THEMATIC MAPS PORTRAYING SUSTAINABLE DEVELOPMENT GOAL INDICATOR DATA AND AN EXPLORATION OF USERS' EMOTIONAL RESPONSES AND ATTITUDES

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September 2018

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Enschede, The Netherlands, September 2018

Thesis submitted to the Faculty of Geo-Information Science and Earth Observation of the University of Twente in partial fulfilment of the requirements for the joint Master of Science in Cartography

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ABSTRACT

Feminist cartography, GIS, and data visualization recognize emotion and affect as legitimate experiences, on par with quantitative methods of knowing. Emotional state and cognitive ability are related, and while spatial cognition is well-investigated and usability studies of maps abound, there is little research at the intersection of maps, data, and users' emotions. Using as a case study unsettling indicator data from the United Nations Sustainable Development Goals about the proportion of women and girls aged 15-49 who have undergone female genital mutilation/cutting, this research evaluates thematic map types as ways to visualize and/or embody this data, changes in users' affective states from engaging with the data in a choropleth, cartogram, and repeating symbol tile map, and their attitudes towards the maps. The results from this preliminary investigation indicate that thematic maps and data can and do evoke emotions, but that some people may also experience low emotional involvement and view maps as clinical or neutral despite the data or issue they portray. Emotional engagement with and attitudes towards the maps arise from many factors, including data, distance, design, and map type, which present many opportunities for future research and user studies to investigate the effects of these aspects in isolation or combination.

ACKNOWLEDGEMENTS

Britta Ricker, this wouldn't have been possible without you! Thank you for being my supervisor and for believing in me and this work even more than I did. Your genuine interest in the topic and research, your engagement, enthusiasm, encouragement, support, positive feedback, open door, and your flexibility, advice, and guidance have been invaluable. You have been a great listener, reader, and pillar. You have always been part of this thesis, and at the same time have emphasized that all the choices and decisions are mine. Thank you for everything.

To Menno-Jan Kraak and Corné van Elzakker, many thanks for your continued concern, guidance, expertise, attention to detail, and coordination at ITC. I truly appreciate your support this semester.

Rob Roth and Meghan Kelly, at the outset of this research our talks in Enschede and Amsterdam were my main source of inspiration and direction, which had a huge influence on what this thesis has become. Thank you for your time, ideas, and suggestions.

Thank you to Yuri Engelhardt for time and input from the very beginning which helped shape this work.

Juliane Cron! I am always so impressed by your dedication to this program and the steady supply of reassuring and friendly answers to questions and emails from cities, countries, and continents away – you are spectacular for everything you do, and you make this program so special. Thank you!

I am grateful for the generous funding and opportunities from the Cartography MSc consortium and Erasmus+ to make possible this unique opportunity to learn, live, and travel. It has been a brilliant experience and I am very, very fortunate.

Thank you to all my excellent classmates from the sixth intake, for being you!

Finally, the biggest thank you to my family, for your unlimited love and patience, constant presence, and boundless support in life, school, work, travel, adventures, and beyond.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

1.1. Context

Maps are an enduring method to convey information (DeLyser & Sui, 2014) and can support productive access to information and knowledge construction (MacEachren & Kraak, 2001). An increase in access and availability to mapmaking tools and data in recent years, in combination with human cognitive factors (visual, thinking, and learning abilities, and cartophilia) has renewed mapping as a useful research and communication method and tool in geography and the spatial humanities and social sciences (DeLyser & Sui, 2014). There has been significant increase in the potential and use of diagrams to engage and bring the attention of large audiences and citizens to social issues (Dörk, Feng, Collins, & Carpendale, 2013; Zambrano & Engelhardt, 2008) including maps and other representations of spatial data. Despite that they are social and political constructs and that no map that tells the whole truth, maps are media for storytelling and knowledge sharing (DeLyser & Sui, 2014).

