Pictures vs. Cartoons

Experimental research into the effects of different types of visual representations used in climate change communication on the comprehension and sense of action of lower educated viewers

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Abstract

The media often use different visualizations (e.g., pictures and cartoons) to make complex topics, such as climate change, understandable to the public (Moser & Dilling, 2004; Wang, Corner, Chapman, & Markowitz, 2018). A frequently used visualization for climate change are pictures (Wang et al., 2018). Pictures can make complex topics more accessible, since they can directly show and "bear witness" (Doyle, 2007, p. 131). However, since pictures often show consequences, they give people a feeling of being already too late to act upon it (Doyle, 2009). On the other hand, cartoons are visualizations that show a clear opinion and "desire for action" (Manzo, 2012). They can show the causes of climate change, which may encourage viewers to take action. Cartoons rely on imaginative symbols, metaphors, and public knowledge that entail analytical challenges for viewers (Manzo, 2012). Since the news media are a major source of information for people, and they can shape the public perceptions of climate change (Wang et al., 2018), it is important to investigate the effects of different visualizations, like pictures and cartoons, in news media on viewers. The aim of this study is to investigate the possible effects of type of visualization and their complexity on the comprehensibility and sense of action of viewers. The current study focuses specifically on lower educated people, since few studies have critically examined how people engage with different visual representations of climate change in the mass media, especially when it comes to this target group.

The effects of type of visualization and complexity were investigated with an experiment in which 40 lower educated participants evaluated visualizations in newspaper articles. The experiment had a 2 (type of visualization: photo/cartoon) x 2 (complexity: simple/complex) within-subjects design. Each news article with visualization was followed by questions that measured actual comprehension, perceived comprehension, and sense of action. The results showed that pictures were easier to comprehend than cartoons, but neither pictures nor cartoons had a greater effect on sense of action. Moreover, the complexity of the visualization had no influence on whether the visualization leads to more or less comprehension or sense of action. Based on these results, it was concluded that news media and designers could use pictures to use and create specific news items for communicating climate change to lower educated people.

Keywords: climate change communication, visualizations, pictures, cartoons, complexity, simple, complex, comprehension, sense of action, lower education

1. Introduction

Extreme weather is a subject that is becoming more popular in news articles. For example, at the beginning of 2019, news articles in America wrote about the polar vortex that caused brutal ice-cold temperatures far below freezing (Simon, 2019), while news articles in Australia wrote about an extreme heatwave (Regan & Westcott, 2019). By writing about and showing visualizations of extreme weather events, a link is potentially created between these disastrous events and human-caused global warming (Lester & Cottle, 2009). However, climate change is a slow and gradual modification of average climate conditions (Weber, 2010). Observations of climate (change) are spaced in time, and memory of past events can be faulty. As a result, climate change is a long-term process that is not easily detected by personal experience (Knebusch, 2008; Weber, 2010).

The media make it possible to visualize climate change. The media can shape, translate, and interpret information for people (Bell 1994, as cited in Moser & Dilling, 2004), and people use these media representations to interpret and make sense of complex topics like climate change (Moser & Dilling, 2004). Visualizations and stories in the news can potentially influence people's perceptions about complex topics. They help to communicate and simplify information, make messages memorable, summarize complex information, communicate concepts instantly, and provide a basis for personal thoughts and social interactions that contribute to people's memories, awareness, and opinions about topics (Farr, 1993). News media should make people aware that climate change is recognized as a global crisis that involves and demands concerted political response from governments, corporations, and citizens around the globe (Lester & Cottle, 2009).

Climate change is represented in the media through a range of visual representations, such as photographs, videos, graphs, charts, cartoons, infographics, and games (Wang, Corner, Chapman, & Markowitz, 2018). Of these forms of visual media, photographs and videos are most frequently used to display climate change in digital media, in online news media, social media, and other areas (Wang et al., 2018). These visual media representations are powerful and important links between people's daily realities and experiences (O'Neill, Boykoff, Niemeyer, & Day, 2013). They are used to communicate the message of climate change (Schneider, 2012) by creating a more tangible idea of this abstract issue (O'Neill & Nicholson-Cole, 2009).

When communicating complex topics such as climate change to the public, pictures are an effective tool for meaning-making (O'Neill et al., 2013). An example of a picture of the polar

vortex can be seen in Figure 1a. It shows a satellite picture of North America that is covered in clouds derived from the North Pole. This is an example of how pictures can make abstract issues more accessible: they can directly show and "bear witness" where words can only describe the issue (Doyle, 2007, p. 131). They furthermore have a function of 'evidence' because pictures of, for example, melting and retreating glaciers can be used as proof of the reality of global warming (Doyle, 2009). However, both academics (e.g., Doyle, 2007) and photographers have noted that the complexity of climate change and its potential and often invisible risks make the issue difficult 'to illustrate photographically' (Smyth, 2007, as cited in Manzo, 2010).

(a) (b)

Figure 1. (a) A satellite picture of the polar vortex in North America; (b) A cartoon of the polar vortex used as a manner to express criticism.

Cartoons are visualizations that do not necessarily need the realism of the world to address and illustrate problems in the real world. Cartoons are "powerful sites and sources of popular geopolitical representations" (Dodds, 2010, p. 2). Cartoons use imaginative symbols and metaphors to visualize concepts that are invisible (Manzo, 2012). Cartoons can construct fantasy scenarios and imaginary worlds through the "metaphorical combination of the real and the imaginary" (El Rafaie, 2009, p. 186). Thus, even though they fail to provide visual evidence of climate change, they can still convey a political message that climate change exists (Manzo, 2012). Figure 1b shows an example of a critical cartoon with the polar vortex as the subject. Since cartoons are so critical, they also "desire for action" (Greenberg, 2002, p. 184-185), perhaps more than pictures do. However, since cartoons use metaphors, they can be ambiguous and complex. Differences of interpretation are possible, even among those with the multiliteracy skills required to decode visual discourse (Manzo, 2012). So while cartoons are normally understood by readers to be satirical depictions of real events, they request public knowledge and a common sense view of the world (Dodds, 2007).

Cartoons are thus quite complex, perhaps even more complex than pictures. The suitability to use either a picture or a cartoon may therefore depend on the receivers and their level of education, which can be higher or lower. For example, different (multiliteracy) skills are needed to understand cartoons and these skills have to be learned and understood. Multiliteracy skills and educational level can be seen as a component of socioeconomic status (SES). Childhood socioeconomic status is associated with cognitive achievement throughout life (Hackman & Farah, 2009). A study from Korat (2005) showed for example that, compared with their higher SES peers, low SES children had poorer knowledge. This gap in knowledge makes it possible that lower educated citizens have more difficulties understanding visualizations like cartoons. Furthermore, Maes (2017) remarks that little is known about the extent to which audiences with lower levels of education are able to make use of visual representations in general and with respect to climate change communication specifically. This difficulty of understanding visual representations may even be even bigger for lower educated people when it comes to complex visualizations. Viewers are expected to have even more knowledge and common sense for complex visualizations, but lower educated may lack of this knowledge.

In sum, more and more studies focused on how to communicate climate change more effectively to different kinds of audiences, mostly addressing language-based communication (Wang et al., 2018). However, people's understanding of the use of visualizations in communication, and how they shape public perceptions of climate change, is less examined (Wang et al., 2018). Few studies have critically examined how people engage with different visual representations of climate change in the mass media, especially when it comes to lower educated people. Little attention has been paid to the possibility that different types of visualizations, with different levels of complexity, may work differently for lower educated people. Designers and journalists could use the results of the current study to create and use better visualizations to communicate complex topics like climate change. The current study would like to investigate the following research question:

How do different visual representations (pictures vs. cartoons) and their complexity affect the comprehensibility and sense of action of lower educated viewers on a complex topic such as climate change?

2. Theoretical Framework

2.1 Dependent variables: comprehension and sense of action

Visualizations about climate change can have various goals, such as comprehension and sense of action. The current study is interested in the effect of different types of visualizations on comprehension and sense of action. Firstly, to explain the comprehension of visual information, the Dual Coding Theory (Paivio, 1971, 1986) can be used. This theory proposes that there are two separate, but interconnected cognitive subsystems that encode, organize, and transform information (Paivio, 1986). The first information-processing system specializes in text and verbal information and can be accessed by linguistic stimuli (Verges & Duffy, 2009). The other information-processing system specializes in graphics and nonverbal information and can be accessed by pictures and other nonverbal stimuli (Verges & Duffy, 2009). Thus, verbal and nonverbal information is processed in separate systems, but creates similar representations for the processed information. For example, when someone sees a polar bear, that person can store the information as the word 'polar bear', but also as an image of a polar bear. When the viewer is asked what he/she saw, the person can retrieve the information either as a word or as an image, or both simultaneously (Clark & Craig, 1992). Since there are two cognitive pathways instead of one way to retrieve the information, it increases the chance of remembering information. This makes it easier to learn, and consequently comprehend, information (Clark & Craig, 1992).

The fact that there are two information-processing systems means that the additive effect of both verbal and visual information is better than a verbal pathway alone (Paivio, 1975). Visual information, like visualizations, can help people to comprehend texts (Glenberg & Langston, 1992) and understand complex topics by organizing complex information and supporting cognitive processes (Schnotz, 1993). According to the Dual Coding Theory, this combination of the two pathways is needed to learn and comprehend information. People have to make a verbal representation of the verbal information, a visual representation of the visual information, and have to make connections between these verbal and visual representations (Mayer & Sims, 1994). Presenting both verbal and visual information increases the likelihood that people will be able to connect the verbally and visually presented information. Since people can connect the information easier, they can understand the information better. This finding, that presenting both textual and visual information can enhance the learning process, has also been found in the study of Mayer (1989) where students were better at understanding what they had learned when text

and visualizations were presented next to each other rather than when text and visualizations were isolated.

However, visualizations can only support the comprehension of texts if people understand the visual information of the visualization. If people do not understand the visualization and the information it conveys, it is not possible for them to make a visual representation from the information. If there is no visual representation, people cannot connect this representation to the verbal representation. As a consequence, the visualization cannot support the text. In order to understand visual information, people might need prior knowledge. According to the model of Hegarty (2011), people can have prior knowledge because of their knowledge of the display scheme. This influences the way a viewer represents the information because he/she can think: normally the visualization looks like this, so now I have to interpret it like this. Another form of prior knowledge is domain knowledge. This is the world knowledge viewers have about the topic of the display. This prior knowledge will interact with new information from the visualization. This new information will be linked to the prior knowledge so that the information from the visualization can be understood (Hegarty, 2011). It is possible that lower educated people are lacking display scheme and/or domain knowledge to interpret and understand visualizations. In sum, visualizations can help texts to make information more comprehensible, but only if one has enough knowledge to understand the visual information.

Besides comprehension, sense of action is the second dependent variable used in the present study. In order to clarify the concept, the Theory of Reasoned Action (TRA) (Ajzen & Fishbein, 1980), and the Theory of Planned Behavior (TPB) (Ajzen, 1985) are used. In general, these theories focus on the likelihood of an individual to perform a specific behavior (Montano & Kasprzyk, 2015). The two theories are represented in Figure 2 (Montano & Kasprzyk, 2015, p. 70). The upper light area shows the TRA and the entire figure shows the TRB. The TRA exists of attitude and subjective norms. The individual's beliefs and evaluations of behavioral outcomes influence the attitude of an individual of performing the behavior. This means that when an individual believes that performing the behavior will have a positive outcome, the individual will also have a positive attitude about performing the behavior. So the individual is, for example, more likely to take action. Conversely, when an individual beliefs that performing the behavior will have negative consequences, he/she will also have a negative attitude about performing the behavior. So the individual is less likely to take action (Montano & Kasprzyk, 2015).

