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The feeling of red and blue – a constructive critique of color mapping in visual climate change communication

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Abstract

This article is guided by the thesis that color is both - a rational way to structure and encode data visually, and a place where emotions like concern, fear and alarm can connect - and thus cultural readings can start from. This becomes particularly clear in visual climate communication where the colors blue and red are used in global future temperature maps and scenario graphs. Here, red colors are used to mark maximum values, temperature increases, great risk, anomalies and worst case scenarios like the RCP8.5 scenario, whereas blue colors denote cold temperatures but also illustrate best case scenarios.

In order to analyze the different cultural layers that get triggered by color, the paper presents results derived by different methodologies. On the one hand image analysis methods of picture theory are used; on the other hand, qualitative interviews performed with a small group of recipients evaluate the thesis derived from theory. For this purpose, the author team, which is formed by a cultural/media scholar and a scholar from computer graphics, has experimentally altered the color scheme of one of the most important figures of the latest Intergovernmental Panel on Climate Change (IPCC) report: the map of historic temperature increases from the IPCC AR5 WGI (figure SPM.1). Testing six different color schemes the team investigated how the perception, emotional reaction and understanding is altered if the scheme employing blue, bright red and purple is replaced by other color schemes. Besides the original IPCC color scheme, the team tested blue-grey-black, green-purple and purple-green as well as less dazzling shades of red. With their study, the authors are able to indicate how the understanding and credibility of climate change visualization is influenced by color, and how different color spectrums significantly change the emotional and associative reaction of the visualization in relation to the recipient group. The outcome of the research provides a guidance to estimate the impact of color in respect to the aim of visually communicating the risks of climate change and convincing different recipient groups about the gravity of the issue.

Introduction

In this article the authors will present some new research gained by different methodologies on color symbolism in climate change visualizations. For this purpose, the authors took questions and insights derived by visual studies methods and transferred them into the test setting of a qualitative survey on impacts of color schemes in climate change maps. The core question is what impact colors have on the interpretation of global climate change visualizations. With their combined setting the authors sought to interpret maps depicting global temperature rises not from a cartographic perspective in the first place but from an *iconic* perspective: what does a certain color scheme applied to global data maps tell different viewers? Does color play a role in the assessments of scientific appearance, risk and danger?

With the outcome of the research the authors hope to offer a contribution to estimate the complex and sometimes conflicting impacts of color in visual climate change communication, by taking into account the following difficulties: the difference of culturally influenced types of risk perception, the gravity of the issue and the dynamic interplay between science, media and the public, that trigger different narratives and speak different languages of catastrophe (Hulme, 2009, chapter 6). Therefore, if an IPCC-map is analyzed in the following this approach is not about criticizing the message of climate science or the work of the IPCC, but to estimate the role IPCC visualizations produced for policy makers play in climate change communication and to value their productive function as communicative instruments for the "honest brokers" of climate change (Pielke, 2007). Nonetheless the authors know that analyzing the complexity of climate change communication today is in itself problematic, because on a level of the post-factual many powerful actors still undermine the findings by a profound and deliberate misunderstanding of skepticism (Washington/Cook, 2011). At the same time, the authors should like to emphasize right at the beginning the limits of their survey: because of the small size of the group interviewed the argument cannot be universalized to any extent; still it is possible to recognize tendencies which would then need further research.

The question was derived from humanity's interpretation of color in the first place. It grounds on the fundamental assumption that no message is neutral, instead facts are always filtered, amplified and rhetoricised in many ways (Hulme, 2009, 225). This holds also true for images also: History of art and visual studies base on the assumption that meaning in imagery can never be completely controlled – this polyphony of pictorial meaning has been studied extensively in the field of semiotics, philosophy and art history (Hatt/Klonk, 2006). Art history has proved that there always is a surplus of uncontrollable meaning. The analysis of pictorial media is able to access layers of "disguised symbolism" (Panofsky, 1953) beyond the factual form, which materialize in any pictorial medium (Bredekamp/Dünkel/Schneider, 2015). In particular, artists and creatives in advertising, who target broader audiences, are very aware of the fact that the meaning of images cannot be restricted completely. This is especially true for color. Colors address human perception immediately, they influence the meaning of a picture. They are able to highlight, to superimpose symbolic layers, to aestheticize, to attract attention, to clarify, to alarm or to balance out what they display.