Women have historically been cast in western intellectual tradition as under the influence of bodily emotions and desires and as irrational and inferior creatures, unable to transcend their embodiment (Huffman, 1997), and rational thinking has historically been privileged over emotional experience (Kennedy & Hill, 2017). Emotions are often trivialized in scientific research and perceived as irrational, biased states inferior to rational ways of processing information (Roeser, 2012). But emotions are aspects of geographic practice that go beyond "representational ways of knowing"; and despite that maps are representations of space, they too can draw in the reader imaginatively and emotionally (Aitken & Craine, 2009, p. 139). Maps are not simple representations of facts, but "the graphic marshalling of selected propositions in a cognitive machine into arguments about the nature of reality" (Sui & Holt, 2008, p. 16).

But the integral role of emotion in user experience has been overlooked (Agarwal & Meyer, 2009), including in data visualization and cartography. Emotions influence reflexes, cognition, memory, economics, health, well-being (Yik, Russell, & Steiger, 2011), decision-making, reasoning (Damasio, 2001), and map reading, and are defining qualities of humans (Griffin & McQuoid, 2012). While research on spatial cognition is plentiful and usability studies of maps abound, there is little work on emotional responses to maps and spatial data. This research explores a small part of that lacuna.

Emotions influence users' engagement with data and visualizations and arise from the data themselves, the context, the design, and users' capacities to understand and engage with the data (Kennedy & Hill, 2017). Maps are visualizations of spatial data, and Griffin and McQuoid (2012) identify three categories of the intersections between maps and emotions: maps of emotions, the use of maps to collect emotional data, and map users' emotions. This research focuses on the last one, by visualizing and embodying an unsettling dataset from the United Nations (UN) Sustainable Development Goals (SDG) about female genital mutilation/cutting, in three thematic map types and by collecting information on users' emotional responses and attitudes from engaging with these visualizations and the dataset in an online survey, through tasks and self-reports of affect (emotion). The research explores the users' affective states prior to

and after engagement with the maps, and preferences, emotions, and attitudes towards the maps and the indicator and data set.

The "sociology of data" comprises sociologies of emotions and everyday life (Kennedy & Hill, 2017, p. 2). From cartographic and geovisualization perspectives, research into emotional responses to maps and data could inform a "sociology of cartography". Several researchers recognize the importance of the intersection of emotions and maps, and call for more attention to this relationship in their work (see, for example, Griffin et al., 2017; Griffin & McQuoid, 2012; Roth et al., 2017; Aitken & Craine, 2009; Craine & Aitken, 2009; Caquard, 2015; Caquard & Cartwright, 2014; Edsall, 2010; Elwood, 2010, Preston, 2008), to affect and geospatial technologies and practices more broadly (Kwan, 2007), to the potentially emotional message a map tries to communicate (Muehlenhaus, 2012; Mccleary & Mccleary, 2003) and to emotions, data, and data visualizations (Kennedy & Hill, 2017; D'Ignazio and Klein 2016).

For many, visualizations are main way to access data, though access is uneven (Kennedy & Hill, 2017). Several sets of visualizations and global, social, and economic data are freely available online, through sites and tools such as Gapminder (Rosling, Rosling, & Rosling, 2018), the World Bank's Open Data (The World Bank, 2018a) and its Visualize Inequality dashboards (The World Bank, 2018b), the Worldmapper Project (Danny Dorling, Barford, & Newman, 2006), Knoema (Knoema, 2018) and Our World in Data (Roser, 2018b) with its accompanying SDG Tracker (Roser, 2018a). Each of these free sources provide global social and economic information as datasets, maps, graphics, and/or data visualizations, and some have tools for users to create or customize visualizations. The proliferation of such tools and access to data for "ordinary people" (Zambrano & Engelhardt, 2008, p. 291) has made available visualizations and tools to spur advocacy and activism (Zambrano & Engelhardt, 2008), and for human rights issues awareness and action (Emerson, Satterthwaite, & Pandey, 2018) – though arguably who "ordinary people" are, and whether they can be defined, remain open and important questions.

