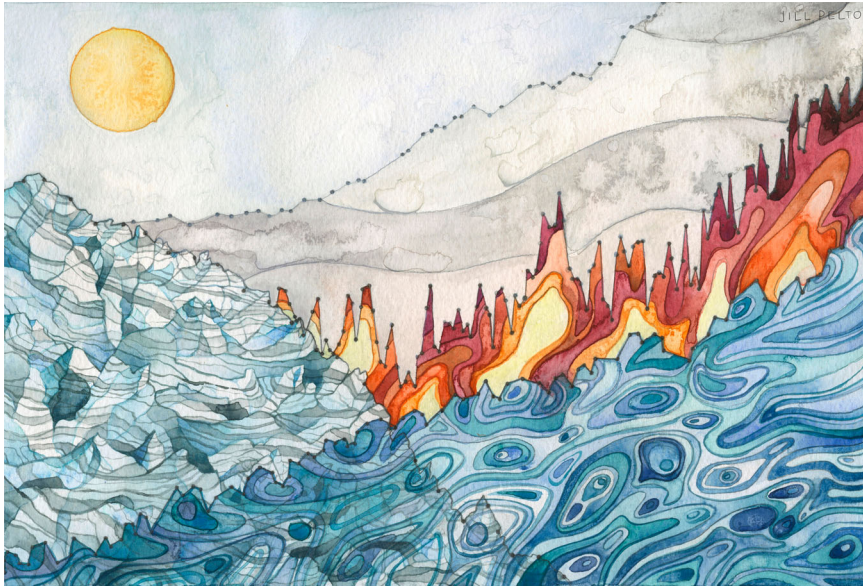


Figure 2. Artistic information visualization (AIV), entitled *Landscape of Change* (2016) by artist Jill Pelto. The work ‘uses data about sea level rise, glacier volume decline, increasing global temperatures, and the increasing use of fossil fuels. These data lines compose a landscape shaped by the changing climate, a world in which we are now living’ (<http://www.jillpelto.com/landscape-of-change>). Watercolour and pencil, 27.9 × 38.1 cm. Artwork reproduced with permission from the artist.

issue salience (importance) has been employed in previous research investigating people’s engagement with climate change through climate change visualizations (e.g. O’Neill et al. 2013), however not yet with a focus on AIVs. Therefore, the goal of this study is to uncover whether the arts, and the AIVs specifically, are effective in creating a sense of salience for climate change.

The AIVs are not judged in isolation but by comparing them to non-artistic visualization forms (non-artistic information visualizations and newspaper photos) as well as non-data based artistic visuals (digital art and cartoons) (see Figure 3). The following exploratory research question 1 (RQ) was formulated:

How *salient* do people perceive climate change through artistic information visualizations?

In addition, this study examines possible reasons thereof. Besides the properties of the visualizations, it explores if a background in the arts (decoding skills) is connected to the viewer’s engagement with the AIVs on climate change (Kennedy et al. 2016; Rose 2016). Finally, it includes

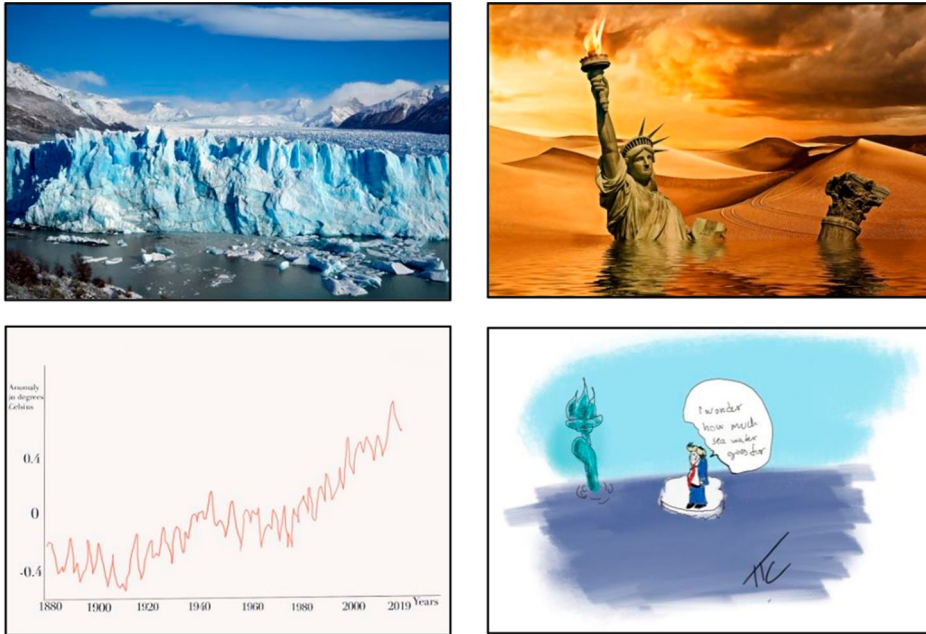


Figure 3. Examples of visual types (mentioned in text), which are often used to communicate climate change information. *News photo* (top left) showing the melting of glaciers and *digital art* (top right) dramatically showing increasing temperatures and flooding (free licence, no attribution required, no modification): *information visualization* (bottom left) representing the increasing global temperature anomalies (modification of open-access data *Our World in Data*, based on Met Office Hadley Centre, Creative Commons BY license); and *cartoon* (bottom right), entitled ‘*I wonder how much sea water goes for*’ by TTC (reproduced with permission from TTC).

how the involvement of art in general (e.g. raised by Miles 2010; Miles 2014), and AIVs specifically, is perceived in the communication of climate change. Therefore, the following RQ 2 was formulated:

What reasoning for issue salience can be identified concerning visual properties, audience decoding skills, and encoder credibility?

