University of Zurich[UZH]

Mapping the COVID-19 Pandemic - The Influence of Map Design Choices by Media Outlets on People's Perception of the State of the Pandemic

GEO 511 Master's Thesis

Author
Anna-Lena Burren
17-727-421

Supervised by
Prof. Dr. Sara Irina Fabrikant
Prof. Dr. Wibke Weber (webw@zhaw.ch)

Faculty representative
Prof. Dr. Sara Irina Fabrikant

26.10.2022
Department of Geography, University of Zurich

Abstract

Following the outbreak of the COVID-19 pandemic in 2019, numerous online newspapers took it upon themselves to inform the public on a daily basis on the spread of the virus. Given their visually appealing, informative, and comprehensive nature, maps were often used for this purpose. The Swiss media have also resorted to this form of data journalism.

Numerous studies in recent years have demonstrated that maps can affect people's perceptions and emotions. Particularly the colours used in the maps can contribute to these effects. In this thesis, it was therefore of interest to find out what emotional, perceptual, and behavioural impact these many COVID-19 maps had on readers. The study shows that especially the COVID-19 topic had significant influence on people's emotions and that warm colour scales evoked more concern and led to more cautious behaviour than cold ones. Maps are therefore powerful tools, which is why it is important to make thoughtful decisions when designing them. This is especially important when maps reach a wide public and provide information about important events. This study therefore seeks to raise awareness and, in the best case scenario, contribute to a more considered and improved map design.

This thesis is divided into two parts. Firstly, it examines what the COVID-19 case rate maps published by the Swiss media looked like and how they were created. Secondly, it is being analysed which emotions, perceptions, and behaviour they generated.

Keywords: COVID-19, cartography, data journalism, colour perception, SAM, facial expression analysis

Acknowledgements

I would like to express my gratitude to my supervisors Prof. Dr. Sara Irina Fabrikant and Prof. Dr. Wibke Weber, who guided me throughout this thesis. Furthermore, I would like to thank the interviewed experts for the exciting and helpful discussions which provided me with a deepened insight into their fields of work. I would also like to thank Dr. Sara Lanini Maggi, who always supported me in dealing with the iMotions Software.

Finally, I would like to thank my family and friends for their constant support throughout my thesis and my studies.

Table of Contents

List of Figures

List of Tables

1 Introduction

With the outbreak of the COVID-19 pandemic at the end of 2019 and early 2020, maps depicting the spread of the virus and the number of cases have emerged massively around the world (Pase et al., 2021). In print and online newspapers, on social media and on television, such maps could be found all over, with the aim of providing readers with a better understanding of the state of the pandemic. The diversity of these maps is particularly striking (Rinner, 2021). With all the different mapping techniques, data metrics, geographical levels and above all the different colour palettes, one cannot help but wonder if there is an optimal way to cartographically convey the state of the pandemic.

In their own way, maps have always influenced how humans perceive and understand the world (Dent, 2008, p. 3). They attract readers through their visually appealing, informative, comprehensive, and simple nature (Schaab et al., 2020, p. 5). Consequently, they are consulted as a source of information and used as a communication tool by decision-makers, companies, and individuals in many different life situations (Cartwright & Ruas, 2021, p. 1). As such, maps are useful tools, particularly in crisis situations. In public health crises, for instance, they can be applied to track outbreaks, plan responses, and notify people in need (Ghazisaeidi et al., 2015; Parrott et al., 2007; WHO, 2018).

For many years cartographers have studied the impact of maps on people's perceptions and emotions. In particular, the colours used in maps have been of interest. As a visual variable in maps, colours strongly contribute to their readability and comprehension (Dent, 2008, p. 259f). However, several studies over the years have shown that colours can have an impact on people's emotions as well (Palmer & Schloss, 2010; Valdez & Mehrabian, 1994; Wilms & Oberfeld, 2018). Accordingly, warm colours such as yellow, orange and red are seen as being more active, exciting, and stimulating, whereas cold colours such as blue and green are seen to be more calm and peaceful (Russell, 1978).

Likewise in Switzerland, a large number of graphics and maps have been published since the outbreak of the pandemic. The various media companies in particular, but also smaller newspapers, have taken it upon themselves to inform the Swiss population daily about the development of the virus through visual displays. This has resulted in a variety of designs of daily updated maps on the same topic. Some studies have already attempted to analyse such maps (Pászto et al., 2020; Rinner, 2021). However, most of them compared famous international COVID-19 dashboards, but did not focus on less known maps, and even less on maps published throughout Switzerland, which were of use and relevance to the local population.

1.1 Research Aim

Due to the lack of studies on COVID-19 maps in Switzerland, the first part of this thesis attempts to capture their diversity by means of a content analysis. Interviews with journalists and researchers in

the fields of cartography and data journalism further provide an insight into how this diversity of maps came about and what the decision-making processes of these visualisations looked like.

In order to provide this insight into this diversity of maps, the following research question with sub-questions were defined.

RQ1: How did the Swiss online media make use of maps to communicate the state of the pandemic?

RQ1.1: What type of information do the COVID-19 maps which were published by the Swiss media, show?

RQ1.2: What cartographic designs were used for the COVID-19 related geovisualisations?

RQ1.3: How and why has the cartographic design changed since the beginning of the pandemic?

RQ1.4: How were these maps perceived and evaluated by experts in the field?

Previous international studies on COVID-19 maps have shown that although the maps differed greatly in colour, the mapping techniques and content were very similar (Cay et al., 2020; Mooney & Juhász, 2020; Rinner, 2021). Moreover, there has been great diversity in the professionalism of cartographic design. Consequently, it is hypothesized that a similar picture can be found in the Swiss COVID-19 maps of the media (H1).

In the second part of this thesis, the focus is on the effect of mentioned maps on the reader. Determining how to design an optimal map on the COVID-19 topic is a complex, difficult and, above all, controversial matter and is not the goal of this thesis. Rather, the aim is to find out in an empirical experiment how these COVID-19 maps influenced our emotions, our assessment of the pandemic and our decisions. It is not intended to produce an optimal visualisation method, but to show how different maps may be perceived differently and what creators have to be aware of when mapping. Two colour scales, a warm-coloured one and a cold-coloured one, both used by the Swiss media for their COVID-19 maps, will be compared and their effect on the reader is to be determined. For this purpose, part 2.1 of the thesis examines the evoked emotions, followed by part 2.2 which studies the perceptual and behavioural responses.

RQ2: What emotional, perceptual and behavioural responses do COVID-19 maps evoke?

RQ2.1a: How do the expressed emotions (arousal, valence) differ when facing warm-coloured maps compared to cool-coloured maps?

RQ2.1b: How do the expressed emotions (arousal, valence) differ when facing maps of COVID-19 compared to maps on population ageing?

RQ2.2a: How does the perception of the pandemic differ when facing warm-coloured maps compared to cool-coloured maps?

RQ2.2b: How do the behavioural decisions differ when facing warm-coloured maps compared to cool-coloured maps?

It is hypothesised that warm-coloured maps evoke more emotions and more negative emotions than cool-coloured maps (H2.1a). This is based on studies that have shown that warm, especially red, colours elicit more emotions than cool ones (Russell, 1978; Valdez & Mehrabian, 1994). Furthermore, it is assumed that COVID-19 maps evoke more emotions (more arousal and more negative valence) than other maps of a different theme (H2.1b). For research questions 2.2a and 2.2b it is being assumed that COVID-19 maps with warm-coloured scales generate more negative, pessimistic perceptions (H2.2a) and produce more cautious behaviour (H2.2b) than cool-coloured ones. This assumption is based on studies showing that red is perceived as an alarming whereas blue and green are associated with calmness, comfort and security (Pravossoudovitch et al., 2014; Wexner, 1954).

2 Research Context and Literature Review

2.1 COVID-19-Pandemic

In December 2019, an unknown virus was discovered in Hubei province, China (WHO, 2020c). The extent that this virus would have on the world's population was not evident at the time. The virus started to spread rapidly worldwide. On 11 February 2020, the disease caused by the *severe acute respiratory syndrome coronavirus 2*, known as SARS-CoV-2, was named coronavirus disease 2019, or COVID-19 for short by the World Health Organization (WHO, 2020d). Just one month later, the World Health Organization (WHO) declared the outbreak to have extended to a pandemic (WHO, 2020e).

SARS-CoV-2 belongs to the Coronaviridae family, which was discovered by June D. Almeida in 1964 (Almeida & Tyrell, 1967). The virus family was named after the distinctive spikes, who visually resemble the structure of the outermost layer of the sun, called *corona* (Interpharma, 2022). Different species of coronaviruses have thus been around for a long time. As can be seen in Figure 1, there have been other recognisable outbreaks in recent years.

Between 2002 and 2003 SARS-CoV-1, also known as the SARS outbreak, spread around the world. SARS lead to approximately 8’096 confirmed cases and resulting in 774 deaths attributed to the virus (WHO, 2015). A decade later, in 2012, MERS-CoV emerged, which could not be eradicated. As of 2022, there have been 2’589 laboratory-confirmed cases and 893 associated deaths registered globally (WHO, 2022c). As the SARS-CoV-2 pandemic is still globally ongoing during the writing of this thesis, no final figures on the number of illnesses and deaths can be presented. However, as of 26 September 2022, 625 Mio. people have been infected and over 6 Mio. deaths have been linked to the disease (WHO, 2022a).

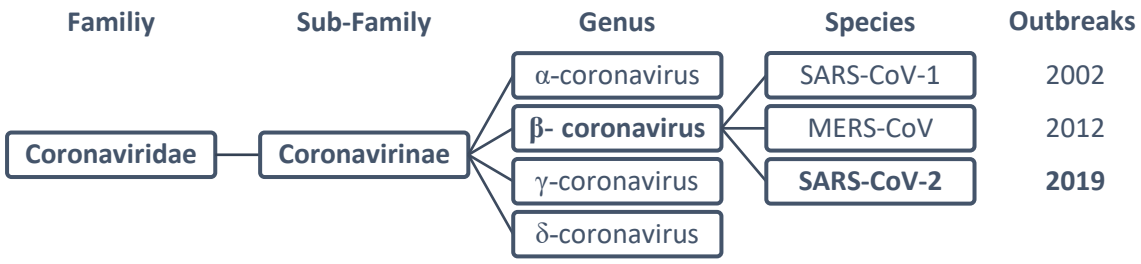


Figure 1: Classification of SARS-CoV-2. Adapted from Rehman et al. (2020, p. 2).

2.1.1 Global Spread of the Virus

The first infections of SARS-CoV-2 were reported in the city of Wuhan, China, in December 2019, from where the virus began to spread rapidly (WHO, 2020c). The Chinese government responded with large-scale lockdowns to control and minimise the spread. Nevertheless, the virus spread beyond the country's borders and was distributed all over the world.

While other European countries were registering cases as well, the virus spread particularly quickly in Italy, leading to a high number of deaths. On 19 March 2020 Italy surpassed China's total number of reported deaths (The Guardian, 2020). China managed to diffuse its situation and reported steady figures on the pandemic. Meanwhile, Europe was declared the epicentre of the virus by the World Health Organisation (2020f). Shortly thereafter, more and more cases were reported in the USA, especially in New York City. In retrospect, it is suspected that most cases in New York were newly transmitted from Europe and no longer primarily from China (Layne & Resnick-Ault, 2020). In April 2020, the number of cases rose to 1 million globally (Rachel Chang, 2020). In its first semester, the COVID-19 pandemic managed to reach almost the entire globe and caused thousands of deaths and even more illnesses.

In the summer months of 2020, the first wave settled down in many parts of the Northern Hemisphere (WHO, 2020b). However, with the onset of the winter months, the number of cases rose again, and a new variant of the virus – the alpha variant – began to spread (WHO, 2022b). Since then, repeated waves of virus outbreaks occurred, the extent and duration of which varied greatly from region to region. From Figure 2 it can be retrieved how the pandemic has developed in different regions of the world since its initial outbreak in 2019.

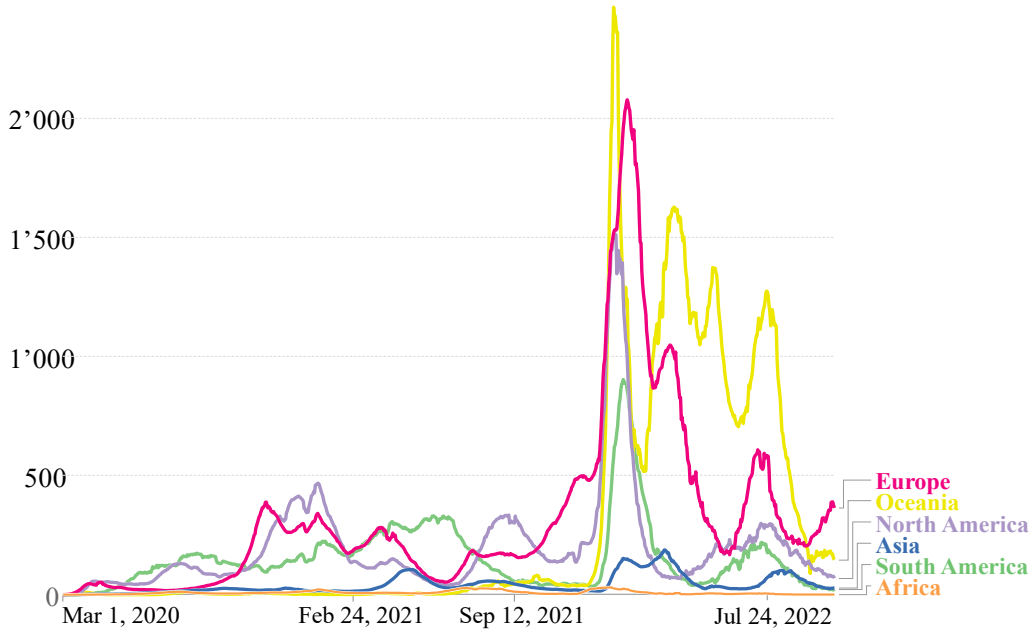


Figure 2: Daily new confirmed COVID-19 cases per million people in different world regions. Data Source: Johns Hopkins University. Adapted from: Our World in Data (2020).

2.1.2 Measures Against the Spread of the Pandemic

How the virus spread, what measures would be effective to reduce it and who was particularly susceptible to severe illnesses was unclear at the beginning of the pandemic. It was certain, however,

that controlling the spread of the virus proved to be a difficult task. This was also underlined by the WHO's Director-General (2020e) in a speech on 11 March 2020, where he said:

> *"This is the first pandemic caused by a coronavirus. And we have never before seen a pandemic that can be controlled, at the same time."*

This statement clarified that the World Health Organization has not classified the extent of the two previously presented spreads of coronaviruses in 2002 and 2012 as pandemic events. Making the severity of the situation even more apparent.

Because the pandemic was caused by a new and unknown virus species, there was initially great uncertainty about how to respond effectively to the spread (Griffin, 2020, p. 12). Very little was known about the forms and rates of infection, the severity of the course of the disease, the vulnerability of high-risk patients and thus the further course of the pandemic. This led many national governments to implement more or less restrictive measures with the aim of greatly reducing contacts between people and thus lowering the rate of virus transmissions (Riehm et al., 2022, p. 3). Non-pharmaceutical interventions included the closure of schools and non-essential workplaces, cancellations of public events, restrictions of social gatherings and international travels as well as the appeal or in some cases obligation to stay at home. Other measures to limit the pandemic included wearing face masks as well as keeping a minimum distance between people.

2.1.3 COVID-19 in Switzerland

Switzerland was not spared from the pandemic. Over the past two years, the virus has posed numerous challenges to the Swiss population. On 25 February 2020, the first person in Switzerland tested positive for SARS-CoV-2 (BAG, 2020a). Three days later, on 28 February 2020, the Federal Council declared a *special situation* (BAG, 2020b). This defined a classification under Switzerland's Epidemics Act (Federal Act of 28 September 2012 on Controlling Communicable Human Diseases), which gave, the Federal Council more competencies than in a *normal situation*, where dealing with public health issues would be the task of the cantons. As a consequence, large events with more than 1000 people were forbidden. From 13 March onwards, public life was massively restricted in order to reduce the spread of the virus. This involved banning all attendance at educational institutions (BAG, 2020c), establishing entry regulations, closing all but essential businesses (BAG, 2020d), and imposing a ban on gatherings of more than five people (BAG, 2020e). As of 16 April, a gradual lifting of the measures began (BAG, 2020f).

Since then, the number of cases has been increasing especially in the winter months, leading to periodic measures to prevent spikes in further infections. On 23 December 2020, the first person in Switzerland was vaccinated against the virus (SRF, 2020) and the nationwide vaccination campaign was launched (BAG, 2020g).

2.1.4 COVID-19 Metrics

The spread of the virus was recorded, monitored and communicated using a variety of metrics (Pászto et al., 2020, p. 16). For instance, the Swiss population was informed daily about the latest developments using absolute case numbers, i.e. the number of registered new infections (Rinner, 2021, p. 16). Just as common was the incidence rate, which provided a relative value, i.e. the registered number of cases per 100'000 or another specific population size within a period of time. Also communicated were the permanent ICU capacities, the number and rate of hospitalisations, the number and rate of deaths, and the reproduction rate. The latter being the estimated average number of people infected by the same person within a period of time. Finally, there was also the positivity rate, which provided information on how many of the tests returned a positive result.

Although these metrics provided an understanding of the situation, the numbers had to be treated with caution. One reason for this is that only the officially reported infections were registered, excluding all unknown infections and self-tested but not officially notified cases (Rosenkrantz et al., 2021, p. 1). The determination of the true number of infections was further complicated by the fact that it depended on the accuracy of the test and the willingness of the population to get tested. It could therefore only be estimated (Pászto et al., 2020, p. 16). The positivity rate has often been used to show how robust the case rates results were. However, Rinner (2021, p. 16), criticised that it was overly relied upon given that the accuracy of the test results was also not accounted for in the metric. Furthermore, considering that people frequently move between zones, Rosenkrantz et al. (2021, p. 1) have criticised the possibility that cases reported at one area could result in further infections in other places as well.

2.1.5 COVID-19 in the Media

In the annually published book series Quality of the Media by the Research Center for the Public Sphere and Society (FÖG), the coverage of COVID-19 by the Swiss media outlets was extensively analysed in the 2020 and 2021 editions. The 2021 version noted that the pandemic has dominated the news like no other event in recent decades (FÖG, 2021a, p. 37). At the beginning of the pandemic, the number of publications even exceeded the number of infections in Switzerland by far. In the course of the year, however, the intensity of reporting on the topic decreased, the FÖG observed.

During the first wave of cases, the Swiss media were often accused of overly alarmistic reporting which was too uncritical of the authorities (FÖG, 2021a, p. 13). However, during the second wave of the pandemic, it was found that the virus was less frequently portrayed as a threat. Furthermore, the content showed to be less authority-affirming. Misinformation was found to circulate mainly on social media (FÖG, 2020, p. 5), but was hardly circulated by the Swiss media houses or the authorities (FÖG, 2021a, p. 11).

2.2 Cartography

2.2.1 Role of Maps in Society

Maps have shaped our perception and understanding of the world for centuries (Dent, 2008, p. 3). Throughout this time, they have been used in all kinds of fields for various reasons and motivations. Maps make it possible to present data and their complex spatial relationships in a visually clear way that allows direct interpretations (Schaab et al., 2020, p. 5). It is therefore only reasonable that maps are used by governments, companies and private individuals to monitor developments, make predictions and to support the decision-making process (Pászto et al., 2020, p. 174). In addition, maps are good analytical tools. For instance, John Snow (1854), one of the founders of modern epidemiology, was able to identify the source of a cholera outbreak by means of cartographic analysis.

However, maps also serve as a communication tool and are used specifically to inform people about events in a timely manner and thereby strengthening their situational awareness (Cartwright & Ruas, 2021, p. 1). Nowadays, maps can be produced quickly and inexpensively and distributed widely, which is particularly of use in crisis situations. Especially in the public health sector, maps are used to monitor outbreaks, coordinate measures and inform those affected (Ghazisaeidi et al., 2015; Parrott et al., 2007; WHO, 2018).

Maps have thus served as useful tools for centuries. And, as such, users tend to put unconditional trust in such visualisations (Tyner, 1982, p. 140). The lack of critical reading of maps leads to viewers being misled and drawing false conclusions, when the map does not portray the truth. Maps have long been used to intentionally mislead people and persuade them into believing incorrect matters (Mode, 2017, p. 8). Such visualisations are called persuasive maps. This visual form of distorting facts, was used extensively by the Nazis in the Second World War as a propaganda tool (Herb, 1989, p. 289; Tyner, 1982, p. 140). However, it is still widely used today. In an attempt to make persuasive maps easier to recognise and label as such, Muehlenhaus (2013) identified several layout variables which distinguish scientific from non-scientific maps. However, there is a variety of ways one might use to present data inaccurately, intentionally but also unintentionally, due to lack of knowledge (Crampton, 2009, p. 97). Moreover, today's population is exposed to an abundance of geovisual content which prevents the controlled management and identification of such misleading maps. According to Monmonier (1996, p. 216) it is therefore of primary importance to inform readers and designers about such insidious methods and teach them to be sceptical.

Unethical behaviour with regard to data communication was reported to have occurred during the course of the COVID-19 pandemic as well. For instance, according to the Associated Press, the Florida government tried to coerce a data analyst into adjusting the infection rates to suit their political interests (Farrington & Calvan, 2020). Incidentally, the pandemic was not spared of inaccurate visualisations (Rinner, 2021, p. 22), inaccurate communication (King & Lazard, 2020, p. 1723), nor inaccurate data (Juergens, 2020). The main way in which graphics were used to mislead people was by taking them out

of context (Brennen et al., 2020; Tufekci, 2022) and to a lesser extent, visually manipulating them (Brennen et al., 2021, p. 289). Nonetheless, most maps were created in good faith and aimed to accurately inform the public.

2.2.2 Conventions in Cartography

In cartography there are some design conventions that have been established over the years. The agreements relevant for this thesis are presented in this subchapter.

Maps are characterised by a multitude of attributes and elements (Bertin, 1983). In order not to lose track of these attributes, it is important to try to focus the reader's attention on the most thematically relevant (Fabrikant & Goldsberry, 2005). For this to succeed, the most relevant element in a map should always be the most perceptually salient (Dent, 2008). The reason for this is that the way an element is presented has an influence on how map readers perceive it. Bertin (1983, p. 60f) shared this view, which led him to identify the seven in his view most important visual variables that relevantly influence the perception of map elements. According to Bertin, position plays a primary role. Compared to being placed on the side, an object placed prominently in the middle is more likely to be noticed. Secondly, size was identified to be important with the idea that the bigger the object, the more prominent it seems. Thirdly, the colour value was mentioned as a variable, which can influence the salience of an attribute. Further, Bertin identified the fineness or coarseness of an attribute's texture. In addition, the colour hue has a significant influence on how strongly an attribute stands out. Finally, Bertin mentioned the orientation of the patterns and the shape of the attributes as variables that can influence perception.

A few years later, the effects of these variables on salience and perception as suggested by Bertin were scientifically proven (MacEachren, 1995). The decision whether and how to use these variables as well as knowing their effects, is in the hands of the cartographer. A considered choice is therefore necessary, given that not every variable is always appropriate (Bertin, 1983, p. 60). Other cartographers such as MacEachren (1995, p. 275f) have further developed and adapted this list of important variables in later years. The variables of hue and colour value are of particular interest in this work, which is why they are discussed in greater depth in chapter 2.4.

The maps primarily published and discussed during the pandemic are thematic maps. Thematic maps are designed to depict and communicate the spatial dimension of a thematic attribute (Slocum et al., 2005, p. 2). To show such distributions on maps, cartographers have developed a variety of mapping techniques over the years. The techniques discussed in this paper include choropleth mapping, hexbin mapping and proportional symbol mapping.

In choropleth maps (see Figure 3), the collected data are classified and colour-coded (Slocum et al., 2005, p. 85). In a second step, the enumeration units (i.e. countries, states, communities) are coloured according to the data. Choropleth mapping is particularly suitable when the data have been collected for the survey zones and there are clear data differences between the zones. One of the disadvantages of

choropleth maps is that large sized enumeration zones stand out more than smaller ones, as mentioned above (Bertin, 1983, p. 60). This effect is also evident in the world map in Figure 3.

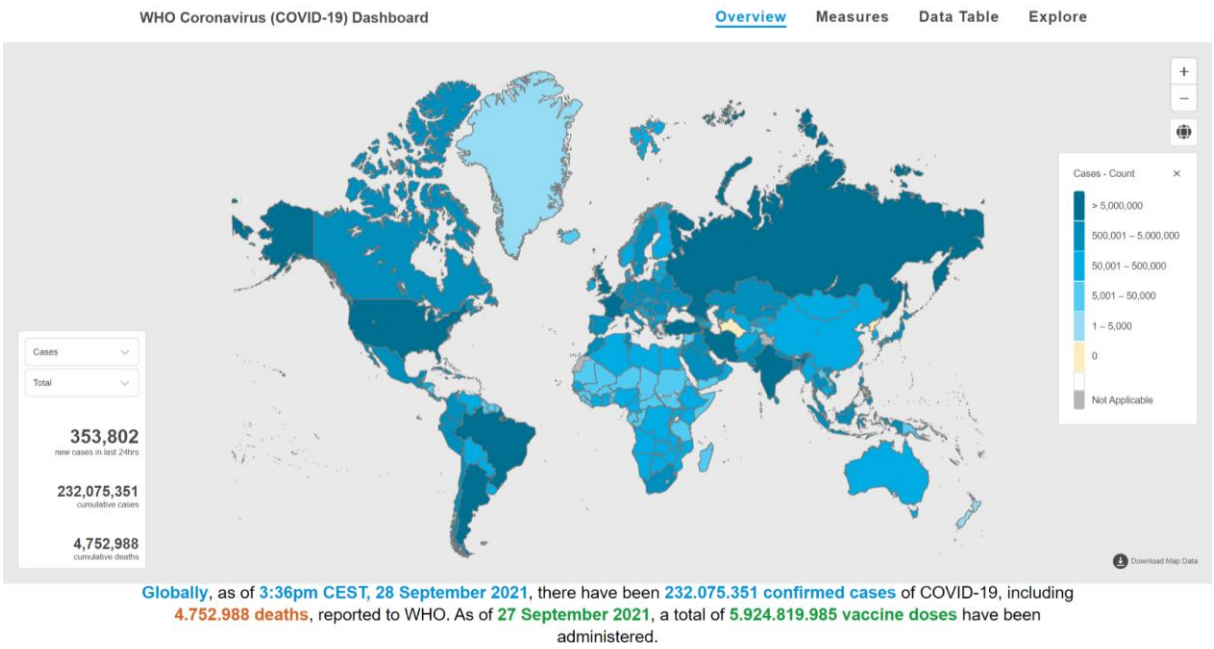


Figure 3: WHO COVID-19 dashboard from September 27, 2021, showing Choropleth world map (WHO, 2020b).

Hexbin maps are similar in the way that the depicted areas are also coloured according to the values. However, they differ in that the enumeration zones are converted into hexagons of the same size (Trautner et al., 2022, p. 66). Compared to choropleth maps, this has the advantage that there are no size difference effects. However, the identifiability of the regions is lost due to their shape, which is why the enumeration zones usually have to be labelled.

Proportional symbol maps, also known as graduated symbol maps, are geovisualisations in which the collected data are drawn on the map in the form of symbols of different sizes according to the magnitude of the data (Slocum et al., 2005, p. 88f). These can be geometric symbols as well as icons corresponding to the theme.

There is a consensus among cartographers that choropleth maps should show data in relative form (i.e. per inhabitant or per area), because of differing sizes of areas (Dent, 2008, p. 104). Proportional symbol maps (or graduated symbol maps), on the other hand, are intended to show the absolute values. Outside cartography, this convention is often not known of, which is why unsuitable visualisation methods are frequently encountered. As a result, many COVID-19 geovisualisations showed choropleth mapping with absolute values (Pászto et al., 2020, p. 177; Rosenkrantz et al., 2021, p. 1). It is noticeable that the default setting of the WHO dashboard (Figure 3) also displays absolute numbers of cases. Even though the dashboard allows the user to change to a map with relative data, it is likely not noticed by many users.

2.2.3 Maps of COVID-19

The issue of COVID-19 has been widely thematised throughout the world since the beginning of the outbreak. It has been reported, discussed, and shared in the media and especially on social media. As early as February 2020, Depoux et al. (2020, p. 1) had the opinion that the panic about the pandemic was spreading faster on social media than the virus in the real world. Likewise, the WHO (2020a) has talked and warned about the development of an "infodemic". Due to the large amount of information available, people were at risk of consuming and sharing untrustworthy sources that misinformed them on the developments (WHO, 2020a, p. 1).

In this abundance of information a large number of pandemic maps have been created and published (Griffin, 2020, p. 10). These refer to any geovisualisation that presents data collected in connection with the pandemic. The topics visualised in these maps ranged from changes in air pollution (BBC, 2020), over the mobility of the population (Teralytics, 2022), to the variety of school closure measures (World Bank Education, 2021). But above all, the number and rates of the cases were geovisualised and published (Rinner, 2021, p. 14). Many media outlets have taken it upon themselves to publish daily updated graphics containing these metrics and with the goal of bringing the developments of the pandemic closer to the population (BBC, 2022; Gutiérrez et al., 2021; SRF, 2022; The New York Times, 2022). People relied on these maps to learn more about the topic, to inform themselves about occurrences, to make comparisons and finally to base their decisions on them (Cay et al., 2020, p. 65).

The pandemic was also the subject of numerous scientific research. Since the outbreak of the pandemic, a large number of studies and articles have been published on the topic. This happened, on the one hand, because global interest in information gathering and research was huge, and on the other hand, because many publishers of scientific journals accelerated the publication of such articles (Pászto et al., 2020, p. 172).

A number of studies already examined the media's daily updated articles and maps (Cay et al., 2020; Mooney & Juhász, 2020; Rinner, 2021). In the studies, it was often criticised that cartographic principles were not followed. Rinner (2021, p. 22) identified COVID-19 maps with distorted map projections, alarming colour palettes, data-obscuring classification methods and absolute data in choropleth maps. Pászto et al. (2020, pp. 177, 184) also identified the latter problem, but further found geovisualisations depicting inconsistencies between legends and maps, or even graphics where the legends were missing. Finally, Rosenkrantz criticised (2021, p. 1) that the resolutions of the enumeration units in most maps were too low for governments to take effective local action and for people to assess their risks. One study investigated in what way maps were used by readers during the pandemic to make informed decisions (Pase et al., 2021). Finally, several studies examined the effects of maps on readers. Cay et al. (2020, p. 71f) found out through elicitation interviews that users rather want to get an overview by means of maps than use them for more in-depth analyses. In general, it was found in the interviews

that participants were easily overwhelmed by the amount of data. Furthermore, according to Cay et al. (2020, p. 71f), participants would rather identify trends than interpret absolute numbers, as they trust the numbers less. Some studies have attempted to directly compare different published maps in order to gain insights into their effect on preference (Li, 2021), comprehension (Thorpe et al., 2021), situational awareness (Li, 2021; Thorpe et al., 2021) and behaviour (Thorpe et al., 2021). However, by comparing pictures of the publications, a number of variables, such as different base maps, legends and map projections were not taken into account in the experiments, which could have influenced the results. Further studies taking these inequalities into account are therefore needed.

2.3 Emotions

Emotion is among the most vital elements of the human experience (Ortony et al., 1988; Plutchik, 1982, p. 529). In their daily lives, most people experience and display a variety of emotions. Nonetheless, defining emotions conclusively and uniformly has proven to be a difficult task. This becomes particularly evident by the fact that scientists have not been able to agree on a clear definition of emotions since the beginning of this topic's research (Meiselman, 2003; Plutchik, 1982; Scherer, 2005). Rather, there are a variety of theories and understandings of what emotions are, how they arise and how they can be classified. This chapter attempts to capture the current state of knowledge and opinion in emotion research and to present the elements that are important for this thesis.

Despite its prevalence, emotion research is very little advanced (Izard, 1991, p. 1). This was noted by Plutchik (1982, p. 530), who justified it by the fact that it was a very difficult task to evoke an authentic, undisturbed emotion during an experiment while also complying with ethical standards.

Over the years, researchers have identified three components which play a significant part in emotion formation: the physiological, behavioural, and cognitive components. According to general understanding, a stimulus needs to trigger an emotion in order to feel it (Prinz, 2004, p. 5). Darwin was interested in the study of emotions as well (Plutchik, 1982, p. 531). His opinion was that emotions are subject to an evolutionary reason and arise as a physical reaction to stimuli in order to protect the individual from possible dangers. For instance, hair stands up when one is in danger. James (1884, p. 189f) also believed that there are uncontrollable, physical, physiological changes in the body in response to the perception of a stimulus. In his theory, the perception of said physiological changes is the emotion.

Other researchers are of the opinion that emotions of an affected person can be derived from their behaviour (Watson, 1919). Skinner (1953, p. 162) believes that the probability of the occurrence of a behaviour after experiencing a stimulus makes it possible to assign it to an emotion. Panic can therefore be shown by stiffening or forgetting where the emergency exit is.

Finally, Ortony et al. (1988) believe that emotions must have a cognitive foundation. If not, they argue, there would be no difference in the reactions of winners and losers after the final whistle of a game. Instead, the event is judged from different sides and based on that, different emotions are generated. The winners express joy while the losers express sadness or anger. Solomon (1976, as cited in Prinz, 2004, p. 8) also sees the cognitive component as the most relevant and describes emotions simply as "evaluative judgements".

Nowadays, however, most scientists agree that emotions are made up of a mixture of these components (Prinz, 2004, p. 10). What remains disputed is the order in which they occur (Frijda, 1986). Hatfield et al. (2014, p. 160) abstain from the debate by being of the opinion that the brain receives the stimulus and as a reaction all components influence each other in no clear order to form an emotion. Even though, this would provide a solution to the problem of definition, Prinz (2004, p. 10) would not

be satisfied by this. To him, if and how the components interact is of great importance, as otherwise the definition of emotion would be too loose, resulting in a loss of the already researched connections of the components. Consequently, there is still a need for more in-depth research into the field of emotion in order to identify precise sequences.

2.3.1 Categorising Emotions

Since emotions are psychologically complex and not easily definable, categorising them systematically and identifying which emotion terms (i.e. sadness, anger) represent pure emotions and which do not, becomes just as challenging. For example, Ortony et al. (1987, p. 346f) point out the important difference between *being* and *feeling*. By understanding this difference, the terms can be better assigned to or omitted from being emotions. The researchers compare *being* and *feeling* angry with *being* and *feeling* abandoned. Only if an emotional state is recognisable in both cases is it an emotion word. Therefore, it is argued, that the adjective abandoned is not an emotion word in itself, but only appears as one in connection with *feeling*. Without this recognition of the necessity of the distinction, the researchers warned, too rough classifications of emotion terms are created.

Using these and other differentiation methods, Ortony et al. (1987, p. 350ff) created an emotion categorisation scheme and applied it to a list of approximately 500 emotion terms. According to the researchers, the best emotions are internal, mental conditions with a cognitive and/or affective and partly behavioural component. Terms corresponding to these specifications include among others happy (affective state), cheerful (affective-behavioural condition), encouraged (affective-cognitive condition), careful (behavioural-cognitive condition) and certain (cognitive condition) (Ortony et al., 1987, p. 349).

Another researcher who studied the definition and categorisation of emotions extensively was the psychologist Plutchik (1980). He was of the opinion that one has the ability to express primary emotions from birth (Plutchik, 1980, p. 9). In his studies he identified eight primary emotions, each of which being opposed to one of the others, creating four pairs (Plutchik, 1980, p. 16). *Anger* is opposed to *fear*, with the understanding that the former indicates attack and the latter flight. *Joy*, as a sign of gain, is contrasted with *sadness*, as a sign of loss. *Acceptance*, or sometimes *trust*, implies taking something in and *disgust* implies wanting to get rid of something. Finally, *surprise*, as something unpredictable, is contrasted with *anticipation*, something predictable. Like Ortony et al., Plutchik is of the opinion that there are many other emotions. However, according to Plutchik (1980, p. 9) they are all mixtures or derivatives of the eight primary emotions.

Similarly to Plutchik, Ekman et al. (1969) understand that there are basic emotions whose expression people know unconditionally. According to their study, these basic emotions even exist pan-culturally. (Ekman et al., 1969, p. 88). People all over the world can therefore feel the same emotions and identify them as the same. However, the factors that trigger these emotions, are culturally determined. Ekman and colleagues however define slightly different basic emotions. Instead of Plutchik's eight primary emotions, Ekman et al. (1972) only recognise the seven basic emotions of *anger*,

fear, *sadness*, *surprise*, *happiness*, *disgust* and *contempt*, whereby the latter are to be regarded as a combination.

Another description and classification method for emotions was developed by the German psychologist Wilhelm Wundt (1897, p. 98). He believed that "simple feelings", as he liked to describe emotions, could be explained with three main dimensions with opposing terms. Firstly, pleasurable feeling and unpleasurable feeling, secondly, arousing feeling and subduing feeling and finally strain and relaxation (Wundt, 1897, p. 103). The first dimension is nowadays being described as hedonic *valence*, which indicates whether a perception of a stimulus is to be classified as positive (pleasant) or negative (unpleasant). The second dimension refers to the intensity of the emotion felt. As the intensity of emotion increases, so does the level of *arousal*. The last dimension refers to the feeling of *dominance*, which gives information about how great the feeling of control is. All emotions can be described with these three dimensions. Wundt's classification of emotions is now well established in psychology and has proven to be a useful method for describing emotions in a basic way (Bradley & Lang, 1994, p. 49; Scherer, 2005, p. 718).

2.3.2 Measuring Emotions

Emotions have many facets, expressing themselves in speech, voice, facial expressions, physical movement, gestures and posture (Collier, 2014, p. ix; Hatfield et al., 2014, p. 160). It is difficult to describe one's own experienced emotions and yet one of the easiest ways to communicate emotions is through language and self-reporting (Ortony et al., 1987, p. 341). Therefore, tests are often conducted in which participants are asked to select and weight the emotions they feel from a list. One such test is the Geneva Wheel of Emotion, where participants are asked to indicate the intensity (arousal) of their felt emotion on a wheel with emotion families divided into valence and dominance (Scherer, 2005, p. 723f). Buck (2014, p. 14f) points out, however, that people who have not learned to deal with their emotions in a healthy way since childhood, find it difficult to label and assess their emotions until adulthood. A non-verbal test therefore offers the possibility of communicating the emotional state without the limitations of a categorical naming of emotions.

Self-Assessment Manikin

Such an alternative is offered by the Self-Assessment Manikin (SAM) test developed by Bradley and Lang (1994). This is an uncomplicated, time-saving test in which participants are asked to indicate which of three ranked series of pictograms most closely corresponds to their feelings. Bradley and Lang make use of the three emotion dimensions presented in chapter 2.3.1: *valence*, *arousal*, and *dominance*. When analysing the results obtained from the three ranked pictograms, precisely these dimensions are identified. Since no written descriptions of the pictograms are required, the test can be administered to almost all age groups. Furthermore, the test allows the ranked results of the participants to be compared with each other and significant differences to be identified.

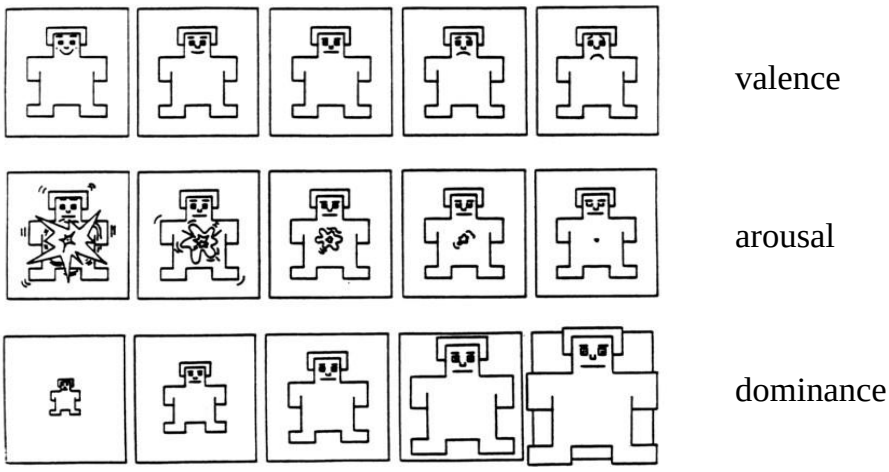


Figure 4: Self-Assessment Manikin dimensions (Bradley & Lang, 1994).

Facial Expression Analysis

Collier (2014, p. viii) believes that expressions are a fundamental part of initial, uncontrolled emotional reactions and do not occur at a later stage. By measuring such expressions, it should therefore be possible to derive information about the emotional affect of the participant. Ekman and Friesen (1976, p. 56) saw in particular a strong link between emotions and facial expressions. Before them, the faces of the participants had hardly been measured directly, but rather it had been mostly analysed whether the participants could interpret emotions seen on faces correctly. Therefore, Ekman and Friesen decided to develop an all-encompassing Facial Action Coding System that includes all possible visually-distinguishable facial movements and thus enables the identification of emotions. This comprehensive system includes a number of action units that describe the various muscle movements in the face. For example, Action Unit 12 describes the lip corner puller in which the zygomatic major muscle moves, to create what we interpret as a smile (Ekman & Friesen, 1976, p. 65). Emotions could then be derived from these action units.

Nowadays, cameras are used to scan faces and computer algorithms automatically read the action units and decode emotions (Sharma et al., 2021, p. 1). Thus, no complex manual processing is necessary anymore. The algorithms, some of which are very newly developed, are based extensively on the coding system of Ekman and Friesen and would hardly be as precise without the researcher's preliminary work. The principle of facial expression analysis includes the detection of the face, the determination of facial expressions and finally the allocation to the appropriate emotion (Sharma et al., 2021, p. 1). But facial expressions can be minimal or unreliable (Jmour et al., 2021, p. 999; Taggart et al., 2016, p. 6). Therefore, one of the biggest challenges of the facial expression analysis method is the misinterpretation of facial expressions. In general, there may be inaccuracies that might have been noticed if the facial expression had been recorded manually. However, due to the rapid development of the research field as well as the ever-improving cameras and algorithms, efforts will continue to be made to accurately identify emotions using facial expression analysis (Taggart et al., 2016).