Because of the polyphony of meaning of colors, very different and powerful symbolic meanings are inevitably assigned to the subject that go beyond the natural coding of red and blue to depict temperatures but which likewise belong to the established semantics of these colors. The appliance of color in map design often is arbitrary and in most cases got ruled only by conventions. A cultural history of color here offers many conflicting paths of interpretation

(Gage, 1993 and 2000). On a physical level the color red is less energetic than blue, opposing the temperature scheme found in map design, because from a color-psychological perspective, red is perceived to be more warm than blue, which is perceived as a cold color (Meadows, 2014, 131). At the same time red has an exceptional position because it occurs only rarely in nature. Therefore, it not only became the color of honor, love and energy, but also got conventionalized as the color of highlighting and of marking danger and action at the same time, because red also stands for the destructive power of fire and blood. The highlighting dimension of the color red applies to information design, where red triggers symbolic layers such as danger, warning signal, intensity and the deviation of a norm—especially in the case of visualizing global risks. Map historian Gilles Palsky even put forward the thesis (Palsky, 1996) that colors turn maps into political maps, because colors always imply meanings and interpretations in the case of scientific climate maps becomes strangely valid also. At the same time, it was stated from a history of science' perspective that black-and-white images in science tend to give a more neutral and objective impression (Daston/Galison, 2007), although it is not clear if this argument applies to map and information design in general, because color plays a crucial role for enriching the image with information.

From an information graphic perspective, data visualization in a scientific sense must fulfill specific quality criteria. In informational design colors denote data, they represent numbers, measurements. At the same time, they denote frontiers within the data because somebody has to decide where to cut the data into zones. With maps one also can highlight certain findings and readings of the data. Informational designers learn certain rules to apply color to maps: A key finding should be recognizable by color spaces. By applying color to a map it is assumed that it gets possible to display more data layers and to make visible more details in the data in a clearer and more direct way (Bertin, 1967). If certain color schemes are used it is possible to display the data in a very exact way. The image becomes readable. Since the early twentieth century, guidelines exist at a level of practical knowledge about the use of colors in a "good" and "effective" way and how to apply this to data graphics and maps (Bertin, 1967; Tufte 1990; Palsky 1996; MacEachren, 1996; Stauffer et al. 2015). As data visualizers know, graphics are capable of containing only a limited amount of information.

Summing up, the case with red and blue is tricky. Colors can trigger symbolic and iconic levels at the same time: In the case of climate science graphs, this lead to the interpretation that the pure informative level of the intensive colors red and purple in contrast to blue in order to code warming can very strongly direct attention to all possible notions of red in connection to the motive: alarm, devastating heat, fire and destruction, meaning that the hot color schemes not only work on a rational level but at the same time heat up the feelings of their beholders and depict future as catastrophe (Schneider, 2016; Horn, 2014).

The interpretation of the IPCC map (fig. 1) by Schneider (2016) using methods of image analysis from a humanity's perspective, came to the following results: It contains alerting effects by the chosen fiery red color spectrum; this impression is increased by the extra color of a bright purple added to the end of the color scheme, where one would expect a darker red. The color purple marks the highest temperature increase on the map. It adds alertness in particular because it carries connotations of unnatural danger, alarm, and abnormal exceeding of extreme values ("the new normal of abnormalities"). If this color scheme is used to present already occurred global warming, the map suggests a burning future of extreme disasters that does not call for action but evokes feelings like powerlessness.

With the survey undertaken here the authors want to change this analysis into a constructive critique, because it is not about interpreting a certain map as “good” or “bad”, but to gain a better understanding in the role of color in relation to climate change maps. Therefore, the authors are interested to ask in a more general way if color plays a crucial role for the impact of global warming imagery, how would a politically constructive and empowering map look like? Or is it just not possible to change the imagination of climate change by modifying color?