A q-sort and post-sorting semi-structured interviews allowed participants to express their views (O’Neill et al. 2013). Finally, this exploratory study was conducted in the Netherlands, a country which partly lies below sea level and lags behind on its emission goals (Koelemeijer et al. 2017).

The environment, climate change and the arts

Artists’ visions of nature have changed depending on the epoch they were part of and the perspective they were taking. There are artworks depicting

the sublime, beautiful nature in romanticism (Miles 2016); and there are artists who are 'less interested in beauty, and more in resistance, interruption, contradictions, and the fissures which demonstrate the dominant society's inbuilt failure' (Miles 2016, 16). Over the past three centuries, for instance, artists have contributed to environmental understanding by addressing colonialism and the forceful taking of indigenous lands, the impact of industrialization on natural resources and contemporary ecological activism, including climate change (Kusserow et al. 2018).

Climate change is a particularly dominant environmental theme of the past decades. It refers to 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods' (United Nations Framework Convention on Climate Change 1992, 7). This definition underlines the *anthropogenic* contribution to climate change. Artists, along with other advocates, realize that even though we are now much more aware of climate change than in the previous century, our climate actions are insufficient. The carbon dioxide (CO₂) and temperature slopes do not decrease, glaciers keep melting, and extreme weather events prevail.

Practitioners and researchers are increasingly calling for the arts and humanities to contribute to the climate change discourse. Through the power of imagination and storytelling, they have the capacity to meaningfully address a topic that feels too overwhelming to understand (Hulme 2011). The arts have also taken a role during international climate change summits. The ArtCOP21, for instance, included performances, installations and exhibitions to creatively advocate for climate action (Sommer and Klöckner 2019). In recent years, numerous art forms, such as theatre, film, music, literature and the visual arts have been addressing climate change (Davis and Turpin 2015; Demos 2017), of which the latter visual form is of interest in this study.

Encoding-decoding visual communication of climate change

Several scholars have built upon the Encoding-Decoding Model of Communication, originally conceived by Hall (1980), for the understanding of environmental visualizations (e.g. O'Neill and Smith 2014). The Encoding-Decoding Model not only encompasses the act of producing the visual (encoding), but also the process of engaging with it (decoding). The present research uses this model as a general guiding framework while incorporating information visualizations and the role of art. Furthermore, it acknowledges recent developments in visual research: The decoding of visualizations is not only influenced by the visual's form and content; it is also subject to audience characteristics (Kennedy et al. 2016; Rose 2016) (see Figure 4).

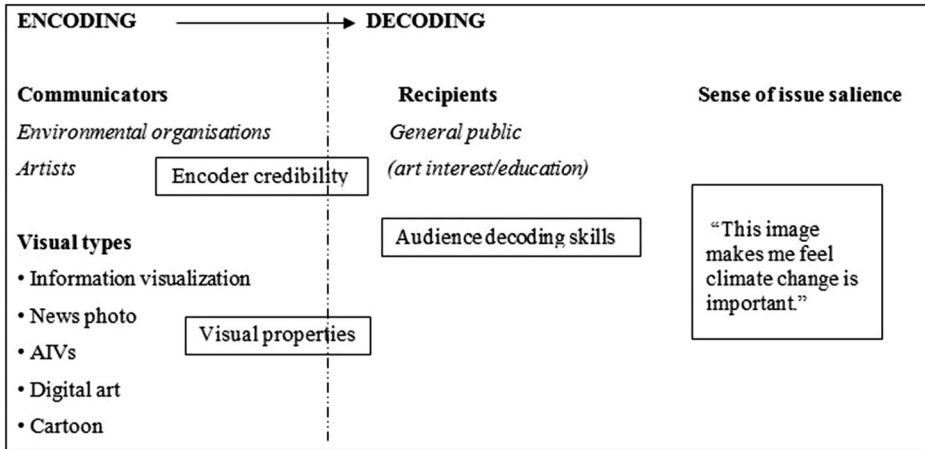


Figure 4. Encoding-Decoding Model of Communication (Hall 1980) applied to present research focus. Encoding: the focal communicators in this article hold certain credibility in the climate change discourse. They can encode various visual types. They strive to communicate to a broader general public. Decoding: the general public possesses certain decoding skills (e.g. for data, art). One common goal for climate change communicators is to improve people's sense of issue salience (Nisbet 2014; Nurmis 2016; O'Neill and Smith 2014).

Encoding climate change visualizations

Visual artists are increasingly addressing the complex topic of climate change in their artworks (Dunaway 2009; Nurmis 2016). Climate change science is based on complex climate model simulations. Its causes, such as CO₂, can be invisible, and its effects can be overwhelming, and feel temporally and spatially distant (Nixon 2011; Schneider 2012). Visualizations can transform this complex climate change science into easily digestible information. They can portray the invisible, the remote, and reach beyond borders (O'Neill and Smith 2014; Schneider 2012).

Moreover, because climate change is not the uncharted territory that it was 20 years ago (Moser 2016), the use of new, attention-capturing styles of communication may be required. A mere fact-based approach is by now seen as insufficient, and the visual arts have been argued to make valuable contributions (Roosen, Klöckner, and Swim 2017; Sommer and Klöckner 2019). Such art aims to 'meet[s] the imaginative deficit of scientific data' (Miles 2010, 13) by adding novel metaphors to the communication of climate change (Roosen, Klöckner, and Swim 2017). Popular examples of scientific data visualizations are the graphs of CO₂ – the Keeling Curve – and temperature developments (Howe 2015; O'Neill and Smith 2014). Artists create artistic modifications of such information visualizations, so-called AIVs, to shed new light on the topic. Differentiating between non-artistic and artistic information visualizations can sometimes be

difficult the former can be as aesthetically appealing as well (Lau and Moere 2007). AIVs can, however, be distinguished by their creator – the artist – and their institutional context, such as cultural institutions, art databases or the artist’s website (Gough 2017).