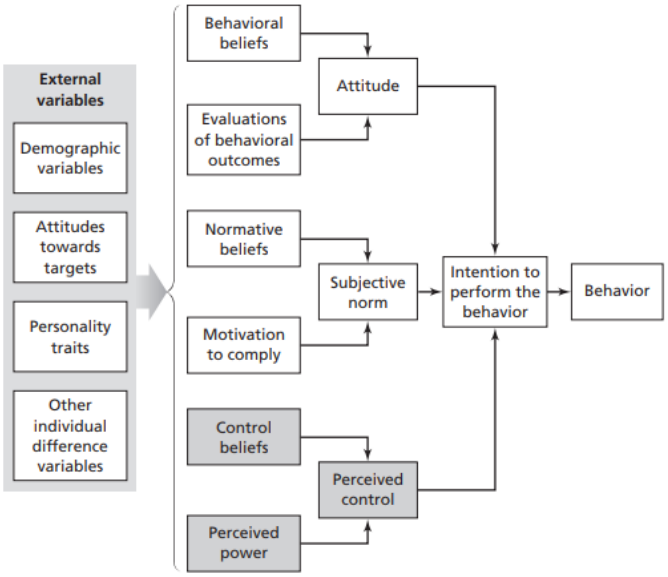


Figure 2. The Theory of Reasoned Action (TRA) and the Theory of Planned Behavior (TPB). Reprinted from "Theory of reasoned action, theory of planned behavior, and the integrated behavioral model", by Montano, D. E., and Kasprzyk, D., 2015, *Health Behavior: Theory, Research and Practice,* p. 70.

An individual's normative beliefs, as well as the motivation to comply, influence the subjective norm. Normative beliefs represent the (dis)approval of performing the behavior of important people in the life of the individual. So an individual who believes that other people think that he/she has to perform a behavior and who is also motivated to comply with those people, will hold a positive subjective norm. Conversely, an individual who believes that other people think that he/she should *not* perform the behavior and who is also motivated to comply, will have a negative subjective norm. When these individuals are less motivated to comply with those people than this will result in a neutral subjective norm (Montano & Kasprzyk, 2015).

Attitude and subjective norm determine whether an individual has the intention to perform a certain behavior, which is why TRA claims that behavioral intention is the most important determinant of behavior (Montano & Kasprzyk, 2015). The success of the theory depends on the degree to which the behavior can be controlled by the individual. However, it is not clear how individuals will behave when the control about their own behaviors is reduced. This is where the TPB (Ajzen, 1985) comes in. More specifically, TPB adds to TRA that

perceived control should also be taken into consideration, since it is another important determinant of behavior. Perceived control and intention together will have an effect on an individual's behavior. Both theories "assume a causal chain that links behavioral beliefs, normative beliefs, and control beliefs to behavioral intentions and behavior via attitudes, subjective norms, and perceived control" (Montano & Kasprzyk, 2015, p. 72).

The type of visualization can determine the extent to which comprehension and sense of action is achieved. In the present study, a comparison will be made between the effects of pictures and cartoons as types of visualizations. The following section explains how pictures and cartoons are different in general (2.2), and the effects of those differences are further explored in 2.2.1 (for pictures) and 2.2.2 (for cartoons).

2.2 General differences between pictures and cartoons

An important distinction between pictures and cartoons is that they differ in their degree of realism. Realism can stand for likeness: the less realistic a visualization is, the fewer characteristics of the represented reality are truthfully incorporated into the visualization. In other words, this means that there are different degrees to which a visualization is visually similar to the reality it represents (Westerbeek, 2016). Pictures are an example of a realistic visualization. Pictures show a similarity to what it depicts, but also show how this depiction is related to what it represents (e.g., a picture can depict a melting glacier that again has to represent global warming). Even pictures can have different degrees of representing reality. For example, a picture in full color is more visually realistic than a picture in black and white and these are in turn more realistic than pictures that show objects in strange or unlikely colors.

In contrast, drawings leave out some details of an object as it is a schematic visualization (Westerbeek, 2016) and could therefore be seen as less realistic than pictures. The style of cartoon drawings are often characterized by simple lines, exaggerating features, sketch like and simplified figures (Hempelmann & Samson, 2008) that are not according to reality. An example of this unrealistic drawing style is that of Gary Larson, as can be seen in Figure 3. His cartoons are characterized by simple lines, round people with small heads, and often containing people with (white) glasses (Hempelmann & Samson, 2008).

Figure 3. A more unrealistic drawing style of Gary Larson.

However, it must be noted that there are differences between styles of cartoonists and that some cartoons are more realistic than others. For example, the drawing style of Robert Crumb is more realistic and detailed than that of Gary Larson (Hempelmann & Samson, 2008). As can be seen in Figure 4, the cartoon consists of more depth and shadow, the proportions of the people are anatomically more correct, and the people have more facial aspects and expressions. Although the cartoon is not entirely realistic, the front man's nose is exaggerated and the back woman's face is simplified, the cartoon as a whole is more realistic than that of Gary Larson.

Figure 4. A more realistic drawing style of Robert Crumb.

Thus, an important difference between the types of visualization is that pictures are generally more realistic than cartoons, but within the visualization there can also be differences in the degree of realism. Since there are differences in realism between the types of visualizations, it is possible that the effects of these visualizations may be different in terms of comprehension and sense of action. The possible effects are discussed in more detail in the following sections.

2.2.1 Pictures as visualizations

When communicating abstract topics such as climate change to the public, pictures are an effective way for meaning-making (O'Neill et al., 2013). While texts are mainly used to communicate climate change, pictures have been considered as a powerful way to "bear witness" to climate change (Doyle, 2007, p. 131). The well-known Apollo 8 photo 'Earth Rise' (Figure 5), taken in December 1968, is an example where the public could finally see what words could not show. This picture was the first view that the general public had of planet Earth in its entirety (Cosgrove, 1994). Even though the world had been described in words many times before, people could now finally "see" what the words tried to visualize.

Figure 5. Photograph of the Earth, taken on December 1968 by Apollo 8.

Besides that pictures give meaning to abstract issues, they also have a function of 'evidence'. In the Western culture there is a notion that seeing is believing (Doyle, 2009). Since Greenpeace first photographed the crack in the Larsen B ice shelf in Antarctica in 1997 (Figure 6), images of melting and retreating glaciers have been used as proof of the reality of global warming, and the resultant climate change: a world visible scarred by a warming planet (Doyle, 2009). The visible evidence of climate change that is recorded by the camera can be given the

status of truth by the "*noeme* of photography": the referential proof that "the thing has been there" (Barthes, 2000, as cited in Doyle, 2009).

Figure 6. Crack in the Larsen B Ice Shelf, Antarctica, 1997. Pictured by Greenpeace.

It is the reality of the past that affects people's feelings since photographs of retreating glaciers depict an already damaged environment. As mentioned before, pictures are a realistic visualization of reality (Westerbeek, 2016). A realistic picture of retreating glaciers is thus a representation of reality that glaciers are melting, but also the related representation that the earth is warming through climate change and has serious consequences (Westerbeek, 2016). Pictures do not only illustrate the current reality of climate change, but also illustrate that humans have failed to take actions in the past to prevent the progression of climate change (Doyle, 2009). They show environmental damage and at the same time give viewers the feeling that the process is irretrievable and that they cannot do anything about it anymore (Doyle, 2009). So even though pictures can help people to become more aware of climate change, they may not contribute to understanding the causes of climate change or show how people unconsciously contribute to it in their daily life. And, unfortunately, that is exactly where people can actually make a difference. The pictures say little about the future (Doyle, 2009).

Furthermore, pictures of glacier recession over time have become symbolic images for climate change. Just like simple and iconic pictures of polar bears and penguins, changing landscapes, floodwaters, forest fires, and bleached coral reefs. Many of these pictures have become clichés (Braasch, 2013). News media often get their images from the same news and

photo agencies, leading to repetition of the same imagery (Leon & Erviti, 2013). This, together with active efforts of leading non-Governmental organizations (NGOs) such as Greenpeace to develop visual icons for climate change, leads to the use of a specific amount of climate imagery, so much so that a "Google image" search for "climate change" produces thousands of variations on a restricted set of image types (Wang et al., 2018). This could possibly mean that viewers become familiar with pictures about climate change.

The drawback of iconic representations of climate change is that they are often distancing (i.e., making climate change seem far away in time and space; Manzo, 2010). They are paradoxical in the way that they heighten people's sense of the issue's importance while simultaneously making them feel less able to do anything about it. A picture can thus be disempowering and raise awareness and consciousness at the same time (O'Neill & Nicholson-Cole, 2009). The findings by Hulme (2009) furthermore suggest that a picture that is highly effective in one domain (e.g., climate change cognition) may be ineffective in another domain (e.g., affect or behavior). So few pictures can effectively address all three aspects of climate change communication at once: cognition, affect, and behavior (Manzo, 2010).

In sum, pictures are important for meaning-making (O'Neill et al., 2013) for abstract issues like climate change and as proof of the existence of climate change (Doyle, 2009). Pictures depict reality (Doyle, 2009) because they do not only show a similarity to what it depicts (e.g., melting glaciers), but also show how this depiction is related to what it represents (e.g., global warming; Westerbeek, 2016). Thus, pictures can possibly show the reality of climate change. Since they are used so often that they have become clichés (Braasch, 2013), it is possible that people are familiar with them. This similarity and familiarity could cause pictures to be comprehensible, even for lower educated viewers. However, pictures show only the consequences and not the causes of climate change. So people only see the already damaged earth and this give people the feeling of being already too late to act upon it (Doyle, 2009). This could possibly result in a lower sense of action.

2.2.2 Cartoons as visualizations

Where pictures may fail to stimulate people for taking action, cartoons do "desire for action" (Greenberg, 2002, p. 184-185). Cartoons are "powerful sites and sources of popular geopolitical representations" (Dodds, 2010, p. 2), and are used by contemporary artists and political

cartoonists to communicate climate change in a creative and inspiring way (Manzo, 2010). They are used as humorous or satirical illustrations in newspapers and magazines (Kleeman, 2006). In 2008, an international political cartoon competition called 'Earthworks' was organized by the Ken Sprague Fund. They invited artists to create 'powerful, uncompromising, and uncomfortable images' designed to express the real meaning of climate change: "not a Costa del Sol on the Welsh coast and palm trees in the garden, but desertification, hunger and poverty" (Adam, 2008, as cited in Manzo, 2012). Most artists used 'barbed humor' to get their message across and did not use 'doom-laden predictions and scientific facts' what is often seen in the news (Adam, 2008, as cited in Manzo, 2012). A number of cartoons from the competition will be shown and discussed to clarify the concept.

Figure 7. "Ampulheta". Sidnei Marques, Brazil.

As Manzo (2012) describes, the cartoon in Figure 7 wants to show that humans are blind to climate change while time is running out. The title of the cartoon is the Portuguese word '*Ampulheta',* which means a glass-shaped sand timer. One thing that stands out in the cartoon is the person on top of the sand timer. Metaphorically, it implies that the subject is (or perceives himself to be) outside of time which means he is both inattentive to global warming and has not yet come into contact with it. In the sand timer it can be seen that the global South has hit the garbage before the North, so the person is probably from the North. This is further reinforced by the financial symbols and the clothes that can be read as either representations of global currencies or as attributes of western societies. So time is running out to save the planet from the

destruction caused by human blindness, inaction, greed, and consumerist lifestyles. It critiques the neo-liberal 'money' frame and addresses that it is the cause of the problem and not a solution to global warming. Cartoons could thus show the cause of the problem, something what often overlooked in most pictures.

Figure 8. "Futuro". Omar Zevallos, Peru.

Besides the cause of climate change, there is another thing that cartoons can show and pictures not, namely the future. As the title of the cartoon in Figure 8 already says, the cartoon shows an imaginative future. Manzo (2012) describes in a clear way what can be seen in the cartoon. The cartoon especially focuses on global warming (the sun) and extreme weather (drought that is symbolized as cracked earth). The message of the cartoon is, once again, that climate change is real and that although people are not aware of it yet, they will feel the consequences if they continue to live like this. The eye catcher in the cartoon is the stage with the numbers. The numbers are used metaphorically to express time. The number one on stage is a tree and represents nature that is first to be affected by climate change. After this, the number two, will be the animals that are going extinct. Although last onto the stage, humans are also part of an earthly biosphere and thus linked to species death and extinction. So even though the effects of climate change are first felt by species more sensitive to biosphere changes than humans, in the end it is inevitable that it will also affect mankind.