2.4 Colour

In this chapter it is avoided going deeply into the theory of colour. Instead, the elements and relationships that are relevant in the context of this thesis are introduced and explained.

To describe colours Munsell (1905) defined the following three dimensions: *hue*, *value* (lightness) and *chroma* (saturation). Munsell describes the dominant wavelength of light that makes up the colour itself (i.e. red, green, blue, yellow). The colour *value* describes how light or dark a colour tone is. Finally, *chroma* describes the saturation of a tone resulting from its purity. Chroma is often explained with the terms vividness and intensity. All three dimensions are individually measurable and thus every colour occurrence can be described by means of the three dimensions. In cartography, knowledge of these three dimensions is particularly important. This is because the dimensions determine the distinguishability of the colours, which leads to an appropriate colour palette and thus to a comprehensible map (Brewer, 1994, p. 123).

2.4.1 Role of Colour in Cartography

As mentioned in chapter 2.2.2 colour hues and colour brightness are important visual variables in cartography. According to Dent (2008, p. 259f) colour can influence the legibility and visual differentiation of a map and plays a role in simplification and comprehension. In addition, colour can have a direct influence on whether data can be accurately retrieved (Brewer et al., 1997, p. 411). This is supported by a study applying elicitation interviews by Cay et al. (2020) where colour was shown to be an important tool in data interpretation.

However, colours also attract attention and can be used to highlight data (Engebretsen & Kennedy, 2020, p. 307). A study by Fabrikant and Goldsberry (2005) showed that dark coloured areas in a map have higher saliency than light coloured areas, provided that the background is light. The researchers assumed that the effect is reversed for a dark background.

2.4.2 Colour Scales

To visualise data, thematic maps usually make use of *qualitative*, *sequential*, or *divergent* colour scales (Brewer, 1994, p. 128). These three types are each appropriate for different types of data and should be applied accordingly. For *qualitative* data which are not subject to any order, such as languages, different colour tones are appropriate (see Figure 5).

If the visualised data are ordered, as is the case with age classes, for example, a *sequential* colour scale should be applied (Brewer, 1994, p. 128). This is a colour gradient that runs either within one hue (single hue scale) or several hues (multi-hue scale). Here, a clear overall decrease or increase in colour brightness should be visible in the course of the colour gradient (Crameri et al., 2020, p. 5). This can be used to communicate where high and where low values are to be found on the map. In general, in cartography "the darker the more" applies, which means that the higher the values, the darker they should

be displayed (Olson, 2002, p. 2528). However, if a dark base map is present, the opposite case can also occur, as for example with fMRI scans in neurology (Krainik, 2011).

The third scale method is the *divergent* colour scale. This is used to represent values with significant midpoints, such as temperatures (Brewer, 1994, p. 128). Diverging colour scales are characterised by the fact that the brightness decreases from a usually bright centre of the scale in both directions in different shades.

Categorical *Sequential* *Diverging*

"Set2" *"YlGn"* *"BrBG"*

Figure 5: Colour scale types with names. Adapted from: Brewer (2003).

2.4.3 Colour Connotations and Associations

Colours can be psychologically connotated with a variety of topics. For instance, people might associate the colour hue blue with water, green with vegetation and brown with soil (Fish, 2020, p. 10). These are precise colour connotations that are ideal in cartography for colouring land use classes (Dent, 2008, p. 261). But colours can by no means be associated with all types of subjects (Ware, 1988, p. 42). As a result, as of the writing of this thesis there is neither a colour that is connotated with population ageing, nor one that is connotated with the coronavirus.

Furthermore, colours are often associated with emotions. Wexner (1954) recognised in an early study that blue hues were associated with emotions of security and comfort. In addition, blue as well as green hues were associated with calm and peaceful emotions. Purple was associated with protective and defending, whereas red hues were associated with excitement and stimulation. Red but also orange were associated with defiant and hostile sentiments. Finally, yellow was associated with being cheerful and joyful. In another study by Pravossoudovitch et al. (2014) a similar picture emerged. The researchers found that danger was associated more quickly and strongly with the colour red than with green or grey. Green, on the other hand, was positively associated with emotions of comfort and security.

However, Elliot and Maier (2014) point out that the association of colours also depends on the specific context. These different associations occur when the hue is increasingly used in a particular context, by means of cognitive reinforcement. This is why red can also be associated with romance and attraction (Elliot & Maier, 2014, p. 99). These associations are sometimes deeply ingrained, yet they can vary substantially between cultures (Jonauskaite et al., 2020).

It has indeed been shown that participants prefer it when the choice of colour in a map also corresponds to their expectations (Fabrikant et al., 2012). In a further study by Anderson and Robinson

(2020) it was then revealed that incongruent colour scales can cause confusion among viewers. It is therefore important to consider common connotations and associations when creating maps in order to appeal to the reader.

2.4.4 Colour Perception

Colours shape everyday life all over the world. However, colours are not perceived in the same way by everyone and not in every context due to interactions with the environment. Some of the differences in colour perceptions that occur are presented in this subchapter.

Colour Blindness and Colour Vision Deficiency

The cones present in the eye's retina are responsible for colour perception (Gordon, 1998, p. 81). There are three types of cones: L-cones (red-sensing), M-cones (green-sensing) and S-cones (blue-sensing). If a person suffers from colour blindness, some of these cones are either absent or non-functional (Britannica, 2022). If the red-sensing L-cones are missing, the person has protanopia (Gordon, 1998, p. 81). Deuteranopia occurs when the green-sensing M-cones do not function. If either of these colour vision deficiencies is present, one cannot distinguish well or at all between red and green areas. In tritanopia, a person cannot distinguish between yellow and blue due to the non-functioning of the S-cones (Colour Blind Awareness, 2022). Without the functioning of any cones, the person is unable to distinguish between colours and is diagnosed with achromatopsia (Gordon, 1998, p. 82). However, this form of colour vision deficiency is very rare. If a person has a minor colour deficiency, one generally speaks of an anomaly.

Overall, colour vision deficiency affects about 6-10 % of men and 0.4-0.7 % of women (Gordon, 1998, p. 81). In most cases, the deficiency is genetically inherited. Cartography generally tries to accommodate peoples' colour vision deficiencies and use colour-blind-friendly colour palettes. Brewer (2003) has taken it upon herself to define such scales and made them freely available for designers online.

Visual Colour Perception

While the subdivision of colours in linguistics is limited and discrete, colour perception is continuous (Jonauskaite, 2021, p. 39). However, the physical steps between colours do not correspond to those perceived perceptually (Ware, 1988, p. 44). In a rainbow colour scale, the green hue, unlike the other hues, does not change during a big part of the gradient (Rogowitz & Treinish, 1996, p. 269). This leads to an uneven progression of colour gradient and data values. Ideally, the steps of hue and lightness in the course of a colour scale should correspond to those of the data. To counteract this problem, colour palettes have been developed in recent years that are adapted not to the physical colour scales but the perceptual abilities of humans (Smith & van der Walt, 2015).

Furthermore, colours can be influenced by their environment through various contrast effects (Ware, 1988, p. 42). A *simultaneous contrast* occurs when a grey field on a white background appears

brighter than on a dark background. This is particularly problematic in geological and choropleth maps with many categories, as the reader may assign the areas to the wrong class (Monmonier, 1996, p. 239). Another perceptually confusing effect is the *chromatic effect*. Due to this contrast effect, when a grey area is surrounded by a red area, the grey area appears greener than when it is surrounded by a green area (Ware, 1988, p. 42). It is therefore of great importance in cartography to choose colour palettes and class sizes in a way that the class division produces differences that are as perceptually distinguishable as possible.

2.4.5 Colour and Emotion

According to Dent (2008, p. 260) emotions can be influenced by colour. This could also be shown in a study by Wilms and Oberfeld (2018). In the study, the physiological emotion dimensions of *arousal* and *valence* were measured at different *hues*, *brightnesses* and *saturations* using a self-assessment manikin. The study showed that all three colour dimensions had a significant influence on emotions, especially arousal. Higher brightness led to higher arousal. Furthermore, higher arousal levels were identified for red compared to green and blue. Finally, at high saturation, an increase in valence from green to red to blue was measured. At low saturation, however, the effect was reversed.

In a study by Valdez and Mehrabian (1994) in which participants were asked how colours, broken down by dimension, made them feel, it was found that brighter, more saturated colour scales made them feel pleased, indicating positive valence. According to the study, saturated colours also increased arousal. Furthermore, blue, green, blue-green, red-purple, and purple colour shades and combinations were found to elicit higher arousal than yellow and yellow-red.

Another study by Palmer and Schloss (2010) indicated that object preferences generated colour preferences. This means that colours that are associated with positive objects generate positive emotions. As an example, the sky is used. People like the sky not because they like blue, but they like blue because they like the sky. Palmer and Schloss called this the *ecological valence theory*. To continue the chain of thought, it could be assumed, that colours that trigger positive emotions because of positively associated objects, should also do so for other objects of the same colour. Thus, it can be assumed that generally preferred colours, such as blue, could also evoke positive emotions.

Finally, Russel (1978, p. 13) identified, that warmer colours overall, such as yellow, orange and red are seen as being more active, exciting and stimulating, thus lead to more arousal, than cold colours such as blue and green, who are seen to be more tranquil and peaceful.

2.5 Print and Online Media

"To seek out the truth, in the interests of the public's right to know, whatever the consequences to him- or herself."
(Swiss Press Council, 2021)

This is the first declaration of duty of every Swiss journalist, as laid down by the Swiss Press Council in 1999. This obligation continues to apply today. However, the approach with which this demanding task is fulfilled has adapted over the years. The new methods used in the search for truth and how this has shaped the field of journalism in recent years will be discussed in this chapter. Furthermore, for the purpose of this thesis, it will be presented how the Swiss media landscape is structured and what the media consumption of its population looks like.

2.5.1 Development of Journalism

The journalism industry has changed significantly over the past decades (del Águila-Obra et al., 2007, p. 197; W. Weber & Rall, 2012, p. 349). While a few decades ago, the editorial offices were the main group who reported on the happenings, a multitude of actors are involved today (Gray et al., 2012, p. 3). Anyone and everyone can present, comment on, and share information about occurrences on social media. People are no longer informed about events in the upcoming print edition of a newspaper first. Thanks to today's technologies, including social media but also online news portals, people can be informed while the event is still happening, which can provide the impression of being live at the scene.

As a result, the demand for, as well as the supply of digital information sources has expanded considerably in recent years (Häuptli & Vogler, 2019, p. 61). The global change in media consumption has strongly influenced print media editors as well. In many places a decline in revenues and a lower coverage of consumers have been observed (Admeira, 2018, p. 14; Ahlers, 2006, p. 30; Häuptli & Vogler, 2019, p. 61). Nevertheless, there has been no collapse of print media, as often predicted, and it has been shown that print media still have their relevance in some areas (Ahlers, 2006, p. 30). What has largely developed, however, is a hybrid solution in which media companies publish articles and reports in print format as well as online. No clear separation of the form of publication is therefore necessary. In order to meet the needs of consumers, who increasingly access information via mobile phones nowadays, an increasing number of articles are produced for the mobile format (Admeira, 2018, p. 14; Engebretsen et al., 2018, p. 2).

One reason why editorial offices that combine print and online media remain relevant and in demand, is because credibility and accuracy are still paramount (Admeira, 2018, p. 20; FÖG, 2021b, p. 2; Swiss Press Council, 2021). This is an objective of print and online media that consumers highly value and demand. It is also an attribute that is often lacking on the far less monitored social media (Admeira, 2018, p. 20; Kennedy et al., 2020, p. 181).

2.5.2 Data Journalism

One form of online journalism whose use has increased considerably in recent years is data journalism (W. Weber & Rall, 2012, p. 348). The term, whose definition has already been attempted by various scholars, can describe both the process and the product of an online article (Antonopoulos & Karyotakis, 2020, p. 440; W. Weber et al., 2018, p. 191). As a process, it involves on the one hand the manipulation and analysis of large datasets by means of coding. As a product, on the other hand, the information derived from such extensive analysis is communicated in a visualised way.

The main objective of data journalism is to present and explain otherwise complex data-based information to readers in an understandable way (Gray et al., 2012, p. 3; W. Weber et al., 2018, p. 191). To do so, visualisations in the form of photos, diagrams, maps, or videos are used, and generally combined with descriptive and explanatory texts (W. Weber & Rall, 2012, p. 349). It is important to choose a design that presents the information as straightforwardly and comprehensibly as possible.

Nowadays, there is access to a vast supply and variety of open datasets published by governments, companies and private individuals (W. Weber & Rall, 2012, p. 349). These data may come in structured form, which is readable to a computer, or they might be unstructured, such as leaked files, which have to be processed first (Tong & Zuo, 2021, p. 156f). It is of interest and importance to compile, filter and analyse these datasets and ultimately to identify patterns and developments in them (Gray et al., 2012, p. 3; W. Weber et al., 2018, p. 191). Visualisations provide a useful way of presenting such findings. However, besides providing an overview, data visualisations may also allow to explore the data by adjusting the settings. This could include zooming into a map, revisiting a timestamp in an animation or getting additional information by hovering over an object (Rodríguez et al., 2015, p. 8). Modern data visualisations are usually no longer simple static images and maps but allow and encourage the user to explore the dataset by interacting with the visualisation. While the authors still determine the extent of interactivity and provide context and narrative, the users are given a new more self-determined role. The visualisation is thus no longer exclusively author-driven but has become more reader-driven (Segel & Heer, 2010, p. 1146; W. Weber et al., 2018, p. 195).

The creation of online articles containing data visualisations requires a combination of skills. That is why journal editors often work together in multidisciplinary teams (W. Weber & Rall, 2012, p. 351). The development of such stories is very labour-intensive and time-consuming. According to a study by Weber and Rall (2012, p. 351f) in which media professionals were interviewed, the greatest importance is put on accuracy. Complex visualisations should therefore not be released hastily and prematurely at their expense. During the COVID-19 pandemic, there was a change in production speed, as the graphics and dashboards were automatically updated with the latest data and published on a regular basis (FÖG, 2020, p. 1). However, this generally did not include any hasty changes to the design of the visualisations.

Information Quality in Data Journalism

As infographics tend to look appealing and attract readers' attention, they carry great responsibility (Kennedy et al., 2020, p. 179). People often trust graphics prematurely because they assume that using data and algorithms for articles will make them more accurate and objective (Tong & Zuo, 2021, p. 156). However, simply because a graph appears professional, it should not be presumed to be credible.

Objectivity describes the exclusion of one's own opinion and judgment when dealing with facts (OED Online, 2022). Any data visualization is based on a variety of judgments. Tong & Zuo (2021, p. 164) argue, therefore, that visualizations in data journalism cannot be objective in principle because decisions are always subjective. From data selection to manipulation to visualization, the decisions always influence the resulting graphics.

In addition to objectivity, concerns about the level of knowledge regarding the origin of the data are raised (Tong & Zuo, 2021, p. 157ff). The source of the data and the method of obtaining it are often difficult to verify. Moreover, there are oftentimes limitations to the dataset, that the journalist is not aware of. Finally, the context of data collection is often lost.

Nonetheless, these criticisms should not stop journalists from making use of open data and creating visualizations to support an article (Gray et al., 2012, p. 6). In general, it is just as important for visualisers to know about the impact their graphics can have on readers as it is to teach the designers about the technique involved to create them (Tong & Zuo, 2021, p. 165). On the one hand, it should only be shown, what is known (W. Weber & Rall, 2012, p. 354). On the other hand, it is more important to take the time and create well thought-out and accurate visualizations than to rush through the process of publishing them (W. Weber & Rall, 2012, p. 351f).

The information is thus to be delivered clearly and correctly to the readers without creating any misconceptions. Since there are no generally accepted conventions in the Swiss newsrooms on how to counter these challenges, it is up to the journalists to implement the most appropriate visualization methods (Kennedy et al., 2020, p. 179). Ways to inform readers accurately about a particular visualization and to encourage critical viewing include accompanying the visualizations with explanatory text, attaching the data source, as well as providing information about the limitations of the graph and the uncertainty of the data.

Design of Data Visualizations

Depending on the skill level of the creators and the time available, everything from simple graphics to complex *scrollytelling articles*[1] are created (W. Weber & Rall, 2012, p. 349). As a result, a variety of forms of data visualizations can be observed. However, to claim that data journalists have complete freedom in their design decisions is not correct. Especially larger media companies and newspapers tend to set corporate identity guidelines that state the parameters according to which visualizations are to be designed.

The purpose of corporate identity is to present a consistent appearance to the public (Brockhaus, 2022). By doing so, the familiarity of the company and its products is strengthened, enabling it to be distinguished from its competitors. This can be done in various ways, such as in the form of corporate behaviour, meaning the behaviour of the company towards its customers and employees, as well as in the form of corporate design, meaning the visual appearance of the company to the public (Wiedmann, 2010, p. 340f). Within the scope of this thesis, the visual appearance is of particular interest, which is why sections on corporate identity always refer to visual guidelines in particular.

Corporate design aims to create a uniform appearance through a consistent use of logos, typefaces, page layouts, colour schemes, and other visual variables (Wiedmann, 2010, p. 340). What has long been established in traditional journalism has started to be applied to data journalism in recent years. Currently, mostly larger newspapers are using recognizable colour palettes, base maps, and other design elements to ensure a corporate identity in their data visualizations (Usher, 2020, p. 255). How detailed these guidelines are, however, is usually not communicated publicly. Through own observations and interviews, it was aimed to identify to what extent newspapers are applying such corporate design guidelines for the creation of COVID-19 maps.

Appliers of Data Journalism

Exploring and displaying complex datasets in journalism is not a new phenomenon (Antonopoulos & Karyotakis, 2020, p. 440). In the 19th century, such methods were already used to uncover stories and present them to readers (Rodríguez et al., 2015, p. 8). However, the possibilities and means available today have strengthened the spread of such visualisations in online media (W. Weber et al., 2018). Data journalism can be applied to all kinds of topics for which data is available. To do so, larger media companies have created data teams in charge of creating such content. Visualisations by the New York Times[2] and The Guardian[3] for example earned global recognition for their engaging and

[1] Scrollytelling describes long-form online journalism that often uses multimedia and interactivity to present complex topics to readers in a visually and contextually engaging way as they scroll down (Seyser & Zeiller, 2018).
[2] https://www.nytimes.com/spotlight/graphics (accessed: 09.08.2022)
[3] https://www.theguardian.com/interactive (accessed: 09.08.2022)

innovative visualisations on topics such as elections, climate change and political crises. But also in Switzerland, the designated teams of Tamedia[4], SRF[5] and NZZ[6] are frequently making use of the mentioned journalism techniques. The COVID-19 pandemic prompted the majority of media companies to create their own data visualisations on the topic, using the vast amount of regularly published data.

2.5.3 Structure of the Swiss Media Landscape

In Switzerland, most newspapers - online and print - are run by larger media groups. The main players include SRG SSR, TX Group, CH Media, Ringier, Unternehmen NZZ and AZ Medien (Thommen et al., 2021d, p. 119ff). Their newspapers reach a large part of the Swiss population and have a great power of opinion. The Swiss media monitor report of 2020, shows, that there is currently no danger of monopoly, meaning that no media group or newspaper editorial office has market dominance (Thommen et al., 2021d, p. 36). In addition to traditional print newspapers, all the media companies mentioned operate a number of digital newspapers and online portals on which journalistic articles are published. Figure 6 displays the main Swiss media groups' most well-known online brands.

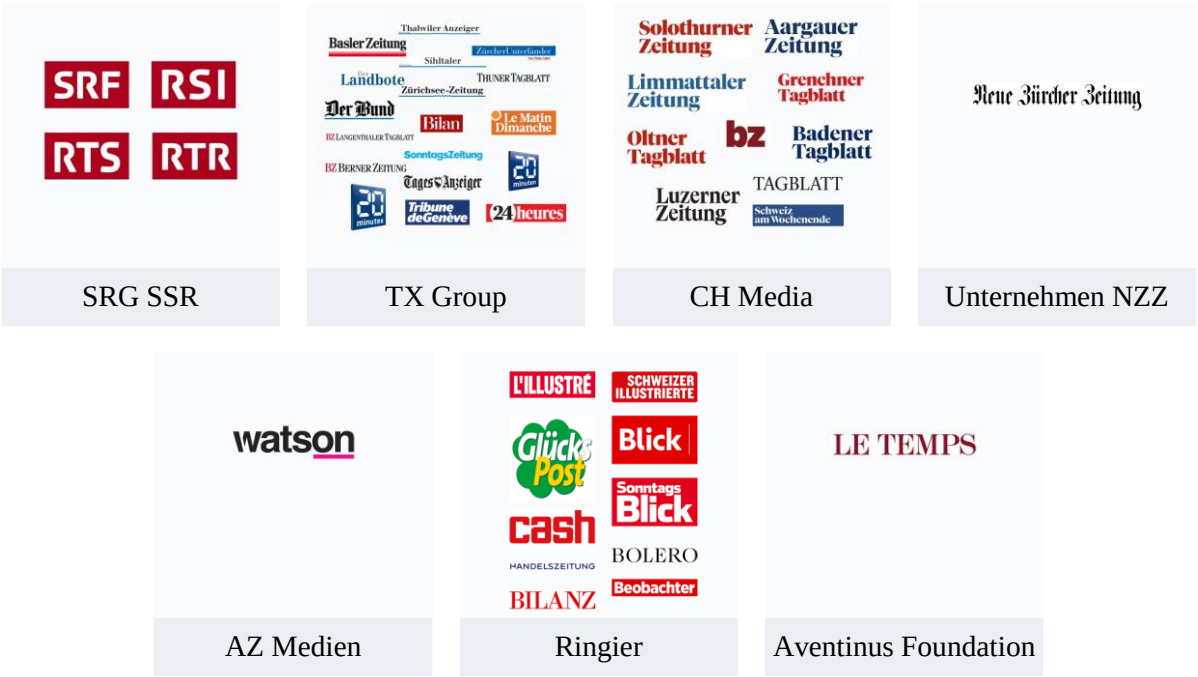


Figure 6: Main Swiss media companies and their brands.

The media companies and organizations that play a significant role in the Swiss media landscape and are of interest to the thesis are briefly introduced in the following subchapters.

[4] https://interaktiv.tagesanzeiger.ch/ (accessed: 09.08.2022)
[5] https://www.srf.ch/news/srf-data (accessed: 09.08.2022)
[6] https://www.nzz.ch/visuals (accessed: 09.08.2022)

SRG SSR

SRG SSR (Swiss Radio and Television Corporation) is the largest media company in Switzerland (Thommen et al., 2021d, p. 119 ff.). The company is to a large extent financed through the Swiss broadcasting levy and provides its content to the entire population in various forms. The main activity however is radio and television programming. SRG SSR is divided into sub-units, including Swiss Radio and Television, which is published in all national languages through SRF (German), RTS (French), RSI (Italian) and RTR (Romansh) respectively.

The written down online content, which is of interest for this study, is small in comparison. It can be found on the respective news portals of the subunits SRF News, RTS Info, RSI News and RTR Novitads.

TX Group

In January 2020, the Swiss media group Tamedia AG was renamed TX Group and underwent further organizational restructuring (Thommen et al., 2021c; TX Group, 2021). Since then, the group consists of several companies, to which different functions are assigned. These include the paid media, which continue to be managed under the name Tamedia, as well as the free commuter media, which are subordinated to the company 20 Minuten. Newspapers that are managed under the TX Group include amongst others Tages-Anzeiger, Der Landbote as well as Der Bund. Most of the TX Group's print media are also available digitally.

CH Media

CH Media was founded in 2018 from a corporate cooperation (joint venture) between the Unternehmen NZZ and AZ Medien, with both partners bringing their regional newspapers along with their respective online newspapers (CH Media, 2017; Thommen et al., 2021a). The Unternehmen NZZ contributed amongst others the Luzerner Zeitung and the St. Galler Tagblatt to the alliance. AZ Medien, on the other hand, brought its media from all its covered areas - print, radio, television and online - including the Aargauer Zeitung as well as the bz Basel. Both partners own 50% of the new joint venture. As a result of the joint venture, CH Media has become the third largest private media company in Switzerland. A considerable development, given that CH Media operates exclusively in the German-speaking part of Switzerland (Thommen et al., 2021d, p. 44).

The goal of the cooperation was a "future-oriented and independent company with strong regional roots" (NZZ, 2017). However, the Unternehmen NZZ as well as AZ Medien still own separate news media on the side (Thommen et al., 2021d).

Unternehmen NZZ

In addition to the joint venture with AZ Medien in 2018, Unternehmen NZZ underwent some internal structural changes in recent years (Unternehmen NZZ, 2021). These changes occurred most

notably at the top management level as well as in the company's own renaming from NZZ Mediengruppe to the Unternehmen NZZ.

AZ Medien

The only news medium that AZ Medien did not bring into the corporate cooperation with Unternehmen NZZ was the online newspaper Watson, founded in 2013 (Thommen et al., 2021a). Watson is a purely online published medium and thus not available in printed form. Since March 2021, the online newspaper, which was founded in German, is additionally being published in French to reach the francophone population of Switzerland with its offering.

Ringier

The Swiss media and entertainment company Ringier owns a large number of larger and smaller media brands in Switzerland and abroad (Thommen et al., 2021b). This includes the commuter newspaper Blick, which has also been published online since 1996.

Aventinus Foundation

At the beginning of 2021, the Aventinus Foundation took over the newspaper Le Temps from its previous owner Ringier. The aim of the purchase was "to support and promote high quality, diversified and autonomous media in French-speaking Switzerland" (Fondation Aventinus, 2020). Which in turn was said to grant the newspaper a long-term economic success.

Independence is of great importance to the foundation, which is why the newspaper was to be supported primarily financially, but not intervened in any other way from the start (Fondation Aventinus, 2020). Consequently, no member of the foundation sits on the board of directors of the Le Temps editorial office.

2.5.4 Swiss Media Consumption

To meet their media demands, the Swiss rely on a broad combination of media formats (Thommen et al., 2021d, p. 30). These include print, television, radio, online and social media. The different media formats are used to cover a variety of demands. At home, for example, people prefer to consume newspapers in print form. When travelling however, they tend to switch to online newspapers (Admeira, 2018, p. 8; Thommen et al., 2021d, p. 31). A sufficient variety of media is an essential requirement to ensure a balanced formation of opinion among the population. Furthermore, it is a prerequisite for a functioning democracy.

In recent years, however, this media diversity has decreased (Thommen et al., 2021d, p. 30f). Due to the difficult financial situation, media companies had started to produce stories on transregional topics once centrally and to share them with the newspapers within the company. Using the same content for several newspapers saves costs. At the same time, however, aligning content threatens the diversity of media articles (Thommen et al., 2021d, p. 40f). As a result, a decline in the diversity of topics as well as geographical areas has been observed (FÖG, 2020, p. 11).

According to the Swiss media monitor report 2020 (Thommen et al., 2021d, p. 46ff), television has the greatest power over the formation of people's opinions ("power of opinion"), followed by online media. In the report, power of opinion, given in percent, combines a newspapers quantitative market success as well as its qualitative assessment by the respondents (Thommen et al., 2021d, p. 39). Online newspapers have been expanding and establishing themselves in Switzerland for some time now (FÖG, 2020, p. 12). As of the year 2020 they have officially surpassed the print media in terms of power of opinion, as can be seen in Figure 7. According to a Swiss survey by Admeira (2018, p. 8ff) carried out with experts and consumers, it is however expected that print media will not disappear in the near future. Rather, it will be used in combination with online newspapers in a hybrid form, depending on the user's preferences.

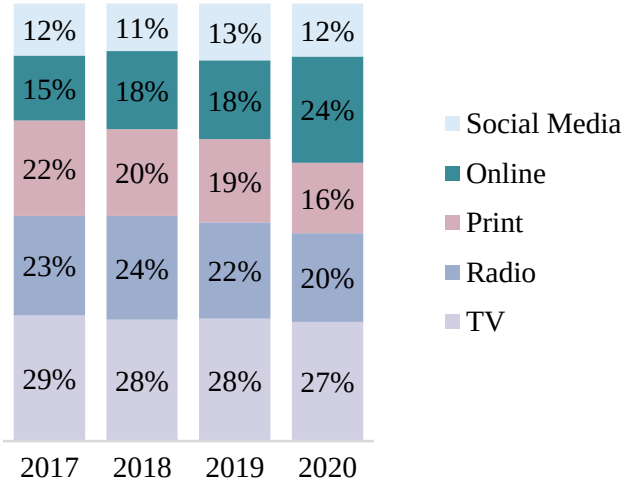


Figure 7: Annual comparison of power of opinion of Swiss media formats. Adapted from: Thommen et al. (2021d, p. 48).

2.6 Integration of this Thesis into the Research Context

So far, this chapter has shown how the pandemic was communicated by the Swiss media and which role maps played in this process. The chapter also explained the different characteristics of maps and how their connection with colours can influence perception and emotions.

Digital media consumption has increased significantly in recent years and has thereby played a relevant role within media communication during the pandemic (Thommen et al., 2021d, p. 48). Especially visual communication in the form of graphics and maps enjoyed great attention (King & Lazard, 2020, p. 1724). It is therefore of interest to examine such map contents and discover how they were constructed, what functionalities they had and how well they conformed to cartographic conventions. The content dashboards of different topics contain was examined before the pandemic, but there was a lack of topic-specific comparisons (Segel & Heer, 2010).

Chapter 2.2.3 showed that a number of studies have critically analysed the published COVID-19 maps. These studies, however, mostly refer to map publications from governmental or organisational platforms in Canada on the one hand (Rinner, 2021) and on the other hand, from a variety of countries with a focus on the Czech Republic (Pászto et al., 2020). No such study has been done on publications in Switzerland specifically, nor with a focus on Swiss media. It is therefore of interest to find out what maps have been published by the Swiss media on the topic of COVID-19. Furthermore, there is a lack of studies that examine how these visualisations have developed over the course of the pandemic (Ivanković et al., 2021, p. 13).

In general, many COVID-19 visualisations have been criticised for their design decisions by different scientists in the field of cartography (Cay et al., 2020; Mooney & Juhász, 2020; Rinner, 2021). By means of interviews with journalists, an insight can be gained into the working process of such map production in data journalism. Moreover, it might help to understand the considerations with which design decisions were made and how challenges were dealt with.

The yearbooks on Swiss media quality of 2020 and 2021 have shown how media consumption and quality have developed in Switzerland during the last two years (FÖG, 2020, 2021a). The focus was primarily on the content of written articles and how appropriate the written information was conveyed. Conversations with data visualisation experts, could reveal how they perceived the published COVID-19 maps and what suggestions they have for improvement.

A number of studies have already looked at the influence of COVID-19 maps on readers' perceptions and emotions (Li, 2021; Thorpe et al., 2021). However, these studies compared published maps with each other and did not use replications that could be experimented with. There was, however, one study that compared identical COVID-19 maps with different colour palettes and mapping techniques conducted by Fang et al. (2021). The eye-tracking study showed that warm colour scales had a significant positive impact on content understanding compared to mixed and cool colour scales.

Furthermore, choropleth maps expressed risk better than graduated symbol maps. No significant difference could be found in risk perception between the warm colour scale in yellow-red tones and the cool colour scale in bluish tones. It would therefore be of interest to see whether the findings on risk perception using other warm and cool colour scales would produce similar results. In addition, it would be interesting to see what influence COVID-19 visualisations would have on emotions. Especially in the health sector , there seems to be a need for more research on emotional responses to health issues (Chou & Budenz, 2020, p. 1718; King & Lazard, 2020, p. 1726)

The effect of situational perception of maps with health themes was also studied before the pandemic. In a study by Fagerlin et al. (2017) in which different visualisation techniques of the influenza A virus were investigated, it was found that after looking at a choropleth map, people rated their own risk higher, were more willing to get vaccinated and were more interested in increasing their knowledge on the topic than after looking at graduated circle maps or bar charts. Fagerlin and colleagues concluded that choropleth maps were the most appropriate way to communicate about diseases. Comparable studies on COVID-19, however, are lacking (Pászto et al., 2020, p. 205). As a result, it would be interesting to explore whether COVID-19 maps have similar effects on perception and behaviour and whether this would be reflected in a non-health related, less emotional topic.

The mentioned research gaps indicate that there is a need to study the influence that different colour scales and different map themes might have on emotional reactions, situational perception, and behaviour. This is especially true for the COVID-19 maps published by the Swiss media, as they carry the crucial task of informing the public as accurately as possible about the state of the pandemic. This thesis aims to provide deeper insight and more clarity into these fields of research.

3 Methods

In order to examine the previously defined research questions, this thesis' study is divided into two parts. The first part aims to examine what kind of COVID-19 maps were published by the Swiss media and how they were created thus responding to research question 1 (RQ1)[7]. In order to do so, a quantitative content analysis (part 1a) as well a series of expert interviews (part 1b) were conducted. The second part of this study investigates the effect of these maps, specifically of two colour palettes used by the media, on people's emotions, perceptions, and behaviour. An empirical study was conducted for this purpose. The way in which the research of these two parts was implemented will be presented in the following chapter.

3.1 Part 1a: Quantitative Content Analysis

3.1.1 Criteria for Quantitative Content Analysis of COVID-19 maps

Part 1a of this thesis aims to identify visualisations related to the topic of COVID-19 that have been published by the Swiss media since the beginning of the pandemic. In order to make the visualisations comparable as well as to provide an overview, several criteria were defined according to which the Swiss media landscape could be examined.

Newspaper Requirements

This subsection addresses the requirements the considered newspapers had to follow. The various newspapers had to publish continuously during the course of the pandemic in Switzerland, that is, from the beginning of 2020 until the summer of 2022. Since the focus is on online media, the newspapers must have been available online at all times and they had to be regularly updated. Furthermore, due to the research focus, only Swiss media were analysed. All Swiss languages - German, French, Italian and Romansh - were taken into account in the search for the newspapers in question.

Swiss media archives were used to look for newspapers who meet these criteria. The Swiss Media Database (SMD) (2022) contains an inventory of print and online articles from 880 national and international sources. The SMD is only available to media professionals. The general public is offered the fee-based subsidiary platform Swissdox[8]. Students at the University of Zurich are offered a licence to use the Swissdox platform. This made it possible to search for the criteria and identify the relevant newspapers.

[7] RQ1: How did the Swiss online media make use of maps to communicate the state of the pandemic?
[8] https://swissdox.ch/

COVID-19 Visualisation Requirements

In addition to the newspaper requirements, a number of requirements were imposed on the visualisations in order to make them comparable with each other. The focus was on visualisations that appeared integrated in articles in online media. They had to communicate the latest figures on the pandemic and thus had to be updated regularly. It was also important that the graphics were created by the newspapers themselves, or by their respective media companies. Thus, no images copied from public authorities or other newspapers were analysed. The content and form of the visualisations were also subject to certain criteria. The graphics had to be presented in georeferenced form, as a map and had to visualise the current COVID-19 case numbers. Other contents, such as cartographically visualised distribution of vaccines, hospital bed capacity or R-values were not considered for the selection of the maps, unless they were the result of a change in the topic of the original map.

3.1.2 Analysed Topics of Published COVID-19 Maps

In order to investigate what kind of maps were published to inform the population about the development and stage of the pandemic, a systematic approach had to be taken. All collected maps were analysed according to the following points.

First, the most fundamental information was of interest: Which editorial team created the maps, what tools were used, in what language were they published and how many versions maps could be collected. In addition, it was examined what type of information was presented, if further explanatory information accompanied the visualization and if the design followed a corporate design standard by the publisher.

Dent's (2008, p. 208) and Slocum's (2005, p. 190) typical map elements were consulted to determine what elements to look for in a map. The analysed map elements included symbology, title, legend, mapped area as well as data source. Some of the typical map elements suggested by the authors, such as maps scale, north arrow, and inset maps, were, however, not examined. This is because these elements are primarily used to explain to the reader the extent and positioning of the mapped area. However, since the focus is on Switzerland, an area assumed to be well known to the viewers, these elements are not of high necessity in the present context.

In addition to the visual map elements, the data format was analysed. It was of interest what type of data (absolute or relative data) was used and what level of measurement (ratio, interval, ordinal, or nominal) it portrayed. Further, it was investigated how many classes the data were divided into and in which sub-steps (Jenks natural breaks, equal intervals, quantiles, manual breaks, etc.) or whether the scale was continuous.

As the colours used in maps are of primary interest in this thesis, it was analysed which colour scales were used and what type – qualitative, diverging, sequential, binary – they were in. If recognised, it was recorded which palette was used in the map. It was further important to test which colour scales

were colour-blind friendly. This was tested using Google Chrome's developer tools feature, which allows to emulate colour deficiencies. Another topic of interest was whether the colour scales used in the visualizations were following the newspaper's corporate design guidelines.

Furthermore, it was interesting to analyse the functionalities of the online maps. Therefore, it was also investigated whether the maps could be zoomed in and out in order to look at the visualization from different levels as well as hovered over, enabling additional details-on-demand. Likewise, it was tested whether the actions could be undone after manipulating the map. In other words, if the maps allowed forgiveness.

For all analysed topics it was also analysed how the map model has changed since the first found version. The changes were mentioned in the context of the examined map elements.

3.2 Part 1b: Expert Interviews

Part 1b of this study is intended to be complementary to part 1a, the analysis of published COVID-19 maps. It was of interest to find out how experts viewed and assessed the visual communication of COVID-19 in the media. For this purpose, interviews were conducted with specialists in the field. This made it possible to compare the experts' perceptions and assessments with the findings from part 1a and possibly provide explanations for them based on the experts' statements. In addition, own observations and assumptions could be clarified while findings in literature could be compared. The results of both analyses, 1a and 1b, are combined in the discussion in chapter 5.1.

The interviews were evaluated through qualitative content analysis, which categorises the statements of the interviewees (Mayring & Fenzl, 2019, p. 634). This allowed the different statements of the participants to be compared amongst each other. The categories largely cover the themes which had also been analysed in chapter 3.1.

In the framework of this thesis, the observations, and assessments only of a small number of experts were collected. Therefore, it cannot be guaranteed that their answers correspond to those of the majority of specialists in the research field. Furthermore, the interviewees themselves did not conduct systematic research on the topic beforehand, but rather shared their direct experiences from working in the field. The interviews were conducted in German and English. For the analysis of the statements, the interviews were recorded and transcribed. The transcriptions were securely saved but were not included in the appendix of this paper for privacy reasons.

The topics on which the experts were consulted included how working in data journalism looks like and how it has developed over the years. Furthermore, they were asked about the reasoning behind publishing COVID-19 visualisations, how they have been created and how they have evolved since the start of the pandemic. The decisions on the colour palette used for data journalism in general and for COVID-19 visualisations in particular were also of interest. In addition, it was discussed how data

uncertainty is dealt with and how the readers' visual literacy has developed. Finally, the experts were asked to assess the published COVID-19 maps and give their opinion on the topic.

3.3 Part 2: Empirical Study

Part 2 of this study dealt with the emotional effects of COVID-19 visualisations and their influence on people's perception of the pandemic. These two parts were examined within one study, which is why their methodological procedure is presented here in one chapter.

3.3.1 Study Structure

The research questions[9] of the part 2 were answered by means of an online experiment. In order to answer the second research question, the technology of facial expression analysis, as presented in chapter 2.3.2 was used. In order to read the facial expressions, a camera had to be used to record the facial features. The experiment was carried out by the participants independently, online on their own devices. For this purpose, a link directed participants to the online tool iMotions, on which the study was conducted, and which then processed the data. The iMotions services used for this study are presented in more detail in chapter 3.3.6. The experiment was divided into three parts: an introduction into the experiment including a pretest, the main test (main research section) and a posttest.

After setting up and calibrating the camera, participants were first asked to complete some socio-demographic questions. This was followed by three pretests, which provided information about the participants' willingness to take risks and their colour vision. Finally, the procedure of the main part of the test was explained to the participants and a practice round on an independent topic was given to help participants get used to the process. This practice round as well as the continuous explanation of the steps was particularly important, as the participants had to complete the study on their own and without support and the option to ask questions. In addition, there was no possibility to stop and resume the experiment at a later stage.

In the second and main part of the experiment the participants were shown different coloured choropleth maps for either the pandemic (group A) or a control topic (group B), while their facial expressions were measured. In total, the participants were shown 20 different maps, which were automatically displayed for 11 seconds. The duration of the display was justified by the fact that it has been proven that it takes a few seconds for emotional reactions to form (Stöckli et al., 2018, p. 1449).

[9] RQ2.1a: How do the expressed emotions (arousal, valence) differ when facing warm-coloured maps compared to cool-coloured maps?
RQ2.1b: How do the expressed emotions (arousal, valence) differ when facing maps of COVID-19 compared to maps on population ageing?
RQ2.2a: How does the perception of the pandemic differ when facing warm-coloured maps compared to cool-coloured maps?
RQ2.2b: How do the behavioural decisions differ when facing warm-coloured maps compared to cool-coloured maps?

After each map, questions were asked about the understanding of the map, the assessment of the situation and the behaviour triggered by it. After completing the tasks associated with the 20 maps, the participants were asked questions about their basic attitudes towards these topics in a posttest. Finally, participants were debriefed and instructed on how to upload and complete the survey.

The structure of the experiment is illustrated in Figure 8. The slides used in the main part of the experiment can be seen in the Appendix C.