Decoding climate change visualizations

As viewers might ‘read’ climate change visualizations differently than intended by encoders (here: artists), it is imperative to study this side of the communication process. How important the AIVs make people see climate change (RQ 1) might be explained by the properties of the visual, decoding skills of the audiences, and encoder credibility (RQ 2), further explained in the following sub sections. Table 1 gives an overview.

Table 1. Information visualizations and artistic information visualizations (AIVs) in climate change communication.

| | Information Visualizations | Artistic information visualizations |
|--|--|---|
| (1) Ability for understandable and novel depiction | • Depends on use of aesthetics and interactivity | • Under-researched (only theory on AIV addressing other topics than climate change) |
| (2) Audience decoding skills support understanding | • Yes | • Under-researched (only research for other art forms than AIVs) |
| (3) Ability to establish credibility | • Yes | • Under-researched (only research for other art forms than AIVs) |

Note: Based on Gough (2017), Johansson, Neset, and Linnér (2010), Kosara (2007), Moser (2016), O’Neill and Smith (2014).

Visual properties: are AIVs understandable and novel depictions of climate change?

Artistic freedom allows artists to choose freely between ways of presentation (Moere and Purchase 2011). Therefore, artists have the unique capability to use ambiguous and interpretive methods, provoking, challenging, and questioning current visualization styles. Consequently, they can produce novel visuals based on data, eliciting emotional responses from the viewer (Lau and Moere 2007; Moere and Purchase 2011). The effect on the audience’s perception can then be that of interest, captivation (Kosara 2007), curiosity, puzzlement, frustration (Pousman, Stasko, and Mateas 2007), and personal reflection (Lau and Moere 2007). As such, ‘art cannot save the planet or the whale; it can represent, critique, and play imaginatively. Art interrupts and exposes contradictions’ (Miles 2014, 3). This appears to be especially important when existing climate

change communication might be lacking such abilities (Roosen, Klöckner, and Swim 2017).

AIVs are not necessarily constrained to creating affective responses alone; just as much as the arts in general have been recognized for their potential to facilitate the full engagement of emotional *and* cognitive systems (Goldman 2001). Art can be – just like science – a source of knowledge providing cognitive insights (Dewey [1934] 2005). In theory, AIVs uniquely combine data and art: facts for cognition on the one side, and art for the novel, attention capturing touch on the other.

The question is, however, how well AIVs are able to do so for complex topics such as climate change, as artists enjoy artistic freedom and are not bound by any degree of data focus or representation (Kosara 2007; Lau and Moere 2007; Moere and Purchase 2011). As mentioned in the introduction, this research not only covered AIVs, but also studied other visual types that appear in climate change discourse. These are not the focus of the present research, but serve as benchmarks for the phenomenon under study.

Audience decoding skills: is art interest and education necessary to understand the AIVs?

Decoding is not only influenced by the visual's technical parameters seen in isolation, but likely also by placing these factors in relation to the audience. Previous studies asserted the influence of the viewer's education and class on the decoding process (Bourdieu 1984; Hall 1980; Rose 2016). However, in the field of information visualizations, the end-users have not received extensive academic attention. Only a few studies have started to pay attention to audience characteristics. Kennedy et al. (2016) demonstrated that the audience's skills have an influence on their engagement with information visualizations, as they need to be confident about their ability to decode them.

This research highlights viewers' interest and education in the arts, and it examines if these are necessary for people to engage with the AIVs. By building cultural capital through academic qualifications and training, people might be more interested and make more sense of artistic visuals than people without it (Bourdieu 1984; Silvia 2005). Artist training and knowledge influence people's interest in artistic visuals. Such art 'experts' hold for instance a higher level coping (understanding) potential, resulting in a higher appraisal of interest in artistic visuals than art novices. This has been shown for complex artistic visuals (Silvia 2005). AIVs could be considered rather complex. This research hence examines if AIVs could be found rendering climate change more salient by art expert participants holding cultural capital through art education and interest.

Encoder credibility: are artists and AIVs trusted in climate change communication?

Some images could be found rendering climate change more or less salient than others. Viewers might (dis)like an involvement of the arts with the issue of climate change. For the arts in general, researchers are exploring its critical role in relation to environmental issues. This role is superseding its romantic conception of nature as beautiful and inspiring. The question is raised if art is an effective means for engaging people with climate change issues, or if it instead distances them (Miles 2010, 2014; O'Neill and Smith 2014). Art's involvement could be connected to a concern about art's instrumentalization, and its loss of autonomy (Nurmis 2016). Artists, like other public intellectuals in the climate change discourse, might also be perceived as lacking expertise to create and communicate such images (Nisbet 2014). Viewers might therefore distrust art's participation in the climate change discourse.

Trust in the source and message, however, plays an important role in the effectiveness of climate change communication: it is an important predictor of people's willingness to support mitigation strategies (Hagen, Middel, and Pijawka 2015). It has also been acknowledged as a factor predicting engagement with the specific field of information visualizations (Kennedy et al. 2016). They are likely to establish credibility, provided they are realistic, and their communicators are trusted, such as environmental organizations (Hagen, Middel, and Pijawka 2015).