Those interpretations, derived from a cultural reading, the authors wanted to study more deeply by changing the methodology from visual studies to a qualitative survey and by at the same time altering the color scheme of an IPCC global temperature map. If color changes perception on an emotional and interpretative level, different colors would have to lead to different interpretations. So what does it change for the understanding and impact of the map to apply colors different to the conventional color scheme of blue (cold) and red (hot)? Therefore, for test purposes, the authors chose a prominent global map from the IPCC AR5 report. In the process of recoloring this map it gets possible to analyze its color scheme and to provide alternatives.

Starting point: discussion of the original IPCC map

For their study the authors decided to change a single global temperature map from the Summary for Policy Makers-Report of the Intergovernmental Panel on Climate Change, Working Group I (see Figure 1). The map represents global temperature changes between the years 1901 and 2012 based on measurement data. It visualizes data of global temperature observations from the last 100 years by using a color scheme that diverges from blue to orange to different shades of red, the highest temperature rise is given in a bright purple. The map played an important role in the recent report, because it proves that global warming is already happening in the present, it is not a distant future anymore. Its importance was confirmed during the press conference of the IPCC on the occasion of the publication date of the last report in September 2013. It was one of the few visualizations that got highlighted during the press conference to emphasize the urgency and the need to act politically because of global warming. At the same time global red maps in general might be called *iconic* for global warming – only that this time for the first time it was not the future of global warming presented in a bright red color scheme but the presence in comparison to the past.

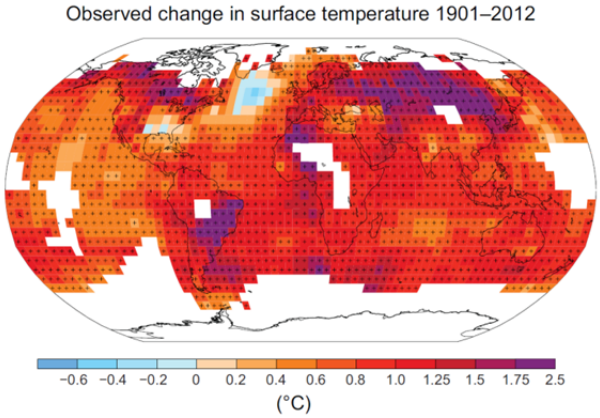


Figure 1: IPCC AR5 WG1-SPM map representing the observed change in surface temperature in a blue - red - magenta color scheme

From a cartographic and visualization science perspective, the graphic has some general shortcomings – which do not touch the general scientificity of the data and the scientific meaning of the map, but communicative and aesthetic requirements. First, the three classes of certainty (represented as the plus marks) and uncertainty (white regions) make it hard to be interpreted by

laypersons. Here, a more comprehensible legend would be beneficial. Second, the color map can be criticized in four aspects:

1. the perceived distances in neighboring colors are not equal, which leads to stronger visual gradients between certain color pairs,
2. less value intervals / colors on the positive difference side would help to keep the colors differentiable,
3. the end of the color map has other tic value differences, which are even stronger highlighted by the purple color tones, and
4. in this case a value range of insignificant differences around zero would make sense, decreasing the visual effect of the very intense colors already at relatively low levels of warming / cooling.

Survey redesign of the IPCC map

For their survey the authors decided to change the map's color scheme only by basing on the color maps from Brewer et al. 2003 and the web portal www.colorbrewer.org, a resource that was designed at the GeoVISTA Center at Penn State, USA, where map designers can try out optimized color schemes adapted to their nature of data. In this case the authors had to look for alternative color schemes for *diverging* data, because this is the nature of the data given here: data that allows the emphasis of a quantitative data display that progresses outward from the reference period of the data range – that is from degrees below zero to degrees plus zero. We retained the number of data classes from the original map, that is 13 different temperature bands ranging from -0,6°C to 2,5°C, with a slight change in step size above 1,25°C (from that point on the steps are changing from 0,2°C to 0,25°C). We maintained the general design and coloring of the map: white squares mark geographical regions where the data set is not robust enough to tell about temperature changes during this period of time (e.g. above the poles, the Pacific Ocean, central Africa and small areas in Asia and South America). Dark little crosses in each colored square highlight those regions where observations permit an especially robust estimate.