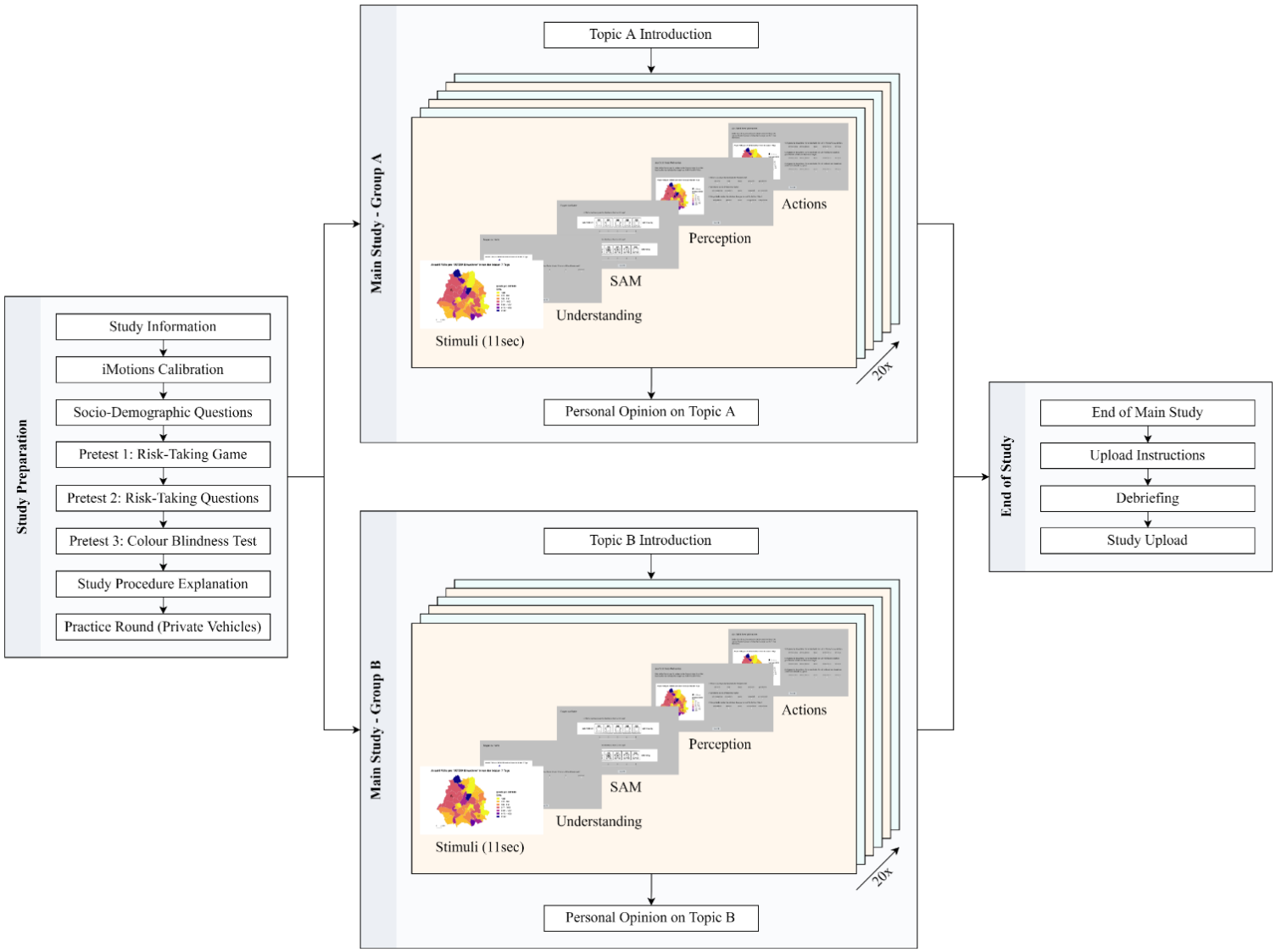


Figure 8: Structure of the empirical experiment.

3.3.2 Pretests

iMotions Requirements and Calibration

As mentioned above, the experiment was conducted online with a camera running. In order for the facial expression recognition to work properly, the participants had to fulfil a number of technical and setting-oriented requirements during the experiment. The study had to be conducted on a laptop or computer with a stable internet connection and a front camera. Participants had to use either the Chrome, Firefox or Edge browser. In addition, the participants were instructed to choose a quiet place in order to be able to carry out the study undisturbed. Finally, the location had to ensure even lighting, i.e. no bright light that would glare on the participants' faces or on the screen should be present.

The participants were informed about these requirements before the start of the experiment so that they could set themselves up accordingly. In addition, iMotions carried out own set-up checks at the start, during which the placement of the camera and the lighting conditions were checked.

Socio-Demographic Questions

To analyse the sample of study participants, the experiment started with some socio-demographic questions. Participants were asked to provide information about their age, gender, and colour vision abilities. Furthermore, they answered questions regarding their experience in the fields of geoinformation, cartography, data journalism and epidemiology. Finally, they were asked to indicate how frequently they consumed Swiss online newspapers.

Pretest 1: Holt & Laury Lottery

Research question 2.2b aimed to find out how the participants would behave in the pandemic situation presented by the stimuli. This behaviour is very much dependent on their basic attitude towards the pandemic as well as their willingness to take risks. The COVID-19 pandemic has oftentimes made people choose between risky and cautious behaviour. Such as, do I avoid social contact to protect myself and the immediate social environment from infection, or do I take the risk to meet up with friends? Do I go to the office for work, or do I work from home? Do I go shopping at busy times or do I choose off-peak times?

According to MacCrimmon and Wehrung (1986, p. 11f), such questions like the above-mentioned make up the simplest basic elements of a risky situation of their Basic Risk Paradigm. In the case of a safe action, the consequence of the action is clear in advance. The person taking the action knows what he or she is getting into. In this case, during the pandemic the person would avoid outside contacts and clearly minimise the risk of infection. In the case of a risky action, on the other hand, the result is not clear. The action can lead to either a gain or a loss for the person involved. There is a risk of infection but there could also be a gain in freedom. If the probability of a loss is higher than that of a gain, the risk of the action is greater. Which behaviour is chosen depends on a person's willingness to take risks. This idea was applied

within the first pretest, created by Holt and Laury (2002), which tested how willing the participants were to take risks.

In the Holt an Laury lottery test, participants are presented with a series of lottery games to win as much money as possible (Holt & Laury, 2002, p. 1645). For the first game, participants must decide whether they would prefer to choose option A, where there is a 10% probability of winning 100 Swiss francs and a 90% probability of winning 80 Swiss francs. Option B has a 10 % probability of winning 190 Swiss francs and a 90 % probability of winning 5 Swiss francs. The participants have to decide which option they would choose. In the ten games, the probabilities of options A and B converge, as can be seen in Table 1. The test is used to find out at which probability ratio the participant is willing to play for the highest lottery prize (CHF 190 in option B).

Table 1: Paired lottery options presented to participants. With P = chance of winning the given value. Adapted from: Holt and Laury (2002, p. 1645).

	Option A				**Option B**				**Expected Payoff**
Game	*P(X)*	*Win [CHF]*	*P(X)*	*Win [CHF]*	*P(X)*	*Win [CHF]*	*P(X)*	*Win [CHF]*	*Difference*
1	1/10	100	9/10	80	1/10	190	9/10	5	*58.50*
2	2/10	100	8/10	80	2/10	190	8/10	5	*42.00*
3	3/10	100	7/10	80	3/10	190	7/10	5	*25.50*
4	4/10	100	6/10	80	4/10	190	6/10	5	*9.00*
5	5/10	100	5/10	80	5/10	190	5/10	5	*-7.50*
6	6/10	100	4/10	80	6/10	190	4/10	5	*-24.00*
7	7/10	100	3/10	80	7/10	190	3/10	5	*-40.50*
8	8/10	100	2/10	80	8/10	190	2/10	5	*-57.00*
9	9/10	100	1/10	80	9/10	190	1/10	5	*-73.50*
10	10/10	100	0/10	80	10/10	190	0/10	5	*-90.00*

Although the test was hypothetical and the participants were not paid the money, an attempt was made to determine the willingness to take risks as real as possible. To do this, some adjustments were made to the original Holt and Laury test (2002). For the experiment, the prize values were increased by 50 times the original. This was done because it was felt that it would motivate the participants to want to win as much as possible. In addition, the currency was displayed as Swiss francs so that the participants could better relate to them. In their studies on the lottery test, Holt and Laury also tested the 50-times version of the experiment. They found that the risk aversion of the participants increased significantly, i.e. the participants were less willing to take risks, when the prize values were scaled 50-times (Holt & Laury, 2002, p. 1650). However, when the winnings were hypothetical and there was no actual pay-out, no such change in risk aversion was found, which is why the test could be conducted in this form. However, the developers added that it was difficult for participants to know how they would decide in a situation with a real payoff possibility (Holt & Laury, 2002, p. 1654).

The Holt and Laury lottery test was nevertheless chosen because, compared to other tests, the risk ratio was known (Pleskac, 2008, p. 171). This signifies that the participants were always able to weigh up the risk themselves and did not have to make decisions blindly. It is argued that this is more in line with the risk awareness that people faced during the COVID-19 pandemic.

Pretest 2: DOSPERT Scale

Nevertheless, personal risk-taking is not only person-dependent, but also domain-dependent (Nicholson et al., 2005; E. U. Weber & Blais, 2006). This means that people are willing to take risks in certain areas of life but not in others. In order to examine risk-taking in different areas, Weber and Blais (2002) developed the Domain Specific Risk-Taking (DOSPERT) Scale. The domains examined are ethics, finance, recreational, social and health/safety. The latter were of particular interest in this work, as risk-taking in health and safety matters was at the forefront of people' behavioural choices during the pandemic. The questionnaire of Weber and Blaise comprises 30 questions which are answered on a Likert scale from 1 (extremely unlikely) to 7 (extremely likely). For this thesis, three of the six safety/ health questions were chosen to be asked to the study participants. The scale was reduced to five subdivisions to simplify the study (Babakus & Mangold, 1992, p. 771). In addition, the German version developed by the researchers was used, as the experiment was conducted in this language (E. U. Weber & Blais, 2006).

The questions selected for the study were:

- Question 5: How likely are you to have five or more glasses of alcohol in a single evening?
- Question 17: How likely are you to sit in the passenger seat of a car without wearing a seatbelt?
- Question 23: How likely are you to expose yourself to the sun without putting on sunscreen?

Pretest 3: Colour Blindness Test

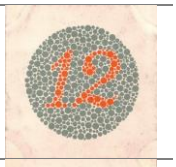
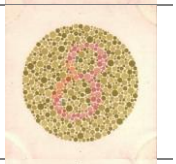
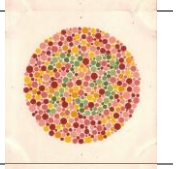
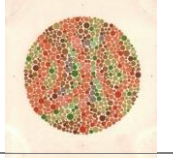
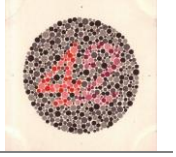
Since the purpose of this study is to investigate the influence of colour scales in a map on situational awareness of the pandemic, it is important that the study participants perceive the colours as clearly and consistently as possible. Whole colour vision was therefore a participation requirement of the study. A colour blindness test was added to the study in case participants did not meet this condition but still participated.

The *Ishihara Test for Colour-Blindness* was first created in 1917 by Ishihara (1972) and has since been used worldwide to detect red-green vision deficiency in patients (Hardy et al., 1945, p. 269). It consists of 24 panels with differently shaded dots, with a dotted object coloured differently on each panel, and thus recognised by people with full colour vision (Ishihara, 1972). People with total colour blindness, protanopia and deuteranopia see a different object or no object at all.

Five colour panels of the original Ishihara test were selected for the study. In order not to prolong the study, the selection was made in such a way that as many features of the test as possible could be investigated with as few panels as possible. Participants were asked to choose between different options that they saw. The first panel was intended to be readable by all participants regardless of colour vision

deficiency. This verified that the participants understood the task correctly. Plate 2 was incorrectly identified as a three by people with red-green vision deficiency. People with total colour blindness did not see anything on it. Plate 13 was not seen by people with red-green deficiency as well as total colour blindness. People with red-green blindness were the only ones who could identify a number on plate 14. Finally, participants were shown plate 17, which people with normal colour vision identified as 42. The plate simultaneously examined the two types of red-green deficiency. According to Ishihara (Ishihara, 1972, p. 9), people with strong protanopia should have seen a 2 whereas people with strong deuteranopia should have seen a 4. If the colour vision deficiency was mild, the other number could be identified but less clearly.

Table 2: Ishihara plates used in the study (Ishihara, 1972).

Plate	Normal Colour Vision	Red-Green Deficiency				Achromatopsia	Plate
1	12	12				12	
2	8	3				-	
13	73	-				-	
14	-	5				-	
17	42	Protanopia		Deuteranopia		-	
		Strong	Mild	Strong	Mild		
		2	(4) 2	4	4 (2)		

In addition to the test, people were also asked to state whether they had colour vision deficiency or colour blindness. The double assessment was needed because the Ishihara colour charts do not test for blue-yellow vision deficiency.

3.3.3 Main Experiment

In an experimental study, the dependent variable should be explained by changing the independent variable (Martin, 2008, p. 26). In the case of this study, this means that the influence of the colour scale (independent variable 1), as well as the theme (independent variable 2) on the emotions, situational perception and behaviour (dependent variables) are examined. The complex structure of this mixed factorial design is explained in this chapter.

Independent Variable 1: Colour Scale

In order to compare the colour scales, it was important to select them among those that have actually been used by the Swiss media outlets to visualize COVID-19. Therefore, the COVID-19 maps collected for part 1a of this study were consulted. Two prerequisites were defined in the selection process. First, the colour scales had to be as contrasting as possible to allow clear hypotheses to be formulated. Secondly, it was of interest to choose colour scales whose creation background was reasonably well known to be able to analyse and compare the scales based on their content and their purpose. Based on these criteria, a cold and a warm colour scale were chosen. The former being the GnBu palette from ColorBrewer and the latter being the Plasma palette from the Viridis package. Both of those colour palettes were applied amongst others by CH Media in various of their newspapers. The properties of both colour palettes will be presented in the following subchapters.

ColorBrewer: GnBu Palette

The GnBu palette, was developed by the cartographers Brewer et al. (2003, p. 6) and made freely available to users in a website launched in 2002 called Colorbrewer[10]. The aim of Colorbrewer is to assist cartographers and data visualisers in choosing an appropriate colour scheme for choropleth maps. The website offers a variety of sequential, diverging, and qualitative colour scales, in a variety of classes. All colour scales, including GnBu, have been carefully developed by the scientists based on cartographic conventions and are still actively used by map creators.

Hex:	#F0F9E8	#CCEBCA	#A5DCBE	#7BCCC4	#55B0C8	#2F8EC0	#0868AC
R:	240	204	165	123	85	47	8
G:	249	235	220	204	176	142	104
B:	232	202	190	196	200	192	172

Figure 9: Colour values of GnBu Colorbrewer palette with codes. Created using unikn package (Neth & Gradwohl, 2022).

The GnBu palette is a sequential two-hue colour scale (Brewer et al., 2003, p. 6). Which progresses from a light green to a dark blue. As such, the colour scale follows the principle of "the darker, the more", whereby light colours tend to be associated with low values and dark colours tend to be associated with high values (Olson, 2002, p. 2528). According to Brewer (2016, p. 152), the most important component of a sequential colour scale is the change in lightness (value), as this enables a ranking of values. Nevertheless, hue changes in combination with lightness changes can further increase the distance between the classes

[10] https://colorbrewer2.org/

and thus lead to a better distinguishability of the classes. For the creation of the sequential colour scales, Brewer et al. (Brewer et al., 2003, p. 11) additionally aimed for a trend from low chroma to high chroma, with a gradual decrease in lightness. This also applies to the GnBu colour scheme and can be seen in Figure 10.

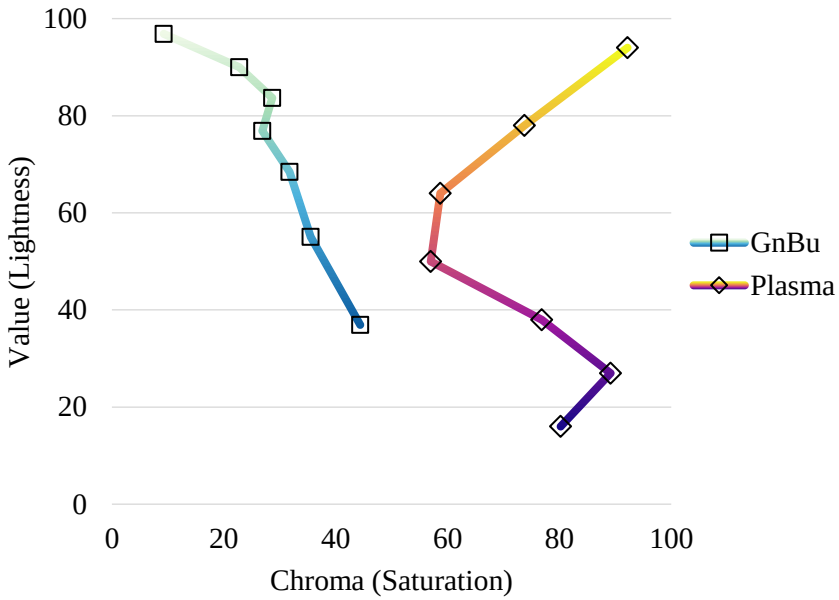


Figure 10: Chroma-value plot of the analysed colour palettes.

Less focus was placed on perceptual uniformity by the colour scheme developers. Although they worked with the Munsell Colour System, Brewer et al. (2003, p. 11f) point out that there were some deviations in hue progressions and low lightness contrasts between classes. Because of experiences with readability losses, they decided against the tedious task of refining these imperfections and granting perceptually equal steps. The *viscm* python tool created by van der Walt & Smith (2015a) allows perceptual properties of a colour scale to be visualised and compared. If a colour scale is perceptually uniform, the perceptual derivative plot of Figure 11 would show a straight line. This demonstrates visually that the GnBu colour scale indeed does not follow perceptually equal steps.

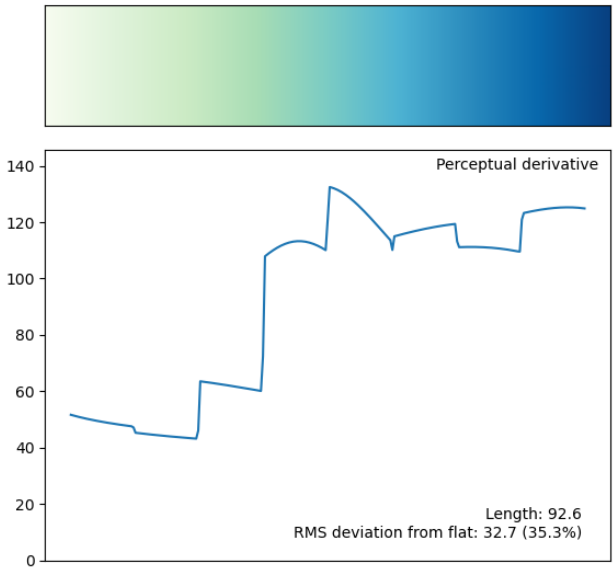


Figure 11: Perceptual properties of GnBu colour scale. Created using viscm package (van der Walt & Smith, 2015a).

The palette was used by CH Media in their newspapers covering of Central Switzerland. The number of cases was divided into seven classes. The graph was created using Datawrapper[11]. The web tool provides an easy and fast method to create maps and other graphs. It is aimed directly at journalists and provides them with tips and information in the form of articles on how to make the design as comprehensible successful as possible. The tool has several colour palettes options. These include the BuGn colour palette, which is presented here, and the Plasma palette, which serves as an alternative to this palette and will be presented in the next subchapter.

Viridis: Plasma Palette

The second palette to be analysed, called Plasma, was first presented at the SciPy conference in 2015 by the creators Stéfan van der Walt and Nathaniel J. Smith (2015). The colour palette was developed together with other palettes invented in a project called Viridis. The motivation to invent new appropriate colour scales came from the need to develop a publicly accessible alternative to the rainbow colour scale. The rainbow colour scale, which is often used as a default colour scale, especially in the medical field, has received much criticism in recent years because it does not offer a continuous brightness gradient and is therefore not useful in black and white and does not represent the data accurately (Borkin et al., 2011). Criteria for new colour scales included therefore that they were sequential, had a continuous lightness

[11] https://www.datawrapper.de/ (accessed: 09.08.2022)

gradient, were perceptually uniform and could be read by people with colour blindness (Smith & van der Walt, 2015).

Hex:	#0D0887	#5D01A6	#9C179E	#CC4678	#ED7953	#FDB32F	#F0F921
R:	13	93	156	204	237	253	240
G:	8	1	23	70	121	179	249
B:	135	106	158	120	83	47	33

Figure 12: Colour values of Plasma palette with codes. Created using unikn package (Neth & Gradwohl, 2022).

The resulting plasma palette progresses over several hues from dark blue to purple to orange to bright yellow. It is noticeable that the principle of the darker the more does not apply here, but the opposite. This is probably because the motivation for the colour scales comes from the medical field, where the background of a medical scan is generally black and particularly high activity is highlighted in bright tones (Krainik, 2011). Nonetheless, the brightness of the colour scheme changes gradually, as can be seen in Figure 10. In contrast to the GnBu palette, the saturation gradient is uneven. The yellow hue has a very high saturation and decreases with the following tones. Only the dark violet hue has a regained high saturation. In general, the saturation is higher than in the GnBu palette. Perceptual uniformity was a criterion of the creators. For the creation of the colour palettes, the CIE CAM02-UCS colour space was used, which made it possible to calculate the colour differences. The perceptual derivative plot in Figure 13 shows an almost straight line, from which it can be concluded that it is indeed a perceptually uniform colour scale.

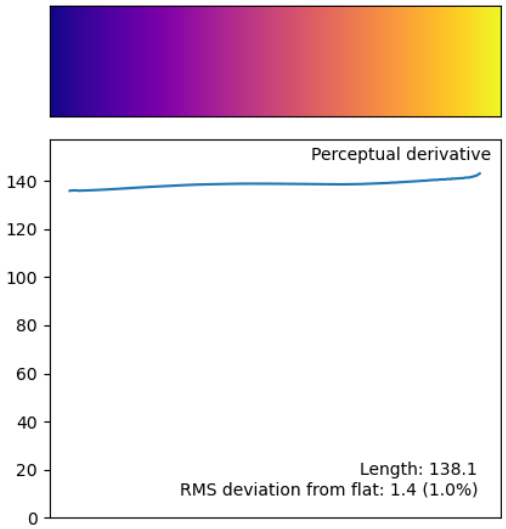


Figure 13: Perceptual properties of Plasma colour scale, Created using viscm Tool (van der Walt & Smith, 2015b).

The plasma palette was used by CH Media as well as RSI News and applied to a total of five different maps. CH Media also used Datawrapper to create these maps. The online tool provides the colour scale as a default in inverted form, so that it corresponds to the "the darker, the more" convention.

Independent Variable 2: Topic

In addition to studying the influence of colour schemes in maps on the experienced emotions and the situation perception, the influence of the theme should also be investigated. The aim was to find out whether colours in maps can generate emotions and perceptions independent of the theme. To test this, the same experiment was conducted with two different themes. In order to be able to infer a change in behaviour from a change in a variable, at least two levels must be compared in an experiment (Martin, 2008, p. 172).

The chosen control topic had to be similar to the COVID-19 pandemic, i.e. a topic that all participants were aware of, that affected everyone to some degree and thereby everyone was able to relate to it. At the same time, the topic was to be as neutral as possible and should trigger little emotion in the readers in order to serve as a control for the experimental condition (Martin, 2008, p. 171). For the experiment, the ageing of society was chosen as the control level.

The proportion of very old people in Switzerland has risen sharply in recent years (BFS, 2022a). Whereas in 1980, 232 out of every 100,000 inhabitants were 90 years old or older, today (2020) this figure is more than four times higher today (969 out of 100,000) (BFS, 2021). This can be explained by the higher life expectancy as well as the lower birth rates nowadays. This increase poses new challenges for society, which will only intensify as the "baby boom" generation enters retirement age. The increasing demands on the AHV (old-age and survivor's insurance) as well as the necessary expansion of infrastructures (barrier-free access, nursing homes, etc.) and services (care, nursing, etc.) are just some examples of these difficulties. In order to appropriately respond to those challenges and to generate the necessary financial resources in the future, various measures are regularly discussed and voted on at national but also cantonal and local level in Switzerland (BSV, 2022).

Consequently, the ageing of society is an issue that affects the entire Swiss population. At times of a popular vote, the topic comes to the fore and is discussed strongly and sometimes emotionally, as it concerns the financial security of the population. Outside of the voting campaigns, however, the issue is rather absent from the political debate. In September 2022, there was another national referendum concerning the AHV (BSV, 2022). However, during the period of the experiment from May to the beginning of August 2022, the issue was still largely in the background and did not occupy the Swiss population to any considerable extent.

It was therefore assumed that the ageing of the population was an appropriate control topic for the study, since on the one hand it concerns the entire population, but on the other hand it is largely non-emotional and less urgent.

The experimental group (Group A) and the control group (Group B) solved the same experiment, with the difference that the former group faced maps and tasks on the COVID-19 pandemic and the latter group faced the aging of society. The same pretests were done with both groups. In the main experiment, the reactions to the different topics were examined, but the stimuli, the maps, were exactly the same, with the same colour scales and the same patterns. Only the titles and thus the topic differed. The posttest questions were also adapted to the themes. Otherwise, the studies were designed exactly the same and the control group received identical instructions and treatment. This is important to be able to clearly identify an effect (Martin, 2008, p. 80).

Study Design

Since the influence of two different variables - colour and topic - on emotions, situational perception and behavioural decisions were to be examined, a factorial experiment was pursued. Factorial experiments have the advantage of allowing the simultaneous investigation of the interactions of several independent variables (Martin, 2008, p. 180). When two variables interact, it signifies that "the relationship between one independent variable and the participant's behaviour depends on the level of a second independent variable" (Martin, 2008, p. 180). For this study, this meant that the emotional response to looking at a map could have not only been dependent on its colour scale, but also on its thematic context. Whether such an interaction in fact existed was to be determined by this experiment.

In a study with a factorial design, all variables (factors) are compared with one another (Martin, 2008, p. 179f). For this study, a *2x2 factorial design* was applied. The stimuli showed warm- and cold-coloured COVID-19 maps as well as warm- and cold-coloured population ageing maps. The stimuli were presented to the participants in a *mixed design* experiment. A *mixed design* involves a combination of both within-subject and between-subject designs. Participants were randomly divided into two groups. For this purpose, a random allocation algorithm was used. This algorithm randomly forwarded the participants, who all reached the study via the same URL, to the experiment of group A or group B. While group A was exclusively looking at COVID-19 maps, group B was shown the maps on population ageing. Both groups saw the maps on their respective topic in both colour scales. The subdivision into groups by topic thus describes the between-subject design of the study. The within-subject design occurred because both groups viewed both colour palettes. This allowed, that the influence of the colour palettes on emotions could be analysed across the groups. This form of experimental design can also be referred to as a mixed factorial design. The following Table 3 shows how the mixed factorial design of the study was implemented.

Table 3: 2x2 Mixed factorial design with colour and topic as factors.

		Topic	
		Group A (COVID-19)	**Group B (Ageing Population)**
Colour	**Warm-coloured maps**	Map 1: Valence, Arousal	Map 1: Valence, Arousal
		Map 2: Valence, Arousal	Map 2: Valence, Arousal
		Map 3: Valence, Arousal	Map 3: Valence, Arousal
		Map 4: Valence, Arousal	Map 4: Valence, Arousal
		Map 5: Valence, Arousal	Map 5: Valence, Arousal
		Map 6: Valence, Arousal	Map 6: Valence, Arousal
		Map 7: Valence, Arousal	Map 7: Valence, Arousal
		Map 8: Valence, Arousal	Map 8: Valence, Arousal
		Map 9: Valence, Arousal	Map 9: Valence, Arousal
		Map 10: Valence, Arousal	Map 10: Valence, Arousal
	Cold-coloured maps	Map 1: Valence, Arousal	Map 1: Valence, Arousal
		Map 2: Valence, Arousal	Map 2: Valence, Arousal
		Map 3: Valence, Arousal	Map 3: Valence, Arousal
		Map 4: Valence, Arousal	Map 4: Valence, Arousal
		Map 5: Valence, Arousal	Map 5: Valence, Arousal
		Map 6: Valence, Arousal	Map 6: Valence, Arousal
		Map 7: Valence, Arousal	Map 7: Valence, Arousal
		Map 8: Valence, Arousal	Map 8: Valence, Arousal
		Map 9: Valence, Arousal	Map 9: Valence, Arousal
		Map 10: Valence, Arousal	Map 10: Valence, Arousal

Extraneous Variables and Effects

In addition to the two independent variables being manipulated, there are several variables that might influence the study's results (Martin, 2008, p. 27). Some can be controlled, while others appear random and cannot be influenced. It is therefore important to be aware of their existence and to take them into account when interpreting the findings.

Since the experiment was conducted online, the existing uncontrollable variables that might have influenced the results were mostly linked to the fact that the study was conducted by the participants on their own device and at a time and place of their individual choice. Thus, computer properties including display brightness settings, time of day, lighting conditions and noise levels, as well as how awake the participants were, could not be influenced. Other factors such as participants' prior knowledge and attitude towards the topic as well as their gender were not controlled for but were assessed during the experiment. Finally, the participants' age and colour vision capabilities were controlled by using entry requirements. This was decided because it is believed that these two characteristics influence the participants' ability to conduct the study.

Many of the above-mentioned factors might have influenced the outcomes and therefore had to be taken into account in the evaluation of the study. At the same time, these conditions correspond to a rather realistic way in which people possibly have consumed and consulted COVID-19 news and dashboards

during the pandemic. Thus, the study conditions became generalisable to the behaviour of the real population during the pandemic. This indicates a relatively high external validity of the study (Martin, 2008, p. 28).

Since it was a mixed design, the within-subject part had to be checked for order effects. Order effects occur when the order in which stimuli are presented affects how participants react to the following stimuli (Martin, 2008, p. 155). This happens when participants over time start to learn the task at hand or experiencing lesser reactions because they get used to the stimuli. These effects have to be considered and if possible, should be reduced, so they do not influence the experiment too much. In the case of this study a randomization of maps was appropriate to address this issue (Martin, 2008, p. 156). The maps were shown in random order, to avoid a situation in which for example, all the warm-coloured maps are shown first, which stimulate emotions and thus influence the reaction to the cooler maps that follow. Through randomization a fatigue effect could be avoided as well.

Main Study Tasks

Stimuli

The effect under investigation was examined by showing differently visualised maps to the participants and recording the emotional response. Five choropleth maps with differing value distributions were created. All maps were showing the same 46 municipalities south of the city of Berne. The participants were not informed where the municipalities were located. Several methods were used to ensure that the participants did not recognise the communities. This was important in order to prevent different familiarities and underlying emotional connections to the localities from being generated between the participants. For instance, the Swiss capital was specifically not shown on the map because the borders of the city would likely be more recognisable than smaller, less known communities. In addition, each map was tilted by 45° and a second version of each map was tilted by 270°. Thus, 10 different map designs were created, all of which were presented to the participants in both colour palettes. This resulted in 10 maps using the GnBu palette and another 10 maps showing the Plasma palette as seen in Figure 14. Since each participant was shown each map in both colour scales, a total of 20 maps were presented to them. For group A, the maps were labelled "Number of cases per 100,000 inhabitants in the last 7 days" (in German: "Anzahl Fälle pro 100'000 Einwohner*innen der letzten 7 Tage"). Group B was shown the maps with the title "Number of ninety-year-olds and older per 100,000 people" (in German: "Anzahl Neunzigjähriger und Älterer per 100'000 Personen"). The values shown in the maps corresponded to realistic COVID-19 incidence values as they were registered in Swiss municipalities during the course of the pandemic between 2020 and 2022. They also matched the proportion of elderly people aged 90 and over that occur in various municipalities. The values assigned to the communities were generated using random.org and assigned to the alphabetically sorted communities. In some cases, the values were slightly adjusted to mimic spatial neighbourhood patterns that might occur during a pandemic.

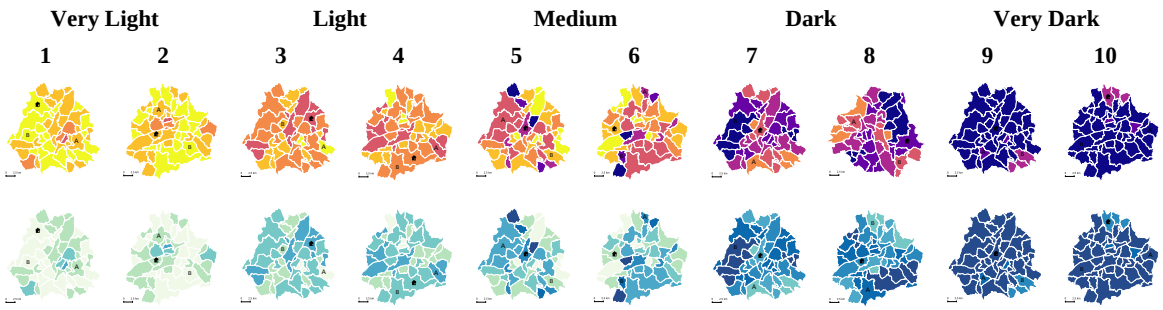


Figure 14: Stimuli of both colour palettes presented to all participants.

All participants were shown the maps for exactly 11 seconds, during which their facial expressions were measured. Meanwhile, no task had to be solved. The participants were simply instructed to observe and study the map and its contents.

Map Comprehension

The accurate map comprehension of information is of particular importance in the case of the COVID-19 pandemic. If a map was fundamentally misunderstood, the situation it was intended to portray could be misinterpreted, a different emotional response could be evoked and finally the reader might opt for a different behaviour. In order to check that this was not the case, participants were asked a comprehension question after each stimulus to check whether they understood its content.

For both study groups A and B, three different types of questions were created, which were asked in alternation to the maps. The questions were structured according to Bertin's (1983) three levels of map understanding. The first and easiest level (Elementary Level) is about whether readers can identify a single variable or information from a map. In the Intermediate Level the readers' ability to compare two variables is examined. The most difficult level, the Overall Level, tests readers on their ability to interpret the map as a whole, globally and to identify potential trends.

In accordance with these levels, the following three questions were defined for group A:

1. Elementary Level: What is the recorded incidence rate in Zone A?
2. Intermediate Level: Which area has a higher incidence rate, A or B?
3. Overall Level: According to your estimate, is the incidence rate of zone A below, above or just at the average of all zones?

Meanwhile, group B answered the following questions on the ageing population:

1. Elementary Level: What is the proportion of very old people in zone A?
2. Intermediate Level: Which zone has a higher proportion of very old people, A or B?
3. Overall Level: According to your estimate, is the proportion of older people in your area below, above, or just about the average for all zones?

Self-Assessment Manikin

Besides the externally measured emotions, participants were also tasked with self-reporting their emotional reactions to the maps. To do so, the valence and arousal dimensions of the Self-Assessment Manikin (SAM) by Bradley and Lang (1994) introduced in chapter 2.3.2 was used. The original test allowed to select between the pictograms, making it a nine-step assessment. In order to make the test simpler for the participants, only the five pictograms per dimension were selectable.

After looking at each stimulus, participants were presented the arousal and valence dimension scales and instructed to choose the pictograms most fitting to their emotional response to the maps. This task was presented identically to both groups. The pictograms' meanings were explained to the participants through descriptive adjectives on both sides. The reasoning behind the SAM and its emotion measurement functionality were not explained to the participants.

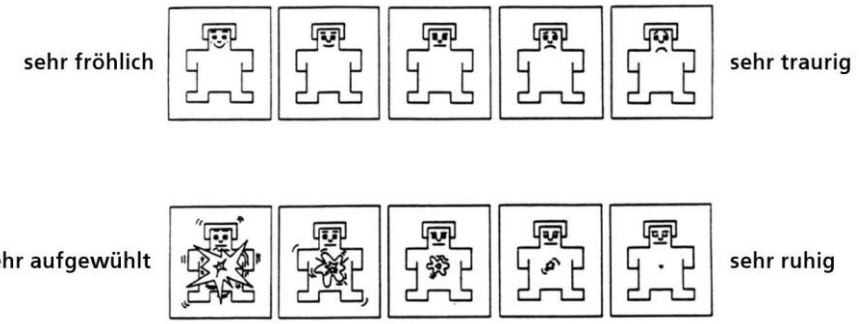


Figure 15: SAM shown to the participants during the experiment. Experiment version in German translates to very happy, very unhappy (top), very excited (aroused), very calm (bottom).

Situational Perception Affected by COVID-19 Maps

In order to answer research question 2.2a, participants were asked about their perception of the situations described in the maps. The purpose of this was to examine whether there was a difference in people's perceptions of the pandemic between the differently coloured visualizations. In order to balance the experiment, both groups were asked three questions corresponding to the topic after viewing the stimuli. The answer options were given in a Likert scale from 1 to 5. Relevant for evaluation of the research question were the answers of group A. In order to help the participants to put themselves in the situation portrayed, a house representing their place of residence was placed on the map. The participants were then asked to answer the questions from the perspective of their home.

Group A was asked the following questions:

1. How serious do you consider the state of the pandemic to be?
2. How optimistic / pessimistic does this map make you feel?
3. How concerned would you be about your health when you are out in public?

For Group B, the questions were adapted to the topic of population aging as follows:

1. How serious do you consider the state of an aging population in society?
2. How optimistic / pessimistic does this map make you feel?
3. How concerned are you about your own retirement provision?

Behaviour Affected by COVID-19 Maps

Finally, each stimuli was accompanied by three statements designed to determine what behaviours might be evoked by the different stimuli. This was of interest because COVID-19 maps and dashboards have frequently been used by the public as a source of information to improve situational awareness and to base decisions on. For this purpose, choices were selected that people typically had faced on a regular basis during the pandemic.

Similar to the questions on people's perception described in the previous subchapter, the task was given to both groups and had to be carried out based on the house marked as a living zone. However, only the answers from group A were relevant for the evaluation.

Group A saw the following statements to which they had to say how much they approved on a Likert scale:

1. Based on the map you are currently looking at, you decide to work from home.
2. Based on the map you are currently looking at, you voluntarily decide to wear a face mask in enclosed public spaces.
3. Based on the map you are currently looking at, you decide not to go shopping during busy hours.

Meanwhile, group B gave input on the following statements:

1. Based on the map you are currently looking at, you decide to participate in a volunteer programme (e.g. shopping assistance) for older people.
2. Based on the map you are currently looking at, you decide to adjust your pension plan.
3. Based on the map you are currently looking at, you decide to donate to the organisation Pro Senectute or a similar foundation.

3.3.4 Posttest

After the main part of the experiment, the participants were asked for their personal opinions on the respective topics. It was important to learn more about the participants' attitudes, as this could have influenced the way the questions were answered and their emotional reactions. If a participant in group A was particularly worried and was in favour of strict measures to stop the spread of the virus, they would likely answer the questions differently than a person who was not concerned and was opposed to strict measures. Group A was asked how afraid they were of contracting the virus themselves or for a family member to do so. Further, they answered how much they agreed with the various measures implemented by the Swiss federal government over the course of the pandemic. Furthermore, it was of interest to know whether the participants themselves or people close to them belonged to the group of particularly vulnerable people. Finally, they indicated how extensively they had informed themselves about the developments of the pandemic in general and through media published geovisualisations. For this part of the study, the questions were adapted for group B as well.

3.3.5 Participants

To be able to generalize the study's findings on a defined population some selection restrictions had to be made (Martin, 2008, p. 233). This thesis deals with maps published by the Swiss media on the topic of COVID-19. For this reason, it was important to conduct the study on people who have consumed such publications. Thus, the experiment was limited to Swiss residents. This selection was additionally appropriate, because due to colour-psychological reasons it was important to consider people with culturally similar colour associations. Since the study was about the emotional influence of colours on readers, it was also important that all participants had full colour vision.

Furthermore, participants had to be conscious of the pandemic's presence and have agency over their decision-making in regard to it. This was of importance because on the one hand the map's perception was dependent on their knowledge of the pandemic and, on the other hand because respondents were asked about their behaviour during the pandemic. Therefore, only adults were allowed to participate in the experiment. Finally, because the study region was Switzerland and there were no English proficiency requirements for the participants, the study was conducted in German. German was the language best understood by the participants and the study leaders, as well as being the language in which the majority of Swiss articles were published.

For the purpose of the study, it was decided that no further knowledge on the topic analysed in this thesis was needed by the participants. It was assumed that the COVID-19 pandemic was an event that affected every individual in Switzerland. Therefore, it was expected that each participant would have a basic understanding of and personal relation to the topic at hand. The same applies to the ageing of the population. oreover, the aim was to investigate the impact of the visualisations on the general Swiss population and not specifically on cartographers, data journalists or other specialists of the topic.

Nevertheless, the level of knowledge of the research areas was assessed in order to be able to analyse potential patterns.

The participants mainly were found in the researcher's own social environment, as well as at the University of Zurich and the Zurich University of Applied Sciences (ZHAW).

3.3.6 Material: iMotions

For the realisation of this thesis' part 2.1a and 2.1b, the iMotions Software[12] was used. This software is specifically developed for human behaviour research (iMotions, 2022). It directly integrates the experiment's set-up, execution, and analysis stages. For the execution stage it offers a variety of functions. Some, such as eye-tracking and facial expression analysis, can be carried out directly on the participant's device, as long as a webcam is included. In addition, the tool allows the application of other features which however require external measuring devices. The online facial expression analysis tool was, however, enough for the study.

iMotions Platform

The rather new desktop application iMotions platform was made use of in order to prepare the experiment. The platform's slide creator was used to set up and design the experiment stimuli, the instructions and the tasks. For each slide, it could be adjusted, how long it should be visible, whether manual advancement (clicking "Next") after engaging with the content was necessary and whether the slide's position in the experiment should be fixed or not.

Once the study was completed, the iMotions platform was again used to process and analyse the facial expression data.

iMotions Cloud

After preparing the slides in the iMotions desktop application, the experiment was uploaded onto iMotions Cloud. From there, final adjustments and preparations were made. For facial expression analysis experiments, where remote data collection is applied, iMotions automatically prepares introductory and closing slides, where participants are guided through the set-up of their device's camera and the positioning of their face. Similarly, after completing the experiment, participants are instructed to wait, while the collected data was uploaded successfully into the cloud and told when they can close their browser. Finally, the online tool prepares a link which leads participants to the start of the experiment.

iMotions Data Output

The Facial Expression Analysis Tool, respectively the Affectiva AFFDEX algorithm, provided the emotion analysis of the participants (iMotions, 2021). It is not known how exactly the AI-based algorithm

[12] https://imotions.com/

works. However, according to the developers, first the face is recognised, then the action units are detected and registered, and finally the facial expressions and emotions are classified (iMotions, 2021). The tool detects a total of 21 action units such as Smile, Eye Widen, Jaw Drop, Nose Wrinkle etc., which are then classified into the 7 basic emotions defined by Ekman et al. (1972): *anger, sadness, disgust, fear, joy, rurprise, contempt*. In addition, the valence data is provided, which is broken down into positive and negative valence. It was derived from the detected action units. The tool can also determine the level of engagement of the participants. This is determined by averaging action units indicating high stimulation (e.g. brow raise) and those indicating low stimulation (e.g. lip press). This is the closest indicator to, though not quite the same, as arousal. The processed data could be exported as the number of observations of the respective emotion channel of a participant per stimuli. Since the determination of emotions using facial expression analysis can be subject to large discrepancies in data accuracy, a threshold of 10 was chosen, which excluded from the data analysis all emotions that had a lower data evidence score, and thus detected an emotion with very low certainty. This decision was made on the recommendation of iMotions. The iMotions Facial Expression Analysis is a very helpful tool to detect uncontrollable emotional responses. However, studies by Taggart et al. (2016, p. 6) as well as by Jmour et al. (2021, p. 999) have shown that the iMotions software cannot always assign a facial expression to an emotion with great certainty. The results must therefore be taken with caution.