AIVs' ability to establish credibility is rather unclear. Whereas scientists and environmental organizations are among the most trusted communicators for communicating climate change in the Netherlands (Hagen, Middel, and Pijawka 2015), the credibility of artists in climate change communication is under-researched. Therefore, the question remains, how trusted are artists as creators of information visualizations, particularly when dealing with the topic of climate change?

Materials and methods

Location and sample

The Netherlands forms a relevant case to examine climate change communication as around one third of the country is situated below sea level. Although potential negative impacts are gauged to be manageable, it has to cope with already existent or likely projected climate change effects (e.g. rising sea levels, and more extreme weather events). Furthermore, the country lags behind in terms of emission reduction and sustainability measures (Koelemeijer et al. 2017). A majority of residents are aware of climate change, and there is a need to involve as many people from the general public as possible in this topic (Hagen, Middel, and Pijawka 2015).

Purposive sampling was used and aimed to include respondents with different background characteristics (Dutch and international, students and workers, men and women, art experts and novices¹). They all shared the common characteristic of being adult citizens living in the Netherlands. A diverse sample of members from the general public holding different perspectives acknowledges that the involvement of the broader public's attitude and behaviour is essential in the combat against climate change (Hagen, Middel, and Pijawka 2015). An in-depth analysis of perceptions of 11 respondents was employed. While being a small sample, it allowed us to sufficiently answer our research questions, which is in line with sampling considerations in qualitative research (Mandal 2018; Marshall 1996). Moreover, instead of including a certain minimum number of participants, this study is concerned with richness of information, appropriateness of data and depth of analysis. *Multiple* methods – surveys, q-sort and interviews – were applied to each of the eleven participants. As O'Reilly and Parker (2012, 195) explain, 'the legacy of quantitative science appears to have left a cultural residue of larger numbers having greater impact. This is not applicable to qualitative work as more data does not necessarily lead to more information'. This initial study about AIVs and climate change helps laying the foundation for future research and extending the present research question and methods.

The respondents were recruited in (semi-)public spaces in Rotterdam, such as in a shopping mall and on university campus. Study participants were approached to take part in a research about peoples' thoughts about climate change visuals, comparable to the way O'Neill et al. (2013) informed their participants semi-openly about the intent of their research.

Climate change visualizations

This research assesses the AIVs with respect to four other visual forms, which are often used in the communication of climate change (Manzo 2012; O'Neill et al. 2013; O'Neill and Nicholson-Cole 2009): (non-artistic) information visualizations, news photos, digital art and cartoons.

The included AIVs, the focus of this study, encompassed types of digital art, sculpture and paintings. They were selected after an online search was conducted, using the keywords 'art', 'data' and 'climate change'. Furthermore, the depicted topics all followed a problem-focused narrative, which can create attention and salience (Corner, Webster, and Teriete 2015) and was dominant in climate change communication at the time of the data collection (O'Neill 2013; O'Neill and Smith 2014; Smith and Joffe 2009). The other visual forms – information visualizations, news photos, digital art and cartoons – were then identified in a similar manner based on the problem-focused climate change topics. This study therefore includes *causes* of climate change, such as the production of

greenhouse gas emission through transportation, and energy. It also involves climate *impacts* such as rising temperatures, intensified weather events, and melting ice. Certainly, these topics do not exhaust all possible climate change causes and impacts. The goal of a q-sort is not to be representative, but to offer an array of available options. [Table 2](#) provides an overview of the included AIVs, along with the other visual forms.

Data collection and analysis

Our research question was examined in multiple ways: By examining participants' arrangement of visuals and striking sorting behaviour (q-sort), verbal expressions (during interview), and written expressions (survey).² The q-sort, interview and survey were audio recorded. Moreover, each participant's q-sort of images was photographed. The transcripts and photographs were inserted into the research software ATLAS.ti for analysis (coding).

Q-sort

The first RQ was mainly investigated through a q-sort. In this sort, participants were asked to arrange several climate change visualizations on a sorting grid according to the statement 'This image makes me feel climate change is important', which measures sense of salience (see [Figure 5](#)). Based on q methodology indications, 25 images can be considered an appropriate number (Watts and Stenner 2013). Five sets of each five images were used in the q-sort.

The goal is to achieve a meaningful sorting from most disagree to most agree, and reveals *which* image is sorted *where*. Before sorting the images on the grid ranging from most disagree -4 to most agree +4, participants were asked to first create three piles: 1. 'These visuals make me feel climate change is not important', 2. 'I am undecided about these visuals', and 'These visuals make me feel climate change is important'. The pile sorting eased the further distribution in the grid into disagreement, undecided and agreement areas.

As images are hardly ever perceived in isolation in everyday decoding, we included captions to provide context for the viewer (see O'Neill [2013]). First, image captions, indicated the depicted content: 'Flight traffic/air pollution'; 'Increasing use of fossil use'; 'Temperature increase'; 'Intensified weather events'; 'Melting ice'. Second, to guarantee comparability, the following sources are indicated in the captions: environmental organization (for information visualization and news photos), data artist (for AIVs), artist (for digital art), and cartoonist (for cartoons).