For the purpose of testing a broad range of different color schemes, the authors created five alternative options for the global climate map, which could then be tested against the original IPCC-map (see Figure 2).

1. **Map I (Blue/Red/Purple):** original color scheme of the IPCC.
2. **Map II (Blue/Black, "less color"):** In this case a map scheme varying from blue (cooling) to black (heating) was developed, in order to analyze how perception would change if colors were reduced as far as possible. One has to note that it was not possible to dispense with color completely because of the diverging nature of the data between cooling and warming temperatures. This is why the authors created a color scheme that uses as less color as possible by diverging from blue to dark gray[1].
3. **Map IV (Purple/Green, "anti-intuitive"):** The authors purposely chose a contra-intuitive map scheme ranging from purple (cooling) to green (heating). By symbolizing heat with green and cooling with a warm color they wanted to underrun the impact of

[1] In the original red-grey color map from the brewer color set we replaced the red part with blue values from another color scheme.

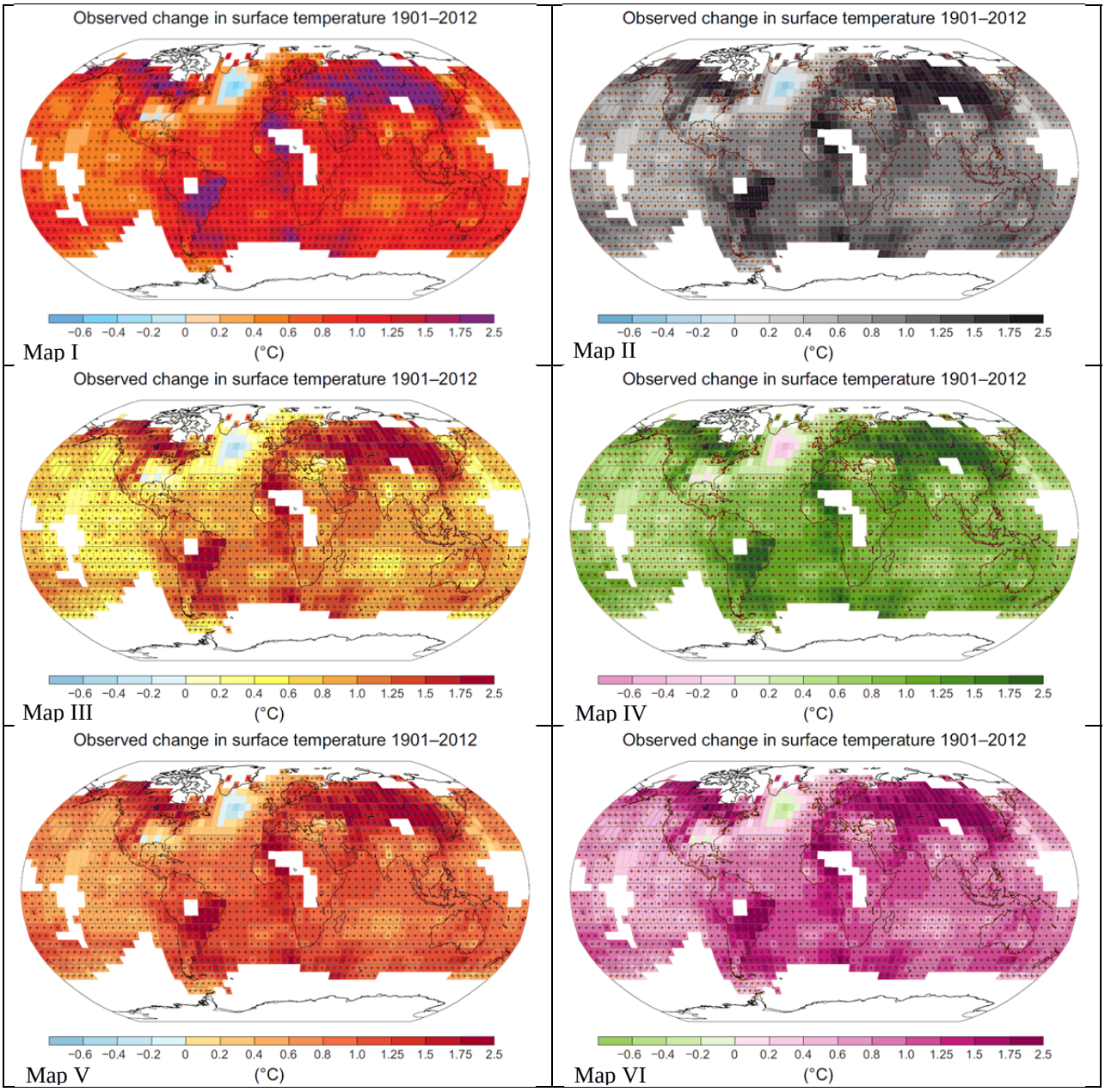


Figure 2: Color-coded maps tested in the survey: the original color map from the IPCC AR5 WG1-SPM (Map I), and four alternate versions basing on the color schemes by Brewer et al. (Map II, IV-VI) and a yellow version (Map III) altering Map V in the orange part.

intuitively chosen colors in the field. The color spectrum stands in contrast to the highly conventionalized color scheme in map design that range from blue to red to symbolize cool resp. warm temperatures.

4. **Map V (Blue/Red, "cleared red without purple extremes"):** For this version the authors tried to optimize the existing color scheme by cutting out the purple part of the legend and by finding a clearer graduation in red hues. The authors will discuss this version and offer a constructive critique of the original map in the "discussions".

5. **Map VI (Green/Purple: “anti-intuitive-inversed”):** Here the color scheme of Map IV was reversed. Now the color scheme runs from green (cooling) to purple (heating).

In the first place the authors also tried out brownish colors, different shades of red, and a reversed scheme of red and blue. Testing with the different versions proved that the survey got to complex by using more than one anti-intuitive color scheme.

Study design

The authors prepared a tabular form with ten short questions relating to the maps and two questions at the end asking for a general estimation of climate change science. Four different selections of six color-coded maps had been prepared, including the original map of the IPCC, varying in choice and order. Figure one shows the six color maps.