For the evaluation of the study, it was decided to use the values of the positive valence, negative valence and engagement observations, as these allowed an approximate comparison with the results of the SAM.

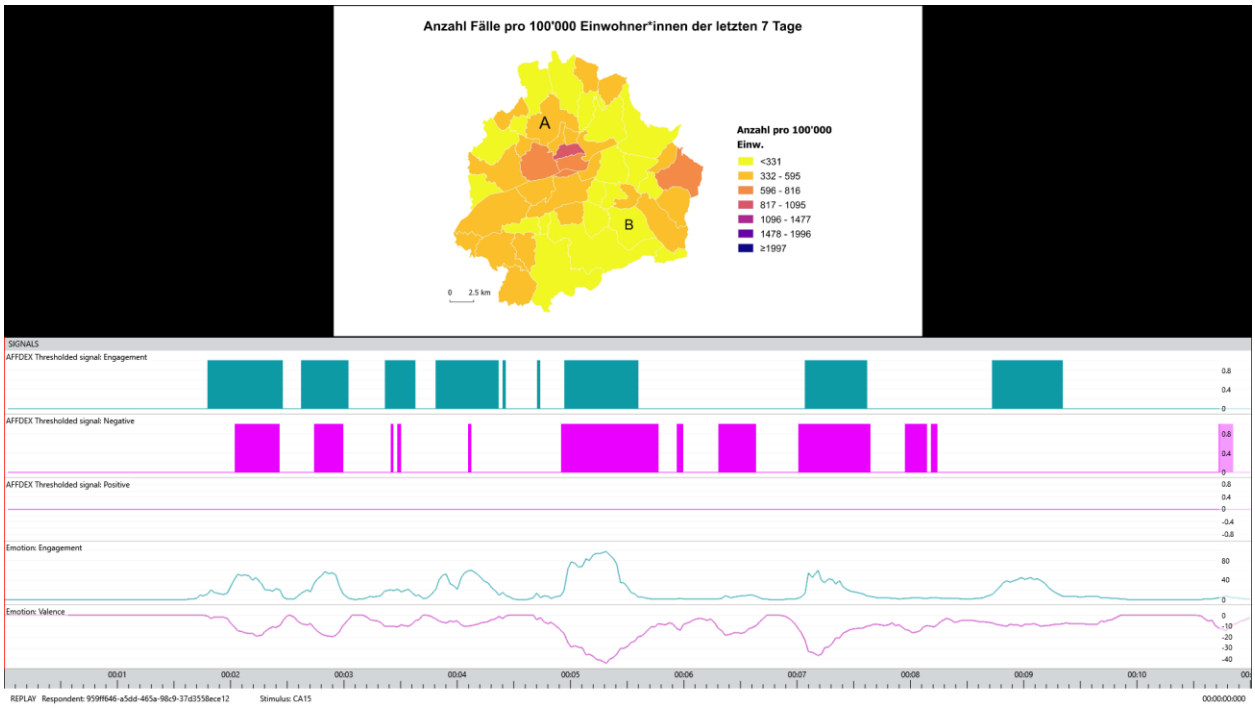


Figure 16: A participant's iMotions result (engagement and valence with and without threshold) for Map 1 in warm colour scale.

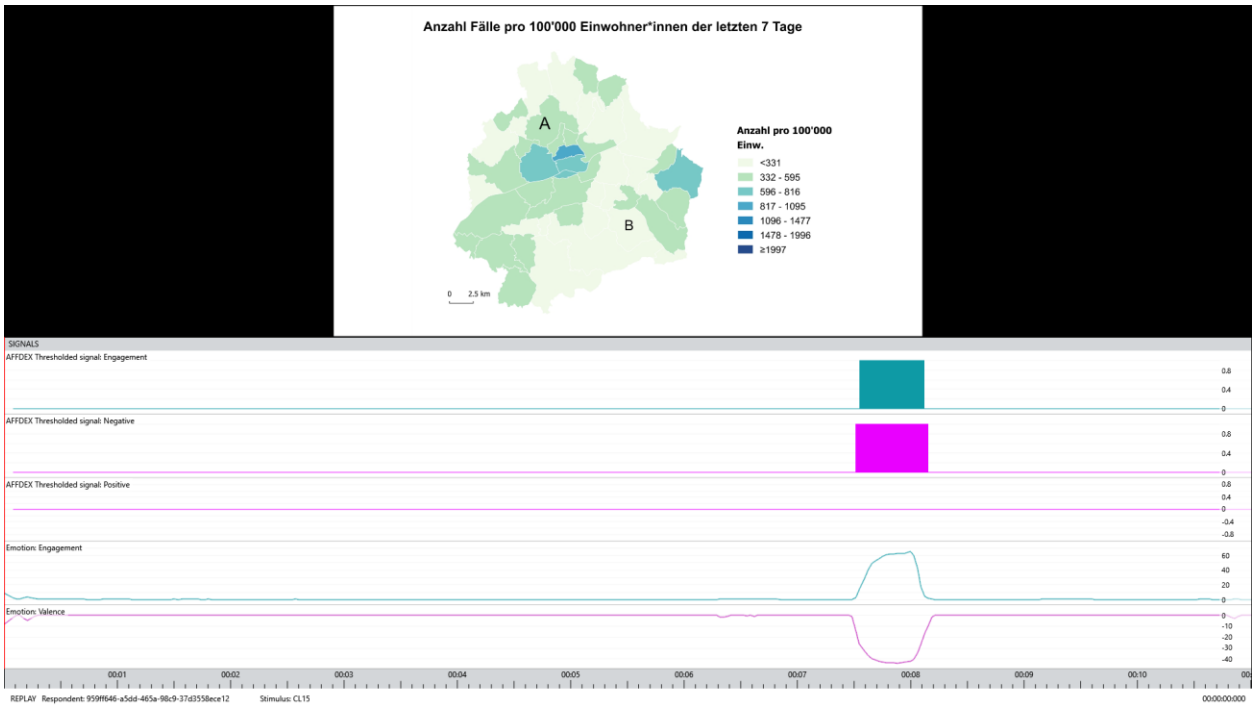


Figure 17: A participant's iMotions result (engagement and valence with and without threshold) for Map 1 in cold colour scale.

4 Results

4.1 Part 1a: Quantitative Content Analysis

According to the public Swiss media database Swissdox, in June 2022 there are 119 Swiss online newspapers that are operated and published regularly for the people in Switzerland (Swissdox, 2022). In 33 out of these 119 online newspapers, regular COVID-19 geovisualizations could be found. Another 82 online media did not publish such visualizations. Finally, four media outlets did not create their own visualizations but rather linked or copied the Federal Office of Public Health[13] (FOPH) figures and graphs. These four include Le Matin (Le Matin - R.M., 2022), Arcinfo.ch (ArcInfo - Keystone SDA, 2022), lacote.ch (La Côte - Keystone SDA, 2022) and lenouvelleiste.ch (Le Nouvelliste - Keystone SDA, 2022). In the context of this study, these four newspapers were not included into the analysis as they did not represent the way in which Swiss media communicated the developments of the COVID-19 pandemic but rather redistributed the data and reports of the Swiss government. Which online newspapers did publish COVID-19 case maps can be seen in the Appendix A.

Table 4: Number of Swiss online news media with and without self-made COVID-19 maps.

Media Content	**Field of Work**	
With COVID-19 Maps	33	(27.7%)
With Copies of Government COVID-19 Maps	4	(3.4%)
Without COVID-19 Maps	82	(68.9%)

4.1.1 Publishers and Online Newspapers

The majority of the 33 collected online newspapers belong to larger media companies. Within these media companies, the same content is oftentimes shared on multiple newspaper websites at once (Thommen et al., 2021d, p. 40f). This is especially the case for data visualizations as they are usually complicated and time consuming to create. Larger media companies and newspaper editorial offices typically have a separate team of data journalists responsible for creating, analysing, and maintaining graphics and geovisualizations on various topics. It is therefore common to encounter the same content on several newspaper websites, which, however, belong to the same media company. One example is Tamedia's Data & Interactive division[14]. The team regularly publishes information-rich content on current topics using a variety of narrative formats, including infographics and scrolly-telling articles.

[13] https://www.covid19.admin.ch/en/overview (accessed: 09.09.2022)
[14] https://interaktiv.tagesanzeiger.ch/ (accessed: 09.09.2022)

Due to this type of collaboration 21 unique COVID-19 maps could be identified in the 33 online newspapers that published visualizations on the topic. Figure 18 shows the number of maps the media companies, or rather their data journalist teams, have designed of the COVID-19 cases.

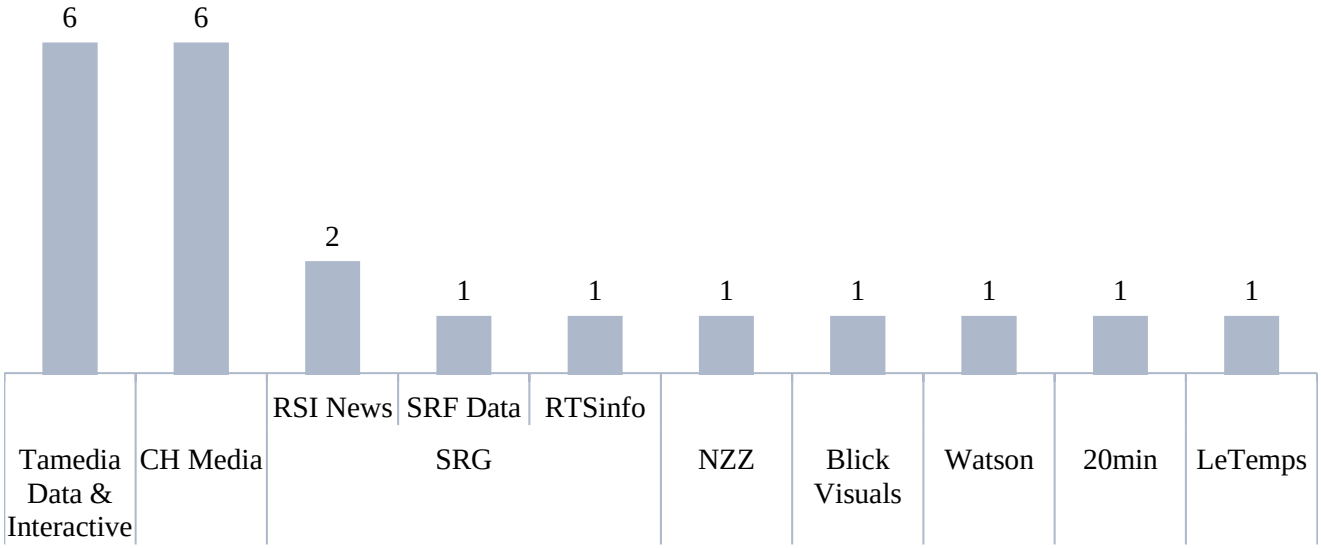


Figure 18: Number of unique COVID-19 maps by media company and creator team.

4.1.2 General Findings

The analysis of the different online newspapers showed that many of them published non-georeferenced charts, namely line charts, bar charts and other graphic forms. Since the focus of this thesis lies with studying the influence of COVID-19 maps on people's perception of the pandemic, these other chart types were not considered and analysed in this study.

In the following subchapters, the different types and designs of COVID-19 maps that have been published online in Switzerland since the beginning of the pandemic are analysed. Since their first publication, some online newspapers have changed the way they design their maps. Changes that have been identified have been mentioned and analysed in this thesis. However, it should be noted that for most maps, a complete chronological record is not available. This limits the analysis of their development.

In order to obtain an overview of the development stages of the COVID-19 maps, the course of the pandemic was divided into 5 semesters (half-year periods). Table 5 shows how these semesters were defined. It was attempted to provide a coverage of these semesters as complete as possible, and thus to find versions of online maps for as many semesters as possible. However, unlike text, self-updating online graphics are archived very poorly and irregularly. This is the case for Swissdox and for the online newspapers themselves. Therefore, this chronicle could only be created with the help of the internet archive

Wayback Machine[15], which is built by actively retrieving and saving websites through volunteers. However, this web tool also has its limitations and difficulties, causing complex graphics such as interactive online maps, as is the case in this study, to oftentimes not be saved either. As a result, a complete chronicle could only be created in some cases. A total of 40 map versions were found of the 21 unique map designs.

On which date within the semester, possible changes were made to the online maps, however, cannot be determined. This is because, as mentioned, only one record was saved per semester.

Table 5: Partitioning of the study period into semesters since the beginning of the pandemic.

Semester	Duration		
Semester 1	January 2020	–	June 2020
Semester 2	July 2020	–	December 2020
Semester 3	January 2021	–	June 2021
Semester 4	July 2021	–	December 2021
Semester 5	January 2022	–	June 2022

Language Distribution

Out of the 21 gathered maps only four (19%) have been published in French and two (3.4%) in Italian. The remaining 15 were published in German. Unlike the other Swiss National Languages, no frequently updated COVID-19 maps could be found in Romansh. This distribution corresponds roughly with the language distribution within the Swiss population. According to the Federal Statistical Office, 62.3% of the permanent resident population speak German, 22.8% speak French, another 8% speak Italian and lastly, 0.5% speak Romansh (BFS, 2022b). No online newspaper has changed its COVID-19 map's language during the span of publishing them.

Mapping Technique

Of all the online newspapers collected, choropleth maps were the most commolny used to visualise COVID-19 data. A total of 18 choropleth maps, two hexbin maps and one graduated symbols map were created as seen in Table 6.

Table 6: Count and percentage of mapping techniques used in COVID-19 maps separated into absolute and relative data.

Mapping Technology	Relative	Absolute	Total	
Choropleth	16	2	**18**	**(85.7%)**
Hexbin	2	0	**2**	**(9.5%)**
Graduated Symbols	0	1	**1**	**(4.8%)**

[15] https://archive.org/web/

In total, 16 of the choropleth maps used relative data values. Two other choropleth maps, on the other hand, applied absolute values to visualise the exact number of cases for each respective zone. The two hexbin maps used relative values while the one map with graduated symbols made use of absolute values. As a result, there were a total of three maps that visualised absolute numbers and 18 maps that visualised relative numbers.

The symbology in the maps has not been modified during the research period in any of the cases, even in the choropleth maps that displayed absolute values.

Geographic Area

Which geographical extent was represented and how it was spatially subdivided, differed greatly between the collected maps. The subdivision into Swiss cantons was displayed and compared most frequently. However, Switzerland could also be seen divided into other zones, such as regions. When looking at a single canton, there were also subdivisions into regions or municipalities. But there were also maps displaying regions and countries at the European level as well as countries at the global level. Which geographic areas are chosen for a map display always depend on the information that is relevant to the readers of the newspaper. Some local online newspapers have therefore chosen to display only the areas within the canton or region of their readership.

Figure 19 in addition shows that in two cases journalists made changes regarding the depicted geographical zones. In the first case, one of the CH Media maps was changed from a 14-day incidence map showing the regions of the Canton of Solothurn to a map displaying the communities of the Canton of Solothurn. In the second case, the daily incidence map of Le Temps was changed regarding its geographical extent. The map initially showed Swiss cantons and was then refined to a map of all Swiss regions. As a result, the spatial differences in the distribution of case numbers were shown more precisely, which was especially noticeable in spatially larger cantons.

Consequently, the number of maps with visualised Swiss cantons was reduced from eight to seven and the number of Swiss cantonal regions from one to zero. Similarly, one map was added to each of the cantonal communes and Swiss regions. This was attempted to be shown in Figure 19 with light grey bars.

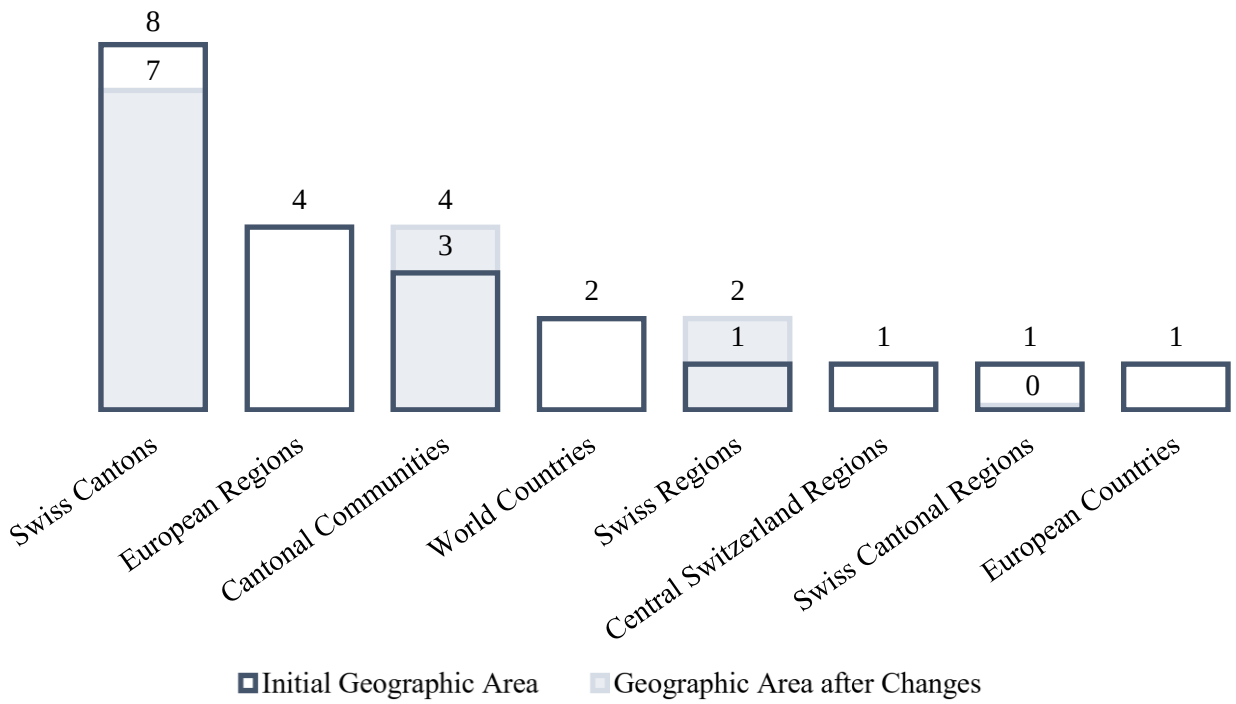


Figure 19: Geographical areas displayed in COVID-19 maps with changes emphasized with light grey bars.

Mapping Tools

For 11 of the 21 maps, it is not known which mapping tool they used to create their maps. What seems to be quite popular is the online tool Datawrapper, which was used for seven maps. In addition to Datawrapper, two in-house tools are known to be available to staff journalists. The RSI NEWS tool was used to create both RSI maps - the 14-day incidence map of the cantons and the 14-day incidence map of the European countries. The NZZ used its own tool for its own 14-day incidence map of the cantons. The tools used for the maps did not change during the pandemic.

Data Sources

Depending on the scale of the COVID-19 maps, the data sources are rather similar. For maps that depicted the cantons or regions throughout Switzerland only the federal government's data, published by the Swiss Federal Office of Public Health (FOPH) were used. The diagnosing test centres, pharmacies, hospitals, doctors' offices and all other testing institutions were obliged to report all positive test results to the FOPH within one day (BAG, 2022). The FOPH thus collected and aggregated the case numbers throughout Switzerland and made them available online[16] for further use and situation communication. Since the beginning of the pandemic, the government published COVID-19 case numbers on a cantonal as well as regional spatial level. In total, the FOPH figures were used for 10 of the 21 online maps.

[16] https://www.covid19.admin.ch/en/overview (accessed: 09.08.2022)

For maps on a communal level, canton-specific data had to be used, which however was not supplied by the FOPH. Data from the public data platform of the cantonal authorities of Zurich, openZH, were used for the cantonal incidence map of LeTemps as well as the incidence map showing all Zurich municipalities from Tamedia. For the absolute case count map of the canton of Aargau published by CH Media newspapers, data of the cantonal authorities of Aargau were used. Finally, the case rate data of the cantonal authorities of Bern were used for the incidence map of all Bernese municipalities by Tamedia.

For the global maps, including those covering the pandemic in Europe, a variety of sources were used. Tamedia's Francophone incidence map of the European regions was compiled using data from the European Centre for Disease Prevention and Control (ECDC). The incidence map of Europe by RSI News made use of data from the FOPH, the ECDC as well as the English government (GOVUK). RTSinfo, on the other hand, visualised the map using data from WHO Europe. Finally, the data set of the American Johns Hopkins University was the source of the Francophone world map of Tamedia, where the case numbers were compared to the previous week.

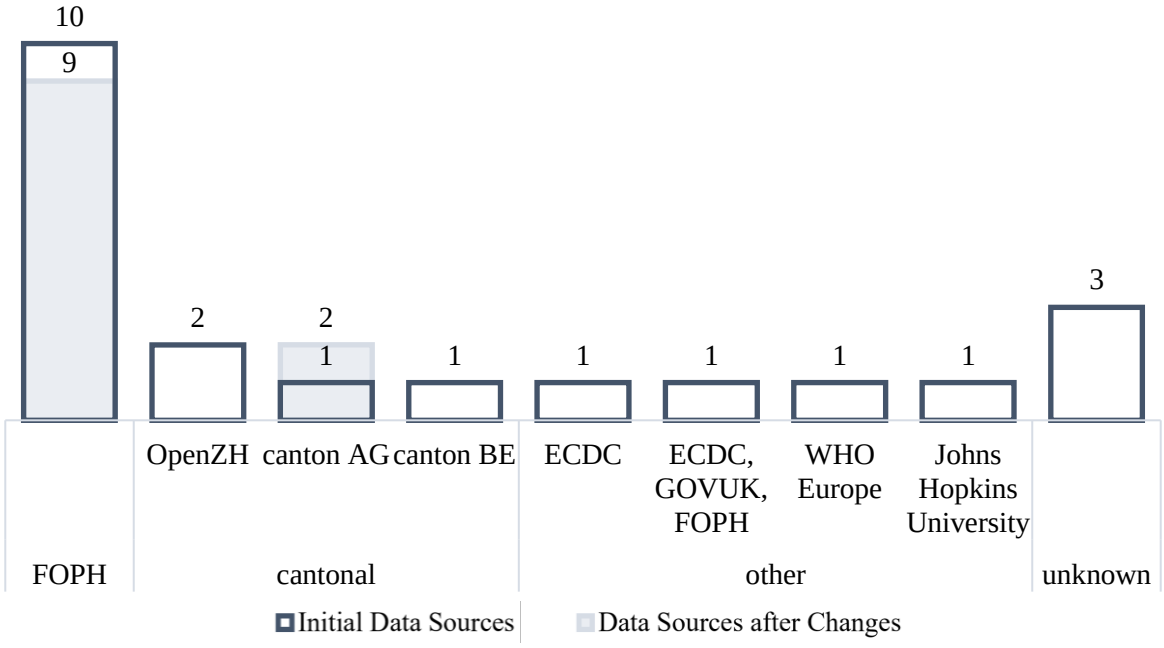


Figure 20: Data sources used for COVID-19 maps with changes emphasized with light grey bars.

The only map that changed source during the study period was CH Media's map on the Canton of Solothurn. While in the autumn semester of 2021 the map still showed the Solothurn regions, whose data could be obtained from the FOPH, the map was more finely resolved in the spring semester of 2022 to show the municipalities. The new data was made available by the canton of Aargau, which also collects data for neighbouring cantons.

Type of Information

An important part of the decision to visually communicate the development of a pandemic is determining in which form the data should be communicated. Journalists generally chose to visualize relative data and opted for absolute case numbers in only a few cases. Specifically, in the map's first version, absolute case numbers were geovisualised in two newspapers.

In epidemiology, incidence rates are a popular data form for determining the current spread of a disease. This measure takes population density into account as well as being calculated over a defined period of time. A 14-day incidence was chosen for 12 maps and a 7-day incidence for 5 maps. LeTemps used a daily incidence for its map, making it the only one to use such a short period of time. Another way of presenting the data is to compare the number of cases with the previous week. This is what the creators of Tamedia's Francophone world map chose for their visualization.

The way in which COVID-19 cases were communicated was adjusted repeatedly during the measurement period. The visualisation of the daily incidence of the LeTemps newspaper for example was changed to a 14-day incidence in the autumn semester of 2021. The Watson newspaper stopped displaying the14-day incidence data and instead visualised the R-value of the cantons from the spring semester 2021 onwards. In addition, the team also visualized the number of hospital beds for a short period of time in spring semester 2021, as well as the positivity rate from autumn 2021 onwards. Finally, journalists at CH Media decided to change their map of the canton of Solothurn from a 14-day incidence map to a choropleth map with absolute values in the spring semester of 2022. Figure 21 aims to visualize the changes made to the information type during the course of the pandemic. Given that three was the highest number of information type changes registered by any newspaper, it was decided to summarise the changes in terms of the encountered versions.

It is worth noting that 20 out of 21 maps used ratio data. An exception to this is the Tamedia world map, comparing the current incidence with that of the previous week. The data appear as increases and decreases in percent and are thus to be classified as interval data.

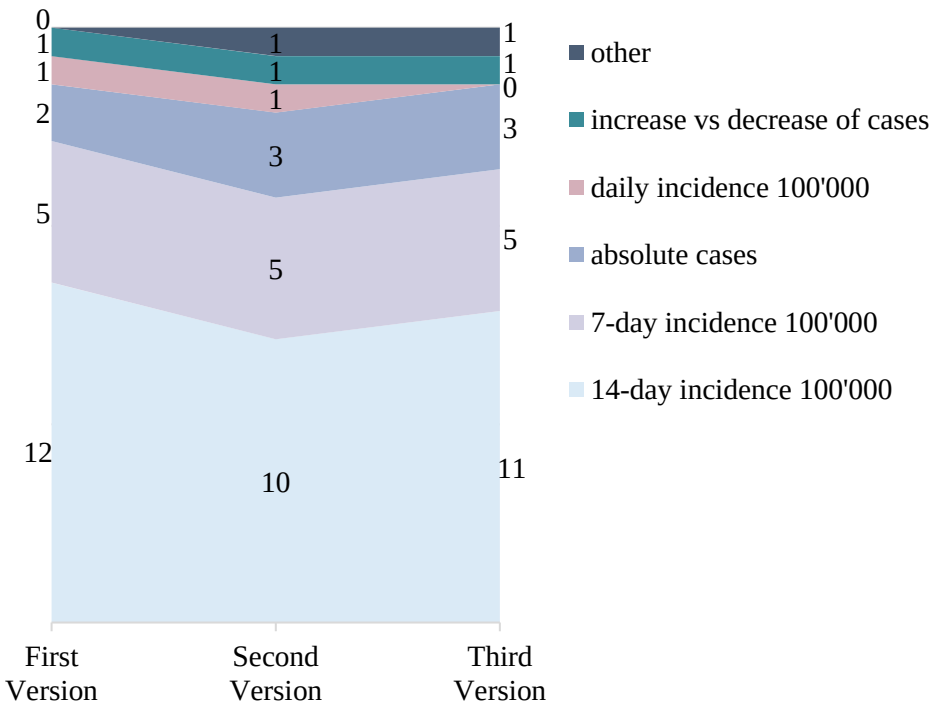


Figure 21: Development of information types in COVID-19 visualizations.

Legend

All but three of the COVID-19 maps analysed contained a legend to help understand and interpret the visualisation. The three maps from the Tamedia editorial team – the graduated symbol's world map, the world map where the case numbers were compared to the previous week as well as the 7-day incidence map of the Bernese communities – did not contain a legend. This accounts for a total of 14 percent of all maps collected. As far as could be detected, no legends were added or removed from any maps during the measurement period. Hence, there were no decisions to make changes on the part of the creators.

Number of Classifications

Another aspect of the COVID-19 maps that was examined was the number of classes into which the data was divided. Generally, four to seven classes were used. Most maps out of them, 8 specifically, were divided into 7 classes. Maps that utilised a continuous colour scale did not classify the data. A total of five maps were designed with continuous classification. Since neither the Tamedia's online map of the canton Berne nor its Francophone world map used a legend, the number of classes cannot be identified. However, it cannot be ruled out that the colour visualisation is continuous. As a result, the data was recorded as "unclear".

The number of classes was changed various times during the measurement period. LeTemps divided the colour scale into 5 classes in the first semester (spring 2020), but in the following autumn 2020 reduced it to a four-part classification. Since autumn 2021, the map showed 7 classes. CH Media's German-language 14-day incidence map of the Swiss cantons, on the other hand, changed from the previous 5 classes to a continuous colour scale in spring 2022. However, a few weeks later it reverted to the previous visualisation

with 5 classes. No other maps registered such changes within one semester. The different changes in versions can be retrieved from Figure 22.

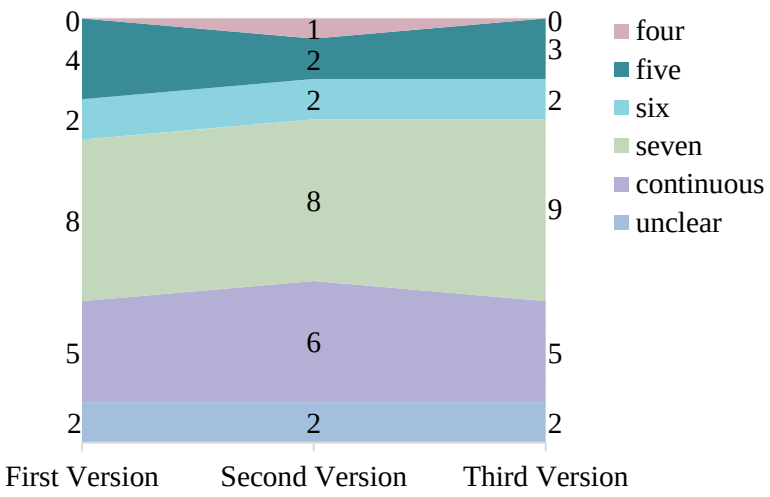


Figure 22: Development of number of classes in COVID-19 visualizations.

Further Explanatory Information on Data and Cartography

The majority of maps simply stated which editorial team created them, which tool, if externally obtained, was used and which data source was needed to create them. The latter information at times included a link to access the data directly. Another six maps, however, contained additional information that provided more details about the data. CH Media stated on several maps that for data protection reasons the data had been divided into seven classes and thus not broken down further. These include the 14-day incidence map of the Swiss regions as well as the maps showing the canton of Solothurn as well as the regions of Central Switzerland. NZZ explained in writing that Jenks Natural Breaks were used for data classification. Tamedia's francophone map of case numbers in European regions additionally informed that overseas regions had been been excluded from the map. However, by far the most additional information was added to Tamedia's map of Zurich municipalities. In the first obtained version, the uncertainty of the data was taken into account by determining the mean value of the reported range of cases to calculate the incidence rate. In the revised version of spring 2022, it was additionally pointed out that particularly low case numbers (0-3 per week) were not represented, and that the place of residence of the infected person determined where the case was reported.

Colour Palettes and Scale Types

Perhaps the most notable difference between the various maps is the choice of colour scale. In the initial map versions, a total of 16 sequential colour scales could be found (see Table 7). This includes Le Temps' visualization, even though hardly any difference in brightness is noticed. Two additional colour scales only partly followed the idea of a sequential colour scale. Particularly low case numbers were highlighted in a different hue and only as the numbers got higher a sequential colour scale followed. Such colour scales were therefore classified as quasi-sequential. This refers to the map of the Blick newspaper

as well as the map with the visualised Bernese municipalities by Tamedia. It appears that all sequential as well as quasi-sequential colour scale follow the principle of the darker the more. Thus, higher COVID-19 case numbers are represented through darker colours.

Furthermore, two diverging colour scales were identified. On the one hand, Tamedia's global map comparing case numbers with the previous week. Where an increase in case numbers is represented with a red hue sequence and a decrease in numbers with a yellow sequence. On the other hand, the 7-day incidence map by Tamedia showed blue for low, white for medium and red for high case numbers. Finally, the graduated symbols map does not differentiate the number of cases through colour values, but by circle size.

Both single and multi-hue scales were selected to visualize the data. Single-hue colour scales were used for the 14-day incidence map of the European regions by SRF, Watson's original and most recent map versions as well as the 7-day incidence maps of the Zurich municipalities by Tamedia.

Table 7: Number and percentage of COVID-19 visualizations in each colour scale type.

Colour Scale Type	**Total (%)**
Sequential	16 (76.2%)
Quasi-Sequential	3 (9.5%)
Diverging	2 (9.5%)
Categorical	1 (4.8%)

It is visible that the way in which the maps were coloured was reconsidered several times during the research period (see Figure 23). The colour scale were switched and adapted by several newspaper editors over the course of the research period. For instance, the 7-day incidence map of CH Media temporarily changed from a pink-purple colour scale to a plasma colour scale in spring 2022 and switched back to its original state in the course of one semester.

Furthermore, NZZ's map creators decided to add a darker hue at the end of its colour scale to represent the increasing number of cases instead of adjusting the numbering within the scale. Watson's team has highlighted particularly low hospital bed occupancy rates with a light blue hue for its hospital bed capacity map. Furthermore, the team decided to darken the colour scale for its maps showing R-values in a similar way to the NZZ. Meanwhile, CH Media has completely changed the colour scale for the Zurich communities map from a sequential map in blue hues to one in red hues. Le Temps changed from a triple hue colour scale (dark green-dark brown-dark red) to a double hue (dark green-dark brown) in autumn of 2020 and finally to an orange single hue colour scale in autumn 2021. Finally, the newspaper Blick removed the violet shading for particularly low cases, turning it into a sequential colour scale staring with light yellow and ending at dark orange.

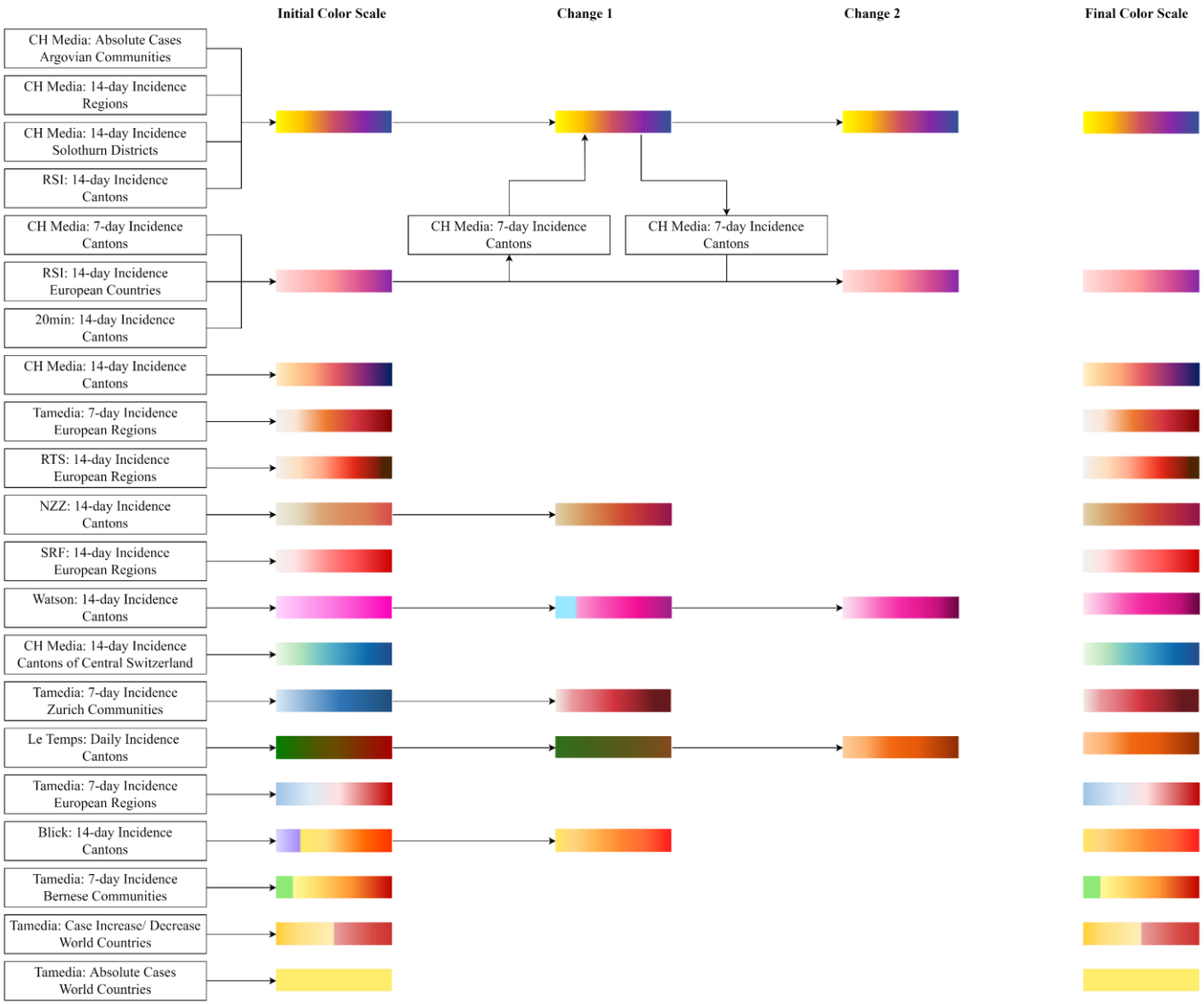


Figure 23: Colour palette development of COVID-19 maps in online newspapers.

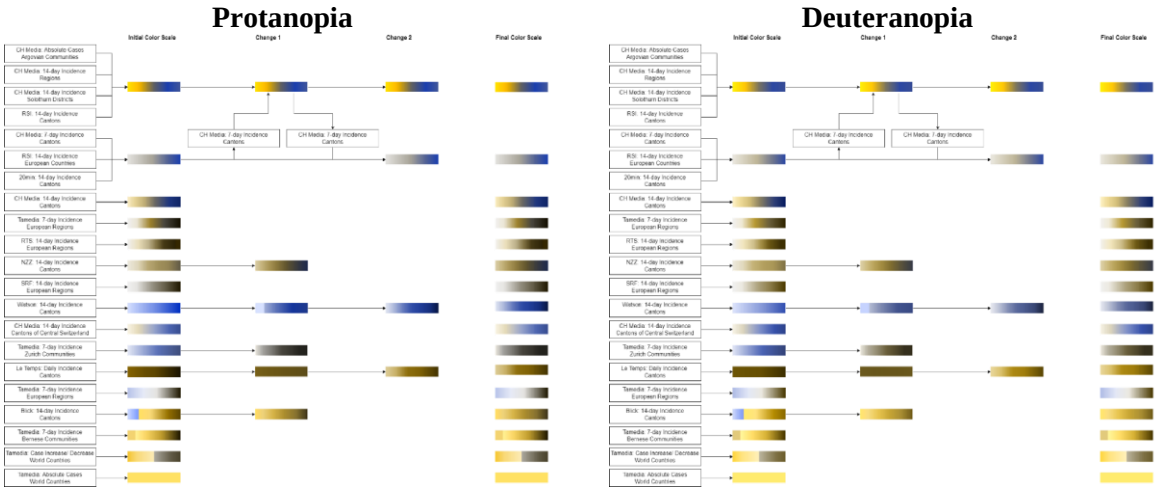
Colour Blindness

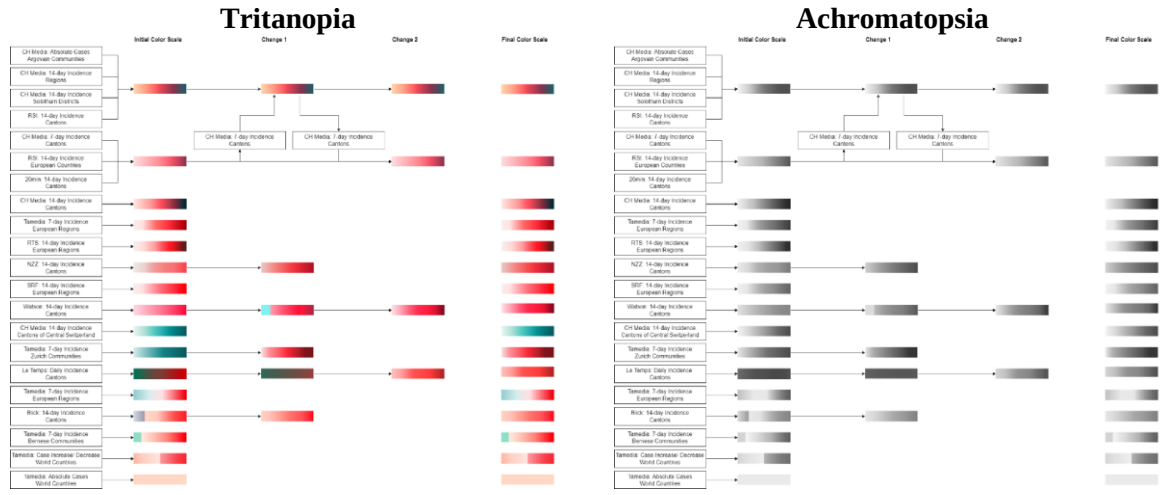
In addition, it was examined whether the colour scales were suitable for people with colour deficiencies or colour blindness. It was found, that except for two map designs, these limitations were taken into account and colour scales were chosen that were readable and comprehensible in terms of colour differentiability (see Table 8).

The two maps that did not take this into account were hardly readable for people with deuteranopia (green blindness) and deuteranomaly (green deficiency) as well as protanopia (red blindness) and protanomaly (red deficiency). This includes, on the one hand, the original map of Le Temps displaying dark green to dark brown to dark red colours as well as the maps later version of autumn 2020 in going from dark green to dark brown colours. On the other hand, the Bernese municipalities' maps by the creator team at Tamedia, which used a green-yellow-red colour scale were not appropriate either. Tritanopia and tritanomaly (blue blindness and blue deficiency) was not a problem with any map. However, people with monochromatic vision, referring to individuals with total colour blindness (achromatopsia) may have problems with some of the colour scales. However, this condition is very rare. According to (Sharpe et al., 1999, p. 50) approximately 1:33,300 for men and 1:50,000 for women are affected. Achromatopsia is therefore only taken into account to a limited extent in cartography. Especially in the case of choropleth maps, an attempt can be made to create an even brightness gradient between the classes, to ensure a suitable colour differentiability.