Table 2. Overview of included visuals, addressed topics, creators, tone, data focus and engagement in terms of sense of salience (Herring et al. 2016; Johansson, Neset, and Linnér 2010; Manzo 2012; O'Neill et al. 2013; Roosen, Klöckner, and Swim 2017; Sommer and Klöckner 2019).

| | Visual type 1 | Visual type 2 | Visual type 3 | Visual type 4 | Visual type 5 | Addressed topic |
|--------------------|-------------------------|---------------------------|-------------------------------------|---------------|---------------------------|-------------------------------|
| | IV 1 | News photo 1 | AIV 1: <i>Painting</i> | Digital art 1 | Cartoon 1 | Increasing use of fossil use' |
| | IV 2 | News photo 2 | AIV 2: <i>Painting</i> | Digital art 2 | Cartoon 2 | Melting ice' |
| | IV 3 | News photo 3 | AIV 3: <i>Painting</i> | Digital art 3 | Cartoon 3 | Temperature increase' |
| | IV 4 | News photo 4 | AIV 4: <i>Digital art</i> | Digital art 4 | Cartoon 4 | Flight traffic/air pollution' |
| | IV 5 | News photo 5 | AIV 5: <i>Sculpture</i> | Digital art 5 | Cartoon 5 | Intensified weather events' |
| Creator | Other than artist | Other than artist | Artist | Artist | Artist | |
| Tone: | Data-based | Realistic | Data-based | Dramatic | Satirist Funny | |
| | | | Artistic | Artistic | | |
| Data focus: | Yes | No | Yes | No | No | |
| Engagement: | No, if only fact-based. | Yes, feelings of salience | Unknown | Unknown | Yes, as visual commentary | |
| | Yes, if interactive | | | | | |

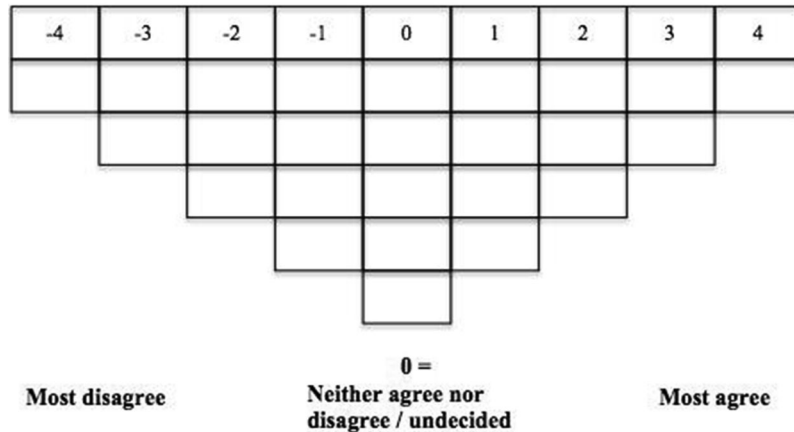


Figure 5. Q-sort grid for the arrangement of 25 visuals regarding the statement 'This image makes me feel climate change is important' (based on O'Neill et al. 2013).

Post-sorting interviews

The second RQ was addressed in post-sorting semi-structured interviews, allowing participants to express their views regarding the capabilities of AIVs and other visual forms, their art interest and education, and regarding art's involvement in climate change. While the q-sort reveals which images are sorted where, the interview uncovers *why* participants arranged the images in the way they did. The interviews therefore allow advancing the data richness and quality of the q-sort (Watts and Stenner 2013). These interviews lasted about an hour on average (interview guide available upon request).

Survey

This research also included a short survey before the q-sort and interview to understand how participants perceive the topic of climate change. This is important as people who are more concerned about climate change might engage differently with climate change visualizations. It included questions such as: how worried are you about climate change? How serious a threat do you consider climate change? Should the Dutch government treat climate change as a very important policy priority? Furthermore, participants were questioned about their interest in climate change and related environmental topics as well as their interest in the arts. Participants indicated their answers to the aforementioned questions on a scale ranging from 1 (not at all) to 5 (very) and added comments in provided spaces (e.g. specifying their interest in the arts). This survey also included questions about participants's age, gender, education, place of residence, international background, and occupation.

Results

Sorting: news photos are most engaging and AIVs are the least engaging

Table 3 depicts each visual type's images sorted in the three broad disagreement, undecided and agreement areas. This general overview shows that news photos and AIVs mirror each other. While the former were found most engaging (average score: +1), i.e. made participants feel climate change is important, the latter were found least engaging. AIVs have the lowest average score of all visual types: -1; participants on average slightly disagreed with them making them feel climate change is important. For the digital artworks, participants' arrangements were almost equally divided between either agreement or disagreement. Cartoons and information visualizations were quite evenly spread across the three areas. Moreover, most participants showed hesitation when sorting the AIVs; they took more time to place them, and changed them around more often, compared to other visual types. A general answer to the first RQ can be formulated: *in comparison* to the other visual types, AIVs were least able to depict climate change as an important topic.

Table 3. Each visual type's count per disagreement, undecided and agreement areas for the five visual forms and the statement 'This image makes me feel climate change is important'.

| | “This image makes me feel climate change is important” | | | | | | | | | Sum | Average (−4 to +4) |
|-------------|--|----|----|-----------|----|-----------|----|---|---|-----|-----------------------|
| | −4 | −3 | −2 | −1 | 0 | 1 | 2 | 3 | 4 | | |
| | Disagreement | | | Undecided | | Agreement | | | | | |
| AIV | | 34 | | | 9 | | 12 | | | 55 | −1 |
| INFO VIS | | 16 | | | 22 | | 17 | | | 55 | 0 |
| NEWS PHOTO | | 12 | | | 8 | | 35 | | | 55 | +1 |
| DIGITAL ART | | 26 | | | 2 | | 27 | | | 55 | 0 |
| CARTOON | | 22 | | | 14 | | 19 | | | 55 | 0 |
| | | | | | | | | | | 275 | |

Reasoning: clarity, immediacy and emotion

Our results point towards three main reasons for a particular sort. First, participants' recurring sorting criteria across the whole sample were 'clarity', 'reality', and 'facts'. Sam (student, Health Care) said, 'I mean metaphors work on some people but they don't work on me. I prefer clear, realistic data and visual depictions about climate change'. Second, 'immediacy' was also frequently mentioned. Ling (student, Arts and Culture Studies) commented:

Here [points at information visualizations], it takes a long time to figure it out what it is about. And here [points at news photos on agree side] I immediately know what it is, I don't even need to think about it. And this [points again at information visualizations], I totally lost connection with it.