As study participants a sample of 22 persons from Germany was recruited. Most of the participants had studied at Universities but did not have anything to do with climate research in their job. The study procedure was conducted by an interviewer who started with explaining the general meaning of the map to a singular interviewee in the first place. After the general meaning was explained the interviewer started to pose the prepared questions regarding colors and their impact. Each interview took approx. 20 minutes to complete. The interviews were not undertaken by the authors but transferred to a research assistant who was not involved in the research process.

For the first task six questions were presented with four selected visual stimuli in comparison. The interviewees were asked to structure the maps regarding different questions by either rating them on a scale from 10 (strong) to 1 (weak/small) or by selecting one individual image. All questions focus on the influence of color on different levels of meaning, taking into account emotional effects and image impressions like readability, intuitiveness, visual rhetoric and effectiveness of color concerning the subject of the map. The detailed questions can be found in table 1 in the next section.

For the second part of the survey we reduced the selection and concentrated on two maps one after the other in order to go into a more profound interpretation of two singular maps:

1. The first question was posed rather open to find out about the understanding of color in the map: “How do you understand the employment of color in the map?”
2. Secondly the interviewees were asked to pick a word that best described their reaction to the map relating to the question: “What emotional reactions does the image evoke in you?” The choice of words was “call for action”, “concern”; “fear”; “alarmism”; “powerlessness” but also left a blank space for other feelings.
3. The following task consisted in naming any free associations that came when looking at the image. A final task gave space to any other idea that did not have space until now (“Any other thoughts concerning the maps you want to share?”).

Afterwards we asked two questions to find out about the individual believe or distrust in climate change findings and personal general sorrows connected to the findings:

1. “Do you trust the findings of climate researchers about human induced climate change?”
2. “How much are you concerned about the current global warming?”

again by rating the answers on a scale from 10 (strong) to 1 (weak/small).

Results

For the interpretation the authors averaged all figures in relation to the frequency of presented image stimuli and the specific number of participants who were presented a certain selection of images. It becomes obvious that for certain maps tendencies are more significant than for others. Those are marked with bold lettering.