As already mentioned in the previous subchapter, the Le Temps map was adjusted in the course of the study period and has been colourblind-friendly since autumn 2021.

Table 8: The way in which the different colour palettes are seen from the perspective of a person with colour deficiencies.





Corporate Design

The results of the analysis of whether journalists create their maps according to corporate design guidelines turned out to be the most uncertain. Since newspaper editors generally do not openly communicate, which design guidelines they work with, the analysis was carried out by comparing the colour palettes in the COVID-19 visualizations with thematically different graphics, maps and website designs. It turned out that only Watson's map was most likely produced according to design guidelines. The distinctive pink colour hue of Watson is very present and appears in their logo, the titles, the website design and in most of the graphics. For other newspaper maps, it can be argued that certain colours are deliberately used by the editors to underline their brand and style. However, these are only assumptions.

SRF for example famously uses the colour red in many publications. It appears on the website, in the logo and in video spots. Therefore, it can be concluded that the colour has been used in the COVID-19 maps to match their design.

The combination of yellow and red appears in many of Tamedia's visualisations. The two world maps produced by the media group could therefore have picked up on this design. Meanwhile, NZZ editors have used similar colour scales to the COVID-19 map as in some other graphics. However, it is doubtful that strict corporate design guidelines are involved.

Last but not least, it could be suspected that the blue hue, which is frequently used in connection with the cantons Lucerne, Zurich and Zug given that it appears in their cantonal flags and many logos, was specifically selected for Tamedia's first map version of the municipalities of Zurich as well as in the Central Switzerland map published by CH Media.

Map Functionality

The functionalities of the maps were analysed as well. Since the study deals with COVID-19 maps published in online media, maps with numerous functionalities were very common, unlike maps in print media which only appear as static maps.

Nevertheless, the variety of functions with which the maps were equipped differed considerably. The zoom function was used in 11 maps. The hover function, on the other hand, which allows more information to be read about the studied zone, was used in 19 maps. The two maps not supporting this functionality were NZZ's hexbin map and Tamedia's graduated symbols map. However, it needs to be noted, that the former map allowed the incidence values to be read directly from the hexagons, while the latter map had overlapping circles, which made hovering difficult. Both maps mentioned are also the ones that did not require a forgiveness function.

The first versions of the LeTemps newspaper map differed greatly from the other online maps. It showed the development of the number of cases in animated form. The sequence could be viewed automatically and stopped by pressing the stop button. The slider above the map could also be moved, allowing the viewer to see the extent of the pandemic at a specific point in time.

Table 9: Functionality of COVID-19 visualizations.

Online Media	**Zoom**	**Hover**	**Forgiveness**
20min: 14-day Incidence Cantons	yes	yes	yes
Blick: 14-day Incidence Cantons	no	yes	yes
CH Media 1: Absolute Cases Argovian Communities	yes	yes	yes
CH Media 2: 7-day Incidence Cantons	yes	yes	yes
CH Media 3: 14-day Incidence Regions	yes	yes	yes
CH Media 4: 14-day Incidence Solothurn Districts	no	yes	yes
CH Media 5: 14-day Incidence Central CH	yes	yes	yes
CH Media 6: 14-day Incidence Cantons	no	yes	yes
Le Temps: Daily Incidence Cantons	no	yes	yes
NZZ: 14-day Incidence Cantons	no	no	no
RSI 1: 14-day Incidence Cantons	yes	yes	yes
RSI 2: 14-day Incidence European Countries	yes	yes	yes
RTS: 14-day Incidence European Regions	yes	yes	yes
SRF: 14-day Incidence European Regions	no	yes	yes
Tamedia 1: 7-day Incidence Bernese Communities	yes	yes	yes
Tamedia 2: 7-day Incidence European Regions	no	yes	yes
Tamedia 3: 7-day Incidence European Regions	yes	yes	yes
Tamedia 4: Case Increase/ Decrease World Countries	yes	yes	yes
Tamedia 5: Absolute Cases World CountRies	no	no	no
Tamedia 6: 7-day Incidence Zurich Communities	no	yes	yes
Watson: 14-day Incidence Cantons	no	yes	yes

4.2 Part 1b: Expert Interviews

To complement the findings of part 1a, interviews were conducted with three journalists (J1, J2, J3) and two scientists (R1, R2) from the fields of data journalism as well as cartography and data visualisation. One journalist provided written answers, while the others were audio recorded. The interviewees consisted of contacts of the supervisors as well as subsequent recommendations. In order to talk about the individual experiences in the interviewees' fields of work, the questionnaire was adapted accordingly. As a result, not all interviewees gave answers on all the topics. The following sub-chapters consist of the statements of the interviewees, categorised according to the topics discussed.

Table 10: List of interviewed experts and their field of work.

Interviewee		**Field of Work**
Researcher 1	*(R1)*	Data Journalism (ZHAW)
Researcher 2	*(R2)*	Cartography/ Data Visualisations (UCL)
Journalist 1	*(J1)*	Tagesanzeiger (Swiss Newspaper)
Journalist 2	*(J2)*	New York Times (US-American Newspaper)
Journalist 3	*(J3)*	Republik (Swiss News Magazine)

4.2.1 Developments in Data Journalism

The discussions with the experts have made it clear that data journalism is a relatively new phenomenon. This can be seen in the different career paths the three interviewed journalists took to become data journalists. J2 studied to be a journalist but given the interest, in communicating information through visualizations they entered the field of data journalism. J1 did a master's degree in geoinformation science and acquired some programming and visualization skills. Since these were in demand in journalism in Switzerland in the years around 2014, J1 became a data journalist. The observation that today's data journalists mostly landed in their work via detours was also confirmed by R1. According to the researcher, Switzerland witnessed an increase in data journalism around the years between 2013 and 2015. R1 came from a journalistic background and was doing research in the field of visual communications at the time. According to them, becoming a data journalist requires some know-how on data analysis and visualization techniques but also attending continuing education courses to deepen said knowledge. Likewise, J1 pointed out that the range of continuing education opportunities in data journalism has expanded in Switzerland in recent years. Until a few years ago, there were no clear career paths to becoming a data journalist. However, according to J1 and R1, the field has established itself in recent years and has now arrived in the middle of Swiss journalism.

According to J1 and R1, there are three big media companies in Switzerland - SRF, NZZ and Tamedia - which are actively and successfully practising data journalism. To do so, each of them has set up teams which regularly publish visualization stories on their websites. Given the high production costs, smaller newspapers, on the other hand, rarely publish such visualizations, R1 explained.

Newspapers belonging to larger companies started producing such visualizations centrally, enabling all newspapers in the network to publish them on their platforms.

4.2.2 Working Procedure in Data Journalism

The experts further shared their procedures for establishing new visualization projects. J2 explained that the process usually starts by selecting a topic the team is interested in and has questions about. Next, they search for suitable data sets and think about how they could visualize the new data. To be able to create a story, they often conduct initial analyses, to get to know the dataset. Similarly, R2 also has a topic-oriented approach in the publications. Before visualizing, the researcher already thinks about the angle and form in which the findings could be presented and what they aim to communicate. Another approach is presented by R1. Nowadays an increasing number of public datasets are available. This allows journalists to just search and analyse them to possibly make interesting discoveries. However, this approach is very time-consuming and may be less common in the stressful daily routine of editorial offices, assumes R1. Nevertheless, R1 acknowledged that it is not always possible to create a visualization. At times, one might have an interesting idea, but no useful data would be available, or one might not find an angle in which to visualize and communicate the data in a meaningful way, the researcher said.

Data journalism is an interdisciplinary field and different skills are needed to create the visualizations, R1 explained. To do so, people often work in teams, with some bringing design and programming skills while others offer their journalistic expertise. Both J1, J2 as well as R2 talk about working in teams to create visualizations.

4.2.3 Purpose of COVID-19 Maps

The question of whether COVID-19 maps should be published at all provided an interesting topic of discussion among the experts. J3 argued that it could be misleading to publish them given the relatively high data uncertainty created by the fact that not all infections were reported and recorded and that the uncertainty levels differ between regions because of different reporting criteria. Meanwhile, R2, answering the question from the UK point of view, stated that they would nevertheless publish maps because the collection of data in the UK was relatively good. Regarding Switzerland, it was added that the decision should depend on the scale of the visualization. "If it's the Swiss canton level [that's visualized], then that's probably okay but if it's down to community districts, there's going to be a lot of uncertainty in the data", (R2, 24.02.2022) the researcher said. R2 further added that maps should only be used as a communication tool when a spatial question was being answered. In other words, they were useful when one wanted to make spatial comparisons to figure out what was happening at which location. However, if the quantity was of interest, such as the COVID-19 case count, then a table with a filter option would be much more effective and manageable, R2 said.

Nevertheless, J1, J3 and R1 agreed that maps have an aesthetic value, which explained why they are regularly used to systematically draw the reader into the newspaper article. J1 pointed out an example

where Tamedia's Zürchersee-Zeitung used maps as teaser images. Such images are displayed before clicking on the article and provide a little insight into what the reader can expect. According to the journalist, these teasers with COVID-19 maps are giving the following message to the reader: "first, something aesthetic and exciting awaits you, and second, we [journalists] have the data at the community level and you can look at your community" (translated from J1, 03.12.2021). Maps can thus be personalized as well, which makes them additionally attractive in the eyes of J1, J2 and R1. Moreover, J2 recognised a need among the population for consistent information. Answering this demand, were accessible and comprehensible data visualisations that appealed to a wide readership.

As a result, the specialists were divided on whether COVID-19 maps should actually be published but largely agreed that they present a good way to attract readers while keeping them informed about and engaged with the ongoing pandemic.

4.2.4 Development of COVID-19 Maps

J2, who works as a data journalist for the New York Times, described in detail how COVID-19 maps were created and developed at the editorial office and why at times changes had to be made. At the beginning of the pandemic, when cases were still focused on China and only sporadic cases occurred in other countries, they chose to display the absolute case numbers in a graduated symbols world map as well as a U.S. states map. As the virus spread, they later switched to a choropleth map showing the United States to adequately represent the high case numbers in low-populated regions. During the course of the pandemic, they continuously adapted their maps to reflect its development and readers' needs, J2 said. For instance, they temporarily coloured counties that had particularly high case counts individually instead of the whole state. This was to avoid making it look like the entire state was heavily affected by COVID-19 cases. However, this stopped being useful when case numbers increasingly spread in rural states, since such a visualization method could underestimate the severity of the spread. Another step the editors took was to personalize the visualizations. This allowed readers to select and track counties that were relevant to them.

Over time, data on COVID-19 hospitalisations and ICU capacities became available and could be visualized by J2's team. A particular feature of the New York Times' Dashboard was the risk-level map. This visualization was intended to show readers how significant the risk was in their area and to help them decide which personal measures were appropriate. For all their maps, for this kind in particular the data journalists worked closely with epidemiologists and other experts to communicate the data in the most informative way possible.

J1 was only directly involved in the creation of COVID-19 visualisations at the beginning of the pandemic, before switching to their current job at Tamedia. The expert stated that mostly choropleth maps and, apart from the German-language world map by Tamedia, almost no graduated circle maps were published in Switzerland. In their opinion, this multitude of choropleth maps was not the result of

adapting to others, as newspapers like to be innovative. Rather, they seem to be easily and rapidly understood by readers and are therefore chosen as a mapping technique, J1 assumed.

Both J1 and J2 talked about how the regular updating and publishing of the maps has been automatised for some time. At the beginning of the pandemic, J2 recalled being responsible for manually updating the website four times a day. Nowadays only major changes to the graphics or texts are still done manually.

Future of COVID-19 Maps

It is difficult to say what the future holds for the COVID-19 maps published by the media. J2 was certain that the visualisations would not be published forever. However, it was not yet known how and when production would be discontinued. Nevertheless, at the time of the interview, 22 May 2022, the journalist knew that they had to continue to publish the maps for some time, as the number of cases was still too high. According to R2, the future of publishing COVID-19 maps was dependent on the development of the virus. The researcher said that if the virus evolved similarly to influenza, it could be possible that maps and visualisations continue to be used to monitor the virus' outbreaks in the future. Given the many visualizations that were produced, a foundation for this has already been laid, R2 assured.

4.2.5 Colour Use in Data Journalism

What and how something is coloured is a question that needs to be considered carefully, R2 said. According to the researcher, every time colour is applied, attention is drawn to it. R1, too, does not take the decision lightly and considers several factors to make the visualisations readable for the widest possible audience. This includes choosing colour palettes that are colour-blind friendly (J1), while also presenting the data as differentiated as possible and without any perceptual issues (R2).

Another important factor mentioned by J1, J2 and R1, was the consistent use of colours. The specialists agreed that if the same colour was consistently attributed to the key value in an article, readers could navigate through the article more easily.

The larger Swiss media companies have partly removed the decision of the colour palette from the journalists by setting corporate design guidelines, R1 and J1 agree. They explained, that at SRF, Tamedia and NZZ, it has been standard for some years for colour palettes, fonts, and the like to be specified. According to J1, CH Media is moving towards standardisation as well. Aside from not having to continuously create new colour palettes, corporate design guidelines also provide the benefit of recognisability, R1 explained. J1 admits, however, that it is important that guidelines are developed in cooperation with data visualisers to ensure that their needs are taken into account and the palettes fit the data structure.

Colour Use in COVID-19 Maps

Likewise, with COVID maps, choosing a colour scale was not a simple process and was approached in different ways by the interviewees. J2 shared that in their editorial office, case numbers were visualised in shades of red from the beginning. While they did not intend to alarm the readers, they felt that the choice of colour was justifiable and sensible as the pandemic was a serious issue. They wanted to use a colour scale that users could look at to understand where the situation was most serious. Furthermore, at the beginning of the pandemic, they needed to publish a visualisation to inform the population as quickly as possible. Therefore, not much time could be spent on discussing and testing different colour scales. "Over time, readers got used to it", said J2 (22.05.2022). Which is why they didn't want to make any significant changes to the scale. When the case numbers increased and the values in the legend had to be raised, they chose to add darker colours on top of the palette instead of re-stretching the colour scale over the adjusted legend. This too had been done in order not to mislead the readers.

Time pressure to publish was also mentioned by J1 as a decisive factor in the already fast-paced journalism. Commenting on the dashboard published by the Tamedia team, J1 said that it was a conscious decision to visualise the case numbers in shades of yellow and the death rates in shades of red. Red is evaluated more negatively than yellow, making the visualisation more intuitive to read, it was explained by J1.

All the interviewees were aware of colour associations. Especially with an emotional topic like the pandemic, it was important for them to use colours appropriately. "You wouldn't wish to over-sensationalise something or pick a colour that is constructed", said R2. R1 further mentioned the importance of communicating data in journalism as truthfully as possible. However, the researcher acknowledged the difficulty of visualising data neutrally, as the process of visualisation is always subjective. When creating the visualisation, J2 thus explained that it was important to ask oneself whether the perception of the map was what one wanted to portray. To the journalist, it came down to whether it felt right.

Overall, J1 acknowledged, however, that the psychological impact of published visualisations, including their colour scales, on readers had hardly been investigated in data journalism. Ultimately, one will always be confronted with practical problems such as time pressure or the differentiability of colour shades, J1 explained.

4.2.6 Managing Data Uncertainty

A major concern in visualizing the development of the pandemic was the lack of certainty and accuracy of the data. “There's no way you get perfect data. It just doesn't exist.”, J2 (22.05.2022) explained. Thus, one just had to work with what was available. It was, however, important to get to know the data and be aware of possible irregularities to then be able to make corrections if needed. For instance, cases were oftentimes not reported over the weekends, which lead to all cases being reported

at once on Mondays. J2 recounted, how such spikes in numbers would be avoided, by creating a rolling average of the data, which smoothed out these irregularities. According to J2, another way to address data inaccuracies was by flagging and explaining anomalies in the visualizations directly.

J1 on the other hand shared how the accompanying texts to the visualizations often included annotations and explanations. As the editorial teams often received questions from readers about the dashboards, the explanations became even more precise. Using the dashboard of the Tagesanzeiger as an example, J1 emphasised how reading instructions and clarifications were added to the illustrations to accustom the readers. However, a more extensive communication of data uncertainty and data accuracy has not been done, said the Swiss data journalist. "Strictly speaking, one would always have to add a confidence interval" (translated from J1, 03.12.2021), the journalist said. But this would have been very difficult to estimate. J1 justified the decision not to visualise uncertainties further by pointing out that the federal government, whose data was almost exclusively used, did not communicate the uncertainty either. If it had done so, journalists would probably have integrated it into the visualisations, J1 assumed. As an exception which takes uncertainty into account, the R-value was mentioned. This scientific value deliberately includes a confidence interval.

R1 generally found that data uncertainty could have been better communicated in COVID-19 visualizations. They feared that when looking at a graph, readers would immediately assume that it communicated entirely the truth. To address this issue, R1 suggested communicating the uncertainty in textual form even more as well as visually portraying it by greying or hatching affected areas on the map. In this field of data journalism, they still saw the potential for improvement.

4.2.7 Development of Reader's Visual Literacy

Both J1 and R1 expressed the wish for more consideration of readers' visual literacy in data journalism. It was important to find out how the published graphics were interpreted and whether they were understood, said J1. The data journalist criticised that the creators were too often projecting their level of knowledge onto the readers. According to them, data journalism would benefit from addressing this issue more closely. R1 also identified a need for better guidance towards the visualisations. "I suspect that many [readers] still just scroll over [the visualisations] because they think they are far too complicated to read", they said (translated from R1, 10.11.2021). The researcher acknowledged, though, that data visualisations in journalism have become more comprehensible in recent years. A decade ago, creators aimed to show as much as possible in one visualisation in order to give it some depth, they explained. However, this seemed to overwhelm readers and is therefore done much less nowadays. Moreover, as mentioned by J1 and R1 in chapter 4.2.6, explanations and descriptions are now often added to the illustrations to meet the readers' needs.

R2 shared a more optimistic perception of readers' visual literacy. The number and variety of data visualisations have increased in recent years. Thus, according to R2, the numerous published visualisations might have had a positive influence on the visual literacy of the people. Although there

was already a trend towards higher reading comprehension of maps and graphics happening, the pandemic was able to accelerate the said trend, R1 suspected.

4.2.8 Evaluation of COVID-19 Maps

Both researchers commented on their assessment of the published COVID-19 maps. R2 was overall very impressed with the maps published by the media. Although, the researcher did note that their assessment was influenced by the media they consumed. But with that in mind, R2 was nevertheless very pleased. They did not recall seeing dashboards that exaggerated the content in order to alarm or misinform the population. Further, R2 felt that the visual communication of the pandemic had been beneficial to data journalism itself and had helped it progress. According to them, many media houses had invested quite a bit in data journalism, thus creating strong teams. Moreover, because of this, data journalism has reached people's minds.

R1 also expressed a generally positive opinion about the published visualisations. Even though the researcher saw potential with other publications in terms of making them easier to read and understand, they hardly noticed this problem with COVID-19 visualisations. Given that the population quickly became familiar with the visualisations, had a concrete interest in them, and knew what type of information could be inferred from them, the textual and visual aids were sufficient, according to the researcher. They were pleased to see that recently "what we know and what we don't know" type articles which explained the state of knowledge to the readers, had become more established. Nevertheless, as mentioned in chapter 4.2.6, they would have liked to see better communication of data uncertainty within the graphics.

Although as a widely publicised and emotional issue COVID-19 could have been exploited to create persuasive maps and graphics, newspapers generally did not do so, according to R2. Rather, an attempt was made to communicate and design the information in an objective and discrete manner. The media companies, certainly, wanted to publish attractive articles which would be consumed, however, they were very careful in doing so, the researcher thought.

4.3 Part 2: Empirical Study

The empirical study was designed to examine the research questions of part 2 of this thesis. Part 2.1 dealt with the analysis of the emotional impact (dependent variable) of the different stimuli. The independent variables were the colour scale (warm vs. cold) and the topic (COVID-19 vs. ageing population). Since different value distributions of the maps were also created in order to examine the effect of the same colour scale in different scenarios, the value distribution played the role of a further independent variable. The two tools, the Facial Expression Analysis by iMotions and the Self-Assessment Manikin, were used to determine the emotional response. As already mentioned in chapter 3.3.6, the iMotions software provided engagement data, which was compared with the arousal data from the Self-Assessment Manikin. Furthermore, information on the detected valence was provided in the form of positive and negative valences, which allowed a comparison with the valence assessment of the SAM.

Part 2.2 focused solely on the results of the COVID-19 group. This was because the group's perception of the pandemic and subsequent behaviour based on the differently coloured maps was of interest. The independent variables were therefore only the colour scale and the different brightness levels of the map.

In order to answer the research questions of part 2, various statistical tests were conducted, which were designed to examine the respective differences of the various variables. This allowed conclusions to be drawn as to whether there were significant differences in the response variable between the independent variables. The results of the empirical study will be presented in the following sub-chapters.

4.3.1 Participants

In the study a total of 72 people participated. Of these, 41 (57%) were female and 31 (43%) male. No participant chose the option "no answer" regarding their gender. As can be seen from the population pyramid in Figure 24, most participants were between 18-29 years old. The median age was at 27.5 years.

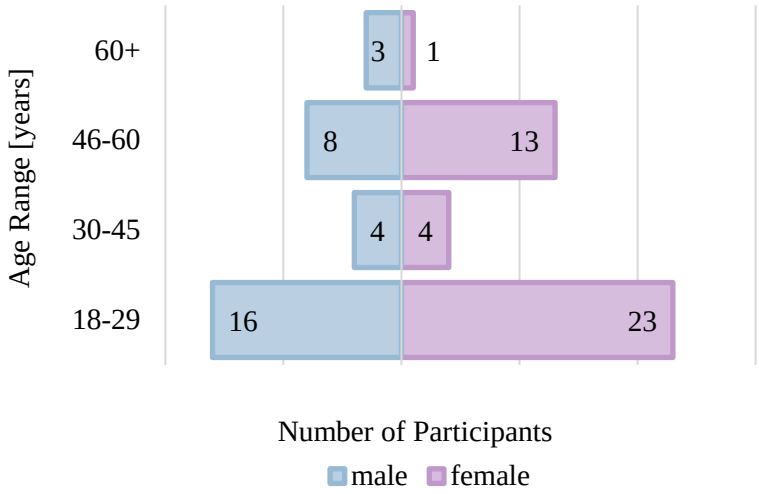


Figure 24: Population pyramid of study participants.

Colour Blindness: Self-Report and Ishihara

Except for one participant who stated to have a colour deficiency, no one else stated to have the condition and could thus be included in the study. 85% (total 61) of the participants completed the Ishihara test without any mistakes. Four out of five correct answers were given by 12% (total 9 persons). One person gave three correct answers, and another person gave one correct answer. It was decided to not exclude the latter person from the study, as their willingness to take risks and their opinion on the topic under consideration could still be analysed.

Media Consumption and Experience in the Subject Areas of Interest

In response to the question about the amount of media consumption, 38 people (53%) stated that they consume Swiss online media frequently (daily) and 17 (23%) regularly (weekly). Furthermore, 14 (19%) people stated to rarely consume it and three (4%) others never consume online media. Most participants, 34 to be exact (47%) said they had no GIS knowledge, 10 participants (14%) had hardly any knowledge, seven (8%) some, 11 (15%) good and 10 (14%) very good knowledge. In the field of cartography, 22 (31%) participants said they had no experience and 21 (29%) had hardly any experience. Somewhat experienced were 11 (15%) participants. A total of 12 people (17%) stated that they deal with cartography on a regular basis and another six (8%) on a daily basis. The majority of participants had little to no experience in the field of data journalism. A total of 38 people (53%) said they had no experience, 17 (24%) said they had little experience and 12 (17%) said they had some experience. Only three (4%) were well experienced and two (3%) were very experienced. The situation is similar in the field of epidemiology. 37 participants (51%) have none, 18 (25%) have hardly any and 11 (15%) have some knowledge in the scientific study of epidemiology. Finally, five (7%) people indicated to have good knowledge and one (1%) stated to have very good knowledge.

Risk Aversion: Holt & Laury Lottery and DOSPERT Scale

Risk aversion was determined with two pretests - the Holt & Laury Lottery and the DOSPERT Scale – as explained in Chapter 3.3.2. The results of both tests are shown in this subchapter.

Except for the last game (Lotto 10) of the lottery, option A is always the safe choice. Even if the higher amount (CHF 100) is not won, one still receives CHF 80. With option B, on the other hand, the chances of winning increase constantly with each game, but there is always the possibility of losing the game and winning only CHF 5 instead of CHF 190, except for game 10. This is a more significant loss than with option A. In general, option A is the safest option. Those who chose option A more often can be classified as more risk averse than those who chose option B more often. Holt & Laury (2002, p. 1649) have developed a key according to which the amount of times a participant chooses option A can be used to decide how risk-loving or risk-averse one is. The level of risk to which the participants were assigned can be seen in Figure 25.

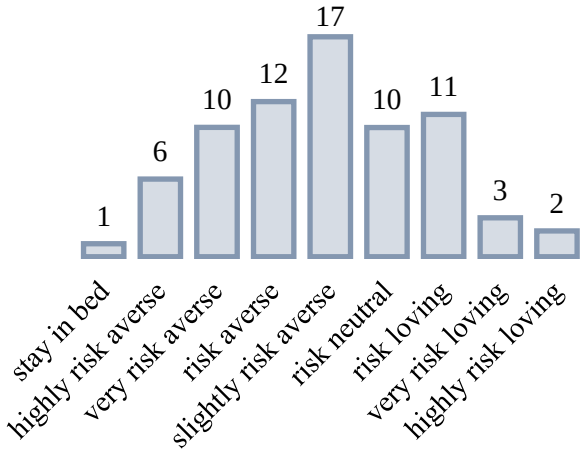


Figure 25: Risk aversion classification of participants by Holt and Laury (2002, p. 1649). Classified as the sum of option A (a): stay in bed (a≥9), highly risk averse (a=8), very risk averse (a=7), risk averse (a=6), slightly risk averse (a=5), risk netural (a=4), risk loving (a=3), very risk loving (a=2), highly risk loving (a≤1).

Out of the 72 participants, 46 (64%) exhibited more or less risk averse behaviour when playing the lottery. 10 (14%) participants were classified as risk neutral and 16 (22%) were more or less risk loving according to the classification. Figure 26 shows at which game the participants were willing to choose the riskier option. The dashed line marks the risk-neutral prediction, i.e. the decision path of a risk-neutral person. According to the test developers, a risk-neutral person generally opts for option A in the first four games and switches to option B from game 5 onwards (Holt & Laury, 2002, p. 1645f). It is noticeable that already in game 4, 28% of the participants chose option B. Holt & Laury's experiment did not see such a jump at game 4 and the time of the switch occurred at game 7. In the experiment here, the switch of the remaining participants to option B happened more moderately and by game 7, it is still 24% who choose option A. This suggests that while there was a notable group of risk-taking participants, the majority tended to be more risk-averse. This supports the findings from the classification of Figure

25. All participants chose option B in game 10, which promised a safe profit of CHF 190. It can be concluded that all participants understood the rules of the game.

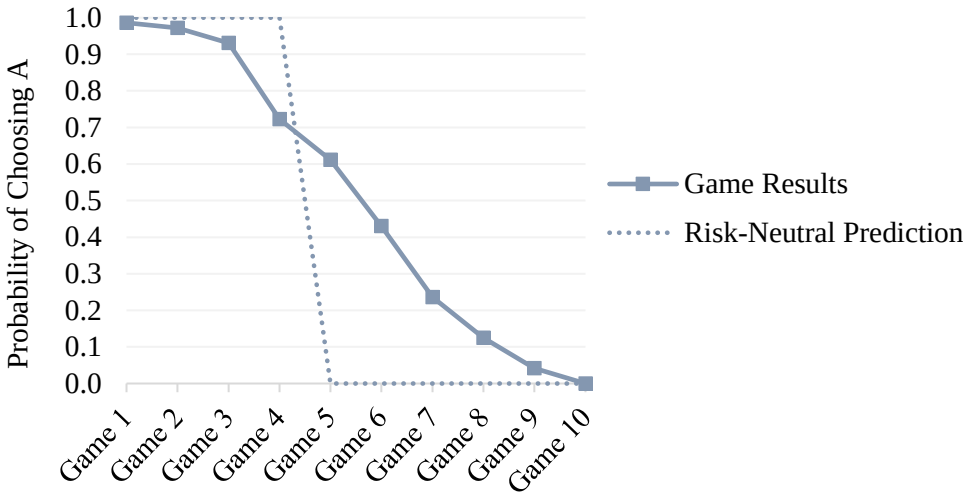


Figure 26: Participant's probability of choosing A. Based on Holt & Laury (2002, p. 1648).

In addition to the lottery, the DOSPERT Scale was applied to determine the participants' willingness to take risks on health issues. Their willingness to engage in risky behaviour in different scenarios was assessed. In contrast to the lottery, the chances of winning and losing in these scenarios are not clearly calculable. The decision is therefore based more on the intuitive assessment of the participants, which in turn corresponds to the type of decisions during the COVID-19 pandemic. Except for one person, riding in the passenger seat of the car without being strapped was not an option for the other participants. Consuming five or more glasses of alcohol in one evening was also very or rather unlikely for the majority of participants. Participants seemed to be less risk-averse when it came to applying sunscreen. A total of 23 (32%) participants were rather likely to and 7 (10%) were very likely to expose themselves to the sun without wearing sunscreen. In general, however, it can be said that the study participants were less or not at all willing to expose themselves to risks, especially when it came to personal health and safety issues.

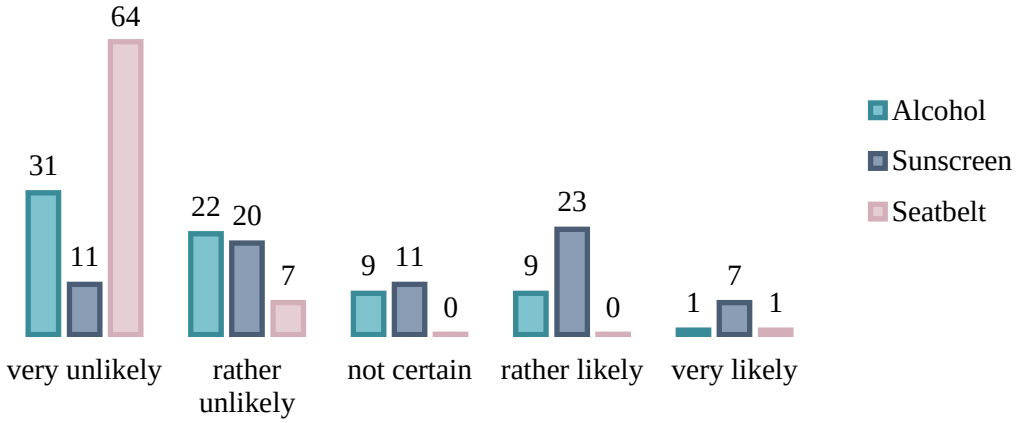


Figure 27: Self-assessed risk behaviour in health and safety issues of participants.

General Map Comprehension

The comprehension questions were primarily intended to test whether the participants understood the content of the maps. However, it was additionally interesting to find out if there were differences in reading abilities between the two colour scales.

For the *Elementary Level*[17] questions, 95% of the questions were answered correctly when consulting the warm-coloured palettes. When looking at the cold-coloured palettes, participants gave correct answers 65% of the time. On the *Intermediate Level*[18] for both colour scales 98% correct answers were given. Finally, the *Overall Level*[19] questions, which looked at whether readers understood the map as a whole, caused the most difficulties. This was shown by the fact that a total of 77% correct answers were given when being presented with warm colour scales and only 67% correct answers were given when being presented with cold-colour scales.

Table 11: Map comprehension of both colour scales.

Comprehension Level	Warm-coloured	Cold-coloured
Elementary	95%	65%
Intermediate	98%	98%
Overall	77%	67%

Personal Attitude Towards the COVID-19 Topic

Lastly, it was of interest to find out how the participants felt about the COVID-19 pandemic and how directly they were affected by it. The aim was to discover more about the respondents in order to help make explanations for findings made in the study.

The survey found that 65% either belonged themselves to the group of particularly vulnerable people or lived in a household with someone who was. One person in participating in the group A of the worked in the health sector with direct contact to patients. Furthermore, most of the participants consulted the published case numbers on a weekly (32%) or even daily (53%) basis. Overall, 6% never consumed COVID-19 themed maps, 38% did so monthly, 35% weekly and 21% daily.

When asked about their fear of infecting themselves or a family member with COVID-19, participants did not respond equally. While 32% were not very afraid of infecting themselves, 21% were somewhat afraid and 38% were quite afraid of infecting themselves. There seemed to be a higher level

[17] What is the recorded incidence rate in Zone A?
[18] Which area has a higher incidence rate, A or B?
[19] According to your estimate, is the incidence rate of zone A below, above or just at the average of all zones?

of concern about infecting family members. A total of 41% said they were quite afraid and 24% very afraid of infecting a family member.

The participants in group A generally agreed or strongly agreed with the measures, though opinions differed slightly between the measures. From Figure 28, the approval ratings of the different national measures can be retrieved.

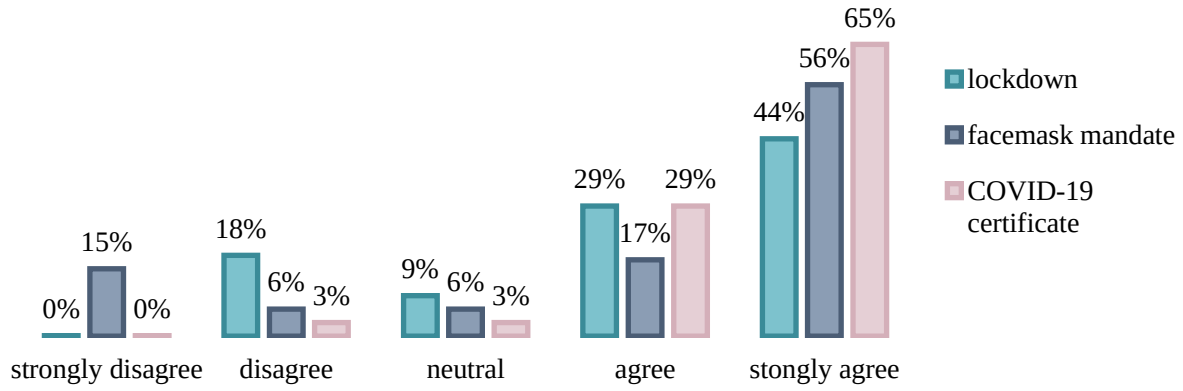


Figure 28: Approval of national measures to reduce the spread of COVID-19.

4.3.2 Part 2.1: Emotion

iMotions

Engagement (Arousal)

Using engagement values obtained through facial expression analysis from iMotions, the aim was to analyse whether there was a difference in arousal between the colour and thematically different maps. In the beginning the Shapiro-Wilk normality test was used to check whether the data were normally distributed. Neither the data of the warm-coloured (W = 0.702, p-value = 8.326e-11) nor cool-coloured (W = 0.699, p-value = 7.2e-11) maps were normally distributed. A further log-transformation was unable to produce a normal distribution, as the data were strongly zero-inflated. For this reason, the data were examined using non-parametric tests, which do not assume a normal distribution. A significance level of 0.05 was chosen for each statistical test. As a first test of differences, a Wilcoxon Signed Rank Test was performed between the mean values of engagement of the warm and the cold colour scales. The null hypothesis assumes no difference between the two variables. The test showed no significant difference (V = 530.5, p-value = 0.917) as seen in Figure 29. However, the effect size was very small (r = 0.011). A Mann-Whitney U test between the COVID-19 and ageing groups (W = 2745.5, p-value = 0.505) with a small effect size (r = 0.056) indicated no significant difference either. The distribution of the engagement data broken down by topic can be seen in Figure 30.

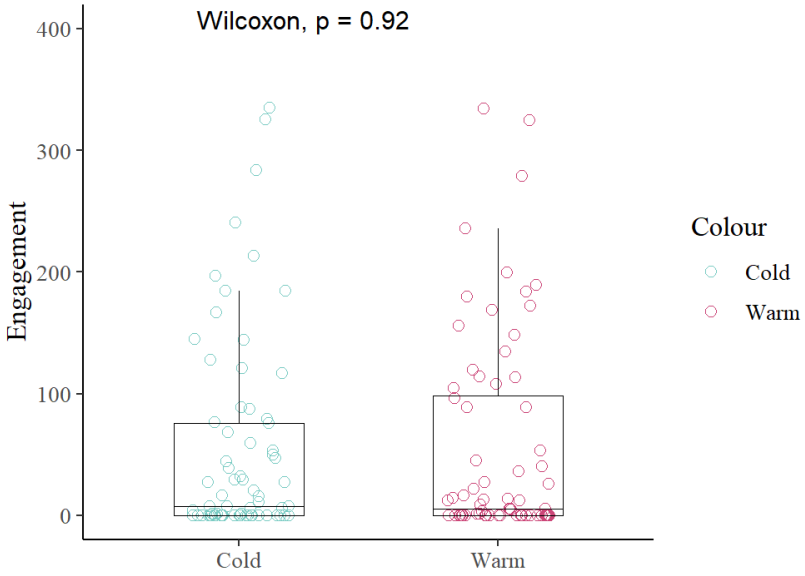


Figure 29: Boxplot of mean engagement count data with Wilcoxon Signed Rank test result between colours (iMotions).

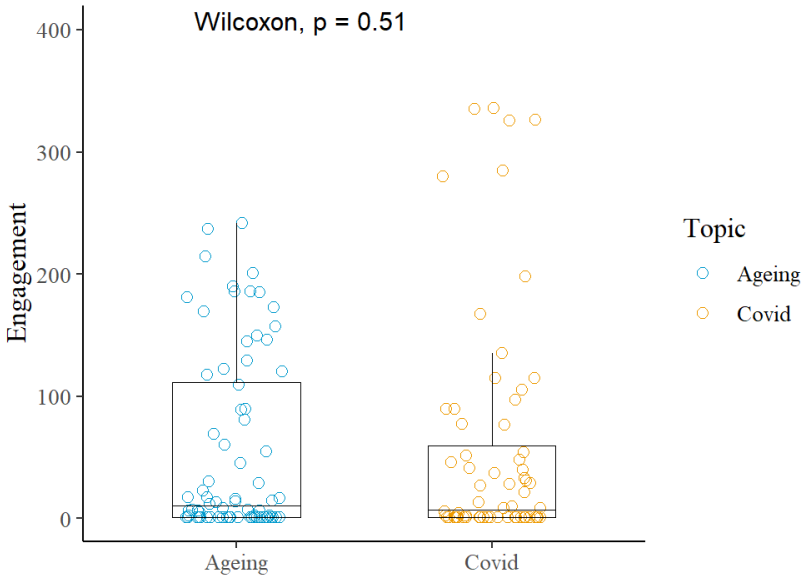


Figure 30: Boxplot of mean engagement count data with Wilcoxon Signed Rank test result between topics (iMotions).

As the different value distributions were created as pairs of two maps with identical colour patterns but tilted, it was aimed to investigate whether there was a similar response to the paired maps. The applied test was a Wilcoxon Signed Rank test. The hypothesis was that similar engagement means were measured within the paired maps and thus no significant differences could be measured between them.

For the warm-coloured pairs of maps, no significant differences were found between the very light (V = 493.5, p-value = 0.239, small effect size r = 0.103), the light (V = 471.5, p-value = 0.330,

small effect size r = 0.139), the medium (V = 697.5, p-value = 0.942, small effect size r = 0.006), the dark (V = 571.5, p-value = 0.375, small effect size r = 0.110) and the very dark pairs (V = 565.5, p-value = 0.644, small effect size r = 0.024).

A similar picture emerged for the cold-coloured pairs of maps. The very light (V = 527, p-value = 0.288, small effect size r = 0.148), the light (V = 817.5, p-value = 0.244, small effect size r = 0.166), the medium (V = 691, p-value = 0.661, small effect size r = 0.022), the dark (V = 549.5, p-value = 0.398, small effect size r = 0.147), and finally the very dark map pairs (V = 681, p-value = 0.763, small effect size r = 0.029) did not show any significant differences. Thus, the maps could be examined in the pairs, which facilitated the subsequent interpretation due to the reduction of the contributing factors.

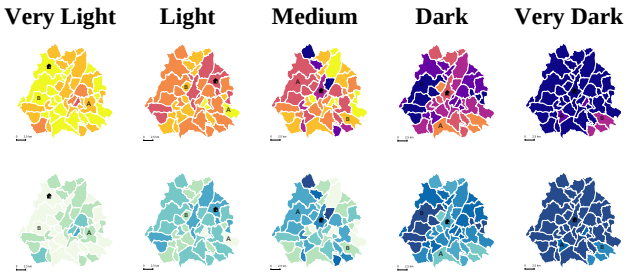


Figure 31: Grouped map pairs of identical patterns but differing orientations.

In order to gain a deeper insight into the influence of the colour scale, the topic as well as the value distribution on the emotion arousal of the participants, an Aligned Rank Transformation (ART) ANOVA, was carried out (Wobbrock et al., 2011). This is an ANOVA method that is suitable for non-parametric data and can investigate interactions of mixed models.

In a first omnibus test (Equation 1), the two *Topics*, both colour scales (*Colour)* and the map value distribution (*Pattern*) classified in brightness levels, were examined. There were no significant differences between the independent variables and no interactions.

$$Model = art(Value \sim Topic * Colour * Pattern + (1|Respondent)) \quad (1)$$

Further pairwise ART models did not show any significance either. However, when comparing *Colour* and *Pattern* (Equation 2), there was a main effect for colour (F = 4.035, df = 1, p-value = 0.045, η_p^2 = 0.006). Accordingly, there was a significant difference between the colour scales as may be seen in Figure 32. The results showed that the cold colour scale had significantly higher arousal values than the warm one. One of the reasons why this effect can only be explained by a model with fewer variables is due to the fact that the error could be better estimated.

$$Model = art(Value \sim Colour * Pattern + (1|Respondent)) \quad (2)$$

In order to determine the effect sizes of ART ANOVA's the partial eta-squared (η_p^2) proposed by Cohen (1988) was calculated. According to which η_p^2 <0.06 is considered to portray a test's small effect size, η_p^2 = 0.06 – < 0.14 a medium and η_p^2 > 0.14 a high effect size.