Third, the majority of participants preferred being emotionally touched by climate change images, as illustrated by Kirsten's (communications manager) comment,

So that's I think pure emotion. Same here [points at news photo 'Increasing temperatures'], I think it's impressive, what you see here, it's something you recognize from the news and you feel the story behind it. And I immediately have to think about the people living there or who used to live there.

Similarly, recurring sorting criteria for disagreement were lack of understanding the visual, insufficiency of connection to climate change, and either dearth or excess of felt emotion. The establishment of credibility was only occasionally among the remarks. In contrast, an appreciation of novelty in the depiction of climate change was not voiced by anyone.

A preliminary answer to the second RQ can hence be formulated. Participants indeed made numerous references to the visual types' capabilities of eliciting cognitive and emotional engagement: clarity, immediacy, and emotional impact. Information visualizations were considered clear by some, but also not emotional enough by many. News photos were perceived as being especially clear and direct. Digital art visuals were considered clear, but their dramatic depictions divided opinions. Cartoons were also found clear, but style and humour separated participants' perceptions. The perception of AIVs, the focus of this research, will be detailed below.

Disagreement with AIVs: lack of clarity and strong emotion

The disagreement sorting criteria for AIVs reveal that this visual type does not fulfil the overall criteria of clarity, immediacy and emotion. This was mainly due to a lack of understanding of them, and insufficiency of perceived connection to the issue of climate change. The question concerning their capability for information provision in climate change communication has thus to be negated, at least for a majority of AIVs and in the context of this small sample. However, disagreement did not necessarily only include negative descriptions. Even disagreeing participants found several positive descriptions, for instance, 'nice', 'interesting', and 'beautiful'. Yet, they then were usually followed by a 'but not understood', or 'but no clear connection to climate change'. This shows how aesthetic appeal and interest were for most participants not sufficient in climate change communication in the absence of recognisability and clarity.

Besides a lack of understanding, another dominant criterion for disagreeing with AIVs was their incapability to elicit *strong* emotions. For

example, Kirsten was among the few participants who said that she liked and understood *some* of them. However, she was not sufficiently emotionally touched when connecting it to the climate change issue, ‘It’s beautifully made but it’s not really giving me that sense of emotion and impact’. Similar remarks concerning a lack of emotion were articulated by other participants. Furthermore, novelty – theorized to be a possible advantage of AIVs in the communication of climate change – was not a dominant sorting criterion. Thus, the expectation concerning AIV’s capability for strong emotional responses and the importance of novelty in climate change communication have also to be rejected for the AIVs.

Agreement with AIVs: degree of abstraction, aesthetics and post-explanation understanding

The agreement sorting criteria for AIVs – while limited in number – help us to further explain their role in audience engagement with climate change. First, respondents only incidentally found AIVs effective (i.e. they made them feel climate change is important). They then referred to the specific visual properties of AIVs: the degree of *abstraction* and thus clarity. ‘Fossil fuel’ (see Figure 1) and ‘Melting ice’ (see Figure 6) – both by the same artist with similar artistic style and clarity – were for instance described by several participants as being clearer depictions of climate change than ‘Temperature’ and ‘Weather’ (by other artists).



Figure 6. Artistic information visualization (AIV), *Moments of Observation*, by artist Jill Pelto. Right image was shown to study participants. Jill Pelto: ‘Within the sunglasses you can see the image of the glacier landscape, reflecting the graphical lines that denote where the glacier used to extend only several decades ago. [...] When an alpine glacier quickly melts, it leaves behind a mess of rocks mixed with the sludge from saturated glacial flour (ground rock). It creates a treacherous zone where any step could give way to a boot filled with mud.’ (<http://www.jillpelto.com/moments-of-observation>). Acrylic and collage, 60.7 × 91.4 cm, 2015. Reproduced with permission from the artist.

Second, respondents could find the AIVs appealing, but then would not find them effective. For instance, Ling recognized that, 'I think these are really good art works, but I focus more on the artwork itself rather than what it represents'. Third, three participants changed their sorting of AIVs towards agreement after the interviewer provided additional post-sorting context about them. This illustrates how further information and understanding might increase agreement with AIVs for at least some people, in line with the abovementioned disagreement reasoning. After being given explanations, Yvonne (student, Fine Arts) re-sorted four AIVs she had previously placed in the disagreement area, resulting from what she referred to as increased understanding. After the re-sorting, all AIVs made her feel climate change is important. She explicitly and strongly praised the mix of data and art, 'I really like how they [...] use data in them to give the message of climate change. The way they combine the data with their art and their perception of it. [...] Clever!'. Furthermore, she deeply enjoyed the aesthetics, 'I like the colours used in them and that there is like this serenity, this calmness'. In sum, AIVs' potential in uniquely combining data and art – facts for cognition on the one side, and art for the novel touch on the other – could only be determined in rare cases, at least for the present sample.