The increase of temperatures in relation to the coloring was most severely perceived in maps with a blue-red color scheme (see Table 1). Map I was perceived to present the temperature increase most drastically (8,3). Concerning readability of data through color map III (Blue/Yellow/Red) was conceived to offer the clearest perception. It is also map III which was rated to employ the most intuitive color scheme for the topic, closely followed by map V (Blue/Red), while it is map IV (Purple/Green) that was rated to be at least intuitive. It was not possible within the framework of the survey to determine an influence of color perception on the scientific appearance of the map. The results here are not significant. Map I was chosen to be the

Table 1: The answers to the six questions comparing multiple images together. Numbers denote mean values for each figure (1-10), ranging answers from 1 for "weak/small" to 10 for "strong"; percentages depict - if only one picture could be selected – the number of chosen images in relation of the total number of participants this picture was shown to.

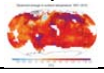
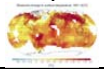
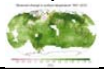
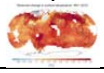
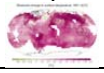
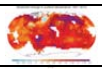
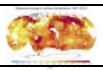
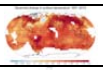
Question	Map I 	Map II 	Map III 	Map IV 	Map V 	Map VI 
How severe would you estimate the global temperature increase with respect to the appeal of colors?" (1-10)	**8.3**	4.3	**6.4**	4.8	**6.7**	4.6
Can you discern the different data values given by the color in one map more clearly than in the others? Choose one.	23%	8%	**50%**	18%	19%	0%
Which color scheme appeals to you the most intuitive one for the topic? (1-10)	**6.2**	4,5	**8.0**	3,9	**7.7**	5.2
Please estimate the effect of the maps according to their scientific appearance. Which version seems to be the most scientific to you?" (1-10)	5.9	5.8	6.2	5.1	5.6	5.2
Which version appeals rhetoric / judgmental to you? (1-10)	**6.9**	4.2	5.5	3.9	4.8	**3.4**
Which map would you choose to affect policy makers to take more action in climate protection? Choose one.	**43%**	15%	**35%**	6%	27%	0%

Table 2: Listing of emotions the interviewed associate with the three reddish map versions; percentages depict the number of emotions associated in relation of the total number of participants this picture was shown to

Questioned emotion	Map I 	Map III 	Map V 
call for action	25%	**44%**	**43%**
Concern	55%	**69%**	43%
Alarming	**75%**	63%	43%
Powerlessness	**30%**	19%	14%
Fear	**50%**	31%	33%
further free emotions	disillusioning; discouraging	confusing; comprising also positive connotations	calmer; clearer; more hope

most judgmental (6.9), whereas map VI (Green/Purple) in contrast turns up to be at least judgmental. To influence policy makers most participants chose map I and III, the least convincing in contrast turned out to be maps VI and IV.

In the second part of the interview participants were asked to concentrate on singular maps. Significantly more interviewees rated map III and V as a "call for action" compared to map I. A general concern was felt most clearly for map III. The most alarming figure is map I. This is also true for the impression of "powerlessness" and "fear". Supplemented impressions brought up by the interviewees affirm this reading: Map I was said to be disillusioning and discouraging. Map III was said to be confusing but to comprise also positive connotations, while map V was evaluated to be calmer, more concise and to allow more hope.

When asked for their free associations for the maps I, III resp. V,[2] interviewees connected map I with terms like alarm, uncontrolled heat, fire, drought, boiling over (9 out of 15 interviewees). The impression of heat and drought was also connected to map III (6 out of 17) but here more associations of desert zones were brought up (4). Map V was described with the associations of burning embers and lava (2 out of 7). At the same time the interviewees estimated map III (8 out of 15) and map V (4 out of 7) in comparison to map I as being less threatening and allowing more space to think about future solutions for human life on Earth. Two persons mentioned that in map III in comparison to map I differences in geographical impacts were better readable which were not recognizable in map I. The different associations can be summarized for map I as giving an impression of the Earth irreversibly steering into a future of extreme drought and heat zones that destroy human life, while in map III and V the problem is still shown in its severity but might leave space for hope and solutions.