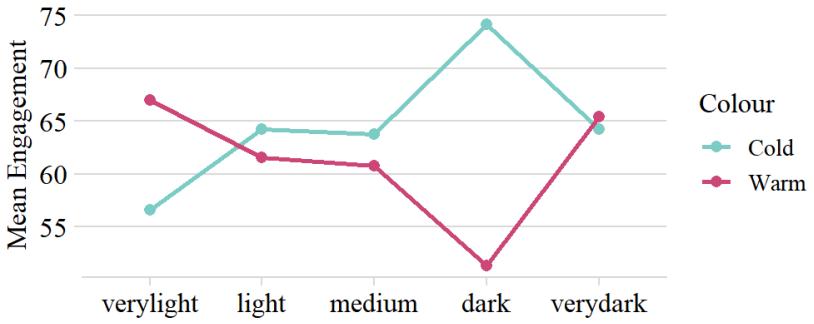


Figure 32: Interaction of map pattern and colour scale for mean engagement (iMotions).

Valence

Positive Valence

For the analysis of the iMotions valence data, the same statistical tests were carried out as for the engagement (arousal). The results of the positive metric are presented first, followed by the negative valence data. The Shapiro-Wilk normality test, showed, that neither the mean positive valences of the warm-coloured (W = 0.19438, p-value < 2.2e-16) nor the cool-coloured (W = 0.26386, p-value < 2.2e-16) maps were normally distributed. As the data was once again heavily zero-inflated, these results were not surprising. A Wilcoxon Signed Rank Test was performed between the mean values of positive valence of the warm and the cold colour scales, which showed no significant difference (V = 17.5, p-value = 0.594, small effect size r = 0.042). As for the difference between the topics, the Mann-Whitney U test did not show significant differences either (W =2637.5, p-value = 0.658, small effect size r = 0.037).

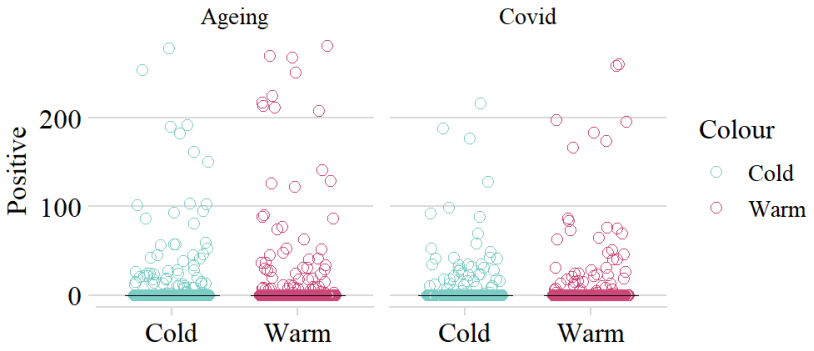


Figure 33: Distribution of positive valence data categorised by topic and colour (iMotions).

Once again, it was tested whether the equally patterned maps showed to evoke similar positive valence in participants. Thus, pairwise Wilcoxon Signed Rank tests were created. For the warm-coloured pairs of maps, no significant differences were found between the very light (V = 69.5, p-value = 0.758, small effect size r = 0.080), the light (V = 99, p-value = 0.578, small effect size r = 0.035), the medium

(V = 56.5, p-value = 0.356, small effect size r = 0.140), the dark (V = 52, p-value = 1, small effect size r = 0.000) and the very dark pairs (V = 565.5, p-value = 0.644, small effect size r = 0.024).

A similar picture emerged for the cold-coloured pairs of maps. The very light (V = 87.5, p-value = 0.948, small effect size r = 0.049), the light (V = 89, p-value = 0.563, small effect size r = 0.101), the medium (V = 90, p-value = 0.862, small effect size r = 0.098), the dark (V = 104.5, p-value = 0.717, small effect size r = 0.076), and finally the very dark map pairs (V = 51.5, p-value = 0.701, small effect size r = 0.094) did not show any significant differences.

Using an ART ANOVA, the influence of the colour scale, the topic as well as the value distribution on the positive valence could be investigated. The overall ART ANOVA, which included all variables, topic, pattern, and colour, as seen in Equation 1, resulted in a main effect for pattern (F = 2.451, df = 4, p-value = 0.045, η_p^2 = 0.015) and a three-way interaction (F = 6.564, df = 4, p-value = 3.533e-05, η_p^2 = 0.040) of all variables. By applying pairwise comparison tests, it could be determined that the significant main effect interactions occurred between the light and the dark pattern (t = 2.875, p-value = 0.034). Thus, as can be seen in Figure 34, for the cold-coloured maps the dark pattern revealed a higher mean of positive valence than the light pattern, whereas for the warm-coloured maps the light pattern was significantly higher than the dark pattern. However, as the partial eta-squared value (η_p^2) reveals that the tests effect size is rather small, the results are not to be weighed too heavily.

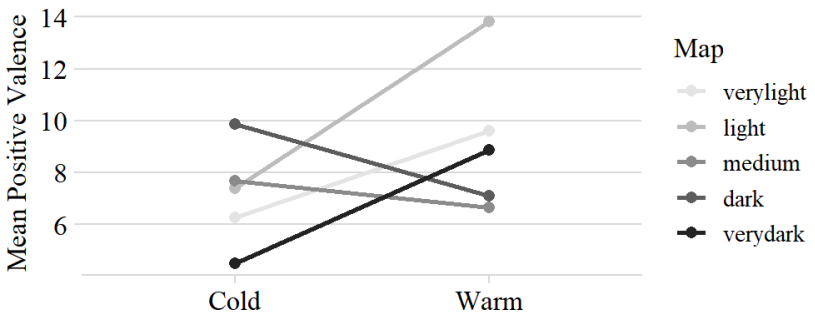


Figure 34: Interaction of map pattern and colour scale for mean positive valence (iMotions).

Upon analysing the three-way interaction through a post-hoc χ^2-Test (Wobbrock et al., 2022), it became clear that the difference between the two topics and the colour scales were significantly different between the light pattern two all other patterns. However, reasons behind this finding are difficult to determine. As no significant two-way interactions were revealed, power in higher order tests is rather small, and partial eta-squared values, as measures of effect size, were small, it was decided to not continue exploring this particular interaction result.

Negative Valence

The Shapiro-Wilk normality test of the negative valence data showed that neither the mean negative valences of the warm-coloured (W = 0.58027, p-value = 4.928e-13) nor the cool-coloured (W = 0.55585, p-value = 1.999e-13) maps were normally distributed. The data was again heavily zero-inflated. Thus, again non-parametric tests were used to analyse the data. First, a Wilcoxon Signed Rank Test was performed between the mean values of negative valence of the warm and the cold colour scales, which showed no significant difference (V = 242.5, p-value = 0.922, small effect size r = 0.071). Second, the Mann-Whitney U test, which studied the difference between the topics, did not show significant differences either (W = 2459, p-value = 0.569, small effect size r = 0.048).

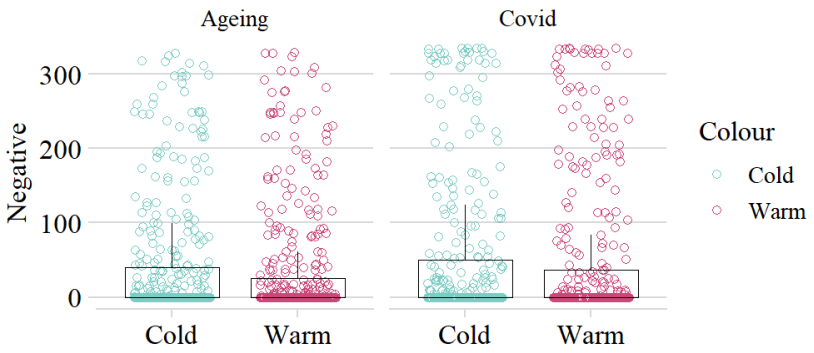


Figure 35: Distribution of negative valence data categorised by topic and colour (iMotions).

To test whether the equally patterned maps evoked similar negative valences, the pairwise Wilcoxon Signed Rank tests were added. For the warm-coloured pairs of maps, no significant differences were found between the very light (V = 216.5, p-value = 0.108, small effect size r = 0.189), the light (V = 362, p-value = 0.908, small effect size r = 0.030), the medium (V = 277, p-value = 0.732, small effect size r = 0.042), the dark (V = 331, p-value = 0.214, small effect size r = 0.253) and the very dark pairs (V = 335.5, p-value = 0.815, small effect size r = 0.026).

A similar picture emerged for the cold-coloured pairs of maps. The very light (V = 264.5, p-value = 0.578, small effect size r = 0.024), the light (V = 354, p-value = 0.192, small effect size r = 0.152), the medium (V = 184.5, p-value = 0.088, small effect size r = 0.196), the dark (V = 370.5, p-value = 0.791, small effect size r = 0.048), and finally the very dark map pairs (V = 468, p-value = 0.440, small effect size r = 0.151) did not show any significant differences. Again, the maps were paired according to their pattern.

Using an ART ANOVA, the influence of the colour scale, the topic as well as the value distribution on the positive valence could be investigated. A three-way ART ANOVA of all independent variables did not reveal any significances. However, a model looking at the colour scales and pattern revealed a significant interaction between the two (F = 3.134, df = 4, p-value = 0.014, η_p^2 = 0.019). A post-hoc pairwise comparison χ^2-Test showed that there is a significant difference between the two colour scales and the very light and very dark pattern (χ^2 = 8.700, p-value = 0.032) as well as both colour

scales and the light and very dark pattern (χ^2 = 8.491, p-value = 0.032). Again, the effect size was small, indicating that the result may not be powerful. Figure 36 visualizes these interactions.

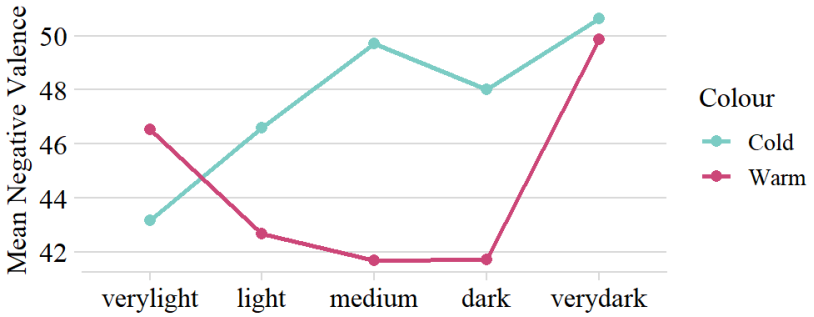


Figure 36: Interaction of map pattern and colour scale for mean negative valence (iMotions).

Self-Assessment-Manikin

In addition to measuring the emotional response to warm and cool-coloured maps using facial expression recognition software, the subjects were asked to self-assess their emotional responses using a self-assessment manikin (SAM). The SAM measured the arousal and valence triggered by the maps. The two variables were analysed similarly to the measured data as seen in chapter 4.3.2. However, because of different output data structures, the statistical tests were adjusted for their level of measurement.

The survey responses of the self-assessment manikins as well as the results of the questions on people's perceptions and decision-making processes were given in ordinal form. The ordinal levels for the arousal assessments ranged from very agitated (level 1) to very calm (level 5) and for the valence statements from very happy (level 1) to very sad (level 5). Since the data were ordinal, determining the arithmetic mean was not a meaningful measure. This is because the differences between the levels (e. g. very agitated and rather agitated) cannot be reasonably calculable and equal distances between them cannot be assumed. Instead, in order to draw conclusions about the differences between the variables, the central tendency of the answers was examined descriptively and statistically, using non-parametric tests. These tests generally make less restrictive assumptions about the type of data (A. Field et al., 2012, p. 654). Most non-parametric tests rank the data before performing the calculations and consequently do not require normally distributed data. Ordinal data are generally presumed to not have a normal distribution, which is why non-parametric tests are commonly recommended (Liddell & Kruschke, 2018, p. 330; Miot, 2020, p. 2). However, these tests are said to have less statistical power and tend to show less statistical significance (A. Field et al., 2012, p. 654; Miot, 2020, p. 3). This concern was taken into account and addressed in this thesis's discussion.

Arousal

For the analysis of the SAM arousal data, the same statistical tests were carried out. The Shapiro-Wilk normality test, showed, that neither the mean arousal of the warm-coloured (W = 0.19438, p-value < 2.2e-16) nor cool-coloured maps (W = 0.88837, p-value = 1.079e-05) were normally distributed. Like with the iMotions data, a Wilcoxon Signed Rank Test was performed between the mean values of arousal of the warm and the cold colour scales, which showed a significant difference (V = 36, p-value = 0.010, moderate effect size r = 0.301). According to the results, the cold colour scale had significantly higher arousal values than the warm one. As for the difference between topic, the Mann-Whitney U test did also show significant differences (W = 1051, p-value = 8.42e-11, large effect size r = 0.541). Thereby, it was found that the COVID-19 maps evoked much higher arousal than the maps on ageing.

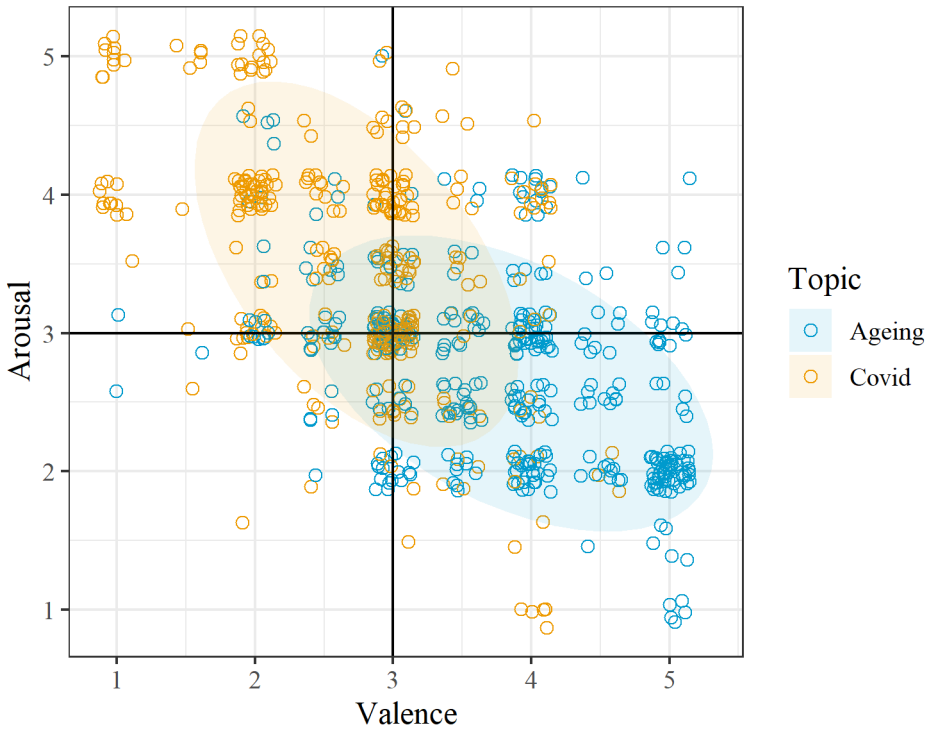


Figure 37: Distribution of valence and arousal data categorised by topic (SAM).

To test whether the equally patterned, but tilted map pairs evoked similar self-reported arousal values, the pairwise Wilcoxon Signed Rank tests were added. For the warm-coloured pairs of maps, no significant differences were found between the very light (V = 119, p-value = 0.911, small effect size r = 0.024), the light (V = 166.5, p-value = 0.240, small effect size r = 0.151), the medium (V = 121.5, p-value = 0.120, small effect size r = 0.184), the dark (V = 162, p-value = 0.218, small effect size r = 0.151) and the very dark pairs (V = 144, p-value = 0.614, small effect size r = 0.004).

A similar picture emerged for the cold-coloured pairs of maps. Except for the very light (V = 735, p-value = 0.042, small effect size r = 0.290) pair, the light (V = 108, p-value = 0.600, small effect size r

= 0.0.034), the medium (V = 95, p-value = 1, small effect size r = 0.023), the dark (V = 242.5, p-value = 0.671, small effect size r = 0.074), and finally the very dark map pairs (V = 144.5, p-value = 0.283, small effect size r = 0.130) did not show any significant differences.

Even though the very light cool-coloured scales showed a significant difference, it was decided to combine the map pairs in the upcoming ART ANOVA. This decision was justified on the one hand by the small effect size (r = 0.290), which the Wilcoxon Signed Rank tests showed, and on the other hand by the fact that all other pairs did not show any significant differences.

An ART ANOVA of all variables, colour scale, topic, and pattern revealed several significant differences. The colour (F = 12.282, df = 1, p-value =0.000, η_p^2 = 0.019) scale showed to have a main affect and so did the topic (F = 36.768, df = 1, p-value = 6.045e-08, η_p^2 = 0.344). This showed what was already recognised in previous tests, namely that on the one hand the cold-coloured maps evoked higher arousal and that the COVID-19 topic evoked higher arousal as well. Further, the interaction of colour scale and topic proved to be significant (F = 5.335, df = 1, p-value = 0.021, η_p^2 = 0.008). Since both variables only contained two levels, no pairwise comparison was needed. This interaction can be seen in Figure 38.

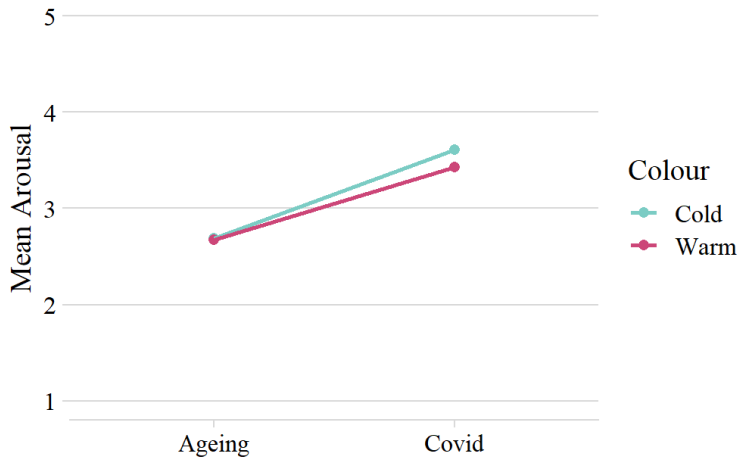


Figure 38: Interaction of topic and colour scale for mean arousal (SAM).

Finally, the ART ANOVA showed an additional significant interaction between topic and pattern (F = 17.845, df = 4, p-value = 6.859e-14, η_p^2 = 0.102). In a pairwise comparison, the significances were analysed, and six out of the ten interactions proved to be significant. It thus revealed with a medium effect size, that differences within the patterns were significantly different between the two topics (see Figure 39). Given that the power for higher order tests is smaller, further two-way ANOVAs of the different variables were conducted. These tests all revealed the same significances and are thus not mentioned here.

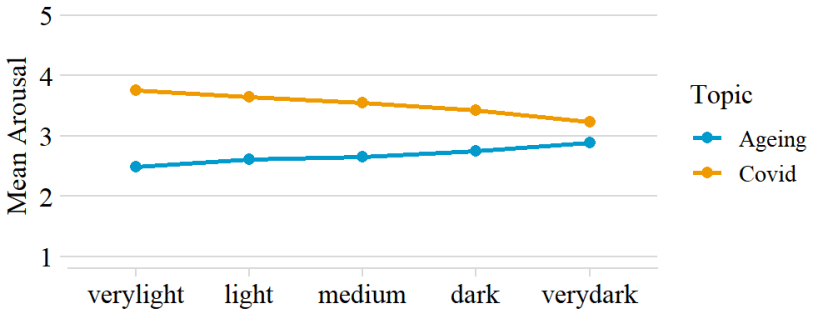


Figure 39: Interaction of topic and map pattern for mean arousal (SAM).

Valence

The Shapiro-Wilk normality test for the SAM valence data showed, that neither the mean arousal of the warm-coloured (W = 0.90635, p-value = 5.548e-05) nor cool-coloured maps (W = 0.90406, p-value = 4.466e-05) were normally distributed. Again, the Wilcoxon Signed Rank Test was performed between the mean values of valence of the warm and the cold colour scales, which showed no significant difference (V = 56, p-value = 0.428, small effect size r = 0.098). As for the difference between topic, the Mann-Whitney U test did show significant differences (W = 4412, p-value = 2.06e-14, large effect size r = 0.637).

To test whether the map pairs evoked similar self-assessed valence values, pairwise Wilcoxon Signed Rank tests were conducted. For the warm-coloured pairs of maps, no significant differences were found between the very light (V = 75, p-value = 0.715, small effect size r = 0.109), the light (V = 90, p-value = 0.846, small effect size r = 0.051), the medium (V = 184, p-value = 0.121, small effect size r = 0.175), the dark (V = 83, p-value = 0.623, small effect size r = 0. 078) and the very dark pairs (V = 74, p-value = 0.615, small effect size r = 0.057).

A similar picture emerged for the cold-coloured pairs of maps. The very light (V = 24, p-value = 0.007, small effect size r = 0.317) and the medium (V = 214.5, p-value = 0.0491, small effect size r = 0.241) pairs did show a significant difference. However, the light (V = 144, p-value = 0.864, small effect size r = 0.005), the dark (V = 162.5, p-value = 1, small effect size r = 0.018), and very dark map pairs (V = 138, p-value = 0.423, small effect size r = 0.082) did not show any significant differences. As once again the significant results came from tests with small effect sizes and the majority of tests did not show significant differences, it was decided to continue with combining the pair for the ART ANOVA.

The three-way ANOVA showed a significant main effect for topic (F = 49.689, df = 1, p-value =1.017e-09, η_p^2 = 0.415) as well as an interaction effect between topic and pattern (F = 17.037, df = 4, p-value =2.824e-13, η_p^2 = 0.098). A further pairwise comparison of the interaction effect revealed that seven out of the ten pairs showed significant interactions. Again, the two-way ANOVAs revealed similar results.

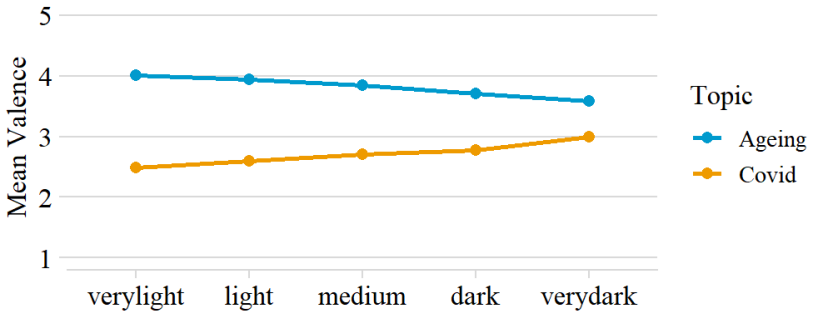


Figure 40: Interaction of topic and map pattern for mean valence (SAM).

4.3.3 Part 2.2: Perception and Behaviour

Perception of Pandemic Situation

Aside from emotion dimensions evoked by differently themed and coloured maps, participant's perception of the map was measured using Likert scales. To answer the research question of how people perceive the displayed state of the pandemic to be when facing differently coloured maps, only the 34 participants form the COVID-19 group (group A) were analysed.

After each map, the COVID-19 group was asked, how serious, how pessimistic, and how risky they perceived the displayed situation to be. Figure 41 shows how the mean answers were distributed between the two colour scales. Visually it becomes apparent, that when facing the warm colour scale the pandemic was perceived to be more serious, pessimistic and risky.

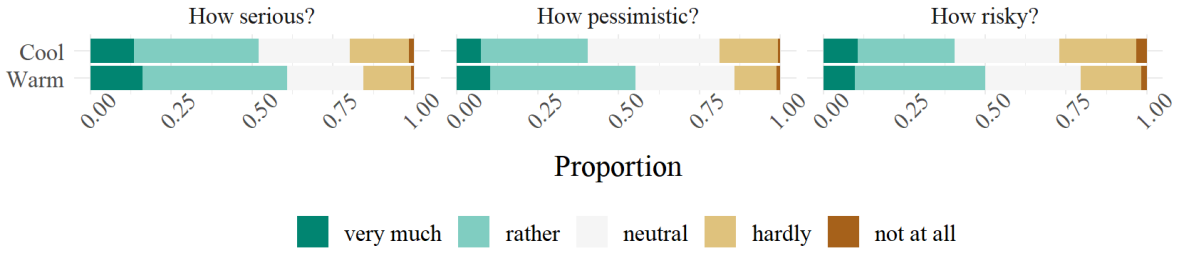


Figure 41: Mean answers to questions on perception of pandemic by colour scale.

Given that the data values were discrete ranging from 1 to 5, medians were used to compare the data distributions. As a first statistical test, the Shapiro-Wilk normality test showed, that neither the median perception of the warm-coloured (W = 0.616, p-value = 3.147e-08) nor cool-coloured (W = 0.715, p-value = 8.29e-07) maps were normally distributed. This was not surprising given that Likert data, especially when having as few as five steps, usually does not produce normally distributed data. Using a Wilcoxon Signed Rank test of the median perception the difference between the warm and cold-coloured scale was calculated. The test produced a significant difference between the colour scales (V = 8, p-value = 0.001, large effect size r = 0.576), which confirmed the above stated assumption.

Additional one-sided t-tests showed whether the median perception was bigger or smaller than the neutral perception (value = 3) option. For both colour scales both tendencies (greater and less) were tested. The median of the warm colour scale was found to be significantly smaller (W = 13, p-value = 2.27e-06, large effect size r = 0.789) than the neutral perception. The median of the cold-coloured scale was also found to be significantly smaller (W = 5.5, p-value = 0.004, moderate effect size r = 0.466) than the neutral perception. This showed, that for both colour scales participants tended to be more negatively inclined.

Pairwise Wilcoxon Signed Rank tests showed too many differences between the perception of the maps. Thus, it was decided to carry on the statistical test without summarising the maps into groups of identical patterns. For the perceptual data, it was decided to perform an ART ANOVA as well, to determine the influence of the pattern in combination with the colour scales on the participant's perception of the pandemic. The structure of the ANOVA equation corresponded to that of equation 2. Main effects were found for both colour (F = 15.323, df = 1, p-value = 0.000, η_p^2 = 0.024) and pattern (F = 82.719, df = 9, p-value < 2.22e-16, η_p^2 = 0.543). However, no variable interactions were found. The main effect of pattern was further investigated to identify which map pattern was responsible for the effect. Pairwise comparison tests showed significant effects for almost all interactions between the maps. The exact model results can be seen in the Appendix D.

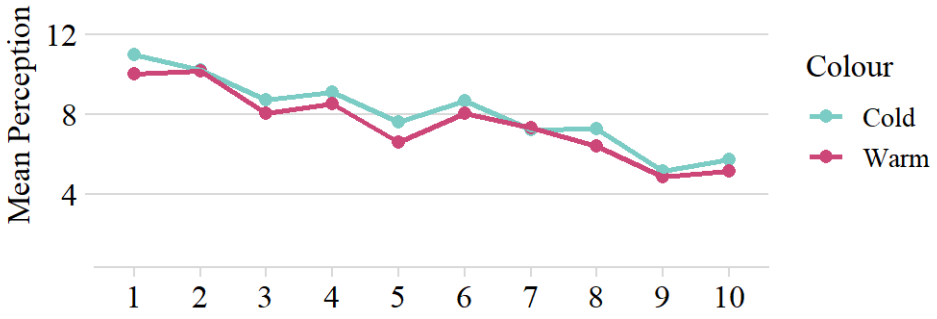


Figure 42: Interaction of map pattern and colour scale for mean perception. With high means corresponding to positive perception of the pandemic.

Behaviour based on Pandemic Situation

Just like the questions on the perception of the state of the pandemic, the COVID-19 group was also asked on their probable behaviour evoked by the maps. The group was asked, how likely they were to work from home, wear a mask when going to enclosed public spaces and avoid busy hours when running errands. As can be seen from Figure 43 median answers were fairly distributed between the five options. However, it appears that participants tend to agree with applying the measures to themselves.

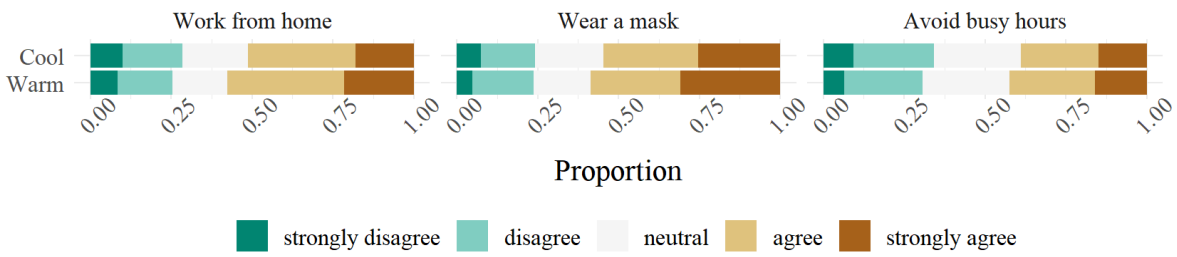


Figure 43: Mean answers to questions on behaviour during pandemic by colour scale.

The Shapiro-Wilk normality test showed, that neither the median behaviour of the warm-coloured (W = 0.867, p-value = 0.001) nor cool-coloured (W = 0.878, p-value = 0.001) maps were normally distributed. A Wilcoxon Signed Rank test of the median behaviour between the warm- and cold-coloured maps (V = 27, p-value = 0.182, large effect size r = 0.243) revealed no significant difference.

Furthermore, in one-sided t-tests it could be found that the median measured behaviour approval was significantly higher than the neutral approval in warm-coloured maps (W = 259, p-value = 0.003, moderate effect size r = 0.473) as well as in cold-coloured maps (W = 216, p-value = 0.023, moderate effect size r = 0.383).

As with the perception data, too many significant differences between the map pairs were identified. Thus, it was decided to not combine them for the ART ANOVA. Again, colour and pattern were compared as presented in Equation 2. Main effects for colour (F =6.447, df = 1, p-value = 0.011, η_p^2 = 0.010) as well as pattern (F = 49.724, df = 9, p-value < 2.22e-16, η_p^2 = 0.416) could be found. A pairwise comparison of the different patterns revealed for the majority of combinations significant interactions. Given that the maps were not broken down into pairs, like with the emotions data, all ten maps were compared to each other. The results are therefore not mentioned here but can be found in Appendix E of this thesis. Furthermore, a significant interaction (F = 2.738, df = 9, p-value = 0.004, η_p^2 = 0.038) between the two variables, pattern and colour, could be identified. Through a post-hoc χ^2-Test, the significant interactions could be retrieved. There is a significant difference between the two colour scales and the patterns of map 5 and 7 (χ^2 = 13.586, p-value = 0.010). In addition, a significant interaction was found between the two colour scales and the patterns of map 6 and 7 (χ^2 = 10.635, p-value = 0.048) as well as between the colour scales and the patterns of map 7 and 8 (χ^2 = 17.030, p-value = 0.002). However, given that the effect size of the interaction between colour scale and pattern was small, the results have to be treated cautiously.

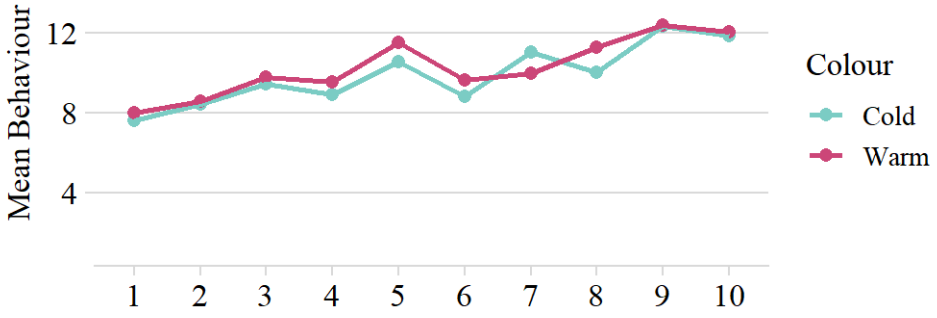


Figure 44: Interaction of map pattern and colour scale for mean behaviour. With high means corresponding to higher willingness to act cautiously.

5 Discussion

5.1 Part 1: COVID-19 Maps pubslihed by the Media

Since the beginning of the pandemic, a great deal of information on the spread of the virus has been published and disseminated. This included amongst other things newspaper articles, media conferences, radio and television reports, social media posts but also graphics and maps. In the first part of this work, we were interested in finding out what information these graphics contained, what they looked like, whether, how and why these graphics changed in the course of the pandemic and what purpose the maps served in all this. To answer these questions, a quantitative content analysis and five expert interviews were conducted.

The quantitative analysis was conducted on all detected COVID-19 case rate maps published by Swiss online newspapers that were updated daily or otherwise regularly. The criteria were set in such a way that the contents of the maps could be compared with each other. For each of the five semesters of the pandemic, starting in January 2020 and ending in June 2022, one version of the media's maps was searched for and analysed. In order to find older versions, the internet archive Wayback Machine was used. In many cases, however, older versions of the maps did not exist anymore. Therefore, it was not possible to create a complete chronology of all media analysed. However, what could be found, was included in the content analysis.

RQ1.1: What type of information do the COVID-19 maps which were published by the Swiss media, show?

The 21 different maps, which were analysed, primarily recorded the development of the pandemic in Switzerland. Most of them focused on the cantons, regions, or communities. However, there were a few, which covered also diverse international areas such European regions and countries as well as the countries all over the world. This corresponds to the expectation that Swiss online media primarily focus on the country's population and its local needs when reporting on the pandemic. This was also confirmed by the languages used in the maps. The fact that the language use in the maps more or less corresponds to the language distribution of the Swiss population has probably to do with national efforts to ensure that an appropriate selection of media is made available to the entire population (FÖG, 2021a).

Given that the majority of maps depicted Switzerland, most media used the data, which was regularly published by the Federal Office of Public Health (FOPH). Only a few newspapers made use of cantonal data sources. For the European and global maps, a mixture of national and international sources was used to show data in all enumeration zones. As the areas covered by the maps in some cases changed during the course of the pandemic, the sources used were also adapted.

In terms of the type of data portrayed, the maps differed significantly more. Most maps showed some type of incidence (daily, 7- or 14-day) per 100,000 residents. In some cases, also the R-value as well as a map visualising the increase and decrease in the number of cases or ICU capacities were found. In two cases, the absolute case numbers were visualised. This was the case with the graduated symbol world map by Tamedia as well as with the choropleth map of the Argovian communities by CH Media. In the course of the measurement period, the data types in general changed frequently. For example, the map of the canton of Solothurn was changed from a relative to an absolute choropleth map. It is not known why the decision to change the data type was made, nor was it mentioned as common in the interviews. Other studies also found that absolute values had been carelessly presented in some choropleth maps (Pászto et al., 2020, p. 177; Rosenkrantz et al., 2021, p. 1). In cartography, this is a common mistake. It implies that these mapmakers likely have little knowledge of cartographic conventions and even less of how to avoid creating unintentionally misleading maps. It further indicates that more cartographic training for the mapmakers would be needed. Field (2014) already expressed concern about this issue almost a decade ago, when data journalism was only just beginning to develop in Switzerland.

RQ1.2: What cartographic designs were used for the COVID-19 related geovisualisations?

A first look at the 21 unique map designs showed that many of the maps looked quite similar. On the one hand, this could be explained by the fact that a majority of the maps were created by the two large media companies Tamedia and CH Media. On the other hand, 85.7% of the maps were created using choropleth mapping, which was identified by Fagerlin et al. (2017) to be a useful tool in epidemiology. Nonetheless, as expected, the maps seemed to differ in their colour palettes. A total of 16 different colour scales were used for the 21 maps.

Why these specific colour scales have been used could be explained by many different factors. First, it could be assumed that in some cases, such as Watson and possibly Tamedia, the NZZ and in some cases CH Media, corporate design guidelines, which aimed to create a recognisable design, were applied. The interviewed experts J1 and R1 confirmed the assumption that in the larger Swiss media companies there has been a move towards design standardisation and that nowadays guidelines define which colours are to be used. However, what these guidelines look like and contain is not publicly communicated outside the media companies. Consequently, it cannot be verified that the colour palettes mentioned were created in accordance with restrictive corporate design guidelines.

Secondly, as there was no clear association of the virus with a particular colour, no clearly obvious colour palette was expected. Thus, the choice of the colour palette was up to the visualisers. Although the intention most likely was not to alarm the readers through a specific colour scale, the journalists J1 and J2 pointed out that a serious topic was being addressed, which had to be represented by the maps. This is in line with the findings of Anderson and Robinson (2020), who demonstrated that thematically

non-convergent colour scales could be seen as inappropriate by readers and even confusing. According to J1, it was therefore a deliberate choice to visualize the number of cases in yellow and use a red hue for the death rate and not vice versa, in order to fit the expectations of the reader.

Third, it was also important to use colour-blind friendly colour scales that can be understood by a majority of readers, J1 pointed out. This statement was in line with the findings of the analysed COVID-19 maps in chapter 4.1.2. The analysis showed that colour deficiencies were largely taken into account by the creators of the 21 analysed COVID-19 maps. In only two cases maps were created that were difficult to read for people with protanopia and deuteranopia. One of which was revised during the measurement period and has been visible in a more colour-blind friendly colour scale since autumn 2021.

Finally, both J1 and J2 mentioned the time pressure under which these maps were initially designed at the beginning of the pandemic in early 2020. Creators did not have much time to think about which colour scales were most appropriate. This could explain why certain decisions were made and, in a few cases, eventually revised later.

In addition to the colour palettes, other design elements were analysed. In three out of the 21 maps, no legend was included. This has also not been changed during the course of the study period. Legends are among the most important elements of maps (Dent, 2008). J1 and R1 expressed the necessity of clear instructions and guidance to help readers interpret the maps content. Excluding legends is frowned upon in cartography. They should always be included when portraying a map, as otherwise it can easily become a misleading persuasive map (Monmonier, 1996).

Most analysed maps made use of interactive functionalities. Many of the maps could be zoomed in, hovered over with the mouse, or clicked on to obtain additional information and allowed the user to go back to its initial state. R1 pointed out that a few years ago, people tried to create complex maps rich in functionalities in order to show as much as possible. In the meantime, the dashboards have become somewhat simpler. This way they are less overwhelming to the readers and lead to less reluctance and aversion towards the content. After all, as shown in a study by Cay et al. (2020, p. 71f) readers tend to shy away from reading into complex content. R1 therefore believed that the COVID-19 visualisations found in the media were quite appropriate in terms of functionality. Mainly because the readers already knew and understood the content and were able to navigate through the maps as much as they pleased.

RQ1.3: How and why has the cartographic design changed since the beginning of the pandemic?

The colour palettes were among the visually recognisable design choices that changed the most during the pandemic. Blick as well as the Bernese map by Tamedia both initially highlighted particularly low case numbers with hues differing from the rest of the gradient. However, while Blick changed this quasi-sequential scale later on, Tamedia did not do so for their Bernese map. As the only media

company, NZZ decided to adjust the hues of the colour scale to the increasing number of cases during the study period. Instead of simply adjusting the case rates within the scale, they decided to add a darker hue at the end to represent the increasing number of cases. In three cases the colour scale was completely changed. CH Media has changed the colour scale for the map of Zurich communities from a sequential map in blue hues to one in red hues. Le Temps changed from a triple hue colour scale (dark green-dark brown-dark red) to a two-hue (dark green-dark brown) in autumn 2020 and finally to an orange single hue colour scale in autumn 2021. As for the CH Media map of the 7-day incidence in Swiss cantons, the colour scale was temporarily changed from a light pink - purple scale to the plasma palette and back.

The reasons for such changes can be very diverse. The interview with J2 showed that for example at the New York Times, a lot of resources were invested in the maps in order to communicate the data visually in the most accurate and understandable way possible. They added darker shades of red to the colour scale at the top as the case numbers increased, rather than stretching the palette across the new distribution of values. According to J2, this and other changes were always made with the reader, his needs and habits in mind and the aim of not misleading him. Consequently, it can be assumed that the teams for the Swiss COVID-19 maps made similar considerations. NZZ, for instance, might have had a similar thought process when adding the darker colour hues on top of the scales. Similarly, Tamedia's Zurich map might have been changed from dark blue to red, when cases were particularly high, to communicate the severity of the situation.

Furthermore, external motivations might also have led to changes in the designs. J1 pointed out during the interview that many comments and criticisms were received from readers, which had been taken into account by the editors. Thus, it can be suspected that after objections from readers or editors, Le Temps' colour scale, which was not colour-blind friendly, was changed.

RQ1.4: How were these maps perceived and evaluated by experts in the field?

The interviews provided a more profound insight into the way maps like the ones analysed are created and how data journalism has evolved over the past few years. Having said that, the interviews also opened up the interesting question of whether such maps should be published at all. The interviews made it clear that it does not always make sense to publish maps. J3 was worried that COVID-19 visualisations might mislead readers and thereby create the belief that the figures are completely accurate and certain. Which was unfortunately not the case with COVID-19 data as discussed in chapter 2.1.4. The experts were aware that the case numbers entails uncertainties. R2 was therefore of the opinion that maps should only be used when a spatial comparison is necessary. On the other hand, it was argued that maps have an aesthetic value and thus attract and inform people who might not otherwise engage with the topic.

The communication of data uncertainty was thereby brought to attention. According to R1, showing uncertainty in visualisations is particularly important and should be done more in future. However, this has not been done in any of the observed COVID-19 maps. Only a few additional texts explained the accuracy of the data. However, they appeared to be much less salient than the maps themselves and thus might not be read. Furthermore, studies on internationally published COVID-19 maps revealed that these maps did not show any data uncertainties either (Griffin, 2020, p. 13). This was however justified by J1 by the fact that the source data did not contain any uncertainty intervals either. It was therefore up to the competent authorities providing the data to supplement the uncertainty data. The interviewed journalists as well as experts agreed that the visualisation of the uncertainty should be increased in order to present the readers with as accurate as possible maps.

Nonetheless, the two researchers interviewed were overall satisfied with the visualisations and praised the diligent work of the journalists. Considering, they had informed a large part of the population daily about the state of the pandemic in a comprehensible way and helped them evaluate their risks and make decisions.