Audience decoding skills: art experts more involved with AIVs

The lines of reasoning discussed above seem to suggest that participants are lacking sufficient interest or education in the arts to interpret or understand AIVs. Yet, the surveys revealed almost all respondents were slightly or even highly interested in the arts. However, some participants believed that someone with a stronger artistic background might be more capable, in terms of expertise, to interpret AIVs. These statements were not voiced regarding the other visual types. Carla (student, Business Information Management) for instance said, 'I think people who are more into art might make more sense of them. What I could imagine is that they are more trained to look at specific details, simply because they know more about artistic styles, about drawing types'. In a similar vein, Pedro (student, Public Health and Research Policy Master) stated that, 'Possibly with an artistic background we would see [...] possibly particularly this mad-looking art to the right side, higher on the scale [of the q-sort]'. These comments were not made concerning a need for a scientific background to understand the AIVs better. A possible reason might be that AIVs were mostly not seen as a *combination* of data and art, but mainly as artistic works.

Still, sorting behaviour does not show a clear relationship between an arts education and a *preference* for AIVs. One respondent (Yvonne)

sorted all of them on the agreement side, another (Jelena) disagreed with all of them, and two others (Ling, Arthur) partly agreed. The sorting reasoning of art experts does show a clear understanding of – and pondering over – aesthetics, even when *disagreeing* or only slightly agreeing with AIVs. Ling strongly focused on the AIV's aesthetic appeal, and although Jelena (illustrator) was disagreeing with all AIVs, she did claim to understand them very well. Her sorting criteria for not agreeing with them actually referred to a strong disapproval of their aesthetics. Yvonne, as was elaborated upon earlier, strongly considered both aesthetics and clarity, as did Arthur (art dealer).

Thus, an arts education does seem to influence engagement when compared to people without arts education (but with an interest in the arts) in this small sample. Art experts are more involved with AIVs (manifested in stronger opinions on aesthetics and understanding) than arts novices.

Encoder credibility: no major credibility considerations

Table 3 already revealed that there is no clear divide in terms of agreement between *artistic* and *non-artistic* visuals in the sorts across the sample. For instance, another artistic visual type, namely digital art visuals, is spread across the whole agreement to disagreement spectrum. This suggests that the AIV's accumulation in the disagreement column is not connected to a general opposition against art's involvement in climate change communication. However, other entities were frequently voiced as more effective social actors to be involved in climate change communication (scientists, politicians), mostly due to artists' assumed lack of scientific knowledge.

With regards to the credibility of artistic sources (trust), participants did *not* voice any general distrust in the arts communicating about climate change. Yet, when asked who they trusted in the communication of climate change, the majority either indicated scientific entities, or environmental organizations. Some compared the arts to these scientific or environmental entities, and while not distrusting the arts per se, they certified the former a higher reliability. Pedro for instance said, 'I would say [artistic visuals] are less reliable in their objectivity. [...] They [information visualizations] are more objective and clear. And then trustworthy.' Moreover, credibility remarks were voiced regarding the *content* of certain visual types, particularly digital art visuals, which significantly influenced their sorting behaviour. The content was found too extreme and incredible and was in these cases sorted on the disagreement columns (e.g. the 'Melting ice' topic was illustrated by a melting earth, and the 'Air pollution topic' depicted Mona Lisa with a gas mask).

When explicitly asked about how trustworthy the AIVs were considered, the majority of participants, both agreeing and disagreeing with the AIVs, indicated (at least some) trust in them. This indication was however usually followed by a 'but', hinting at other problems they had with the AIVs. Pedro said, 'Maybe it's objective information but it's actually confusing'. In a similar vein, Sam said, 'I guess she is a trustworthy source, even if she deals with it in a funny way'. This shows how trust concerning AIVs cannot be an explanation for the disagreement with the AIVs. The restrictions after mentioning the trust ('but', 'even') suggest how other explanations (visual properties and required arts education) appear to be connected to them, and that perceived trust could not make up for these.

Although not a key sorting rationale, participants articulated preferences on how the arts should be involved in climate change communication. Unsurprisingly, most interviewees referred to a clear, non-abstract, non-ambiguous, and self-explanatory artistic style. Ling commented, 'I think it's about communication between the artist and the audience you know. [...]. Let me understand it. [...]. You must let people understand it because you want them to get aware of it'. Participants often mentioned digital art visuals and cartoons as examples about how the arts should be involved in climate change communication. Some participants referred to possibly agreeing with AIVs more in a different context, for instance when seeing the original works in a museum. Moreover, almost all participants had some remarks on how AIVs should be designed when they want to be effective in climate change communication. In line with the recurring overall clarity criteria of climate change visuals, participants want AIVs to be more understandable, for instance by being provided with additional legends on the side, indications and meanings. However, some participants also questioned such improvements. Carla for instance pondered this measure to be going against art's nature, 'My question would then just be: Does the art meets its target if it needs tremendous explanation and does not make *myself* [emphasis] think "Oh ok something is wrong here"'. Ling did not want anyone to explain the visuals to her, 'Because you know, if this is really important, I would have preferred to discover this, the data, by myself rather than have someone explain it to me', and Jelena noted, 'I don't think they should change. Because [...] that's the beautiful thing of being an artist [...], there are no rules. So you can make what your heart desires for'.

In summary, art's instrumentalization, loss of autonomy and trust considerations were of no concern to the present sample. Hence, across the whole sample, art is not opposed to in the communication of climate change. It rather seems that the AIVs were found less effective *than* the other visualization types for reasons of lack of clarity and emotion.

Discussion

This research examined audience engagement with climate change visualizations, emphasizing AIVs and their capability to render the issue of climate change important. Answering the first RQ, AIVs were found to be the least engaging based on sorting behaviour (i.e. their visualizations made participants least feel climate change is important). In addition, this research supports previous research in Australia, the United Kingdom and United States, which focused on photos as dominant visualization type depicting different climate change discourses (O'Neill et al. 2013; O'Neill and Nicholson-Cole 2009). The connection between information visualizations and sense of salience could not be validated in this research. This supports recent claims that merely fact-based communication about climate change might be insufficient (Roosen, Klöckner, and Swim 2017; Sommer and Klöckner 2019). Furthermore, both the digital art visuals and cartoons strongly divided participants' opinions on making them feel climate change is important.