1.2. The Sustainable Development Goals

The SDG consist of 17 global goals for social, economic, and environmental progress, which form the 2030 Agenda for Sustainable Development. These goals comprise 169 targets measured by 232 individual indicators in a global indicator framework adopted by the UN General Assembly on 6 July 2017. The framework is meant to track SDG progress, inform policy, and ensure stakeholder accountability (United Nations Statistics Division, 2018a).

The goals were adopted by world leaders in 2015 at the UN Sustainable Development Summit and came into effect on 1 January 2016 (United Nations, 2018b). Indicator data is available through the Global Database (United Nations Statistics Division, 2018a) and spatially referenced data through the UN SDG Open Data Hub (United Nations Statistics Division, 2018b). Data completeness and timeliness varies by country and indicator.

1.3. Research questions and objectives

Kennedy and Hill (2017) find that emotions – fear, surprise, pleasure, frustration, confusion, anger, pity, shame, guilt, etc. – are significant in how users experience and engage with data and their visualizations, and are influenced by design, visual style, subject matter, source, and the users' visualization literacy skills.

This research asks:

1. What are the characteristics of 'unconventional' thematic maps to represent SDG indicator data? How might a thematic map embody selected SDG indicator data?
2. (How) are users' emotions affected (or not) by engaging with thematic maps and an SDG indicator about female genital mutilation?

The research objectives are:

1. To evaluate a range of thematic map types suitable for SDG data.
2. To embody the data of SDG indicator 5.3.2 in one of the above map types and to conduct a user study to measure users' affective states before and after they view three thematic map types portraying indicator 5.3.2, to collect information on self-reported emotions, task responses, attitudes, and comments towards the map types and data.

1.4. Contributions

There is little research into users' emotional responses to thematic maps and data. This research investigates this connection through maps which visualize as a case study an SDG indicator directly related to the experience of girls and women.

1.5. Outline

This chapter introduced the research context and objectives. Chapter 2 offers background information about female genital mutilation/cutting, and emotion/affect as discussed in psychology. Chapter 3 offers a selective overview of less common thematic map types for SDG indicator data and related studies. In Chapter 4, I present the empirical research I conducted, including the methods and results of the user study, which leads to Chapter 5, where I discuss the results, limitations, and areas for future research. Chapter 6 synthesizes the findings of this thesis.

2. BACKGROUND INFORMATION

2.1. Emotion and affect

People automatically and continuously evaluate objects and situations (Feldman Barrett, 2006b). A conscious or involuntary evaluation of maps and data visualizations would have some affective or emotive properties and characteristics. "Core affect" is a term used by some psychologists to describe "the basic building block of emotional life" (Feldman Barrett, 2006, p. 30). Griffin & McQuoid (2012) identify this theory of emotion and affect as aligning best with "geographical conceptions of emotion" (p. 292). Core affect is caused even when non-intentional and when people don't know why they feel how they do, and is thus free-floating (Russell, 2009, p. 1265) and "always potentially accessible: whenever asked, people can tell you how they feel" (Yik et al., 2011, p. 705).

Emotion is often referred to as 'affect' in psychology. The concepts are not necessarily or exactly the same, though they are often used interchangeably, including in this research, for convenience and clarity. Slowly, there is emerging agreement on the relationship and difference between terms such as emotion, affect, mood, and temperament in psychology research, and the structure of the affective space: when humans conceptualize and categorize an affective feeling, they experience an emotion (Feldman Barrett, 2006a). Measures of emotion thus suggest a person's affective state.

A prototypical emotional episode is discrete and can be described, such as fear, surprise, disgust, anger, and happiness; it is an anticipated or experienced chain of events of antecedents; appraisals; physiological, affective, and cognitive changes; and behavioural responses. Meanwhile, core affects are the accessible elements of an anticipated emotional reaction, a present emotion, or a current mood – and are always present (Västfjäll, Friman, Gärling, & Kleiner, 2002).