The reviewed literature, the analysed maps, but above all the conducted expert interviews have shown, data journalism has arrived in Switzerland and has established itself. In recent years, there have been many changes in the way journalism was presented and consumed (W. Weber et al., 2018). This has been especially the case with COVID-19. A large number of Swiss online newspapers have taken it upon themselves to produce COVID-19 maps. Without knowing the exact reflections of the map creators, changes in design including improvements could be detected.

Many larger media companies have created teams that nowadays take care of the creation and further development of data visualizations. In doing so, interested users have been given the opportunity to consume content in an interactive and personalised and thus an engaging and visually appealing way. As R1 mentioned, the COVID-19 visualisations have been relatively reduced in functionality to provide the reader with a quick overview. Still, all these visualisations, according to R2, might have helped readers improve their visual literacy. Thus, it is reasonable to assume that the pandemic has helped to advance data journalism but by doing so might also have influenced the visual literacy of users.

When presenting the research questions for the first part of this thesis, it has been stated that, according to international studies, COVID-19 maps tended to differ greatly in colour as well as the professionalism of cartographic design. The mapping techniques and content, however, were very similar. It was hypothesized (H1) that the similar image would result when looking at the COVID-19 maps of Swiss online newspapers. The discussion above has demonstrated that the assumption was well founded.

5.1.1 Limitations

The content analysis revealed how the Swiss online media communicated the COVID-19 pandemic visually to the population. However, this part of the study also has some limitations that need to be taken into account. Although an attempt was made to create as complete a picture as possible of all COVID-19 case rate maps that were regularly updated by Swiss online media, it was not possible to create a complete set of maps. For example, since the collection of maps started in autumn 2021, it might be that maps that were published before then, but whose production stopped before autumn 2021, have not been included. In addition, the Wayback Machine was used to regenerate as many older versions of the maps as possible, but this only worked in some cases, and therefore did not result in a complete archive of the maps. This in turn influenced the analysis of the changes in design, as certain changes might not have been detected due to missing versions. The timing of the collection for each semester also had an influence on which maps were analysed. It could be that the designs were changed within a semester and thus not being detected. In addition, the publication of some maps was discontinued during the course of the measurement period. As a result, not a balanced set of versions could be found. In addition, this means that some web links no longer show the same content as before. Therefore, it has to be considered, that the analysed maps present more of a snapshot of all discovered maps, but not a guaranteed complete collection.

Enquiries with various newspapers about their older versions of COVID-19 maps have shown that they do not create archives for automated maps either. This makes it generally difficult to monitor and research progressions and older versions. With new emerging media forms and information representations, it is apparent that there will be a need for changes in the way archiving is done, in order to capture such moments in history as comprehensively as possible.

The interviews have provided an insight into the works and thought processes of data journalism. However, only to a limited extent. By conducting further interviews with the map creators, it could have been possible to reveal how, why and with what motivations the COVID-19 maps have been created. However, this would have exceeded the scope of this part of this thesis and was prevented further due to limited availability of the journalists. As a consequence for the analysis, the exact thought processes and motivations for the creation of the maps and in particular the reasons for the changes made could not be established with certainty, but often had to be based on assumptions. Furthermore, the experts interviewed shared their own experiences and observations rather than relying on studies. However, this had a great added value, as it led to an authentic, up-to-date assessment of the topic.

5.2 Part 2: Empirical Study

In a study with 72 participants, facial expression analysis and self-assessment manikins were used to find out whether and to what extent the emotional reaction to thematically and colourfully different visualisations varied. In a second part of the empirical study, Likert scale questions were used to investigate how the participants of group A perceived the content of the differently coloured COVID-19 maps and how they would behave accordingly.

The facial expression analysis tool iMotions was used to obtain engagement data as well as positive and negative valence data from the participants' video recordings. In addition, values for arousal and valence were determined using the SAM. As announced in chapter 4.3, the iMotions engagement data were compared with those of the SAM arousal.

The iMotions data were generally very zero-inflated. This signifies that for most participants, little to no emotion values were detected. This can be explained on the one hand by the fact that the people hardly show expressive emotions when looking at maps. On the other hand, it could be due to the fact that the iMotions software could not read minor changes in facial expressions. This latter problem was already recognised by Taggart et al. (2016, p. 6) as well as by Jmour et al. (2021, p. 999). Due to their qualitatively less informative data and the very small effect sizes, the iMotions findings were only considered in the discussion of this study to a limited extent.

RQ2.1a: How do the expressed emotions (arousal, valence) differ when facing warm-coloured maps compared to cool-coloured maps?

The SAM as well as the iMotions data showed that there was a significant difference in arousal between the warm and cold colour scale and that the cold colour scale had significantly higher arousal values than the warm one. This clearly contradicts the hypothesis related to this question (H2.1a) as well as studies that have been done on the topic of warm and cold colours. These state that warm colour scales evoke more emotional arousal than cold ones (Russell, 1978). The null hypothesis could thus not be rejected.

First of all, it should be pointed out that both the SAM data ($\eta_p^2 = 0.019$) as well as the iMotions data ($\eta_p^2 = 0.006$) showed very small effect sizes. The results of these two tests are therefore not very meaningful and should not be given too much importance.

In the following sections, however, possible causes are being discussed as to why the results did not meet the expectations. Previous studies focused mainly on the comparison of individual colour hues, which were assigned to the warm or the cool colours (Russell, 1978). However, the colour scales in this study were multi-hue palettes and not individual hues. Thus, yellow, orange, red and purple, which were regarded as warm colour scales, were compared with cold colours such as green and blue. This leads to a comparison of multiple hues, which all underlie different emotional responses. This is further

complicated by the fact, that the different value allocations between the maps (pattern) contained different amounts and distributions of the colour classes. Thus, in the warm colour scale the maps with the lowest values (very light) contained mostly yellow colour tones while the maps with the highest values (very dark) contained mostly dark purple colour tones. However, neither showed a clearly arousal-producing red hue.

Furthermore, Jonauskaite (2021, p. 58) pointed out that the comparison between colour tones is not advisable. This is because it is difficult to compare colour tones of the same colour dimensions, i.e. with the same saturation and the same brightness. As an example, a salient, highly saturated blue has a lower brightness than an equally highly saturated yellow. To adjust the yellow to that of the blue in order to be able to compare the effect of the hue, the brightness would have to be significantly lowered. This would correspond to a brownish rather than a radiant yellow. This problem becomes even more apparent in cartography where entire colour scales especially multi-hue palettes are aimed to be compared, as brigthnesses, saturations and hues usually change irregularly over the course of the gradient.

When looking at the colour dimensions of the scales in the experiment (Figure 10), it becomes apparent that the cooler colour scale contains much lighter colour classes than the warm colour scale. A study by Wilms (2018), has proven that lighter colour scales trigger more emotions than darker ones. Consequently, it could be argued that more emotions could be expected from the cool colour scale. This would contradict the hypothesis but could explain the results detected here. However, since the effect sizes are rather small, as mentioned above, the findings are not considered to be particularly powerful.

As for the valences, no significant differences were found in either the iMotions or the SAM data. In general, unlike arousal, it is more difficult to associate valences with different colour warmth, given that within such groups, valences differ greatly (Valdez & Mehrabian, 1994, p. 402). While cold colours such as green and blue are typically associated with high valence, warm colours do not show a clear tendency. As such, yellow is shown to evoke much smaller levels of valence than red. Furthermore, it has been found that depending on the saturation of the hues, different valences were measured (Wilms & Oberfeld, 2018). In view of these studies, it is not surprising that no clear difference was found between the valences of the two colour scales. Nevertheless, it would be interesting to find out in the future what role the colour palettes have on valence.

RQ2.1b: How do the expressed emotions (arousal, valence) differ when facing maps of COVID-19 compared to maps on population ageing?

When analysing the two topics, COVID-19 and population ageing, a clearer picture emerged. A significant difference was found between the topics both in the comparison of the mean values and in the three-way ART ANOVA of the arousal data. The COVID-19 case rate maps elicited higher emotions, regardless of the pattern, according to the participants. Consequently, the two groups of

participants reacted emotionally different to the stimuli. In addition, the effect of both statistical tests could be classified as large (Wilcoxon r = 0.541; ART ANOVA η_p^2 = 0.344). Although the effect was not found in the facial expression measurements, such a clear difference was, however, visually recognisable in the SAM dimensions plot in Figure 37. It can thus be assumed that it is a trustworthy effect. With these findings, the null hypothesis of the tests that topic has no influence on emotions can be rejected.

The SAM valence data also produced a significant difference in the mean comparison of the Mann-Whitney-U test as well as in the ART ANOVA, each with a high effect size (Mann-Whitney-U r = 0.637; ART ANOVA η_p^2 = 0.415). Thus, maps about ageing were consistently associated with higher valence and thus more positive emotions than COVID-19 themed maps. COVID-19 thus evoked more emotions, and more negative emotions in study group A than ageing did in study group B. These findings reflect the hypothesis (H2.1b), which allows for the null hypothesis of the statistical tests to be rejected.

The two findings are consistent with the assumption that COVID-19 is an emotive and negatively perceived subject (Cay et al., 2020; Chou & Budenz, 2020). And as such, it triggers more emotions than other issues such as the ageing of the population. Thus, it can be concluded that the topic of a map clearly lays a foundation for how it will be responded to emotionally. This supports the idea by Ortony et al. (1988) and Solomon (1976, as cited in Prinz, 2004, p. 8) that emotions have an important cognitive component. In cartography, this implies further that even the most reduced maps in terms of design can evoke very positive or negative emotions with high arousal, depending on the topic. Consequently, it is important in both cartography and data journalism to consider what is appropriate to visualise and what is not, given the topic. Especially when the topic is an emotive one with a lot of uncertainty in its data, as is the case with COVID-19.

RQ2.2a: How does the perception of the pandemic differ when facing warm-coloured maps compared to cool-coloured maps?

In addition to measuring participants' emotional responses to the maps, it was determined how the COVID-19 group perceived the pandemic upon looking at the different colour scales. Data from three questions about seriousness, optimism and risk were presented to the group with a 5-point Likert scale. The values were calculated in such a way that the lower the numbers, the more negative was the perception of the pandemic, and the higher the number, the more positive it was perceived. A Wilcoxon test of the mean values of the two colour scales showed with a high effect size (r = 0.576) that there was a significant difference between the two colour scales. This result was supported by an additional ART ANOVA with a medium effect size (η_p^2 = 0.024), which examined the perception of the pandemic in the different maps. The tests showed that the warm-coloured scale triggered a significantly more negative perception of the pandemic than the blue one. This result is in line with the corresponding

hypothesis (H2.2a). Thus, the null hypothesis stating that there is no difference between the colour scales on the perception of the pandemic can be rejected.

The findings correspond to the results of studies that have identified warm, especially red colour hues as particularly alarming (Pravossoudovitch et al., 2014; Wexner, 1954). This indicates that the chosen colour scales do have an impact on the perception of the pandemic. Consequently, in visual data communication, it is important to consider how colour design decisions are made. Especially given that people's perceptions can be influenced by them.

One-sided T-tests showed that for both colour scales the perception of the maps was predominantly negative. This reflects the assumption linked to research question 2.2a that COVID-19 is an unpleasant issue. However, the ART ANOVA additionally showed that the perception is very much dependent on the value allocation. Maps that displayed lower case numbers on average (very light) were rated more optimistic and were perceived to be less serious and less risky. This is a reasonable reaction and indicates that the participants understood the content of the maps. In addition, it also indicates that maps do have an influence on people's perception of the pandemic.

The comprehension questions displayed after each map demonstrated that the participants were able to read and understand the maps well. This speaks for a high visual literacy among the participants. Furthermore, it was noticed that the warm-coloured maps were better understood than the cool-coloured versions. This could be because the two-hue *GnBu* palette, which was used for the cool colour scale, showed a lower differentiability between the classes than the multi-hue *plasma* palette. This is supported by other findings, which suggest that multi-hue colour scales support the differentiability of classes and thus the comprehensibility of the map better than single hue (Herrmann & Williams Pickle, 1996, p. 175). This means for data visualisers that the readability of a map also depends on the colour palette choice and thus a considered choice is necessary to meet the needs of the reader.

RQ2.2b: How do the behavioural decisions differ when facing warm-coloured maps compared to cool-coloured maps?

The participants' anticipated behaviour on the basis of the visualised maps was analysed in the same way as the perception questions. However, in this case the higher values indicated a higher willingness to take action and thus to be more careful. The Wilcoxon Signed Rank test did not identify a significant difference between the two colour scales. However, when analysing the ART ANOVA, a main effect for colour was found. The warm colour scale showed significantly higher willingness to adopt voluntary measures than the cold colour scale. Although the effect size was small ($\eta_p^2 = 0.01$), a difference in behaviour could also be determined visually when comparing the two colour scales (Figure 42). As a result, the corresponding hypothesis (H2.2b), according to which warm-coloured scales generate more cautious behaviour seemed to be proven by the statistical tests. The null hypothesis could

be rejected. Nevertheless, due to the small effect size mentioned above, this result should be treated with caution and should not be given too much importance. Still, given that warm colours are said to evoke more emotions and red hues in particular are more alarming (Russell, 1978, p. 13), it can be assumed that warm-coloured scales could elicit more cautious behaviour than cool-coloured scales.

The one-sided T-tests further revealed that the COVID-19 group's willingness to adopt voluntary measures was high and that they tended to show cautious behaviour when looking at both colour scales. Furthermore, a main effect for pattern in the ART ANOVA showed that the distribution of values in the map had an influence on people's willingness to take action. This corresponds with the expectations that generally lower numbers of cases should trigger less desire to act carefully on the part of the observers and that, on the other hand, more cautious behaviour is expected with high numbers of cases. This implies that maps could have contributed to people' behavioural decisions during the pandemic.

5.2.1 Overall Discussion of Empirical Study Results

The empirical study revealed that the topic of the map in particular had an influence on the emotions of the participants. Furthermore, it became apparent that perception as well as behaviour could differ depending on the colour palette considered. These findings were in line with the expectations of the study based on the literature.

That the topic would have an influence on emotion formation was to be expected. Nevertheless, it became clear that it plays a crucial role which topic is visualised. It can be assumed that even minimalist designs can evoke strong emotions, both in terms of valence and arousal, depending on the topic. It is important that cartographers, and in this case especially journalists, are aware of this. In data journalism, maps are often used as aesthetic tools to attract the reader’s attention and make them spend as much time as possible with the article. In doing so, they contribute to the reader's emotional state. It may well be that this is the intention of the author. However, if not, the author should be aware of the effect maps have in order to avoid unintentionally triggering an emotional response.

Interestingly, while the difference between the two colour palettes did not correspond to the expectations in the analysis of the emotions, it did correspond all the more to the perception of the pandemic and the expected behaviour. Why this was the case is not immediately clear. One possible reason is that colour associations, according to which blue and green are associated with comfort and security (Pravossoudovitch et al., 2014) and orange and red with hostility (Wexner, 1954), had a greater influence on the perception of the pandemic and the willingness to take measures than on the emotions generated by the maps. Another explanation could be that it was difficult for the participants to evaluate their own emotions and to put themselves emotionally in the situation displayed in the maps.

All in all, this study has shown that maps do indeed have an influence on the emotions of the viewers, their perception of the situation and their behaviour. It is therefore of great importance that publishers are aware of these effects. Especially given that readers tend to put a lot of trust in maps (Skarlatidou et al., 2011). Readers often assume that what is depicted with data represents the complete

truth and therefore interpret it as fact. At the same time, however, the study has shown that viewers have emotional reactions to maps, even if subconsciously. These alleged facts therefore trigger emotional reactions, which can be particularly dangerous, given that maps are abstractions of reality and are oftentimes subject to limitations regarding data accuracy and data completeness and data consistency.

5.2.2 Limitations

The empirical study also has some limitations that need to be taken into account. On the one hand, the study was conducted with a total of 72 participants, most of whom came from the extended environment of the study organiser. The study quality could benefit from a larger scale study with a more diverse, random sample of participants. Another limitation is the measurement of emotions using the facial expression analysis tool from iMotions. The determination of emotions with the tool only worked to a limited extent and the certainty of the emotion signals found was rather low. However, it was further found that the participants showed only limited emotions when looking at static maps. Participant feedback revealed that due to the camera being switched on and the effort involved in not moving the face too much in order to remain in the frame of the camera, participants could not really relax and react impartially to the maps. This limitation was further complicated by the fact that the study was conducted online, and participants could not be given direct reassurance that they were correctly positioned. As announced in chapter 3.3.3, conducting the study online had some further limitations. For example, the conditions under which the study was conducted could not be controlled. Also, the participants were on their own when it came to completing the study. For some of them, the upload of the study did not work directly online, which is why they had to send the study including the video file to the study leader themselves.

Finally, a limitation that relates to the result of the entire study has to do with the timing of its implementation. In the spring and summer of 2022, the COVID-19 topic was much less relevant in Switzerland than in the two previous years. It can be assumed that a certain pandemic fatigue had spread among the population and many people no longer actively applied self-protection measures. Consequently, it is likely that at an earlier stage in the pandemic the study would have identified different and potentially stronger emotional, perceptual, and behavioural responses. Nevertheless, at this point in time, the study provides a valuable snapshot of the attitudes and perceptions of the Swiss population towards the pandemic in 2022.

6 Conclusion and Outlook

This thesis was comprised of two parts. Firstly, it was examined what the COVID-19 case rate maps published by the Swiss media looked like and how they were created. Secondly, it was analysed which emotions, perceptions, and behaviour they generated.

The first part revealed that very similar maps were published in terms of content, which, however, mainly differed in the colour palettes used. Interviews with journalists and scientists showed that nowadays online media are increasingly committed to design guidelines that specify colour palettes. At the same time, many data journalists try to adapt the design to the data and its content whenever possible or needed. In many cases changes become necessary to ensure that the graphics and maps give an accurate picture. Given the fast-paced nature of the media, decision-making and design time is often limited. The interviews showed that this is particularly true for COVID-19 maps. Nevertheless, the experts drew a positive conclusion from the maps that were published and were of the opinion that, although not perfect, the media managed to inform the Swiss population about the status of the pandemic in a comprehensible, aesthetic, and informative manner and as quickly as possible.

The second part of this thesis revealed that the subject matter in particular has an influence on emotions. It further showed that COVID-19 themed maps evoke higher and more negative emotions than a more neutral subject matter. The fact that the topic had an influence on the emotions was to be expected. However, it was surprising how strong this effect turned out to be. With regard to the influence on perception, it was shown that when looking at warm-coloured maps people assessed the COVID-19 pandemic as significantly more serious, pessimistic, and risky than when facing cool-coloured maps. A similar picture emerged for the expected behaviour of the participants. According to the results of the study results, participants tend to be more likely to voluntarily work from home, wear a facemask and avoid busy hours when looking at warm-coloured map than when looking at cool-coloured maps.

Over the past decade, data journalism has grown and established itself in Switzerland. Especially in times of the pandemic, it gained momentum and managed to reach a considerable amount of people. The published maps and graphics have thereby become indispensable sources of information and decision-making tools for readers. Against this background it is nowadays more important than ever to make well-informed and deliberate decisions when creating maps. The aim should be to provide readers with the most accurate representation of reality possible.

This thesis was written in a time when numerous studies on COVID-19 maps have been conducted. It is clear that the pandemic is a pervasive issue that requires extensive research. This thesis also identified several areas in which research can and should be deepened in the future. For instance, the findings of research question 2.1a have highlighted difficulties when comparing two overly different colour palettes. It was important for the study to choose colour palettes that have been used by the Swiss media for the COVID-19 maps in order to make statements about their effects. However, there were

hardly any palettes used in the published maps that corresponded to a comparable progression of the dimensions while still generating different expectations of the emotional response. Thus, in a future study, it would be interesting to see what results more dimensionally controlled colour scales, i.e. with similar saturation and brightness gradients, would produce. Furthermore, there seems to be a lack of research which, in addition to the classic saturated colour hues (red, green, yellow, orange, blue, etc.), has investigated the influences of dimensionally different colours on peoples' connotations, perceptions and emotions. Research in this area could benefit not only the fields of colour psychology and cartography, but also data journalism. Finally, facial expression analysis with the iMotions Affectiva AFFDEX tool has not been able to measure very clear reactions. One reason for this could be that static maps result in few expressive reactions. Therefore, it would be interesting to see the results of a similar experiment when using other emotion measurement methods such as arousal-measuring wristbands or the Geneva Wheel of Emotion.

When looking at this thesis as a whole, the following can be noted. Although the media have made an effort to create understandable and accurate maps, a number of things remain that need to be considered when publishing them. Maps are capable of influencing emotions, perceptions as well as the behaviour of their audience. This is especially critical with emotional, universal issues such as a pandemic where feelings of uncertainty and insecurity are high. In such situations visualisations can help to get a sense of clarity. However, they still remain an abstraction of reality and thus are only able to portray part of the truth. Consequently, it is necessary, on the one hand, that the visualisers are aware of these challenges. When designing their maps, they should pay attention to the ways they are visualising and communicating the uncertainty of the data accuracy. Furthermore, they should make use of distinguishable colour classes to enhance readability. Finally, remains key to make a considered, appropriate choice of colour palettes, in line with the portrayed situation. On the other hand, it is also up to the readers to critically and thoughtfully engage with the content and not put unconditional trust in the visualisations.

As mentioned at the beginning of this thesis, it was not the aim of this study to identify an optimal COVID-19 map design. Rather, the objective was to find out how the published maps affected their readers. While there might not be such a thing as an everlasting ideal COVID-19 map, this study revealed that maps should be continuously and critically revised. This suggestion was also shown in an interview study by Cay et al. (2020, p. 71), which found that it might be appropriate to adjust the map design depending on the pandemic phase. Based on further research and scientific findings, it will remain the task of data journalists to strive for improved map designs. Either way, this will only be possible with the cooperation of cartographers, colour psychologists and data journalists as well as critical reviews of the readership.

References

Admeira. (2018). *Medien der Zukunft 2022. Kurzfassung*. Admeira.

Ahlers, D. (2006). News Consumption and the New Electronic Media. *Press/Politics*, *11*(1), 29–52.

Almeida, J. D., & Tyrell, D. A. J. (1967). The Morphology of Three Previously Uncharacterized Human Respiratory Viruses that Grow in Organ Culture. *Journal of General Virology*, 175–178.

Anderson, C. L., & Robinson, A. C. (2020). Affective Congruence in Visualization Design: Influences on Reading Categorical Maps. *IEEE Transactions on Visualization and Computer Graphics*, 1–12.

Antonopoulos, N., & Karyotakis, M.-A. (2020). Data Journalism. In D. L. Merskin (Ed.), *The SAGE International Encyclopedia of Mass Media and Society* (pp. 440–441). SAGE Publications, Inc.

ArcInfo - Keystone SDA. (2022, May 10). *Covid: 12'929 nouveaux cas, 21 décès et 198 hospitalisations en 7 jours*. https://www.arcinfo.ch/suisse/covid-12929-nouveaux-cas-21-deces-et-198-hospitalisations-en-7-jours-1181613

Babakus, E., & Mangold, W. G. (1992). Adapting the Servqual Scale to a Private Hospital Emergency Services: An Empirical Investigation. *HSR: Health Services Research*, *26*(6).

BAG. (2020a, February 25). *Neues Coronavirus COVID-19: Erster bestätigter Fall in der Schweiz*. https://www.bag.admin.ch/bag/de/home/das-bag/aktuell/medienmitteilungen.msg-id-78233.html

BAG. (2020b, February 28). *Coronavirus: Bundesrat verbietet grosse Veranstaltungen*. https://www.bag.admin.ch/bag/de/home/das-bag/aktuell/medienmitteilungen.msg-id-78289.html

BAG. (2020c, March 13). *Bundesrat verschärft Massnahmen gegen das Coronavirus zum Schutz der Gesundheit und unterstützt betroffene Branchen*. https://www.bag.admin.ch/bag/de/home/das-bag/aktuell/medienmitteilungen.msg-id-78437.html

BAG. (2020d, March 16). *Coronavirus: Bundesrat erklärt die «ausserordentliche Lage» und verschärft die Massnahmen*. https://www.bag.admin.ch/bag/de/home/das-bag/aktuell/medienmitteilungen.msg-id-78454.html

BAG. (2020e, March 20). *Coronavirus: Bundesrat verbietet Ansammlungen von mehr als fünf Personen*. https://www.bag.admin.ch/bag/de/home/das-bag/aktuell/medienmitteilungen.msg-id-78513.html

BAG. (2020f, April 16). *Bundesrat lockert schrittweise Massnahmen zum Schutz vor dem neuen Coronavirus*. https://www.bag.admin.ch/bag/de/home/das-bag/aktuell/medienmitteilungen.msg-id-78818.html

BAG. (2020g, December 22). *Covid-19: Der Bund informiert die Bevölkerung umfassend über die bevorstehenden Impfungen*. https://www.bag.admin.ch/bag/de/home/das-bag/aktuell/medienmitteilungen.msg-id-81798.html

BAG. (2022). *Neues Coronavirus (Covid-19) Verdachts-, Beprobungs- und Meldekriterien vom 02.05.2022*.

BBC. (2020, February 29). *Coronavirus: Nasa images show China pollution clear amid slowdown*. https://www.bbc.com/news/world-asia-51691967

BBC. (2022, July 5). *Covid map: Coronavirus cases, deaths, vaccinations by country - BBC News*. https://www.bbc.com/news/world-51235105

Bertin, J. (1983). *Semiology of Graphics: Diagrams, Networks, Maps*. The University of Wisconsin Press.

BFS. (2021). *Demografische Bilanz nach Alter - 1971-2020*. https://www.bfs.admin.ch/bfs/de/home/statistiken/bevoelkerung/stand-entwicklung/alter-

zivilstand-staatsangehoerigkeit.assetdetail.18424668.html

BFS. (2022a). *Alterung der Bevölkerung*. https://www.bfs.admin.ch/bfs/de/home/statistiken/bevoelkerung/alterung.html

BFS. (2022b). *Sprachen*. https://www.bfs.admin.ch/bfs/de/home/statistiken/bevoelkerung/sprachen-religionen/sprachen.html

Borkin, M. A., Gajos, K. Z., Peters, A., Mitsouras, D., Melchionna, S., Rybicki, F. J., Feldman, C. L., Pfister, H., & Member, S. (2011). Evaluation of Artery Visualizations for Heart Disease Diagnosis. *IEEE Transactions on Visualization and Computer Graphics*, *17*(12).

Bradley, M. M., & Lang, P. J. (1994). Measuring emotion: The self-assessment manikin and the semantic differential. *Journal of Behavior Therapy and Experimental Psychiatry*, *25*(1), 49–59.

Brennen, J. S., Simon, F. M., Howard, P. N., & Nielsen, R. K. (2020). *Types, Sources, and Claims of COVID-19 Misinformation*. 1–13.

Brennen, J. S., Simon, F. M., & Nielsen, R. K. (2021). Beyond (Mis)Representation: Visuals in COVID-19 Misinformation. *The International Journal of Press/Politics*, *26*(1), 277–299.

Brewer, C. A. (1994). Color Use Guidelines for Mapping and Visualization. In *Modern Cartography Series* (Vol. 2, Issue C). Elsevier Science Ltd.

Brewer, C. A. (2016). *Designing Better Maps: A Guide for GIS Users, 2nd Edition* (2nd editio). ESRI Press.

Brewer, C. A., Hatchard, G. W., & Harrower, M. A. (2003). ColorBrewer in Print: A Catalog of Color Schemes for Maps. *Cartography and Geographic Information Science*, *30*(1), 5–32.

Brewer, C. A., MacEachren, A. M., Pickle, L. W., & Herrmann, D. (1997). Mapping mortality: Evaluating color schemes for choropleth maps. *Annals of the Association of American Geographers*, *87*(3), 411–438.

Britannica, T. E. of E. (2022). Colour Blindness. In *Encyclopædia Britannica*.

Brockhaus. (2022). Corporate Identity. In *Brockhaus*.

BSV. (2022). *Reformen & Revisionen*. https://www.bsv.admin.ch/bsv/de/home/sozialversicherungen/ahv/reformen-revisionen.html

Buck, R. (2014). *Emotion: A biosocial synthesis*. Cambridge University Press.

Cartwright, W., & Ruas, A. (2021). Maps–essential information resources for integration, analysis and informing. *International Journal of Cartography*, *7*(1), 1–2.

Cay, D., Nagel, T., & Yantac, A. E. (2020). Understanding User Experience of COVID-19 Maps through Remote Elicitation Interviews. *2020 IEEE Workshop on Evaluation and Beyond: Methodological Approaches for Visualization (BELIV)*, 65–73.

CH Media. (2017, December 7). *AZ Medien und NZZ-Mediengruppe gründen gemeinsames Medienunternehmen*. https://chmedia.ch/news/az-medien-und-nzz-mediengruppe-gruenden-gemeinsames-medienunternehmen

CH Media. (2021a). *So entwickeln sich die Coronazahlen in der Zentralschweiz*. Luzerner Zeitung. https://www.luzernerzeitung.ch/zentralschweiz/kanton-luzern/coronavirus-so-entwickeln-sich-die-zahlen-in-der-zentralschweiz-ld.2238273

CH Media. (2021b, October 31). *Das sind die neusten Corona-Zahlen im Aargau*. https://www.aargauerzeitung.ch/aargau/kanton-aargau/uebersicht-1968-neuinfektionen-44-16-spitaleintritte-das-sind-die-neusten-corona-zahlen-im-aargau-ld.2245760?reduced=true

CH Media. (2021c, October 31). *So entwickeln sich die Corona-Zahlen im Kanton Solothurn*. Solothurner Zeitung. https://www.solothurnerzeitung.ch/solothurn/kanton-solothurn/uebersicht-so-entwickeln-sich-die-corona-zahlen-im-kanton-solothurn-ld.2082953

CH Media. (2021d, October 31). *Wie entwickeln sich die kantonalen und nationalen Zahlen?* Aargauer

Zeitung. https://www.aargauerzeitung.ch/schweiz/coronakrise-wie-entwickeln-sich-die-kantonalen-und-nationalen-zahlen-ld.1205558#subtitle-die-aktuellsten-zahlen-second

Chou, W. Y. S., & Budenz, A. (2020). Considering Emotion in COVID-19 Vaccine Communication: Addressing Vaccine Hesitancy and Fostering Vaccine Confidence. *Health Communication*, *35*(14), 1718–1722.

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences* (2nd Editio). Lawrence Erlbaum Associates.

Collier, G. (2014). Emotional Expression. In *The Lancet*. Psychology Press.

Colour Blind Awareness. (2022). *Types of Colour Blindness*. https://www.colourblindawareness.org/colour-blindness/types-of-colour-blindness/

Crameri, F., Shephard, G. E., & Heron, P. J. (2020). The misuse of colour in science communication. *Nature Communications*, *11*(5444), 1–10.

Crampton, J. W. (2009). Cartography: Maps 2.0. *Progress in Human Geography*, *33*(1), 91–100.

del Águila-Obra, A. R., Padilla-Meléndez, A., & Serarols-Tarrés, C. (2007). Value creation and new intermediaries on Internet. An exploratory analysis of the online news industry and the web content aggregators. *International Journal of Information Management*, *27*(3), 187–199.

Dent, B. D. (2008). *Thematic Map Design*. McGraw-Hill Education.

Depoux, A., Martin, S., Karafillakis, E., Preet, R., Wilder-Smith, A., & Larson, H. (2020). The pandemic of social media panic travels faster than the COVID-19 outbreak. *Journal of Travel Medicine*, *27*(3).

Ekman, P., & Friesen, W. V. (1976). Measuring Facial Movement. *Environmental Psychology and Nonverbal Behavior*, *1*(1), 56–75.

Ekman, P., Friesen, W. V., & Ellsworth, P. (1972). *Emotion in the Human Face: Guidelines for Research and an Integration of Findings*. Pergamon Press.

Ekman, P., Sorenson, E. R., & Friesen, W. V. (1969). Pan-Cultural Elements in Facial Displays of Emotion. *Science*, *164*(3875), 86–88.

Elliot, A. J., & Maier, M. A. (2014). Color psychology: Effects of perceiving color on psychological functioning in humans. *Annual Review of Psychology*, *65*, 95–120.

Engebretsen, M., & Kennedy, H. (2020). *Data visualization in society*. Amsterdam University Press.

Engebretsen, M., Kennedy, H., & Weber, W. (2018). Data visualization in Scandinavian newsrooms: Emerging trends in journalistic visualization practices. *Nordicom Review*, *39*(2), 3–18.

Fabrikant, S. I., Christophe, S., Papastefanou, G., & Maggi, S. (2012). Emotional Response to Map Design Aesthetics. *GIScience 2012: Seventh International Conference on Geographic Information Science*.

Fabrikant, S. I., & Goldsberry, K. (2005). Thematic Relevance and Perceptual Salience of Dynamic Geovisualization Displays. *Proceedings of the 22th International Cartographic Conference*, *1*(805), 11–16.

Fagerlin, A., Valley, T. S., Scherer, A. M., Knaus, M., Das, E., & Zikmund-Fisher, B. J. (2017). Communicating infectious disease prevalence through graphics: Results from an international survey. *Vaccine*, *35*(32), 4041–4047.

Fang, H., Xin, S., Pang, H., Xu, F., Gui, Y., Sun, Y., & Yang, N. (2021). Evaluating the effectiveness and efficiency of risk communication for maps depicting the hazard of COVID-19. *Transactions in GIS*, 1–24.

Farrington, B., & Calvan, B. C. (2020, May 23). Public remarks prompted Florida virus data curator's firing. *Associated Press*.

Field, A., Miles, J., & Field, Z. (2012). Discovering Statistics using R. In *Annals of Internal Medicine*.

SAGE Publications Inc.

Field, K. (2014). A Cacophony of Cartography. *The Cartographic Journal*, *51*(1), 1–10.

Fish, C. S. (2020). Elements of Vivid Cartography. *The Cartographic Journal*, 1–17.

FÖG. (2020). *Jahrbuch 2020. Qualität der Medien Hauptbefunde*. Research Center for the Public Sphere and Society (fög). University of Zurich.

FÖG. (2021a). *Jahrbuch 2021. Qualität der Medien*. Schwabe Verlag.

FÖG. (2021b). *Jahrbuch 2021. Qualität der Medien Hauptbefunde*. Research Center for the Public Sphere and Society (fög). University of Zurich.

Fondation Aventinus. (2020, November 3). *Communiqués de presse*. https://aventinusfondation.ch/communiques-de-presse/

Frijda, N. H. (1986). *The Emotions*. Cambridge University Press.

Ghazisaeidi, M., Safdari, R., Torabi, M., Mirzaee, M., Farzi, J., & Goodini, A. (2015). Development of Performance Dashboards in Healthcare Sector: Key Pracical Issues. *Acta Inform Med*, *23*(5), 317–321.

Gordon, N. (1998). Colour blindness. *Public Health*, *112*, 81–84.

Gray, J., Chambers, L., & Bounegry, L. (2012). *The Data Journalism Handbook* (1st editio). O'Reilly Media.

Griffin, A. L. (2020). Trustworthy maps. *Journal of Spatial Information Science*, *20*, 5–19.

Gutiérrez, P., Clarke, S., & Kirk, A. (2021, December 1). *Covid world map: which countries have the most coronavirus vaccinations, cases and deaths?* The Guardian. https://www.theguardian.com/world/2021/dec/01/covid-world-map-which-countries-have-the-most-coronavirus-vaccinations-cases-and-deaths

Hardy, L. H., Rand, G., & Rittler, M. C. (1945). Tests for the Detection and Analysis of Color-Blindness. The Ishihara Test: An Evaluation. *Journal of the Optical Society of America*, *35*(4).

Hatfield, E., Bensman, L., Thornton, P. D., & Rapson, R. L. (2014). New Perspectives on Emotional Contagion: A Review of Classic and Recent Research on Facial Mimicry and Contagion. *Interpersona: An International Journal on Personal Relationships*, *8*(2), 159–179.

Häuptli, A., & Vogler, D. (2019). Presse - gedruckt und online. *Qualität Der Medien: Jahrbuch 2019*, 115–128.

Herb, G. H. (1989). Persuasive Cartography in Geopolitik and National Socialism. *Political Geography Quarterly*, *8*(3).

Herrmann, D., & Williams Pickle, L. (1996). A Cognitive Subtask Model of Statistical Map Reading. *Visual Cognition*, *3*(2), 165–190.

Holt, C. A., & Laury, S. K. (2002). Risk Aversion and Incentive Effects. *The American Economic Review*, *92*(5), 1644–1655.

iMotions. (2021). *Affectiva - Emotion AI*. https://imotions.com/affectiva-requestdemo/

iMotions. (2022). *iMotions: Unpack Human Behavior*. https://imotions.com/

Interpharma. (2022). *Corona - ein Virus verändert die Welt*. https://biotechlerncenter.interpharma.ch/themen/corona-ein-virus-veraendert-die-welt/die-familie-der-coronaviren/

Ishihara, S. (1972). *Tests for Colour-Blindness. The Series of Plates Designed as a Test for Colour-Blindness*. Kanehara Shuppan Co., LTD.

Ivanković, D., Barbazza, E., Bos, V., Fernandes, Ó. B., Gilmore, K. J., Jansen, T., Kara, P., Larrain, N., Lu, S., Meza-Torres, B., Mulyanto, J., Poldrugovac, M., Rotar, A., Wang, S., Willmington, C., Yang, Y., Yelgezekova, Z., Allin, S., Klazinga, N., & Kringos, D. (2021). Features constituting

actionable COVID-19 dashboards: Descriptive assessment and expert appraisal of 158 public web-based COVID-19 dashboards. *Journal of Medical Internet Research*, *23*(2).

Izard, C. E. (1991). *The Psychology of Emotions.* Springer New York.

James, W. (1884). *What is an Emotion?* Simon and Schuster.

Jmour, N., Masmoudi, S., & Abdelkrim, A. (2021). A New Video Based Emotions Analysis System (VEMOS): An Efficient Solution Compared to iMotions Affectiva Analysis Software. *Advances in Science, Technology and Engineering Systems Journal*, *6*(2), 990–1001.

Johns Hopkins Coronavirus Resource Centre. (2021). *COVID-19 Dashboard by the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University.* https://coronavirus.jhu.edu/map.html

Jonauskaite, D. (2021). *Universality of Colour-Emotion Associations*.

Jonauskaite, D., Abu-Akel, A., Dael, N., Oberfeld, D., Abdel-Khalek, A. M., Al-Rasheed, A. S., Antonietti, J. P., Bogushevskaya, V., Chamseddine, A., Chkonia, E., Corona, V., Fonseca-Pedrero, E., Griber, Y. A., Grimshaw, G., Hasan, A. A., Havelka, J., Hirnstein, M., Karlsson, B. S. A., Laurent, E., … Mohr, C. (2020). Universal Patterns in Color-Emotion Associations Are Further Shaped by Linguistic and Geographic Proximity. *Psychological Science*, *31*(10), 1245–1260.

Juergens, C. (2020). Trustworthy COVID-19 Mapping: Geo-spatial Data Literacy Aspects of Choropleth Maps. *Journal of Cartography and Geographic Information*, *70*, 155–161.

Kennedy, H., Weber, W., & Engebretsen, M. (2020). Data Visualization and Transparency in the News. In *Data Visualization in Society*. Amsterdam University Press.

King, A. J., & Lazard, A. J. (2020). Advancing Visual Health Communication Research to Improve Infodemic Response. *Health Communication*, *35*(14), 1723–1728.

Krainik, A. (2011). Functional MRI. In H. Duffau (Ed.), *Brain Mapping: From Neural Basis of Cognition to Surgical Applications*. Springer.

La Côte - Keystone SDA. (2022, June 14). *Covid: les nouveaux cas ont augmenté de 61% en une semaine*. https://www.lacote.ch/suisse/covid-les-nouveaux-cas-ont-augmente-de-61-en-une-semaine-1191809

Layne, N., & Resnick-Ault, J. (2020, April 25). *Coronavirus came to New York from Europe, not China*. Reuters. https://www.reuters.com/article/healthcare-coronavirus-usa-new-york-idUSKCN2262NJ

Le Matin - R.M. (2022, June 14). *Coronavirus: 6 morts en une semaine en Suisse, plus de 16'000 cas*. https://www.lematin.ch/story/6-morts-en-une-semaine-en-suisse-plus-de-16000-cas-121700780426

Le Nouvelliste - Keystone SDA. (2022, June 14). *Covid: les nouveaux cas ont augmenté de 61% en une semaine*. https://www.lenouvelliste.ch/suisse/covid-les-nouveaux-cas-ont-augmente-de-61-en-une-semaine-1191809

Li, R. (2021). Visualizing COVID-19 information for public: Designs, effectiveness, and preference of thematic maps. *Human Behavior and Emerging Technologies*, *3*(1), 97–106.

Liddell, T. M., & Kruschke, J. K. (2018). Analyzing ordinal data with metric models: What could possibly go wrong? *Journal of Experimental Social Psychology*, *79*, 328–348.

MacCrimmon, K. R., & Wehrung, D. (1986). *Taking Risks: The Management of Uncertainty*. The Free Press.

MacEachren, A. M. (1995). *How Maps Work. Representation, Visualization, and Design*. The Guilford Press.

Martin, D. W. (2008). *Doing Psychology Experiments* (7th editio). Wadsworth Cengage Learning.

Mayring, P., & Fenzl, T. (2019). Qualitative Inhaltsanalyse. In N. Baur & J. Blasius (Eds.), *Handbuch Methoden der empirischen Sozialforschung*. Springer.

Meiselman, H. L. (2003). *Emotion Measurement*. Woodhead Publishing.

Miot, H. A. (2020). Analysis of ordinal data in clinical and experimental studies. *Jornal Vascular Brasileiro*.

Mode, P. (2017). 'Not Maps A All' - What Is Persuasive Cartography? And Why Does It Matter? *The Protolan - Journal of the Washington Map Society*.

Monmonier, M. (1996). *Eins zu einer Million. Die Tricks und Lügen der Kartographen* (German Ver). Springer Basel AG.

Mooney, P., & Juhász, L. (2020). Mapping COVID-19: How web-based maps contribute to the infodemic. *Dialogues in Human Geography*, *10*(2), 265–270.

Muehlenhaus, I. (2013). The design and composition of persuasive maps. *Cartography and Geographic Information Science*, *40*(5), 401–414.

Munsell, A. H. (1905). *A Color Notation*. Ellis & Co.