As can be seen in the two examples above, imaginative symbols and metaphors enable the cartoon visualization of concepts that are invisible (Manzo, 2012). Cartoons can construct fantasy scenarios and imaginary worlds through the "metaphorical combination of the real and the imaginary" (El Rafaie, 2009, p. 186). They are not realistic depictions of reality (Westerbeek,

2016), since they contain simplified figures, metaphors and even imaginative symbols. The cartoons contain elements that we know from reality such as a human, an hourglass, a skeleton, etc., but they do not occur in reality as shown here. They are placed in a fantasy environment in which there are things that are not possible in reality (e.g., seeing a cloud with someone's thoughts) and in which objects have been taken out of proportion (e.g., an hourglass that is larger than a human being). Even though the cartoons fail to provide visual evidence of climate change, they can still convey a political message that climate change exists (Manzo, 2012), just like pictures do.

Cartoons can be challenging to understand, since they are not very realistic and ask for knowledge of the viewer (Manzo, 2012; Westerbeek, 2016). However, they can still provide a broader perspective on climate change issues (Manzo, 2012). When taken together, cartoons provide numerous illustrations of the various climate change frames as well as broader perspectives on time, space and power. That very diversity, along with the ability of the cartoon form to present complex issues in simplified and accessible forms, causes them to be less realistic, but it is what gives cartoons such as these a useful role to play in climate change communication: not as visual evidence of climate change but as vehicles for education, awareness and debate (Kleeman, 2006; Manzo, 2012).

Thus, cartoons can be useful, but also ambiguous and complex (Manzo, 2012). People have to, for example, understand the metaphors in the cartoon. Viewers can interpret cartoons very differently and it even occurs among those with the right multiliteracy skills required to decode them. Cartoons often consist cultural symbols and metaphors which do not have the same universal meaning. They therefore entail analytical challenges for audiences as well as tensions between clarity and creativity at their sites of production (Manzo, 2012). So while cartoons are normally understood by readers to be satirical depictions of real events, they nevertheless draw from an available stock of public knowledge and reproduce a common sense view of the world (Dodds, 2007). This could possibly mean that cartoons are difficult to comprehend, especially for lower educated viewers. However, cartoons do "desire for action" (Greenberg, 2002, p. 184-185). Cartoons are "powerful sites and can communicate climate change in a creative and inspiring way (Manzo, 2010) that may result in a higher sense of action.

2.3 The current study: type of visualization, complexity and educational level

The current study compares the effects of two visual representations of news visualizations: pictures and cartoons. The study examines the effects of pictures and cartoons on a specific target group: lower educated people. Highly educated people often have less trouble understanding complex topics (e.g., climate change) than lower educated people (Korat, 2005). It is therefore important to examine how complex information can be best displayed to lower educated people so the information can be made understandable for this group.

For this reason, the present study not only looks at the difference between different types of visualizations, but also looks at differences within visualizations. This means that the current study uses both simple and complex pictures and cartoons. Complexity is a general term that seems to mean something different to everyone (Adami, 2002). In the current study, complexity is about the difficulty of processing the visualization. If little extra knowledge is needed and the information in the visualization is easy to process and understand, then it is a simple visualization. However, if more knowledge is needed and the information in the visualization is difficult to process and understand, then it is a complex visualization. A simple picture could be a picture of a sunflower. This is a striking flower that occurs regularly in nature and that people often recognize quickly. People do not need to make extra mental computations to understand the information in the picture. A complex picture is a picture of a microorganism. People cannot see microorganisms with the naked eye, but with the help of a microscope they can. Because people do not encounter these organisms, people are less familiar with them, and have to compute more mental computations to understand what they see. An example of a simple cartoon could be a cartoon with recognizable human beings or animals, while a complex cartoon could consist of drawings full of imaginative figures or metaphors that are not immediately recognizable and need extra mental computations to understand the information in the cartoon.

Although pictures and cartoons address different dimensions of news visualizations, this does not mean that they are used to communicate different messages. They can both communicate aspects of climate change, but they can differ in the way in which they represent the message. In other words, they can have the same content, but this content can be represented differently on a visual level: pictures by depicting reality (Doyle, 2009) and cartoons by depicting illustrations of climate change in broader perspectives on time, space and power (Manzo, 2012). Since pictures are a depiction of reality (Doyle, 2009) and cartoons rely on

imaginative symbols, metaphors, and public knowledge (Manzo, 2012), one could argue that pictures are easier to understand and comprehend than cartoons. However, the comprehensibility of a particular picture or cartoon also depends on the complexity of the visualization. A picture (or cartoon) that demands the viewer to compute extra mental computations to understand the information, may be less comprehensible than a picture (or cartoon) that does not demand such difficult cognitive processes. For example because the difficult information is explained, or because the visualization does not contain any difficult elements. This led to the following hypotheses:

H1: Pictures of climate change are overall easier to comprehend for lower educated viewers than cartoons visualizing climate change.

H2: The effect of H1 is the greatest for simple pictures and the smallest for complex cartoons, with complex pictures and simple cartoons scoring in between.

Furthermore, pictures of climate change are often distancing (Manzo, 2010). They are paradoxical in the way that they heighten people's sense of the issue's importance while simultaneously making them feel less able to do anything about it (O'Neill & Nicholson-Cole, 2009). It seems that it is difficult to show the causes of climate change in pictures and that they give people a feeling of being already too late to act upon it (Doyle, 2009). Thus, pictures may not really encourage viewers to take action. However, cartoons often convey a political message that climate change exists (Manzo, 2012). Cartoons show a clear opinion and "desire for action" (Manzo, 2012) and they can show the causes (and even the imaginative future) of climate change which may encourage viewers to take action. Also here complexity plays a role: a simple visualization is less difficult to process and should rather lead to sense of action, with vice versa for complex visualizations. This results in the following hypotheses:

H3: Cartoons give lower educated viewers more of a feeling that they can do something about climate change than pictures do.

H4: The effect of H3 is the greatest for simple cartoons and the smallest for complex pictures, with complex cartoons and simple pictures scoring in between.

3. Method

3.1 Design

The predicted effects of the factors type of visualization and complexity were examined with an experiment. The experiment had a 2 (type of visualization: picture vs. cartoon) x 2 (complexity: simple vs. complex) within-subjects design. The dependent variables were comprehensibility and sense of action.

3.2 Participants

A total of 43 participants participated in the study. Three people were excluded from the analysis, since they did not fall within the desired educational levels of high school education or secondary vocational education. Among the remaining 40 participants were 19 men (47.5%) and 21 women (52.5%). The youngest participant was 14 years old and the oldest participants was 70 years old (M = 24.65, SD = 13.98). Of the participants, 35 people (87.5%) studied or completed secondary vocational education and 5 people (12.5%) high school education as their highest degree of education.

3.3 Material

The stimulus material consisted of a series of news items constructed by the researcher. The news items contained a short text (approximately 200 words) and a corresponding visualization. In total, there were four short texts about a particular topic of climate change. The four topics were: air pollution, drought, extreme weather, and melting glaciers. The texts for the four topics were searched for on the internet. The texts were written in Dutch, and all news items had a neutral white background and a striking title about the subject of climate change. The texts and the websites from which they were obtained can be found in Appendix 1. The decision to place the corresponding visualization on the right side of the text and to use both text and visualization, instead of just showing the visualization, was made as news items also occur like this in real life to improve the ecological validity.

Four conditions were constructed for one topic of climate change: a news item with a simple picture, a complex picture, a simple cartoon, and a complex cartoon. Thus, the text (and the striking title) remained the same, but the visualizations changed for every condition. It was decided to choose different subjects of climate change in order to avoid possible effects of

‘subject’. This means that multiple topics were chosen to avoid that the topic would affect the dependent variables. Furthermore, to prevent the sequence of visualizations from having an effect on the dependent variables, participants saw the visualizations in a random order.

The independent variable type of visualization was manipulated by placing either a picture or a cartoon in the news item. For both pictures and cartoons, existing visualizations were searched for on the internet. Figure 9 shows a picture and a cartoon on the same topic air pollution.

(a) (b)

Figure 9. (a) A cartoon illustrating air pollution; (b) A picture illustrating air pollution.

Furthermore, the visualizations also differed in complexity, which was the second independent variable. Both pictures and cartoons had a simple and complex version. As mentioned earlier, complexity was about how difficult it was to process the information in the visualization. Simple pictures in the current study were pictures taken of nature as one has seen often. These were for example pictures of factories, polar bears, and (rotting) trees. The objects in the pictures were recognizable and had been pictured in an appropriate environment (e.g., factories in the city, polar bears in ice and water, and trees in nature), this should have possibly made it easy for viewers to process the information in the pictures. On the other hand, complex pictures were taken of objects that one would not encounter in daily life or has seen often. They consisted of a strange composition of objects and unusual ‘neutral’ backgrounds which made it difficult to recognize where or in what environment the picture was taken. This may have caused the information in the pictures difficult to process. Simple cartoons, just like simple pictures, had some similarities with reality: recognizable factories, polar bears, and (rotten) trees. Even though the cartoons were not completely truthful as in reality (e.g., trees with faces and talking polar

bears), they were recognizable and it should not have been difficult to process the information. Contrarily, complex cartoons contained metaphors that created unusual fantasy environments that were not easy to recognize (e.g., a completely dried world with a stage). Viewers possibly made extra mental computations to understand the information in the cartoons which made the information in these cartoons harder to process.

An example of all four conditions can be found in Figure 10. All four visualizations showed the emission of gases by factories (e.g., air pollution). The simple cartoon showed a cloud of gas created by the emission of companies. It furthermore indicated in the gas cloud itself that these were harmful substances and that it was destructive for the climate. The objects were recognizable and extra information was given to make the information in the visualization easy to process. In the simple picture, the emission of the gases was very similar to the easy cartoon and the picture contained recognizable objects such as buildings, towers, factories, and clouds. The information in the picture should therefore not have been difficult to process. The complex cartoon did not look like reality. The cigarettes represented the towers of the factories that emitted carbon dioxide and these were harmful to the world indicated by the ashtray where the cigarettes end up. The more cigarettes were lit (i.e., the more the factories grow), the more the world (i.e., the air) was polluted. Metaphors were used that required additional mental computations. This made the information in the cartoon possibly more difficult to process. The complex picture was recreated with real objects from the world and was put together in such a way that it looked almost identical to the complex cartoon. The information was, as in the complex cartoon, possibly more difficult to process.

(a) (b)

(c) (d)

Figure 10. (a) A simple cartoon; (b) A simple picture; (c) A complex cartoon; (d) A complex picture.

First the simple and complex cartoons were chosen and then similar pictures were selected and created. A simple cartoon about air pollution (Figure 10a) got a simple picture of air pollution (Figure 10b) for comparison. However, it was difficult to make a distinction between simple and complex pictures. So for the comparison of complex cartoons it was chosen to recreate complex pictures with the help of Photoshop. An overview of all visualizations can be found in Appendix 2.

A pre-test was carried out to check whether the simple/complex pictures/cartoons were really considered to be simple/complex. The pre-test was done by 12 participants who were shown either 8 (4 topics x 2 conditions) pictures or 8 cartoons. The order in which they saw these visualizations was randomized. Below each visualization was the question: "How understandable do you think most people will find this picture?" which they could answer on a 7-point scale (1 = very simple to 7 = very complex). The results of the pre-test can be found in Table 1. On average, complex pictures were rated as more complex (M = 3.30, SD = 0.57) than simple

pictures (*M* = 2.90, *SD* = 0.89). However, this difference was not significant, *t*(4) = -.75, *p* = .495. Complex cartoons were rated as more complex (*M* = 4.46, *SD* = 0.97) than simple cartoons (*M* = 4.39, *SD* = 0.76). However, this difference was not significant, *t*(6) = -.18, *p* = .865.