Only one interviewee was skeptical about climate change research, all others rated their trust in science very high (8-10). The evaluation of the maps of the skeptical person did not allow to draw conclusions about the impact of colors.

[2] From 22 interviewees 15 person were prestented map I and III in comparison, 5 persons saw I and V and 2 were presented map III and V in comparison.

Discussion

The authors are aware that the survey undertaken has limitations in size, diversity of interviewed people (mainly living in Berlin with a bias towards academic and arts professions) and the survey setup with a limited number of testable color schemes. However, it can be seen as a test case for the general question how to investigate emotional impacts and interpretations of color schemes in climate change maps by laypeople quantitatively for the goal to constructively criticize and redesign climate change visualizations. In the following the authors will interpret the results we achieved by the survey for each map individually and then turn to some general remarks.

Map I (Blue/Red/Purple, original color scheme of the IPCC**):** Lead by the outcome of the image analysis from the humanity's perspective (Schneider, 2016), the authors were expecting to find map I to be alerting by emphasizing present climate change as grave risk that affects the notion of climate normality by at the same time being the most disillusioning and disempowering. From an informational design standpoint, the authors also had evaluated map I to offer an undistinguishable perception of the different hues especially in the temperature coding of the three highest temperature steps (dark shades of red and purple). Some of the underlying theses were approved by the new methodology of qualitative interviews of the study at hand but also complemented by new insights. For example, the purple shade at the end of the color scale was perceived as disturbing and also as an irregular continuation of the red color spectrum. As a result of the study at hand, it must be taken into account that this version of the map has difficulties in the possibility of a nuanced reading of colors: it does not facilitate to relate certain increases of temperatures to specific regions, with a tendency to amplify an impression of high temperature increases that seem to flow into each other. To summarize, the survey results indicate that the color scheme of Map I tends to present climate change in a rhetoric and alerting manner. In addition, the viewer is confronted with the map's restricted readability, which might turn the map into a warning without conveying the full knowledge about the distribution of climate change visually. The two arguments might explain the reading of the map by many interviewees in terms of visually presenting Earth as a differentiable arid zone of droughts and heat.

Map II (Blue/Black, "less color"): The authors wanted to find out about the impression of greyscale maps in contrast to colored maps, although it was clear to us that a pure greyscale color scheme was not possible because of the diverged nature of the data given. Most clearly rated was the problem of poor readability for this color scheme (for the multitude of color intervals provided by the original map I). Also for many interviewees the scheme did not seem to present climate change as severe as the red maps. This correlated with the evaluation of map II as being not intuitive for the topic of the map. At the same time, map II was said to be much less judgmental than the red maps and some interviewees pointed to the neutrality of the map because it does not employ bright colors. Then again, only very few interviewees would choose this map design to influence policy makers.

Map III (Blue/Yellow/Red, "more nuances"): Interviewees rated this map to be the most readable map. Based on the feedback of the interviewees we conclude that this map design – although we are aware that it does not use an equally distributed color spectrum with respect to the luminosity value, and thus the yellow color band is strongly highlighted – in comparison to map I draws a more nuanced picture of the geographical difference of increasing temperatures

above land regions and oceans. It very clearly shows where current climate change has taken place (the land regions). Therefore, we might say that this map gives a most concise geographical impression of climate change connected to specific regions of the world. At the same time the map in comparison to Map I was estimated to be less alarming by at the same time allowing feelings of concern and call for action.

Map IV (Purple/Green, "anti-intuitive"): The green map does not tell the story of an alarming and severe climate change taking place. The color scheme is not intuitive for the topic. The authors were surprised that interviewees did not rate this map to be rhetorical also, because from their perspective it could also be estimated to downplay the results of global warming. Then again, interviewees would not choose this map to show it to policy makers in order to convince them to take more actions.

Map V (Blue/Red, "cleared red without purple extremes"): This version seemed to the authors, when we were redesigning the map, to offer a good balance between intuitive color scheme and meeting the challenges of information design in maps (using equidistantly perceived color differences, less intensive than Map I in the lower positive values). Interestingly the map was not rated to be readable as good as map III but even worse than map I. Then again, the intuitiveness of the color scheme was rated high by at the same time not being very judgmental. The map was not chosen by a significant number of interviewees to be presented to policy makers.