Neth, H., & Gradwohl, N. (2022, September 20). *Graphical Elements of the University of Konstanz's Corporate Design [R package unikn version 0.6.0]*. Social Psychology and Decision Sciences, University of Konstanz. https://cran.r-project.org/package=unikn

Nicholson, N., Soane, E., Fenton-O, M., & Willman, P. (2005). Personality and domain-specific risk taking. *Journal of Risk Research*, *8*(2), 157–176.

NZZ. (2017, December 7). *AZ Medien und NZZ-Mediengruppe gründen gemeinsames Medienunternehmen*. https://www.nzz.ch/wirtschaft/az-medien-und-nzz-mediengruppe-gruenden-gemeinsames-medienunternehmen-ld.1336705?reduced=true

OED Online. (2022). objectivity, n. In *OED Online*. Oxford University Press.

Olson, J. M. (2002). Using Color in Statistical Graphs an Maps. *Joint Statistical Meetings - Section on Statistical Graphics*, 2524–2529.

Ortony, A., Clore, G. L., & Collins, A. (1988). *The Cognitive Structure of Emotions* (2nd ed.). Cambridge University Press.

Ortony, A., Clore, G. L., & Foss, M. A. (1987). The Referential Structure of the Affective Lexicon. *Cognitive Science*, *11*, 341–364.

Palmer, S. E., & Schloss, K. B. (2010). An ecological valence theory of human color preference. *Proceedings of the National Academy of Sciences of the United States of America*, *107*(19), 8877–8882.

Parrott, R., Hopfer, S., Ghetian, C., & Lengerich, E. (2007). Mapping as a visual health communication tool: Promises and dilemmas. *Health Communication*, *22*(1), 13–24.

Pase, A., Presti, L. Lo, Rossetto, T., & Peterle, G. (2021). Pandemic cartographies: a conversation on mappings, imaginings and emotions. *Mobilities*, *16*(1), 134–153.

Pászto, V., Burian, J., & Macků, K. (2020). Covid-19 data sources: Evaluation of map applications and analysis of behavior changes in europe's population. *Geografie*, *125*(2), 171–209.

Pleskac, T. J. (2008). Decision Making and Learning While Taking Sequential Risks. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *34*(1), 167–185.

Plutchik, R. (1980). A General Psychoevolutionary Theory of Emotion. In *Theories of Emotion* (pp. 3–33). Academic Press Inc.

Plutchik, R. (1982). A Psychoevolutionary Theory of Emotions. In *Social Science Information* (pp. 529–553). SAGE Publications Inc.

Pravossoudovitch, K., Cury, F., Young, S. G., & Elliot, A. J. (2014). Is red the colour of danger? Testing an implicit red-danger association. In *Ergonomics* (Vol. 57, Issue 4, pp. 503–510). Taylor & Francis.

Prinz, J. J. (2004). *Gut Reactions: A Perceptual Theory of Emotion*. Oxford University Press.

Rachel Chang. (2020, April 2). *The World Hits 1 Million Coronavirus Infections April 2, 2020 - Bloomberg*. Bloomberg. https://www.bloomberg.com/news/articles/2020-04-02/the-world-just-hit-1-million-coronavirus-infections

Rehman, S. U., Shafique, L., Ihsan, A., & Liu, Q. (2020). Evolutionary Trajectory for the Emergence of Novel Coronavirus SARS-CoV-2. *Pathogens*, *9*(3), 240.

Riehm, K. E., Badillo Goicoechea, E., Wang, F. M., Kim, E., Aldridge, L. R., Lupton-Smith, C. P., Presskreischer, R., Chang, T. H., LaRocca, S., Kreuter, F., & Stuart, E. A. (2022). Association of Non-Pharmaceutical Interventions to Reduce the Spread of SARS-CoV-2 With Anxiety and Depressive Symptoms: A Multi-National Study of 43 Countries. *International Journal of Public Health*, *67*, 20.

Rinner, C. (2021). Mapping COVID-19 in context: Promoting a proportionate perspective on the pandemic. *Cartographica*, *56*(1), 14–26.

Ritchie, H., Mathieu, E., Rodés-Guirao, L., Appel, C., Giattino, C., Ortiz-Ospina, E., Hasell, J., Macdonald, B., Beltekian, D., & Roser, M. (2020). *Coronavirus Pandemic (COVID-19)*. Our World in Data. https://ourworldindata.org/covid-cases

Rodríguez, M. T., Nunes, S., & Devezas, T. (2015). Telling Stories with Data Visualization. *Proceedings of the 2015 Workshop on Narrative and Hypertext (NHT '15)*, 7–11.

Rogowitz, B. E., & Treinish, L. A. (1996). How not to lie with visualization. *Computers in Physics*, *10*(3), 268–273.

Rosenkrantz, L., Schuurman, N., Bell, N., & Amram, O. (2021). The need for GIScience in mapping COVID-19. *Health and Place*, *67*, 1–4.

RSI News. (2021). *La pandemia in grafici*. https://www.rsi.ch/news/svizzera/La-pandemia-in-grafici-13562149.html

Russell, R. J. (1978). *Color Preference as a Function of Personality*. Western Michigan University.

Schaab, G., Adams, S., & Coetzee, S. (2020). Conveying map finesse: thematic map making essentials for today's university students. *Journal of Geography in Higher Education*, *00*(00), 1–27.

Scherer, K. R. (2005). What are emotions? and how can they be measured? *Social Science Information*, *44*(4), 695–729.

Segel, E., & Heer, J. (2010). Narrative Visualization: Telling Stories with Data. *IEEE Transactions on Visualization and Computer Graphics*, *16*(6).

Seyser, D., & Zeiller, M. (2018). Scrollytelling: An Analysis of Visual Storytelling in Online Journalism. In *2018 22nd International Conference Information Visualisation*.

Sharma, P., Sharma, P., Deep, V., & Shukla, V. K. (2021). Facial Emotion Recognition Model. *Lecture Notes in Mechanical Engineering*, *1*, 751–761.

Sharpe, L. T., Stockman, A., Jägle, H., & Nathans, J. (1999). *Opsin genes, cone photopigments, color vision, and color blindness*. 3–52.

Skarlatidou, A., Haklay, M., & Cheng, T. (2011). Trust in Web GIS: The role of the trustee attributes in the design of trustworthy Web GIS applications. *International Journal of Geographical Information Science*, *25*(12), 1913–1930.

Skinner, B. F. (1953). *Science And Human Behavior*. Macmillan.

Slocum, T. A., McMaster, R. B., Kessler, F. C., & Howard, H. H. (2005). *Thematic Cartograohy and Geovisualization* (Third). Pearson/Prentice Hall.

SMD. (2022). *Über uns*. https://www.smd.ch/SMDView/kontakt.jsp

Smith, N., & van der Walt, S. (2015, July 7). A Better Default Colormap for Matplotlib. *SciPy*.

Snow, J. (1854). The Cholera Near Golden Square, and at Deptford. *Medical Times Gazette*.

SRF. (2020, December 23). *Impfstart in der Schweiz - Luzernerin erhält erste Impfung – auch weitere Kantone gestartet - News - SRF*. https://www.srf.ch/news/schweiz/impfstart-in-der-schweiz-luzernerin-erhaelt-erste-impfung-auch-weitere-kantone-gestartet

SRF. (2022, September 9). Karte und Grafiken - In welchen Regionen Europas sich Corona gerade ausbreitet - News - SRF. *SRF News*.

Stöckli, S., Schulte-Mecklenbeck, M., Borer, S., & Samson, A. C. (2018). Facial expression analysis with AFFDEX and FACET: A validation study. *Behavior Research Methods*, *50*(4), 1446–1460.

Swiss Press Council. (2021). *Code of Conduct - Declaration*. https://presserat.ch/en/journalistenkodex/erklaerungen/

Swissdox. (2022). *Unser Medien-Angebot im Überblick*. https://swissdox.ch/medien/

Taggart, R. W., Dressler, M., Kumar, P., Khan, S., & Dr. Coppola, J. F. (2016). Determining Emotions via Facial Expression Analysis Software. *Proceedings of Student-Faculty Research Day*, 1–8.

Teralytics. (2022). *Mobility and COVID-19*. https://www.teralytics.net/mobility-and-covid-19/

The Guardian. (2020, March 19). *G7 to convene remotely and Covid-19 death toll in Italy overtakes China*. https://www.theguardian.com/world/live/2020/mar/19/coronavirus-update-live-news-who-covid19-cases-outbreak-us-states-uk-school-closures-australia-europe-eu-africa-asia-latest-updates

The New York Times. (2022, September 9). Covid-19 World Map: Cases, Deaths and Global Trends - The New York Times. *The New York Times*.

Thommen, S., Eichenberger, R., & Sasso, S. (2021a). *Medienmonitor - Factsheet AZ Medien 2020*.

Thommen, S., Eichenberger, R., & Sasso, S. (2021b). *Medienmonitor - Factsheet Ringier 2020*.

Thommen, S., Eichenberger, R., & Sasso, S. (2021c). *Medienmonitor - Factsheet TX Group 2020*.

Thommen, S., Eichenberger, R., & Sasso, S. (2021d). *Medienmonitor Bericht Schweiz 2020*.

Thorpe, A., Scherer, A. M., Han, P. K. J., Burpo, N., Shaffer, V., Scherer, L., & Fagerlin, A. (2021). Exposure to Common Geographic COVID-19 Prevalence Maps and Public Knowledge, Risk Perceptions, and Behavioral Intentions. *JAMA Network Open*, *4*(1), 19–22.

Tong, J., & Zuo, L. (2021). The Inapplicability of Objectivity: Understanding the Work of Data Journalism. *Journalism Practice*, *15*(2), 153–169.

Trautner, T., Sbardellati, M., Stoppel, S., & Bruckner, S. (2022). Honeycomb Plots : Visual Enhancements for Hexagonal Maps. *Vision, Modeling, and Visualization*.

Tufekci, Z. (2022, July 4). Scolding Beachgoers Isn't Helping. *The Atlantic*.

TX Group. (2021). *Organigramm TX Group*.

Tyner, J. A. (1982). Persuasive cartography. *Journal of Geography*, *81*(4), 140–144.

Unternehmen NZZ. (2021). *Geschichte des Unternehmens NZZ*. https://unternehmen.nzz.ch/unternehmen/geschichte/

Unternehmen NZZ. (2022). *Corona in der Schweiz: Aktuelle Fallzahlen und Statistiken*. https://www.nzz.ch/visuals/die-zahl-der-neuinfektionen-sinkt-leicht-und-alles-weitere-zum-coronavirus-in-der-schweiz-in-neun-grafiken-ld.1542774?reduced=true

Usher, N. (2020). News cartography and epistemic authority in the era of big data: Journalists as map-makers, map-users, and map-subjects. *New Media and Society*, *22*(2), 247–263.

Valdez, P., & Mehrabian, A. (1994). Effects of Color on Emotions. *Journal of Experimental Psychology: General*, *123*(4), 394–409.

van der Walt, S., & Smith, N. J. (2015a). *matplotlib/viscm: A tool for visualizing and designing*

colormaps using colorspacious and matplotlib. https://github.com/matplotlib/viscm

van der Walt, S., & Smith, N. J. (2015b). *viscm matplotlib. A principled tool for analyzing and designing high-quality colormaps for data visualization*. https://github.com/matplotlib/viscm

Ware, C. (1988). Color Sequences for Univariate Maps: Theory, Experiments, and Principles. *IEEE Computer Graphics and Applications*, *8*(5), 41–49.

Watson, J. B. (1919). *Psychology from the Standpoint of a Behaviorist*. Lippincott Company.

Weber, E. U., & Blais, A.-R. (2006). A Domain-Specific Risk-Taking (DOSPERT) scale for adult populations. *Judgement and Decision Making*, *1*(1), 33–47.

Weber, E. U., Blais, A.-R., & Betz, N. E. (2002). A domain-specific risk-attitude scale: Measuring risk perceptions and risk behaviors. *Journal of Behavioral Decision Making*, *15*(4), 263–290.

Weber, W., Engebretsen, M., & Kennedy, H. (2018). Data stories. Rethinking journalistic storytelling in the context of data journalism. *Studies in Communication Sciences*, *18*(1), 191–206.

Weber, W., & Rall, H. (2012). Data Visualization in Online Journalism and Its Implications for the Production Process. *16th International Conference on Information Visualisation Data*, 349–356.

Wexner, L. B. (1954). The degree to which colors (hues) are associated with mood-tones. *Journal of Applied Psychology*, *38*(6), 432–435.

WHO. (2015, June 24). *Summary of probable SARS cases with onset of illness from 1 November 2002 to 31 July 2003*. https://www.who.int/publications/m/item/summary-of-probable-sars-cases-with-onset-of-illness-from-1-november-2002-to-31-july-2003

WHO. (2018). *Managing epidemics: Key facts about major deadly diseases*. World Health Organization.

WHO. (2020a). How Infodemics Affect the World & how they can be Managed. *1st WHO Infodemiology Conference*.

WHO. (2020b). *WHO COVID-19 Dashboard*. https://covid19.who.int/

WHO. (2020c, January 5). *Pneumonia of unknown cause*. https://www.who.int/emergencies/disease-outbreak-news/item/2020-DON229

WHO. (2020d, February 11). *WHO Director-General's remarks at the media briefing on 2019-nCoV on 11 February 2020*. https://www.who.int/director-general/speeches/detail/who-director-general-s-remarks-at-the-media-briefing-on-2019-ncov-on-11-february-2020

WHO. (2020e, March 11). *WHO Director-General's opening remarks at the media briefing on COVID-19 - 11 March 2020*. https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020

WHO. (2020f, March 13). *WHO Director-General's opening remarks at the media briefing on COVID-19 - 13 March 2020*. https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-mission-briefing-on-covid-19---13-march-2020

WHO. (2022a). *Coronavirus (COVID-19) Dashboard*. https://covid19.who.int/

WHO. (2022b). *Tracking SARS-CoV-2 variants*. https://www.who.int/activities/tracking-SARS-CoV-2-variants

WHO. (2022c, March). *Middel East Respiratory Syndrome - MERS situation update, March 2022*. http://www.emro.who.int/health-topics/mers-cov/mers-outbreaks.html

Wiedmann, K.-P. (2010). Corporate Identity und Corporate Design. In M. Bruhn, F.-R. Esch, & T. Langner (Eds.), *Handbuch Kommunikation. Grundlagen - Innovative Ansätze - Praktische Umsetzungen* (1st ed., pp. 337–355). Gabler Verlag.

Wilms, L., & Oberfeld, D. (2018). Color and emotion: effects of hue, saturation, and brightness. *Psychological Research*, *82*(5), 896–914.

Wobbrock, J. O., Elkin, L. A., Higgins, J. J., Findlater, L., Gergle, D., & Kay, M. (2022, March 7). *ARTool: Align-and-rank data for nonparametric factorial ANOVA*. Association for Computing Machinery, Inc.

Wobbrock, J. O., Findlater, L., Gergle, D., & Higgins, J. J. (2011). The Aligned Rank Transform for nonparametric factorial analyses using only ANOVA procedures. *Conference on Human Factors in Computing Systems - Proceedings*, 143–146.

World Bank Education. (2021). *COVID-19 School Closures Map*. https://www.worldbank.org/en/data/interactive/2020/03/24/world-bank-education-and-covid-19

Wundt, W. M. (1897). *Grundriss der Psychologie*. Wilhelm Engelmann.

Appendix

A. List of Swiss Online News Media Regularly Publishing COVID-19 Visualizations Grouped by Publishers

TX Group: Tamedia	**TX Group: 20 Minuten**	**CH Media: Online Newspapers**	**CH Media: Digital News Portals**	**SRG SSR**	**NZZ**	**Ringier**	**AZ Medien**	**Le Temps**
24heures.ch	20min.ch	aargauerzeitung.ch	argovia.ch	rsi.ch	nzz.ch	blick.ch	watson.ch	letemps.ch
bazonline.ch		badenertagblatt.ch	fm1today.ch	rtr.ch				
berneroberlaender.ch		bzbasel.ch	pilatustoday.ch	rts.ch				
bernerzeitung.ch		grenchnertagblatt.ch		srf.ch				
derbund.ch		limmattalerzeitung.ch						
landbote.ch		luzernerzeitung.ch						
langenthalertagblatt.ch		oltnertagblatt.ch						
tagesanzeiger.ch		solothurnerzeitung.ch						
tdg.ch		tagblatt.ch						
thunertagblatt.ch								
zsz.ch								
zuonline.ch								

B. Analysis table of the published online maps

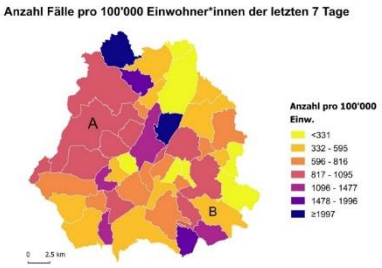
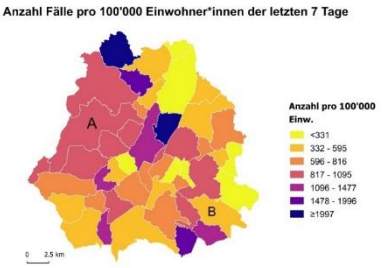
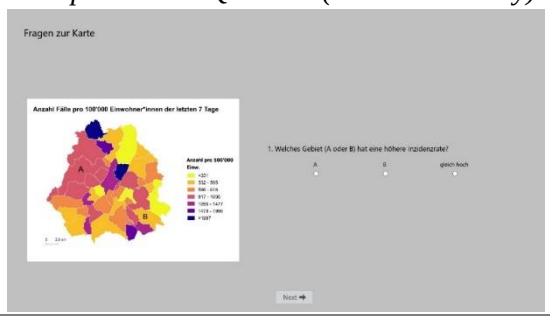
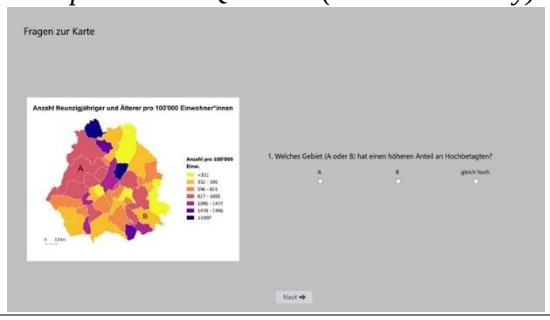
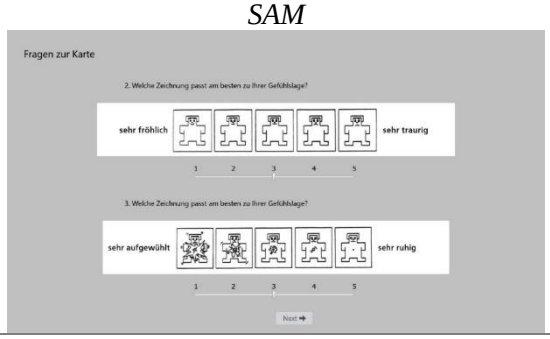
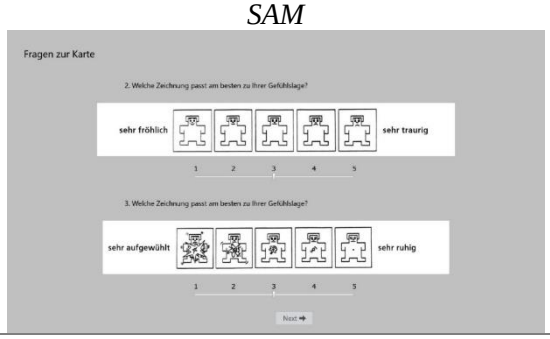
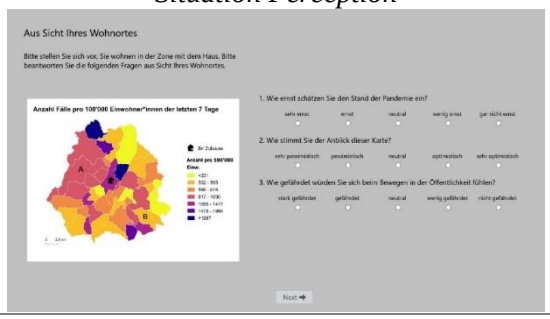
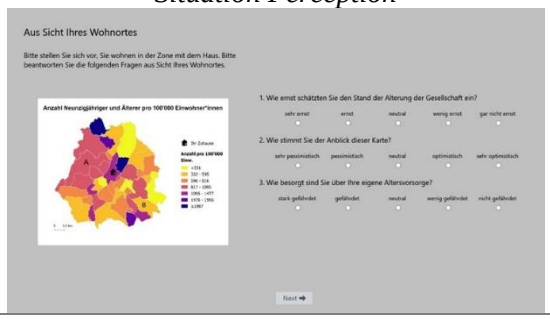
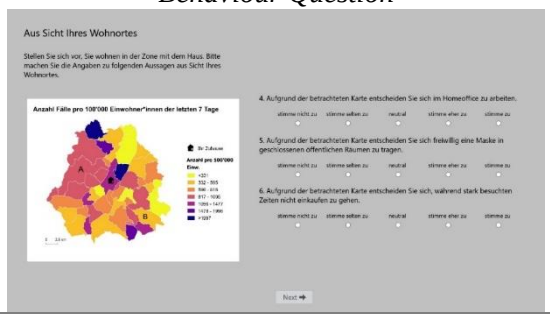
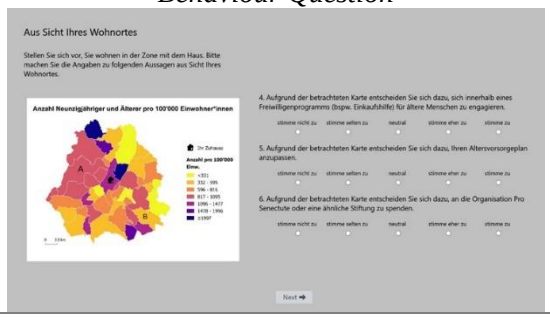
News Media	Language	Team	Tool	Semester	Title	Perimeter	Source	Information Type	Relative	Symbol	LOM	Break Type	Classes	Legend	Scale Type	Palette	Colours			Colour Save	Zoom	Hover	Forgive-ness	Corporate	Notes and Changes	Link (3.6.22)
20 minuten online	German	20min	unknown	S4	14-Tage-Inzidenz	Swiss cantons	FOPH	14-day incidence 100'000	relative	choropleth	ratio	continuous		yes	sequential	unknown	nude	pink	purple	yes	yes	yes	yes			Link
blick.ch	German	Blick Visuals	unknown	S4	Laborbestätigte Fälle pro Kanton und 100'000 Einw. In den letzten 14 Tagen	Swiss cantons	FOPH	14-day incidence 100'000	relative	hexbin	ratio	unclear	7	yes	quasi-sequential	unknown	violet	yellow	orange	yes	no	yes	yes		unfit colour scale	Link
				S5	Fälle der letzten 14 Tage pro 100'000 Einwohner/innen	Swiss cantons	FOPH	14-day incidence 100'000	relative	hexbin	ratio	equal interval	6	yes	sequential	unknown	yellow	orange	red	yes	no	yes	yes		removal of purple, violet in colour scale, sequential, equal interval	Link
CH Media 1	German	CH Media	Datawrapper	S4, S5	Neuinfektionen Woche x bis y	AG communities	canton AG	absolute cases	absolute	choropleth	ratio	unclear	5	yes	sequential	plasma	yellow	orange	dark blue	yes	yes	yes	yes		absolute choropleth	Link
CH Media 2	German	CH Media	Datawrapper	S4	Wie viele Infektionen pro 100'000 Einwohner in den vergangenen sieben Tagen es gab in den Kantonen	Swiss cantons	FOPH	7-day incidence 100'000	relative	choropleth	ratio	equal interval	5	yes	sequential	unknown	nude	pink	purple	yes	yes	yes	yes			Link
				S5	Wie viele Infektionen pro 100'000 Einwohner in den vergangenen sieben Tagen es gab in den Kantonen	Swiss cantons	FOPH	7-day incidence 100'000	relative	choropleth	ratio	continuous		yes	sequential	plasma	yellow	orange	dark blue	yes	yes	yes	yes		continuous, plasma palette	Link
				S6	Wie viele Infektionen pro 100'000 Einwohner in den vergangenen sieben Tagen es gab in den Kantonen	Swiss cantons	FOPH	7-day incidence 100'000	relative	choropleth	ratio	equal interval	5	yes	sequential	unknown	nude	pink	purple	yes	yes	yes	yes		scale adjusted	Link

News Media	Language	Team	Tool	Semester	Title	Perimeter	Source	Information Type	Relative	Symbol	LOM	Break Type	Classes	Legend	Scale Type	Palette	Colours			Colour Save	Zoom	Hover	Forgive-ness	Corporate	Notes and Changes	Link (3.6.22)
CH Media 3	German	CH Media	Datawrapper	S4, S5	Fälle pro 100'000 Einw. vergangene 14 Tage (Kategorien)	Swiss regions	FOPH	14-day incidence 100'000	relative	choropleth	ratio	doubling	7	yes	sequential	plasma	yellow	orange	dark blue	yes	yes	yes	yes			Link
CH Media 4	German	CH Media	Datawrapper	S4	Fälle pro 100'000 Einw. vergangene 14 Tage (Kategorien)	SO regions	FOPH	14-day incidence 100'000	relative	choropleth	ratio	doubling	7	yes	sequential	plasma	yellow	orange	dark blue	yes	no	yes	yes			Link
				S5	Tägliche Neuinfektionen in den Solothurner Gemeinden	SO communities	canton AG	absolute cases	relative	choropleth	ratio	unclear	7	yes	sequential	plasma	yellow	orange	dark blue	yes	no	yes	yes		from 7 to 6 classes, communities, removed zoom, absolute cases	Link
CH Media 5	German	CH Media	Datawrapper	S4	Fälle pro 100'000 Einw. vergangene 14 Tage (Kategorien)	Central Switzerland regions	FOPH	14-day incidence 100'000	relative	choropleth	ratio	doubling	7	yes	sequential	GnBu	mint	turquois	dark blue	yes	yes	yes	yes	blue		Link
CH Media 6	German	CH Media	Datawrapper	S4	Fälle in 14 Tagen pro 100'000 Einwohner	Swiss cantons	FOPH	14-day incidence 100'000	relative	choropleth	ratio	continuous		yes	sequential	magma	light yellow	orange	dark purple	yes	no	yes	yes			Link
				S5	Fälle in 14 Tagen pro 100'000 Einwohner	Swiss cantons	FOPH	14-day incidence 100'000	relative	choropleth	ratio	continuous		yes	sequential	magma	light yellow	orange	dark purple	yes	no	yes	yes		adjusted scale	Link
letemps.ch	French	LeTemps	unknown	S1	Taux pour 100'000 habitants	Swiss cantons	OpenZH	daily incidence 100'000	relative	choropleth	ratio	unclear	5	yes	sequential	unknown	dark green	brown	red	no	no	yes	yes		too dark, info tiles overlap small cantons	Link
				S2, S3	Taux de nouveaux cas pour 100'000 habitants	Swiss cantons	FOPH	daily incidence 100'000	relative	choropleth	ratio	unclear	4	yes	sequential	unknown	dark green	green-brown	brown	no	no	yes	yes		from 5 to 4 classes, red removed, more specific title, new source (BAG)	Link

News Media	Language	Team	Tool	Semester	Title	Perimeter	Source	Information Type	Relative	Symbol	LOM	Break Type	Classes	Legend	Scale Type	Palette	Colours			Colour Save	Zoom	Hover	Forgive-ness	Corporate	Notes and Changes	Link (3.6.22)
				S4, S5	Incidence sur 14 jours pour 100'000 habitants	Swiss regions	FOPH	14-day incidence 100'000	relative	choropleth	ratio	doubling	7	yes	sequential	unknown	nude	orange	dark orange	yes	no	yes	yes		orange scale, Swiss regions, 7 classes, 14-day incidence	Link
nzz.ch	German	NZZ	in-house	S3	Sars-CoV-2 Fälle pro 100'000 Einwohner in den letzen zwei Wochen, nach Kanton	Swiss cantons	FOPH	14-day incidence 100'000	relative	hexbin	ratio	Jenks	7	yes	sequential	unknown	nude	dark orange	red	yes	no	no	no		methodology	Link
				S5	Sars-CoV-2 Fälle pro 100'000 Einwohner in den letzen zwei Wochen, nach Kanton	Swiss cantons	FOPH	14-day incidence 100'000	relative	hexbin	ratio	Jenks	7	yes	sequential	unknown	nude	dark orange	berry	yes	no	no	no		methodology, colour palette extended with berry red	Link
rsi.ch 1	Italian	RSI News (SRG)	in-house	S5	Numero di casi su 100'000 abitanti negli ultimi 14 giorni	Swiss cantons	FOPH	14-day incidence 100'000	relative	choropleth	ratio	unclear		yes	sequential	plasma	yellow	orange	dark blue	yes	yes	yes	yes			Link
rsi.ch 2	Italian	RSI News (SRG)	in-house	S5	Numero di contagi per 100'000 abitanti negli ultimi 14 giorni	european countries	ECDC, FOPH, GOVUK	14-day incidence 100'000	relative	choropleth	ratio	unclear		yes	sequential	unknown	nude	pink	purple	yes	yes	yes	yes			Link
rts.ch	French	RTSinfo (SRG)	Datawrapper	S5	Covid-19: nouveaux cas sur 14 jours pour 100'000 habitants	european regions	WHO Europe	14-day incidence 100'000	relative	choropleth	ratio	unclear	7	yes	sequential	unknown	light gray	orange	braun	yes	yes	yes	yes			Link
srf.ch	German	SRF Data (SRG)	unknown	S4	Fälle pro 100'000 i nden letzten 14 Tagen	european regions	unknown	14-day incidence 100'000	relative	choropleth	ratio	unclear	6	yes	sequential	unknown	light gray	rose	red	yes	no	yes	yes	red		Link
				S5	Fälle pro 100'000 in den letzten 14 Tagen	european regions	unknown	14-day incidence 100'003	relative	choropleth	ratio	unclear	6	yes	sequential	unknown	light gray	rose	red	yes	no	yes	yes		adjusted scale	Link

News Media	Language	Team	Tool	Semester	Title	Perimeter	Source	Information Type	Relative	Symbol	LOM	Break Type	Classes	Legend	Scale Type	Palette	Colours			Colour Save	Zoom	Hover	Forgiven.	Corporate	Notes and Changes	Link (3.6.22)
Tamedia 1	German	Tamedia Interaktiv	unknown	S4, S5	Hier zirkuliert das Virus am stärksten	BE communities	canton BE	7-day incidence 100'000	relative	choropleth	ratio	unclear		no	quasi-sequential	unknown	light green	orange	red	no	yes	yes	yes		no legend	Link
Tamedia 2	German	Tamedia Interaktiv	unknown	S4	Bestätigte Fälle 7 Tage pro 100'000 Personen	european regions	unknown	7-day incidence 100'000	relative	choropleth	ratio	doubling	7	yes	sequential	unknown	light gray	orange	dark red	yes	no	yes	yes			Link
				S5	Bestätigte Fälle 7 Tage pro 100'000 Personen	european regions	unknown	7-day incidence 100'000	relative	choropleth	ratio	doubling	7	yes	sequential	unknown	light gray	orange	dark red	yes	no	yes	yes		adjusted scale	Link
Tamedia 3	French	Tamedia Interaktiv	unknown	S5	Incidence sur 7 jours	european regions	ECDC	7-day incidence 100'000	relative	choropleth	ratio	unclear	5	yes	diverging	unknown	blue	nude	red	yes	yes	yes	yes		diverging colour scale	Link
Tamedia 4	French	Tamedia Interaktiv	unknown	S5	Par pays, nombre total de nouveaux casconfirmés durant les 7 derniers jours en comparaison avec la semaine précédente.	world countries	Johns Hopkins University	increase vs decrease of cases	absolute	choropleth	interval	unclear		no	diverging	unknown	yellow		red	yes	yes	yes	yes	yellow, red	no legend	Link
Tamedia 5	German	Tamedia Interaktiv	unknown	S4	Weltweite Covid-19-Fälle	world countries	unknown	absolute cases	absolute	graduated circles	ratio	continuous		no	categorical	unknown		yellow		yes	no	no	no	yellow, red	no legend, no zoom, no overlap	Link
Tamedia 6	German	Tamedia Interaktiv	unknown	S4	Positiv getestete Personen pro 100'000	ZH communities	OpenZH	7-day incidence 100'000	relative	choropleth	ratio	equal interval	6	yes	sequential	unknown	light blue	blue	dark blue	yes	no	yes	yes	blue	methodology	Link
				S5	Positiv getestete Personen in den letzten 7 Tagen pro 100'000 Personen	cantonal communities	OpenZH	7-day incidence 100'000	relative	choropleth	ratio	unclear	7	yes	sequential	unknown	light red	red	dark red	yes	no	yes	yes		methodology, red palette, more informative title	Link
watson.ch	German	Watson	unknown	S2	Kantone nach Fällen in den letzten 14 Tagen (pro 100'000 Einwohner)	Swiss cantons	FOPH	14-day incidence 100'000	relative	choropleth	ratio	unclear	7	yes	sequential	unknown	light rose	rose	pink	yes	no	yes	yes	pink		Link
				S3	Freue Bette in 20% Schritten	Swiss cantons	FOPH	Free hospital beds in 20% steps	relative	choropleth	ratio	unclear	7	yes	sequential	unknown	dark purple	pink	light blue	yes	no	yes	yes		new topic (hospital beds), new colour scale with light blue	Link
				S4, S5	R-Werte	Swiss cantons	FOPH	r-value	relative	choropleth	ratio	unclear	7	yes	sequential	unknown	light rose	pink	purple	yes	no	yes	yes		new r-values, very dark purple	Link

C. Main Study Slides of both Groups

Group A (COVID-19)	Group B (Population Ageing)
Stimuli	*Stimuli*
	
Comprehension Question (here Elementary)	*Comprehension Question (here Elementary)*
	
SAM	*SAM*
	
Situation Perception	*Situation Perception*
	
Behaviour Question	*Behaviour Question*
	

D. Pairwise Comparison of Map Patterns of Perception

```
$lsmeans
 Map lsmean   SE  df lower.CL upper.CL
 1      536 20.6 119    495.3      577
 2      519 20.6 119    478.0      560
 3      390 20.6 119    349.2      431
 4      427 20.6 119    386.1      468
 5      292 20.6 119    251.7      333
 6      392 20.6 119    351.5      433
 7      296 20.6 119    255.4      337
 8      264 20.6 119    223.1      305
 9      134 20.6 119     92.9      174
 10     155 20.6 119    114.3      196

Results are averaged over the levels of: Color
Degrees-of-freedom method: kenward-roger
Confidence level used: 0.95

$contrasts
 contrast     estimate   SE  df t.ratio p.value
 Map1 - Map2     17.24 21.4 627   0.807  0.9985
 Map1 - Map3    146.07 21.4 627   6.837  <.0001
 Map1 - Map4    109.17 21.4 627   5.110  <.0001
 Map1 - Map5    243.62 21.4 627  11.403  <.0001
 Map1 - Map6    143.74 21.4 627   6.728  <.0001
 Map1 - Map7    239.92 21.4 627  11.229  <.0001
 Map1 - Map8    272.17 21.4 627  12.739  <.0001
 Map1 - Map9    402.35 21.4 627  18.832  <.0001
 Map1 - Map10   380.95 21.4 627  17.830  <.0001
 Map2 - Map3    128.82 21.4 627   6.030  <.0001
 Map2 - Map4     91.93 21.4 627   4.303  0.0008
 Map2 - Map5    226.38 21.4 627  10.595  <.0001
 Map2 - Map6    126.50 21.4 627   5.921  <.0001
 Map2 - Map7    222.68 21.4 627  10.422  <.0001
 Map2 - Map8    254.93 21.4 627  11.932  <.0001
 Map2 - Map9    385.10 21.4 627  18.025  <.0001
 Map2 - Map10   363.71 21.4 627  17.023  <.0001
 Map3 - Map4    -36.90 21.4 627  -1.727  0.7798
 Map3 - Map5     97.55 21.4 627   4.566  0.0003
 Map3 - Map6     -2.32 21.4 627  -0.109  1.0000
 Map3 - Map7     93.85 21.4 627   4.393  0.0006
 Map3 - Map8    126.10 21.4 627   5.902  <.0001
 Map3 - Map9    256.28 21.4 627  11.995  <.0001
 Map3 - Map10   234.88 21.4 627  10.994  <.0001
 Map4 - Map5    134.45 21.4 627   6.293  <.0001
 Map4 - Map6     34.57 21.4 627   1.618  0.8391
 Map4 - Map7    130.75 21.4 627   6.120  <.0001
 Map4 - Map8    163.00 21.4 627   7.629  <.0001
 Map4 - Map9    293.18 21.4 627  13.722  <.0001
 Map4 - Map10   271.78 21.4 627  12.721  <.0001
 Map5 - Map6    -99.88 21.4 627  -4.675  0.0002
 Map5 - Map7     -3.70 21.4 627  -0.173  1.0000
 Map5 - Map8     28.55 21.4 627   1.336  0.9449
 Map5 - Map9    158.73 21.4 627   7.429  <.0001
 Map5 - Map10   137.33 21.4 627   6.428  <.0001
 Map6 - Map7     96.18 21.4 627   4.502  0.0003
 Map6 - Map8    128.43 21.4 627   6.011  <.0001
 Map6 - Map9    258.60 21.4 627  12.104  <.0001
 Map6 - Map10   237.21 21.4 627  11.102  <.0001
 Map7 - Map8     32.25 21.4 627   1.509  0.8883
 Map7 - Map9    162.43 21.4 627   7.602  <.0001
 Map7 - Map10   141.03 21.4 627   6.601  <.0001
 Map8 - Map9    130.18 21.4 627   6.093  <.0001
 Map8 - Map10   108.78 21.4 627   5.091  <.0001
 Map9 - Map10   -21.40 21.4 627  -1.001  0.9921

Results are averaged over the levels of: Color
Degrees-of-freedom method: kenward-roger
P value adjustment: tukey method for comparing a family of 10 estimates
```

E. Pairwise Comparison of Map Patterns of Behaviour

```
$lsmeans
 Map lsmean   SE   df lower.CL upper.CL
 1      200 27.4 53.1      145      254
 2      236 27.4 53.1      181      291
 3      311 27.4 53.1      256      366
 4      285 27.4 53.1      230      340
 5      401 27.4 53.1      346      456
 6      284 27.4 53.1      229      339
 7      365 27.4 53.1      310      420
 8      376 27.4 53.1      321      431
 9      486 27.4 53.1      431      541
 10     462 27.4 53.1      407      517

Results are averaged over the levels of: Color
Degrees-of-freedom method: kenward-roger
Confidence level used: 0.95

$contrasts
 contrast     estimate   SE  df t.ratio p.value
 Map1 - Map2    -36.12 18.8 627  -1.918  0.6570
 Map1 - Map3   -111.31 18.8 627  -5.910  <.0001
 Map1 - Map4    -85.88 18.8 627  -4.560  0.0003
 Map1 - Map5   -201.28 18.8 627 -10.687  <.0001
 Map1 - Map6    -84.53 18.8 627  -4.488  0.0004
 Map1 - Map7   -165.68 18.8 627  -8.797  <.0001
 Map1 - Map8   -176.43 18.8 627  -9.367  <.0001
 Map1 - Map9   -286.60 18.8 627 -15.217  <.0001
 Map1 - Map10  -262.18 18.8 627 -13.920  <.0001
 Map2 - Map3    -75.19 18.8 627  -3.992  0.0029
 Map2 - Map4    -49.76 18.8 627  -2.642  0.2003
 Map2 - Map5   -165.16 18.8 627  -8.769  <.0001
 Map2 - Map6    -48.41 18.8 627  -2.570  0.2340
 Map2 - Map7   -129.56 18.8 627  -6.879  <.0001
 Map2 - Map8   -140.31 18.8 627  -7.450  <.0001
 Map2 - Map9   -250.49 18.8 627 -13.300  <.0001
 Map2 - Map10  -226.06 18.8 627 -12.003  <.0001
 Map3 - Map4     25.43 18.8 627   1.350  0.9414
 Map3 - Map5    -89.97 18.8 627  -4.777  0.0001
 Map3 - Map6     26.78 18.8 627   1.422  0.9202
 Map3 - Map7    -54.37 18.8 627  -2.887  0.1115
 Map3 - Map8    -65.12 18.8 627  -3.457  0.0205
 Map3 - Map9   -175.29 18.8 627  -9.307  <.0001
 Map3 - Map10  -150.87 18.8 627  -8.010  <.0001
 Map4 - Map5   -115.40 18.8 627  -6.127  <.0001
 Map4 - Map6      1.35 18.8 627   0.072  1.0000
 Map4 - Map7    -79.79 18.8 627  -4.237  0.0011
 Map4 - Map8    -90.54 18.8 627  -4.807  0.0001
 Map4 - Map9   -200.72 18.8 627 -10.657  <.0001
 Map4 - Map10  -176.29 18.8 627  -9.360  <.0001
 Map5 - Map6    116.75 18.8 627   6.199  <.0001
 Map5 - Map7     35.60 18.8 627   1.890  0.6757
 Map5 - Map8     24.85 18.8 627   1.320  0.9490
 Map5 - Map9    -85.32 18.8 627  -4.530  0.0003
 Map5 - Map10   -60.90 18.8 627  -3.233  0.0420
 Map6 - Map7    -81.15 18.8 627  -4.309  0.0008
 Map6 - Map8    -91.90 18.8 627  -4.879  0.0001
 Map6 - Map9   -202.07 18.8 627 -10.729  <.0001
 Map6 - Map10  -177.65 18.8 627  -9.432  <.0001
 Map7 - Map8    -10.75 18.8 627  -0.571  0.9999
 Map7 - Map9   -120.93 18.8 627  -6.421  <.0001
 Map7 - Map10   -96.50 18.8 627  -5.124  <.0001
 Map8 - Map9   -110.18 18.8 627  -5.850  <.0001
 Map8 - Map10   -85.75 18.8 627  -4.553  0.0003
 Map9 - Map10    24.43 18.8 627   1.297  0.9542

Results are averaged over the levels of: Color
Degrees-of-freedom method: kenward-roger
P value adjustment: tukey method for comparing a family of 10 estimates
```

Personal Declaration

I hereby declare that the submitted Thesis is the result of my own, independent work. All external sources are explicitly acknowledged in the Thesis.

Anna-Lena Burren Unterägeri, 30.09.2022