Table 1. *Overview of the means and standard deviations of the pre-test.*

	Topic 1: Air pollution	Topic 2: Drought	Topic 3: Extreme weather	Topic 4: Melting glaciers
Simple pictures	3.40 (1.95)	3.20 (2.17)	3.40 (2.30)	1.60 (0.89)
Complex pictures	5.20 (0.45)	2.40 (1.67)	2.80 (1.92)	2.80 (2.39)
Simple cartoons	4.14 (1.57)	4.86 (2.04)	5.14 (1.35)	3.43 (1.62)
Complex cartoons	4.43 (1.40)	4.86 (1.68)	4.43 (1.72)	4.14 (1.68)

Note: none of the results were significant.

In the case of the topic 2 and topic 3, it can be seen that the results were not as expected: simple pictures/cartoons were identified as more complex than complex pictures/cartoons. An explanation could have been that the simple cartoon of topic 2 contained a sentence that could be considered as more complex than intended: "Just how much carbon are we supposed to offset" while the complex cartoon did not contain an explanatory sentence. Since the differences were not significant in the case of pictures (*t*(4) = .55, *p* = .614) and the results were exactly the same for cartoons, it was decided to remove the text below the simple cartoon and to leave everything else the same. For topic 3, the opposite was present that the complex cartoon contained an explanatory sentence that could make the cartoon easier to understand, while the simple cartoon did not contain an explanatory sentence. Again, the differences were not significant for pictures (*t*(4) = .34, *p* = .753) and cartoons (*t*(6) = 1.05, *p* = .334) and it was decided to replace the simple pictures/cartoons with the complex pictures/cartoons. Thus, what was once considered as simple was now complex and vice versa.

3.4 Instrumentation

The first dependent variable, comprehension, was measured on two levels: actual and perceived comprehension. The construct of actual comprehension was measured with two questions. To answer the questions of actual comprehension, the pictures or the cartoons were shown with the corresponding question underneath. Several questions were asked for pictures and cartoons. The two questions were partly based on the study of Bateman et al. (2010, p. 2576), but with minor adjustments. Table 2 shows an overview of the used questions for each visualization.

Table 2. *Questions to measure actual comprehension*.

Pictures	Cartoons
What is the picture about?	What is the cartoon about?
Is the sender trying to communicate some message through the picture?	Is the sender trying to communicate some message through the picture?

The answers to these actual comprehension questions could get a score of 0 (incorrect), 0.5 (incomplete), or 1 (correct). The answers were scored as shown in Table 3. The rest of the scoring tables can be found in Appendix 3.

Table 3. *Scoring table actual comprehension for a simple picture about air pollution.*

	1 point	0.5 points	0 points
Question 1: *What is the picture about?*	Factories, air pollution and bad substances.	Factories or air pollution or bad substances.	City or clouds.
Question 2: *Is the sender trying to communicate some message through the picture?*	Factories emit bad substances that end up in the air and cause air pollution.	Factories cause air pollution.	No, or answer that is off topic.

Perceived comprehension was measured using scale questions. The questions that were used in the current study to measure the construct perceived comprehensibility, were based on

the study of Maes, Ummelen, and Hoeken (1996). The same 7-point Likert scale could be applied to both pictures and cartoons (Table 4). The scale was balanced for the dimensions in order to prevent bias and straightliners (Maes et al., 1996). The scale was originally designed to analyze texts (see Appendix 4), but it is argued that the scale can be applied to visualizations like infographics (that combines text and visualizations) (Van Zon, 2018; Trines, 2017) and could therefore also possibly be applied to other visualizations as well. The choice was made to leave out a number of items in the current study and to change some items because these were not suitable for the current target group. For this construct, Cronbach's alpha was $\alpha = .74$, and the scale could therefore be considered reliable.

Table 4. *Questions used to measure perceived comprehensibility on a 7-point scale.*

I think this picture/cartoon is		
Hard to understand	0 0 0 0 0 0 0	Easy to understand
Clear	0 0 0 0 0 0 0	Unclear
Simple	0 0 0 0 0 0 0	Complex

The second dependent variable, sense of action, was measured through a questionnaire that measured indirect behavioral intention. The questionnaire was based on parts of the Theory of Planned Behavior by Ajzen (1985). As described earlier, this theory focuses on the likelihood of an individual to perform a specific behavior (behavioral intention) and depends on an individual's attitude towards the behavior, an individual's subjective norm, an individual's perceived control (Ajzen; 1985; Montano & Kasprzyk, 2015), and also their past behavior. These five constructs together should determine whether an individual's sense of action became higher or lower after seeing a news item with a visualization.

The five constructs (attitude, subjective norm, perceived control, past behavior, and behavioral intention) were measured by specific items. In the current questionnaire, the constructs were measured using one item each. These items were adjusted to fit the topic of climate change. The original 7-point Likert scale from Ajzen (2013) was used. By using this scale, participants could indicate whether they disagreed (1 = completely disagree) or agreed (7 = completely agree) on an item. An overview of the constructs and their corresponding items can

be found in Table 5. For this construct, Cronbach's alpha was $\alpha = .96$, and the scale could therefore be considered reliable.

Table 5. *Questionnaires for measuring sense of action.*

Construct	Question
Attitude towards the behavior	Changing my behavior to take action against climate change is necessary.
Subjective norm towards the behavior	Most people who are important to me would approve me taking action against climate.
Perceived behavioral control	I am confident that I can maintain my behavior in taking action against climate change.
Past behavior	In the past three months, I have engaged in actions against climate change.
Behavioral intention	I intend to engage in behavior against climate change.

3.5 Procedure

The participants were approached by the researcher who went to a school in order to approach the right target group, through acquaintances, and through social media with the request to participate in the study. The study consisted of a questionnaire that was conducted with the online survey software Qualtrics. To start with, participants were given a screen with instructions to read. In the instructions it was told that four news items would be shown and that some accompanying questions would be asked.

After the instruction, participants first saw a news item with a topic about climate change (e.g., air pollution, drought, extreme weather, or melting glaciers) with a corresponding visualization (e.g., an easy picture, a complex picture, a simple cartoon, or a complex cartoon). After watching and reading the first news item, they saw the visualization from the news item again along with the questions about comprehensibility and sense of action. Participants were thus able to answer the questions about the visualization while also being able to see the visualization. After answering the questions, participants saw the second news item with a

different topic about climate change with a corresponding visualization. If the first news item was about air pollution with a simple picture as the corresponding visualization, they would not see another news item about air pollution nor a simple picture as a visualization in the other news items again. After seeing the second news item, participants were then shown again the visualization and the questions about comprehension and sense of action. This was repeated for the third and fourth news item.

After seeing the four news items and answering the corresponding questions, the participants were asked to fill in some general data such as gender, age, and highest level of education. The participants were thanked for their participation and the data was automatically saved in Qualtrics. It took on average 10 minutes to complete the questionnaire.

4. Results

The current study measured the effects of the independent variables type of visualization and complexity on two dependent variables: comprehension and sense of action. Of these, comprehension was measured in two ways: through actual comprehension and perceived comprehension. In the next sections, the results are discussed for each dependent variable.

4.1 Actual comprehension

In order to check whether the independent variables type of visualization and complexity had an effect on actual comprehension, a repeated measures ANOVA was conducted. The Kolmogorov-Smirnov test and the Shapiro-Wilk test determined whether the underlying distribution of the data was normal. It was decided to also include the Shapiro-Wilk test because the current study consisted of 40 participants and this test was more likely to detect non-normality for smaller sample sizes. Although the z-scores for skewness and kurtosis were normally distributed, there were problems with the other tests. The actual comprehension scores were not normally distributed, since all Kolmogorov-Smirnov tests and Shapiro-Wilk tests were significant for all scales (see Table 6). Although the assumption of normality was violated, further analyses are still interpretable as the ANOVA is fairly robust against violations of normality. Despite the robustness of the ANOVA, further analyses should be interpreted with caution.

Table 6. *Results of normality tests for the six actual comprehension difference scales.*

	Z-score skewness	Z-score kurtosis	Kolmogorov-Smirnov test	Shapiro-Wilk test
Picture/simple-cartoon/simple	-0.31	-0.53	$D(40) = .15$, $p = .021$	$D(40) = .94$, $p = .035$
Picture/simple-picture/complex	0.26	-0.48	$D(40) = .19$, $p = .001$	$D(40) = .94$, $p = .031$
Picture/simple-cartoon/complex	0.37	-0.22	$D(40) = .21$, $p < .001$	$D(40) = .90$, $p = .002$
Cartoon/simple-picture/complex	0.34	-0.40	$D(40) = .20$, $p < .001$	$D(40) = .92$, $p = .005$
Cartoon/simple-cartoon/complex	0.97	-0.56	$D(40) = .27$, $p < .001$	$D(40) = .88$, $p = .001$
Cartoon/complex-picture/complex	-1.38	-1.09	$D(40) = .23$, $p < .001$	$D(40) = .87$, $p < .001$

The analysis showed that there was a main effect of type of visualization ($F(1,39) = 11.04$, $p = .002$, $\eta^2 = .22$). Pictures ($M = 0.28$, $SD = 0.18$) led to better actual comprehension than cartoons ($M = 0.18$, $SD = 0.02$). Furthermore, there was a main effect of complexity ($F(1,39) = 6.95$, $p = .012$, $\eta^2 = .15$). Simple visualizations ($M = 0.26$, $SD = 0.02$) were comprehended better than complex visualizations ($M = 0.19$, $SD = 0.02$). Finally, no interaction effect was found between type of visualization and complexity on actual comprehension ($F(1,39) = .44$, $p = .512$, $\eta^2 = .01$). Table 7 shows the average scores and standard deviations for actual comprehension as a function of type of visualization and complexity.

Table 7. *Actual comprehension scores for the visualization*complexity conditions.*

	Pictures			Cartoons		
	N	*M*	*SD*	*N*	*M*	*SD*
Simple	40	.33	0.04	40	.20	0.03
Complex	40	.23	0.04	40	.16	0.03

Note. The minimum score was 0 (no correct answer) and the maximum score was 1 (correct answer).

4.2 Perceived comprehension

A second repeated measures ANOVA was conducted to check whether the independent variables had an effect on perceived comprehension. All the data for this variable was normally distributed, as can be seen in Table 8.

Table 8. *Results of normality tests for the six perceived comprehension difference scales.*

	Z-score skewness	Z-score kurtosis	Kolmogorov-Smirnov test	Shapiro-Wilk test
Picture/simple-cartoon/simple	0.26	-0.45	$D(40) = .09$, $p = .200$	$D(40) = .98$, $p = .621$
Picture/simple-picture/complex	-1.65	-0.35	$D(40) = .14$, $p = .059$	$D(40) = .95$, $p = .072$
Picture/simple-cartoon/complex	0.52	1.21	$D(40) = .11$, $p = .200$	$D(40) = .98$, $p = .523$
Cartoon/simple-picture/complex	1.59	0.36	$D(40) = .13$, $p = .087$	$D(40) = .97$, $p = .246$
Cartoon/simple-cartoon/complex	0.05	-0.11	$D(40) = .11$, $p = .200$	$D(40) = .98$, $p = .727$
Cartoon/complex-picture/complex	-1.21	-0.24	$D(40) = .13$, $p = .096$	$D(40) = .97$, $p = .408$

The analysis showed that there was no main effect of type of visualization ($F(1,39) = 1.43$, $p = .239$, $\eta^2 = .04$). Pictures ($M = 3.35$, $SD = 0.18$) were not perceived as being more comprehensible than cartoons ($M = 3.64$, $SD = 0.21$). However, there was a main effect of complexity ($F(1,39) = 5.70$, $p = .022$, $\eta^2 = .13$). Simple visualizations ($M = 3.25$, $SD = 0.20$) were perceived as more comprehensible than complex visualizations ($M = 3.74$, $SD = 0.18$). Finally, no interaction effect was found between type of visualization and complexity on actual comprehension ($F(1,39) = 1.24$, $p = .272$, $\eta^2 = .03$). Table 9 shows the average scores and standard deviations for perceived comprehension as a function of type of visualization and complexity.