Map VI (Green/Purple: "anti-intuitive-inversed"): The most significant finding concerning the purple color scheme was that it was rated even less intuitive than the green one. Nobody would use a pink map to influence policy makers. At the same time, it was chosen to be the at least rhetoric map – maybe because the color pink does not highlight any symbolic layer of the topic in a significant way like heat = red, plant growth = green.

A discussion of the free associations that were told by the interviewees in relation to Map I, III and V in the second part of the survey, is also fruitful. The associations of map I (Blue/Red/Purple) were most significant. Individual interviewees told us the following impressions: it is too late to act; it is too warm everywhere; the impression of over boiling; feelings of fatalism and being trapped; deadly danger; drought; fire; threatening scenario for the future; extreme heat; no trees, no growth of plants anymore; devastation; the color purple was connected to the notion of "rotten" but also to the radioactive pollution symbolized on maps after Chernobyl. Map V was said to produce an image of fire and lava, but being less frightening and alarming. The same was said for Map III.

At this point the authors should like to emphasize what they could not find out by their survey. The authors were not able to get significant numbers in relation to differences in the scientific appearance of the maps. Many interviewees said that the scientific nature of the map, being a data map, would not be touched by different color schemes. This might be the reason why they rated the different maps similarly. Secondly, it would be interesting to find out about the correlation of a particular aesthetic ("beautiful") impression of a certain map and the evaluation of its intuitiveness. This might give some more detailed insights in the good rating of map III, because this map drops out in the "gestalt" it draws of global climate change. Here we do not see a red world map but a yellow map with red continents.

Conclusion

In their study the authors took arguments and interpretations derived from an art historian and visual study's approach and tried to test them with qualitative interviewing methods. For this purpose, a main geographical visualization of present climate change taken from the recent summary for policy makers published by the IPCC was altered according to its color spectrum. With a set of questions 22 interviewees were asked to compare different colorations in respect to the impact of color on the comprehension of the map, its credibility, the gravity of climate change as a risk, free associations to the color and different emotional reactions to the map.

The authors found some of the interpretations derived by image analysis from a humanities' approach (Schneider, 2016) confirmed by the survey, but also new insights could be brought up. The original map used by the IPCC in the Summary for Policy Makers 2014 (Map I) – as the results from the survey also suggest – is the most alerting by at the same time calling up disillusioning associations of powerlessness, fear, global heat waves and devastation. Several interviewees criticized it for its problematic nuanced differentiation of colors but at the same time suggested to be chosen for the purpose of influencing policy makers to act. The blue-yellow-red color map version (Map III) scored considerably better in several aspects like the readability, and by at the same time not appearing as disillusioning as the original IPCC version (Map I).

The authors already stated that the aim of the study is not a simple criticism of the original map, but the attempt to take into account the complexity of visual climate change communication, because there cannot be an all-in-one solution that works similarly for all possible recipients of the map. Still, the authors think that their study has shown that in order to balance out possible emotional reactions with the comprehensibility and the key message of the visualization, it might be useful to establish a dialogue integrating manifold expertise – art history, visual studies, interface design, computer graphics to assess the polyphony of meaning that visualizations can unfold beyond science.

If the authors could recommend a new map design for the original IPCC map (Map I), they would propose to take less colors and equally distributed interval values, around zero an interval with a color close to white, and a blue-white-red color map (because of its standardization) with visually equally distributed colors, and which avoids too dark colors at the highest temperature differences.

For future work, it might be interesting to incorporate maps of possible climate futures and their employment of red color schemes into a broader study design. It would be fruitful to study laypeople's perceptions and interpretations of the different future RCP scenarios in relation to the color scheme used for the map visualizing past observed warming. In addition, it would be necessary to study a larger and more culturally diverse group of participants, and to see what arguments can be universalized. But it would be even more fruitful to study a group of different policy makers on the level of NGOs, stake holders or different administrators in relation to color perception and policy implementation.

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