The second RQ addresses *why* particular visualizations did (not) make participants feel climate change is important (i.e. investigated their sorting *reasoning*). Given the answer to the first RQ, the investigation of this part especially attempted to ascertain: why did the AIVs perform less well than the other types, at least in this small sample size? First, for most participants, many AIVs did not fulfil the criteria desired in effective communication of climate change: clarity, immediacy, and emotional impact. Thus, AIVs, especially the more abstract ones, were perceived as less suitable to communicate climate change effectively. Furthermore, novelty was not considered a key sorting reasoning. The combination of art and data was neither mentioned nor cherished. These sorting rationales could imply a need to adjust the theoretical concepts surrounding AIVs, for a complex issue like climate change. AIVs's core competency in being able to show various degrees of data focus and artistic style (Kosara 2007; Lau and Moere 2007) might indeed be somewhat limited in climate change communication. The issue of climate change might demand a need for certain recognizability, or necessitating additional explanations, for instance in the form of accompanying texts and legends.

Second, this choice between data focus and artistic freedom might also depend on what audiences AIVs are targeted at. This research has demonstrated that an education in art contributes to meaningful *engagement with the visualization*. Participants who praised AIVs's aesthetics, showed high interest, increased understanding, or acknowledged the clarity of some of the AIVs. There is the risk, however, that for art-minded people, AIVs might actually distract the focus away from the communication topic. Overall, this research confirms an art novice – art expert

difference for the interest in, and understanding of, complex artworks such as AIVs (Bourdieu 1984; Silvia 2005). It might suggest that AIVs could be especially targeted at art experts (artistically educated audiences such as arts students and artists), rather than the general public (or more explanations can be provided). Moreover, it substantiates very recently voiced claims in the field of information visualization pointing toward the urgent need to integrate audience decoding skills into the study of peoples' perceptions of information visualizations (Kennedy et al. 2016).

Third, a sorting according to an art versus non-artistic form (i.e. information visualization versus AIVs, digital art and cartoon) did not emerge, and hence could not explain the limited engagement with AIVs. While scientific and environmental organizations are more trusted than artistic sources, in line with Hagen, Middel, and Pijawka (2015) findings on the most trusted sources in the communication of climate change, participants did not distrust the art's role in the climate change discourse. Although many AIVs were disagreed with, the majority of participants did trust them, and did not show an aversion to their specific role in climate change communication. Climate change permeates society and art is an integral part of society. This may show how scholars could be less concerned about art's participation in the climate change debate, and more about *how* artists could be involved.

While AIVs suffered from clarity issues, digital art visuals and cartoons, although performing better than AIVs, resulted in mixed opinions because of their dramatic depictions and suitability of humour. For a majority, they even undermined their perceived ability to *do* something about climate change. This adds to previous research on apocalyptic content in news photos leading to helplessness (O'Neill et al. 2013; O'Neill and Nicholson-Cole 2009). It substantiates scholars' findings on the importance of trust for engagement with climate change communication (Hagen, Middel, and Pijawka 2015).

Conclusion and avenues for future research

Regarding RQ 1 (how salient) it can be concluded that the AIVs least made viewers consider climate change as important. Yet, this finding has to be situated in comparison to the other visual forms that participants were exposed to. With respect to RQ 2 (reasoning for issue salience), it can be concluded that some AIVs appear to be more effective than others. They were judged clearer and more agreed with than other AIVs, suggesting that a less abstract, clearer AIVs style might be more suitable than others. AIVs required art education or training for a more meaningful engagement. Possibly, accompanying further explanatory descriptions to the visualizations could support the viewer's understanding of the

visualizations. Overall, the study participants did not show distrust in art's involvement in the climate change discourse. This supports this article's premise to further develop the role of the arts and humanities in addressing climate change, one of the biggest challenges for humanity and the planet.

The design of this research – small-scale, non-random, and non-quantitative – does not allow for generalizability regarding the effectiveness of the visualizations. In fact, its value lies exactly in its exploration and particularity rather than broad generalizability of the findings. This research is the first to explore the effectiveness of AIVs in climate change visualization and offers various avenues for future research at the intersection of climate change and art. First, future research could include numerous different styles of AIVs in terms of abstraction and compare AIVs with different explanatory statement lengths. This would allow adding to insights concerning the struggle between data and art focus (Kosara 2007). Second, other relevant types of engagement could be studied, for instance the connection between exposure to climate change visualizations and behavioural engagement with climate change.

Besides further investigating different AIVs styles and levels of engagement, another fruitful avenue for future research pertains to the narrative employed in the visualizations. As Dunaway (2015) has shown by analysing a wide range of photos, cartoons, films and other visual forms, images have the power to meaningfully portray climate change, but also to create anxiety. A problem-focused narrative, although dominant for years in the communication of climate change, might need to be replaced or complemented by alternative narratives (Roosen, Klöckner, and Swim 2017), such as *solution*-focused narratives. This is where the arts and humanities can play a major role. Next to complementing the scientific narrative, they can add inspiring, hopeful imaginations of our future (Hulme 2011; Roosen, Klöckner, and Swim 2017).

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Supplemental data

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Notes

1. Defining art experts as holding an academic education and training in the arts, while art novices are not educated in the arts.
2. Materials and methods based on previous research of visual imagery in climate change communication (Nicholson-Cole 2004; O'Neill et al. 2013; O'Neill and Nicholson-Cole 2009).

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