Table 9. *Perceived comprehension scores for the visualization*complexity conditions.*

	Pictures			Cartoons		
	N	*M*	*SD*	*N*	*M*	*SD*
Simple	40	2.96	0.26	40	3.54	0.30
Complex	40	3.75	0.23	40	3.73	0.25

Note. The minimum score was 1 (easy to understand/clear/simple) and the maximum score was 7 (hard to understand/unclear/difficult).

4.3 Sense of action

Finally, a third repeated measures ANOVA was conducted to check whether the independent variables had an effect on sense of action. The results of the repeated measures ANOVA showed that sense of action scores were not normally distributed: all six Kolmogorov-Smirnov tests and Shapiro-Wilk tests were significant. In addition, there was a significant amount of skewness in four of the six difference scales and a significant amount of kurtosis in five of the six difference scales (see Table 10). Because the assumption of normality was violated, further analyses should be interpreted with caution.

Table 10. *Results of normality tests for the sense of action difference scales.*

	Z-score skewness	Z-score kurtosis	Kolmogorov-Smirnov test	Shapiro-Wilk test
Picture/simple-cartoon/simple	9.64	23.69	$D(40) = .28$, $p < .200$	$D(40) = .64$, $p < .001$
Picture/simple-picture/complex	7.54	16.41	$D(40) = .28$, $p < .001$	$D(40) = .73$, $p < .001$
Picture/simple-cartoon/complex	0.20	6.01	$D(40) = .29$, $p < .001$	$D(40) = .83$, $p < .001$
Cartoon/simple-picture/complex	-0.32	1.31	$D(40) = .25$, $p < .001$	$D(40) = .93$, $p = .014$
Cartoon/simple-cartoon/complex	-3.68	3.95	$D(40) = .27$, $p < .001$	$D(40) = .83$, $p < .001$
Cartoon/complex-picture/complex	2.68	1.42	$D(40) = .21$, $p < .001$	$D(40) = .89$, $p = .001$

The analysis showed that there was no main effect of type of visualization ($F(1,39) = .13$, $p = .716$). Cartoons ($M = 3.79$, $SD = 0.19$) did not lead to more sense of action than pictures ($M = 3.81$, $SD = 0.18$). Furthermore, there was no main effect of complexity ($F(1,39) = .002$, $p = .964$). Simple visualizations ($M = 3.80$, $SD = 0.18$) did not lead to more sense of action than complex visualizations ($M = 3.80$, $SD = 0.19$). Finally, no interaction effect was found between type of visualization and complexity on sense of action ($F(1,39) = .764$, $p = .388$, $\eta^2 = .02$). Table 11 shows the average scores and standard deviations for sense of action as a function of type of visualization and complexity.

Table 11. *Sense of action scores for the visualization*complexity conditions.*

	Pictures			Cartoons		
	N	*M*	*SD*	*N*	*M*	*SD*
Simple	40	3.85	0.20	40	3.75	0.19
Complex	40	3.78	0.18	40	3.83	0.20

Note. The minimum score was 1 (completely disagree) and the maximum score was 7 (completely agree).

5. Conclusion and discussion

This study provides new insights into climate change communication by investigating how a complex topic, such as climate change, can be best communicated when looking at the type of visualization and the complexity of visualizations. This final chapter begins with a conclusion section in which the four hypotheses that have been tested are discussed. This conclusion is followed by a discussion section in which explanations are given for the absence of some of the predicted effects. Finally, limitations of the current study are discussed, and suggestions for future research are given.

5.1 Conclusion

For the first dependent variable, comprehension, it was expected that pictures of climate change were overall easier to comprehend than cartoons visualizing climate change (H1). This hypothesis was partially confirmed, as there was indeed an effect in the expected direction when looking at actual comprehension, but not when looking at perceived comprehension. Furthermore, an interaction was expected between type of visualization and complexity: the effect of H1 would be greatest for simple pictures and smallest for complex cartoons (H2). However, the results showed no significant interaction effect, and the hypothesis can be rejected.

For the second dependent variable, sense of action, it was expected that cartoons would lead to more sense of action than pictures (H3). However, the results showed that there was no significant difference in sense of action between cartoons and pictures. This hypothesis can therefore be rejected. Last, an interaction between type of visualization and complexity was expected, where the effect of H3 would be greatest for simple cartoons and smallest for complex pictures (H4). However, no significant interaction effect was found, and the hypothesis can therefore be rejected.

5.2 Discussion

5.2.1 Effects of type of visualization

When looking at actual comprehension, the results showed that pictures of climate change were easier to comprehend than cartoons visualizing climate change. This result was as expected and partly based on literature by Westerbeek (2016). According to Westerbeek, visualizations can differ in their visual representation: pictures are visualizations in which many characteristics of

reality are incorporated, while cartoons are line drawings in which details of objects are omitted (Westerbeek, 2016). It may therefore be possible that the difference in comprehensibility between pictures and cartoons is based on the number of details that visualizations contain. However, cartoons may differ in the extent to which they are schematic. The current study contains cartoons that are realistic and detailed. For example, the cartoons contain color, use of light and shadow, and details such as the barcode on the pack of cigarettes and lines to represent structure (e.g., lines for cracked ground and lines on the igloo). If a difference was to be expected in the form in which a visual representation is displayed, then it is unlikely to expect it in the current study as the difference in detail between pictures and cartoons is minimal.

The expectation that pictures are more comprehensible than cartoons was also partly based on literature describing that cartoons are more difficult to comprehend, because they entail analytical challenges for viewers, since they rely on imaginative symbols, metaphors, and public knowledge (Manzo, 2012). So, besides details, there are other properties in which visualizations could differ in their visual representation, for example: metaphorical elements (e.g., the pack of cigarettes that is used as a representation of exhaust towers that emit carbon dioxide), humorous elements (e.g., polar bears joking about running out of ice), and personification (e.g., trees that seem to have facial expressions and arms; Manzo, 2012). Especially cartoons seem to rely on these properties in their visual representation. These properties can add a complex layer to cartoons, and cartoons could therefore be more difficult to comprehend than pictures.

Metaphorical elements, for example, create an extra layer of complexity, because the illustration must be interpreted figuratively, instead of literally. The complex layer can also be displayed in other forms, such as texts that are often used as humorous elements. Cartoons have the ability to add texts that are less explicit and often unusual in pictures. These texts can be added to cartoons to convey a political message in a serious or humorous manner (El Rafaie, 2009). It is possible that cartoons convey messages that are more difficult to comprehend. For example, in the subtopic extreme weather, the picture only shows a storm, but the cartoon also includes texts such as “climate denial”. Therefore, the cartoon not only shows that there is a storm, just like the picture, but also indicates in a humorous way that extreme weather exists due to climate change and that people can no longer deny this.

In conclusion, there are differences in the interpretation of cartoon elements, such as the distortion of reality and adding texts. As a result, the general level of interpretation of cartoons is

probably higher. It may be that this has occurred in the current study, and that cartoons are therefore less comprehensible than pictures. However, in the current study, the use of imaginative symbols, metaphors, or other properties in the visualizations, was not manipulated systematically. They may have had some differences based on metaphorical meaning, and this may have had an effect, but cannot be taken as a completely valid explanation.

When looking at perceived comprehension, participants did not perceive pictures as more comprehensible than cartoons. This lower perceived comprehension may have had something to do with the feature that characterizes this target group: their lower level of education. A great deal of data about human beings of the last years is based on a relatively small, but intensively studied population: first-year undergraduate university students (Keuleers, Stevens, Mandera, & Brysbaert, 2015). The current study distinguishes itself from these researches by taking a different sample of people who are not necessarily highly educated. For the external validity, it is useful that other target groups, such as lower educated people, are included. However, because little is known about this target group, it is possible that the results are not as expected.

An explanation for the lack of the expected effect of perceived comprehension may be that participants were aware of their lower education and weaker knowledge of complex topics like climate change. This possible awareness of their lack of understanding may have caused them to have a lower self-esteem of their knowledge. Lower educated people can show lower levels of self-esteem than higher educated people, as found in the study of Orth, Trzesniewski, and Robins (2010). This finding could also be applicable to the current study. Their lower self-esteem may be caused by experiences in the past where others could come up with answers to questions faster and more easily than they did. For example, when the teacher asked a question to the class and other students responded faster, or when they regularly scored lower grades on tests than their classmates. This confrontation to their lack of knowledge may have led to a lower 'feeling of knowing'. This means that people have the feeling that they have specific information in their memory, but that it is not directly retrievable at a given time (Hart, 1965). Usually people have definite feelings whether they do or do not know the answer to a question (Hart, 1965). Since lower educated people may have experienced that they are not as good as others in understanding and retrieving information, it is possible that they have a lower self-esteem of their knowledge and have a lower feeling of knowing answers to questions. This may have

caused them to give generally lower answers on the perceived comprehension scale for both pictures and cartoons.

When looking at sense of action, the results showed that there were no differences between pictures and cartoons. It was theorized that pictures would lead to a lower sense of action than cartoons, since pictures show consequences of climate change, which gives people the feeling of being already too late to act upon it (Doyle, 2009). On the other hand, cartoons "desire for action" (Greenberg, 2002) and may have the potential to show causes instead of only showing consequences of climate change. Cartoons may show causes of climate change, since they are drawings and do not have to be fully realistic. As mentioned earlier, cartoons rely on imaginative symbols and metaphors. They use these symbols and metaphors to visualize concepts that are invisible, like climate change (Manzo, 2012). With the help of these symbols and metaphors, cartoons can tell an imaginary story about a self-created world, but at the same time, they also refer to real-life events and characters (Manzo, 2012). This combination of the real and the imaginary is one of the features of cartoons that distinguish them from pictures, and this possibility to create fantasy illustrations makes it possible to depict causes and consequences of climate change (Manzo, 2012). Therefore, it seems that pictures show the consequences of climate change, while cartoons can also show the causes of climate change, since they can deviate from reality.

A possible explanation for the absence of the expected effect could be that the current study did not address the effects of causes and consequences in the material. In most visualizations, only consequences were shown in both the picture and the cartoon versions. In the subtopic drought, for example, only the dry soil and the little vegetation were shown, while the causes, such as deforestation, could also have been shown. In the cases of extreme weather and melting ice caps, only the storms and little remaining ice were shown, but not what led the situation to be as it is. By manipulating the material in this way, only a difference in visual representation could have been found, but not whether one variant (picture or cartoon) is better at showing causes or consequences. If the current research had wanted to measure the effects of sense of action, then the differences between pictures and cartoons should have been greater than just visual representation. It was maybe optimistic to think that the form in which a visual representation is represented can cause an effect of sense of action. In a certain way, this only concerns more or less (irrelevant) details. In hindsight, it might have been better to focus on a

clear difference in visualization. For example, pictures and cartoons showing both causes and consequences. For further details, see the limitations.

5.2.2 Interaction effects between type of visualization and complexity

The main effect of complexity can be seen as a control variable. It is reasonable to expect that simple visualizations are (seen as) easier and more comprehensible than complex visualizations. The results of the current study showed indeed that simple visualization were more comprehensible than complex visualizations. Thus, the manipulation of complexity seems successful. However, these results should be interpreted with caution. The need to take a critical look at the manipulation of complexity becomes apparent when looking at possible interaction effects of type of visualization and complexity. For comprehension, it was expected that simple pictures would be the easiest to comprehend, complex cartoons would be the hardest to comprehend, with complex pictures and simple cartoons scoring in between. For sense of action, it was expected that simple cartoons would give people the greatest feeling of sense of action, complex pictures would give the smallest feeling of sense of action, with complex cartoons and simple pictures scoring in between. Contrary to the expectations, the results showed that there were no significant interaction effects between type of visualization and complexity.

An explanation for the lack of interaction effects is that complexity was not well defined in the current study. Complexity was defined as: the difficulty of processing the visualization. If little extra knowledge is needed and the information in the visualization is easy to process and understand, then it is a simple visualization. However, if more knowledge is needed and the information in the visualization is difficult to process and understand, then it is a complex visualization. Complexity, as defined here, is about cognitive processing, which is a relatively vague term. Since the term complexity was not well defined, it is possible that the material was not properly construed. The results of the pre-test seem to confirm this. The participants in the pre-test could not find in the material what the researcher had put in as a manipulation of simple and complex: some visualizations that were labelled as simple by the researcher, were judged by the participants as complex visualizations and vice versa. This meant that for one subtopic the simple and complex visualizations had to be replaced (simple became complex and complex became simple). This should have alerted the researcher that the variables in the material were not manipulated correctly and that it might have been better to use other material.

It would have been better to define complexity more precisely, for example in terms of metaphoric where it is necessary to make an extra thinking step. In the case of a metaphor, the illustrated represents something else with which it has a similarity. The depicted image should therefore not be interpreted literally, which requires an extra thinking step on the part of the viewer, which creates a certain complexity. Half of the cartoons in the present study already contained this extra layer of complexity in the form of, for example, metaphoric, humor, or text. If these properties only occurred in the complex visualizations, then it would have been possible to make certain statements about them. However, these properties occurred in both the simple and the complex visualizations, which meant that no statements could be made about possible effects of these properties. In sum, no interaction effects are expected, since there are too many impurities in the way complexity is defined. This has caused the material to be improperly manipulated. For further details, see the limitations.

5.3 Limitations

A number of improvements can be made to enhance the current study, which are listed below. First of all, complexity is not well defined in the current study. As discussed earlier, it might be better to define complexity more specific, for example, in terms of metaphoric. It has been discussed in the literature that metaphors can be better visualized in cartoons, because cartoons are drawings and may deviate from reality by constructing fantasy scenarios and imaginary worlds (Manzo, 2012). They can tell an imaginary story about a self-created world, but at the same time, they also refer to real-life events and characters (Manzo, 2012). They use a metaphorical combination of the real and the imaginary (El Rafaie, 2009, p. 186; Manzo, 2012). Therefore, it seems that metaphors are more common in cartoons than pictures and that they lead to a figurative interpretation of what is depicted. It is possible that people are more likely to understand that it is a metaphorical representation if it is visualized as a cartoon rather than as a picture. If it is indeed the case that cartoons encourage more metaphorical interpretation, then this should be apparent from the answers given by participants. How participants interpreted the visualizations, can be determined using the actual comprehension data where participants were able to give open answers. Thus, the (metaphorical) interpretation of the visualizations can be deduced from this data.

If cartoons encourage indeed more metaphorical interpretation, then this should be apparent from the complex visualizations of air pollution (Figure 11). These visualizations are an example where no manipulation problems are reported: the visualizations only differ on visual representation as intended, and they are also metaphorically complex. The visualizations contain several metaphors: the lighter that represents the growth of mankind, the cigarettes that represent the emission of carbon dioxide, and the ashtray that represents the pollution of the earth. It is metaphorical because, for example, cigarettes do not really contain carbon dioxide, but the cigarettes have a similarity with the towers of factories that they both emit harmful substances in the form of smoke. The lighter also contains interpretive text (i.e., 'growth'), which should give viewers the tendency that the object is not shown literally, but that it represents something else. The underlying message is that with the growth of mankind, the emission of carbon dioxide increases, and that this is polluting the earth. If the literature is right, it would be the case that participants understand this message better when it is represented as a cartoon, because they encourage metaphorical interpretation, then when it is represented as a picture.

(a) (b)

Figure 11. (a) A complex picture about air pollution; (b) A complex cartoon about air pollution.

The additional analysis shows that there is little difference in the metaphorical interpretation of pictures and cartoons (see Appendix 5). Half of the participants understand that it is meant to be metaphorical (e.g., "air pollution destroys the earth"), and the other half does not (e.g., "people should smoke less"). This outcome does not mean that literature is wrong, but it does mean that the effect of metaphorical interpretation is not as self-evident as literature would describe it. However, this is a cautious conclusion since only 8 participants interpreted the visualizations and only one example was used. In sum, in the current study was complexity not well defined and it would have been better to manipulate complexity in terms of metaphoric. Follow-up research could look deeper into the effects of pictures and cartoons in depicting

metaphoric. For example, by depicting metaphorical and non-metaphorical as both picture and cartoon, and investigating whether pictures are better for literal interpretation and cartoons for metaphorical interpretation.

Another limitation, as mentioned before, is that it was maybe optimistic to think that the form in which a visual representation is represented can cause an effect of sense of action. In a certain way, this only concerns more or less (irrelevant) details. It might have been better to focus on a clear difference in visualization. For example, showing causes and consequences. It is possible to make a picture and a cartoon variant for both causes and consequences (cause: picture vs. cartoon and consequence: picture vs. cartoon). There is a possibility that pictures are better at showing consequences, while cartoons are better at depicting causes. As can be seen back in Figure 6, pictures can show the consequences of climate change. People can see the already damaged earth and the pictures can be seen as visible evidence of climate change (Doyle, 2009). Cartoons can also show consequences of climate change, for example by drawing fantasy scenarios and imaginary worlds as shown in Figure 8. However, pictures are the referential proof that "the thing has been there" (Barthes, 2000, as cited in Doyle, 2009), while cartoons are not as strong of a proof, since they are drawn and not necessarily realistic. Pictures can therefore probably better be used to show consequences than cartoons, because they could leave a stronger impact on the viewers. Since cartoons are not realistic depictions of reality (Westerbeek, 2016), they may have the ability to visualize the causes of climate change. This can be seen, for example, in Figure 7, which critically shows that money is the cause of global warming and not the solution. This is difficult to visualize through a picture. Therefore, cartoons seem to be more suitable than pictures to show causes of climate change. By manipulating the material in this way (i.e., pictures and cartoons showing both causes and consequences), it may be possible to find differences in the effects of pictures and cartoons in sense of action. It is interesting for follow-up research to elaborate on the possible effects.

Another limitation with regard to the material is that the complex pictures in this study are not real pictures, but photoshopped images of real objects. The complex pictures are visualizations of different objects that are placed in a frame, but do not necessarily resemble reality of which a picture has been taken. For example, it is unrealistic that a real polar bear or Eskimo is placed inside a snow globe, or that a lighter is flat with no depth, whereas in reality from this angle people would expect that the side of the lighter is also shown. Since the complex

pictures are not exactly the same as reality and can look fake, it might be difficult for viewers to consider it as real pictures. This could mean that possible effects, which are expected for pictures, may not occur, because the visualizations are not considered as pictures. To make the complex pictures as realistic as possible, the most important elements that were shown in the visualization were pictures of realistic objects, which were copied in such a way that proportions and shadows were as truthful as possible. Although there was no 'real' variant of the complex pictures, it was decided to use complex pictures in this study, since the design would have otherwise been incomplete. It is better to use photoshopped pictures to get a complete design, than to conduct the study with an incomplete design. Future research could, instead of using Photoshop, place the realistic objects in such a way that they resemble the complex cartoon and take a real picture of it, and use that picture as a complex picture in the study. However, note that for certain cartoons it is simply not possible to recreate them with real pictures. There are cartoons that contain fantasy images or pieces from the future that cannot be photographed. A solution would be to use other advanced photoshopping techniques to recreate pictures that look more realistic and credible than the current ones.

A limitation regarding sense of action is that there was no pre- and post-measurement of sense of action. In the current study, sense of action was only measured after participants had seen a visualization. However, it is possible that participants did not take the visualization into account when answering the questions about sense of action. Since no pre-measurement of sense of action was done, it is not clear whether the stimulus caused a possible change in sense of action of participants. It is not possible to determine whether participants, after seeing the stimulus, wanted to increase their commitment to climate change, reduce their commitment, or whether the stimulus had no impact at all on their sense of action. The current measurement only made it possible to determine whether a certain visualization differed from the rest in terms of sense of action. Follow-up research could apply a pre- and post-measurement to have a better understanding whether the sense of action of viewers actually changes after seeing a certain stimulus.

A final limitation in this study could be that the scores for actual comprehension were fairly subjective and only assessed by one person (the researcher). One could argue that the researcher knew what results he/she expected and acted upon it when assessing the answers from the participants. In order to counteract this argument, a coding scheme was compiled in advance

and used by the researcher in order to assess scores. By using the coding scheme, the assessment of the scores was carried out in a more objective manner. Future research could use multiple evaluators or independent evaluators to assess the scores in order to make it more reliable.

5.4 Practical implications

To end with, it is useful to provide some useful information for designers and journalists who want to convey the information of a complex topic like climate change. To effectively communicate climate change it is important to know who your target group is and what they do, and do not understand. In the case of lower educated people, it seems that they understand the information that is depicted, but they do not have the feeling that they actually understand it. For this target group it is important to use realistic visualizations, such a pictures, if the goal is to let them understand something (e.g., communicating climate change in newspapers). Cartoons seem to be too complex and it is not advisable to use this type of visualization to help lower educated people to understand difficult information.

References

Adami, C. (2002). What is complexity?. *BioEssays*, *24*(12), 1085-1094.

Ajzen, I. (1985). From intentions to actions: A theory of planned behavior. In J. Kuhland & J. Beckman (Eds.), *Action control: From cognitions to behavior* (pp. 11-39). Heidelberg, Berlin: Springer.

Ajzen, I. (2013). Theory of planned behavior questionnaire. Measurement Instrument Database for the social science. Retrieved from: ww.midss.org/sites/default/files/tpb.construction.pdf

Ajzen, I., & Fishbein, M. (1980). *Understanding attitudes and predicting social behavior*. Englewood Cliffs, NJ: Prentice-Hall.

Bateman, S., Mandryk, R. L., Gutwin, C., Genest, A., McDine, D., & Brooks, C. (2010, April). Useful junk?: the effects of visual embellishment on comprehension and memorability of charts. *In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 2573-2582). ACM.

Braasch, G. (2013). Climate change: Is seeing believing?. *Bulletin of the Atomic Scientists, 69*(6), 33-41.

Clark, R. E. & Craig, T. G. (1992). Research and theory on multi-media learning effects'. In M. Giardina (Ed.), *Interactive multimedia learning environments: Human factors and technical considerations on design issues* (pp. 19-30). Heidelberg, Berlin: Springer.

Cosgrove, D. (1994). Contested global visions: one-world, whole-earth, and the Apollo space photographs. *Annals of the Association of American Geographers*, *84*(2), 270-294.

Dodds, K. (2007). Steve Bell's Eye: cartoons, geopolitics and the visualization of the war on terror. *Security Dialogue*, *38*(2), 157-177.

Dodds, K. (2010). Popular geopolitics and cartoons: Representing power relations, repetition and resistance. *Critical African Studies*, *2*(4), 113-131.

Doyle, J. (2007). Picturing the clima(c)tic: Greenpeace and the representational politics of climate change communication. *Science as Culture*, *16*(2), 129-150.

Doyle, J. (2009). Seeing the climate? The problematic status of visual evidence in climate change campaigning. In S. I. Dobrin & S. Morey (Eds.), *Ecosee: Image, rhetoric, nature* (pp. 279–298). Albany, NY: SUNY Press.

El Refaie, E. (2009). Multiliteracies: How readers interpret political cartoons. *Visual*

Communication, *8*(2), 181-205.

Farr, R. M. (1993). Common sense, science and social representations. *Public Understanding of Science*, *2*(3), 189-204.

Glenberg, A. M., & Langston, W. E. (1992). Comprehension of illustrated text: Pictures help to build mental models. *Journal of Memory and Language*, *31*(2), 129-151.

Greenberg, J. (2002). Framing and temporality in political cartoons: A critical analysis of visual news discourse. *Canadian Review of Sociology/Revue Canadienne de Sociologie*, *39*(2), 181-198.

Hackman, D. A., & Farah, M. J. (2009). Socioeconomic status and the developing brain. *Trends in Cognitive Sciences*, *13*(2), 65-73.

Hart, J. T. (1965). Memory and the feeling-of-knowing experience. *Journal of Educational Psychology*, *56*(4), 208-216.

Hegarty, M. (2011). The cognitive science of visual-spatial displays: Implications for design. *Topics in Cognitive Science*, *3*(3), 446-474.

Hempelmann, C. F., & Samson, A. C. (2008). Cartoons: drawn jokes. *The Primer of Humor Research*, 609-640.

Hulme, M. (2009). *Why we disagree about climate change: Understanding controversy, inaction and opportunity*. New York: Cambridge University Press.

Keuleers, E., Stevens, M., Mandera, P., & Brysbaert, M. (2015). Word knowledge in the crowd: Measuring vocabulary size and word prevalence in a massive online experiment. *The Quarterly Journal of Experimental Psychology*, *68*(8), 1665–1692.

Kleeman, G. (2006). Not just for fun: Using cartoons to investigate geographical issues. *New Zealand Geographer*, *62*(2), 144-151.

Knebusch, J. (2008). Art and climate (change) perception: Outline of a phenomenology of climate. *Sustainability: A new frontier for the Arts and Cultures*, 242-261.

Korat, O. (2005). Contextual and non-contextual knowledge in emergent literacy development: A comparison between children from low SES and middle SES communities. *Early Childhood Research Quarterly*, *20*(2), 220-238.

Leon, B., & Erviti, M. C. (2013). Science in pictures: Visual representation of climate change in Spain's television news. *Public Understanding of Science*, *24*(2), 183–199.

Lester, L., & Cottle, S. (2009). Visualizing climate change: Television news and ecological

citizenship. *International Journal of Communication*, *3*, 1-17.

Maes, A. (2017). The visual divide. *Nature Climate Change, 7*, 231-233.

Maes, A., Ummelen, N., & Hoeken, H. (1996). Instructieve teksten: Analyse, ontwerp en evaluatie. Amsterdam, Netherlands: Coutinho.

Manzo, K. (2010). Beyond polar bears? Re-envisioning climate change. *Meteorological Applications*, *17*(2), 196-208.

Manzo, K. (2012). Earthworks: The geopolitical visions of climate change cartoons. *Political Geography*, *31*(8), 481-494.

Mayer, R. E., & Sims, V. K. (1994). For whom is a picture worth a thousand words? Extensions of a dual-coding theory of multimedia learning. *Journal of Educational Psychology*, *86*(3), 389-401.

Montano, D. E., & Kasprzyk, D. (2015). Theory of reasoned action, theory of planned behavior, and the integrated behavioral model. *Health behavior: Theory, Research and Practice*, 95-124.

Moser, S. C., & Dilling, L. (2004). Making climate hot. *Environment: Science and Policy for Sustainable Development*, *46*(10), 32-46.

O'Neill, S. J., Boykoff, M., Niemeyer, S., & Day, S. A. (2013). On the use of imagery for climate change engagement. *Global Environmental Change*, *23*(2), 413-421.

O'Neill, S. J., & Nicholson-Cole, S. (2009). "Fear won't do it" promoting positive engagement with climate change through visual and iconic representations. *Science Communication*, *30*(3), 355–379.

Orth, U., Trzesniewski, K. H., & Robins, R. W. (2010). Self-esteem development from young adulthood to old age: a cohort-sequential longitudinal study. *Journal of Personality and Social Psychology*, *98*(4), 645-658.

Paivio, A. (1971). *Imagery and Verbal Processes*, Holt, Rinehart, and Winston, New York (Reprinted 1979, Erlbaum, Hillsdale, New Jersey).

Paivio, A. (1975). Coding distinctions and repetition effects in memory. In Bower, G. H. (ed.), *The Psychology of Learning and Motivation*, Vol. 9, Academic Press, New York, pp. 179-214.

Paivio, A (1986). *Mental representations: A dual coding approach*. New York: Oxford University Press.

Regan, H., & Westcott, B. (2019). *Australia suffers through searing temperatures as heatwave reaches its peak.* Retrieved from https://edition.cnn.com/2019/01/18/australia/australia-heat-wave-peak-intl/index.html

Schneider, B. (2012). Climate model simulation visualization from a visual studies perspective. *Wiley Interdisciplinary Reviews: Climate Change*, *3*(2), 185-193.

Schnotz, W. (1993). Some remarks on the commentary: On the relation of dual coding and mental models in graphics comprehension. *Learning and Instructions, 3*, 247-249.

Simon, J. (2019). *How cold is North America this week? Picture this*. Retrieved from https://qz.com/1539102/polar-vortex-2019-pictures-of-the-cold-weather-gripping-the-us/

Trines, L. (2017). *Colour congruence in infographics.* (master's thesis)

Van Zon, D. (2018). *Het ontwerpen van infographics*. (master's thesis)

Verges, M., & Duffy, S. (2009). Spatial representations elicit dual-coding effects in mental imagery. *Cognitive Science, 33*(6), 1157-1172.

Wang, S., Corner, A., Chapman, D., & Markowitz, E. (2018). Public engagement with climate imagery in a changing digital landscape. *Wiley Interdisciplinary Reviews: Climate Change, 9*(2), 1-18.

Weber, E. U. (2010). What shapes perceptions of climate change?. *Wiley Interdisciplinary Reviews: Climate Change, 1*(3), 332-342.

Westerbeek, H. G. W. (2016). *Visual Realism: Exploring effects on memory, language production, comprehension, and preference.* Tilburg: Tilburg University.

Appendix 1. *News articles used in the current study with retrieved website.*

Topic 1: Air pollution

Luchtvervuiling door klimaatverandering kost in 2030 tienduizenden levens

Verergerde luchtvervuiling, veroorzaakt door klimaatverandering, zorgt tegen 2030 naar schatting wereldwijd voor de vroegtijdige dood van zestigduizend extra mensen. Dat aantal kan oplopen tot 260.000 in het jaar 2100, schrijven onderzoekers van de universiteit van North Carolina in Nature Climate Change. Momenteel sterven er jaarlijks wereldwijd zo'n 5,5 miljoen mensen vroegtijdig aan de gevolgen van luchtvervuiling. De auteurs zeggen dat dit de meest uitgebreide studie tot nu toe is over dit onderwerp. Zij zetten de klimaatmodellen uit landen als de Verenigde Staten, Frankrijk, Japan en Nieuw-Zeeland naast elkaar voor het onderzoek. Naar verwachting zorgt verergerde luchtvervuiling door klimaatverandering wereldwijd voor meer sterfgevallen, behalve in Afrika. "Luchtvervuiling heeft invloed op dingen als hartaanvallen, beroertes en longkanker", zegt onderzoeker Jason West tegen CBS News. Verder wordt verwacht dat klimaatverandering ook meer hittestress (opwarming van het lichaam, waardoor 'warmteziekten' ontstaan) tot gevolg heeft en zorgt voor een bredere verspreiding van besmettelijke ziekten en minder toegang tot schoon water en voedsel.
Een gezamenlijke inspanning om klimaatverandering tegen te gaan, zou volgens de onderzoekers een groot verschil kunnen maken.

Retrieved from: https://www.nu.nl/gezondheid/4864145/luchtvervuiling-klimaatverandering-kost-in-2030-tienduizenden-levens.html

Topic 2: Drought

Meer droogte door klimaatverandering

Er zijn drie aspecten die de temperatuur op aarde beïnvloeden: de hoeveelheid zonlicht, de reflectie van vooral het witte aardoppervlak en de hoeveelheid broeikasgassen. NOS-weerman Kuipers Munneke: 'Vroeger draaide de natuur aan de knoppen en kwam er soms minder zonlicht op het noordelijk halfrond. Sinds 150 jaar draait de mens aan de CO2-knop.' Door verbranding van fossiele brandstoffen is de hoeveelheid CO2 in de atmosfeer toegenomen en is de temperatuur op aarde in een eeuw tijd gemiddeld met 1 graad Celsius gestegen. In Nederland ongeveer 1,8 graad Celsius, want op land gaat de opwarming sneller. Door de hogere temperatuur neemt de verdamping toe en kan de beschikbaarheid van water in het groeiseizoen afnemen. Droogte zal in de toekomst vaker voorkomen. 'Natte periodes worden natter en droge periode droger', zegt Kuipers Munneke. 'De droogte van 2018 kwam door meerdere hogedrukgebieden en dat is toeval. Eens in de dertig à veertig jaar komt dat voor.' De afgelopen winter

waren er (nog) niet genoeg regen- en sneeuwbuien om het neerslagoverschot van normaal te halen. De relatief lage grondwaterstand door de droogte van 2018 is daardoor nog onvoldoende aangevuld. 'Klimaatverandering is een langdurig proces. We glijden af en kunnen ons bijna nergens aan vasthouden. Alleen draaien aan de CO2-knop is effectief', zegt de NOS-weerman.

Retrieved from: https://www.nieuweoogst.nu/nieuws/2019/02/20/meer-water-en-droogte-door-klimaatverandering

Topic 3: Extreme weather

Extreem weer door klimaatverandering zorgt voor steeds meer problemen

Grote kans dat je daar al wat van merkt. Een leeg schap in de supermarkt, omdat een oogst is mislukt. Of je vakantieplannen die door extreem weer in het water vallen. Letterlijk. Tegelijkertijd heb je geluk. Nederland is een rijk land. Met stevige dijken. En huizen die tegen een stootje kunnen. Boeren lopen hier zeker risico als het maar blijft regenen. Gelukkig kunnen ze zich wel verzekeren tegen een mislukte oogst. In heel veel landen is dat anders. Mensen verdienen er (veel) minder. Huizen zijn er van klei en riet in plaats van steen. En een weersverzekering bestaat er niet – of is onbetaalbaar voor boeren die hun land nog met de hand bewerken. In die landen zijn lange periodes van regen of droogte en extreme kou en warmte catastrofaal. Gelukkig was 2015 een spectaculair jaar. In Parijs besloten de machtigste mensen op aarde dat extreem weer een groot gevaar is voor iedereen. En dat we er dus samen iets aan moeten doen. Wat niemand voor mogelijk had gehouden, gebeurde. Alle landen ter wereld ondertekenden het klimaatakkoord. Daarmee beloven ze de opwarming van de aarde te stoppen. Om zo extreem weer een halt toe te roepen.

Retrieved from: https://www.oxfamnovib.nl/blogs/dilemmas-en-oplossingen/wie-betaalt-de-rekening-van-extreem-weer

Topic 4: Melting glaciers

Zeespiegel stijgt sneller dan gedacht door smeltend ijs Antarctica

De zeespiegel stijgt nog sneller dan onderzoekers dachten, doordat het ijsverlies bij Antarctica de afgelopen tien jaar is verdrievoudigd. Iedere seconde smelt er een hoeveelheid ijs die bijna drie olympische zwembaden vol water oplevert. In de afgelopen 25 jaar heeft het afsmelten van Antarctica bijgedragen aan een zeespiegelstijging van bijna 8 millimeter. Dat lijkt misschien verwaarloosbaar, maar onderzoek toont aan dat 40 procent hiervan in de laatste vijf jaar is gebeurd. Het smelten gaat dus steeds harder en dat is precies waar de wetenschappers zich zorgen om maken. Met dit onderzoek worden de

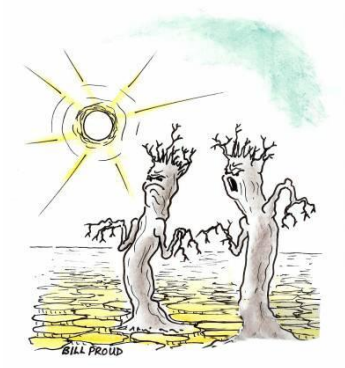
gevolgen van klimaatverandering steeds duidelijker. Het uitstoten van broeikasgassen, zoals CO2, leidt tot de opwarming van de aarde. "90 procent van deze warmte wordt opgenomen door de oceaan. Antarctica is hier vooral gevoelig voor," zegt hoogleraar Van den Broeke. Warmer water doet de honderden meters dikke ijsplaten van onderaf smelten. Wetenschappers verwachten dat de zeespiegel tot wel anderhalve meter kan stijgen deze eeuw. Sommigen houden zelfs rekening met meer dan 4 meter. Dit heeft grote gevolgen voor bewoners van eilanden. Maar bijvoorbeeld ook op steden en gebieden langs kusten, zoals Nederland.

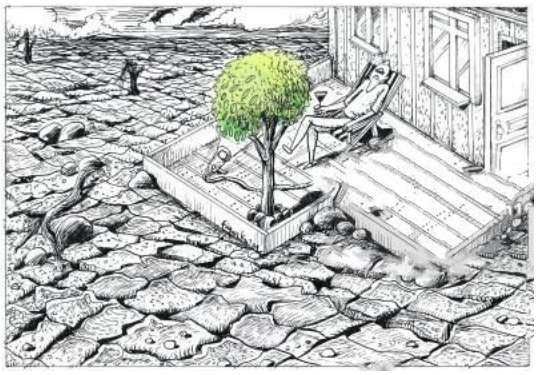
Retrieved from: https://www.hier.nu/themas/klimaatwoordenboek/klimaatverandering-oorzaken-en-gevolgen en https://nos.nl/artikel/2236352-zeespiegel-stijgt-sneller-dan-gedacht-door-smeltend-ijs-antarctica.html

Appendix 2. *Used materials in the present study: simple picture, complex picture, simple cartoon, and complex cartoon.*

Topic 1: Air pollution

Topic 2: Drought





Topic 3: Extreme weather

Topic 4: Melting glaciers

Appendix 3. *Used coding schemes in the present study for actual comprehension.*

Air Pollution Picture Simple

	1 point	0.5 points	0 points
Question 1: *What is the picture about?*	Factories, air pollution and bad substances.	Factories or air pollution or bad substances.	City or clouds.
Question 2: *Is the sender trying to communicate some message through the picture?*	Factories emit bad substances that end up in the air and cause air pollution.	Factories cause air pollution.	No, or answer that is off topic.

Air Pollution Picture Complex

	1 point	0.5 points	0 points
Question 1: *What is the picture about?*	Growth of factories and air pollution that is damaging to the world.	Factories or carbon dioxide or air pollution or world or ashtray.	Smoking or deadly.
Question 2: *Is the sender trying to communicate some message through the picture?*	The growth of factories that emit carbon dioxide cause more air pollution and damage to the world.	Air pollution is bad for the world or reduce the emission of carbon dioxide.	No, or answer that is off topic.

Air Pollution Cartoon Simple

	1 point	0.5 points	0 points
Question 1: *What is the cartoon about?*	Factories, air pollution, and climate destruction.	Factories or air pollution or climate destruction.	Environmental pollution, houses, clouds.
Question 2: *Is the sender trying to communicate some message through the cartoon?*	Factories emit bad substances that end up in the air and cause air pollution and are destructive to the climate.	Factories cause air pollution or reduce the emission of carbon dioxide.	No, or answer that is off topic.

Air Pollution Cartoon Complex

	1 point	0.5 points	0 points
Question 1: *What is the cartoon about?*	Growth of factories and air pollution that is damaging to the world.	Factories or carbon dioxide or air pollution or world or ashtray.	Smoking or deadly.
Question 2: *Is the sender trying to communicate some message through the cartoon?*	The growth of factories that emit carbon dioxide cause more air pollution and damage to the world.	Air pollution is bad for the world or reduce the emission of carbon dioxide.	No, or answer that is off topic.

Drought Picture Simple

	1 point	0.5 points	0 points
Question 1: *What is the picture about?*	Global warming and drought that destroys nature.	Global warming or drought or (dying) tree.	Desert or summer.
Question 2: *Is the sender trying to communicate some message through the picture?*	Global warming is causing a lot of drought, which is bad for nature.	Drought is causing trees to die or global warming is bad for nature.	No, or answer that is off topic.

Drought Picture Complex

	1 point	0.5 points	0 points
Question 1: *What is the picture about?*	Global warming and drought.	Global warming or drought.	House or heat wave.
Question 2: *Is the sender trying to communicate some message through the picture?*	People are indifferent to global warming as long as they don't notice it.	Global warming is causing drought or the earth dries out (which is bad for nature).	No, or answer that is off topic.

Drought Cartoon Simple

	1 point	0.5 points	0 points
Question 1: *What is the cartoon about?*	Global warming and drought that destroys nature.	Global warming or drought or (dying) trees.	Desert or summer.
Question 2: *Is the sender trying to communicate some message through the cartoon?*	Global warming is causing a lot of drought, which is bad for nature.	Drought is causing trees to die or the earth dries out (which is bad for nature).	No, or answer that is off topic.

Drought Cartoon Complex

	1 point	0.5 points	0 points
Question 1: *What is the cartoon about?*	Global warming and drought.	Global warming or drought.	House or heat wave.
Question 2: *Is the sender trying to communicate some message through the cartoon?*	People are indifferent to global warming as long as they don't notice it.	Global warming is causing drought or the earth dries out (which is bad for nature).	No, or answer that is off topic.

Extreme Weather Picture Simple

	1 point	0.5 points	0 points
Question 1: *What is the picture about?*	Extreme weather and the different opinions about it between news and scientists.	Extreme weather or tornado/hurricane or news station or scientist.	Nature or weather.
Question 2: *Is the sender trying to communicate some message through the picture?*	The news is lying that extreme weather does not exist while scientists have evidence.	Extreme weather exists or natural disasters will occur.	No, or answer that is off topic.

Extreme Weather Picture Complex

	1 point	0.5 points	0 points
Question 1: *What is the picture about?*	Satellite picture of a tornado/hurricane coming ashore.	Tornado/hurricane or meteorological picture or extreme weather.	Weather, Coastal area, rain, clouds.
Question 2: *Is the sender trying to communicate some message through the picture?*	Extreme weather exists and is dangerous for human beings.	Extreme weather exists or climate change causes extreme weather.	No, or answer that is off topic.

Extreme Weather Cartoon Simple

	1 point	0.5 points	0 points
Question 1: *What is the cartoon about?*	Extreme weather and the different opinions about it between news and scientists.	Extreme weather or tornado/hurricane or news station or scientist.	Nature or weather.
Question 2: *Is the sender trying to communicate some message through the cartoon?*	The news is lying that extreme weather does not exist while scientists have evidence.	Extreme weather exists or natural disasters will occur.	No, or answer that is off topic.

Extreme Weather Cartoon Complex

	1 point	0.5 points	0 points
Question 1: *What is the cartoon about?*	Hurricane Sandy and people who deny climate change.	Hurricane or Sandy or climate denial(s)/ man being sawn through.	Cloud.
Question 2: *Is the sender trying to communicate some message through the cartoon?*	Hurricane sandy is proof that climate change exists and causes extreme weather.	Hurricane Sandy is an example of extreme weather.	No, or answer that is off topic.

Melting Glaciers Picture Simple

	1 point	0.5 points	0 points
Question 1: *What is the picture about?*	Melting ice and polar bears.	Melting ice or polar bears or habitat.	Water.
Question 2: *Is the sender trying to communicate some message through the picture?*	Due to global warming, the ice caps melt and polar bears lose their habitat.	Ice caps melt due to global warming.	No, or answer that is off topic.

Melting Glaciers Picture Complex

	1 point	0.5 points	0 points
Question 1: *What is the picture about?*	Snow globes with Eskimos and polar bears.	Glass sphere(s), Eskimos, igloo, polar bears or (melting ice on) Antarctica.	Sea level.
Question 2: *Is the sender trying to communicate some message through the picture?*	The ice caps/Antarctica remain(s) only a memory because they/it will disappear.	Ice caps will melt due to global warming or melting ice caps/rising sea levels are dangerous for habitants of Antarctica.	No, or answer that is off topic.

Melting Glaciers Cartoon Simple

	1 point	0.5 points	0 points
Question 1: *What is the cartoon about?*	Melting ice and polar bears.	Melting ice, polar bears.	Water.
Question 2: *Is the sender trying to communicate some message through the cartoon?*	Due to global warming, the ice caps melt and polar bears lose their habitat.	Ice caps melt due to global warming or melting ice caps/rising sea levels are dangerous for habitants.	No, or answer that is off topic.

Melting Glaciers Cartoon Complex

	1 point	0.5 points	0 points
Question 1: *What is the cartoon about?*	Snow globes with Eskimos and polar bears.	Glass sphere(s), Eskimos, igloo, polar bears or (melting ice on) Antarctica.	Sea level.
Question 2: *Is the sender trying to communicate some message through the cartoon?*	The ice caps/Antarctica remain(s) only a memory because they/it will disappear.	Ice caps will melt due to global warming or melting ice caps/rising sea levels are dangerous for habitants of Antarctica.	No, or answer that is off topic.

Appendix 4. *Original scale from Maes, Ummelen, and Hoeken (1006, p. 208-209).*

Ik vind de tekst:		
Moeilijk	0 0 0 0 0 0 0	Makkelijk
Eenvoudig	0 0 0 0 0 0 0	Ingewikkeld
Onduidelijk	0 0 0 0 0 0 0	Duidelijk
Onoverzichtelijk	0 0 0 0 0 0 0	Onoverzichtelijk
Logisch opgebouwd	0 0 0 0 0 0 0	Onlogisch opgebouwd

Appendix 5. *Outcomes of the additional analysis (answers are given in Dutch).*

Complex picture air pollution

Waar gaat de foto over	Welke boodschap heeft de foto
Dat wij als mensen de aarde als een asbak/afval gebruiken.	Dat wij verantwoordelijk zijn voor wat er allemaal gebeurt op aarde.
Luchtvervuiling.	Dat roken bijdraagt aan luchtvervuiling.
Roken.	Slechte rook dampen.
Door de uitbreiding van de mensheid zorgt het verhoogde carbondioxide ervoor dat de opwarming van de aarde toeneemt.	Groei tegengaan.
Dat luchtvervuiling de aarde vernietigd.	Dat luchtvervuiling de aarde vernietigd dus dat we daar mee moeten stoppen.
Dat de aarde vervuilt wordt door sigaretten.	Dat we minder moeten gaan roken.
CO2 uitstoot die de opwarming van de aarde veroorzaakt.	Dat we de CO2 uitstoot moeten verminderen.
Sigarettenrook die vervuilt.	Roken is niet goed voor de wereld.

Complex cartoon air pollution

Waar gaat de cartoon over	Welke boodschap heeft de cartoon
Dat roken ongezond is voor de aarde in zijn algemeenheid.	Dat opwarming net zo ongezond is als roken, goed gebruik van jarenlange aanvallen op de tabak industrie nu doortrekken voor eigen gebruik of misbruik van diverse doelen, gewoon 2 vliegen in een klap slaan.
Luchtvervuiling.	Dat luchtvervuiling ziektes kunnen veroorzaken.
Luchtvervuilingen.	Stoppen met roken.
Roken en de wereld.	De roken de wereld in principe kapot maakt.
Dat er slechte stoffen de wereld in komen door mensen.	Dat mensen moeten opletten wat ze doen in verband met natuur in tact houden.
Over luchtvervuiling.	Niet te veel luchtvervuiling maken.
Peuken de aarde vervuilen.	Dat mensen stoppen.
Vervuiling aarde en lucht.	Visuele ondersteuning verhaal combi luchtvervuiling en opwarming aarde.