Research shows that two dimensions to characterize the affective space are sufficient, which organize core affect in a circumplex or circular structure. These dimensions or axes are usually some form of the terms valence and activation, described below. Despite differences between models of affective space and structure, some are interchangeable and are rotational variants (Västfjäll et al., 2002).

The dimensional structure of mood and emotion has appeared many times in literature, as an orthogonal representation of emotion with two bipolar dimensions of valence (pleasure-displeasure, positive-negative, good-bad) and arousal (high-low activation, arousal-sleepiness, energy-lethargy). Circumplex models are circular representations of the relationships between variables of mood and emotion. This type of model complements the dimensional view of mood and emotion (Yik et al., 2011). Joy, for example, is a state characterized by high valence (pleasure) and moderate arousal, while other affective states arise from the same neurophysiological systems when they are activated to different extents (Posner, Russell, & Peterson, 2005).

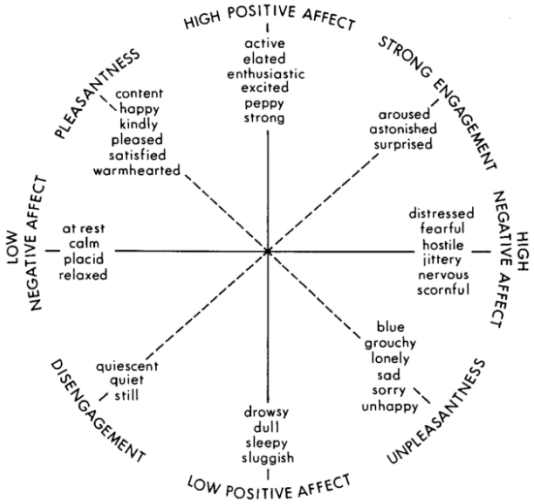

Figure 1: A two-dimensional structure of the affective space (Watson & Tellegen, 1985).

Watson and Tellegen (1985) suggested an alternative circumplex model focussing on valence, where the two dimensions are positive affect (PA) and negative affect (NA) (see Figure 1), rather than valence and activation. PA characterizes affects such as "euphoric" and "peppy", indicating combined valence and activation; NA reflects unpleasant affective states such as anxiety and anger which imply both high activation and unpleasantness. The Positive Affect and Negative Affect Schedule (PANAS) is a mood scale that Watson, Clark, and Tellegen (1988) created based on PA and NA as the two dimensions of affect. One critique of the PA and NA model is that low values of PA are unpleasant affective states and low values of negative affect are pleasant affective states. The authors revised the PANAS scales to encompass the full circumplex with high and low on both dimensions, and renamed them as positive activation and negative activation (Västfjäll et al., 2002; Watson, Wiese, Vaidya, & Tellegen, 1999) – a change in nomenclature, but not in structure.

The study in this research uses PANAS (Watson et al., 1988) scales for users to self-report their affect because as has been indicated, to some extent the models of affective space are interchangeable. The PANAS form can be seen in the screenshots of the user study survey, in the Appendix.

2.2. Female genital mutilation/cutting

Female genital mutilation/cutting (FGM/C) is the intentional injury to the external female genitalia for non-medical reasons, including the removal, in part or completely, of the female genital organs. It is a form of gender- and sex-based violence; it is a harmful practice with no health benefits, which interferes with a girl's or woman's normal bodily functions and has short- and long-term health consequences, physical, mental, and sexual. It is painful and traumatic (World Health Organization, 2018; 2008).

An estimated 200 million women and girls worldwide have undergone FGM, 44 million of whom are under 15 years old (World Health Organization, 2018). This number has increased: in 2008, the World Health Organization estimated the total number to be between 100 and 140 million women and girls with three million girls at risk every year (World Health Organization, 2008). The practice is global. It has been reported to occur in thirty African countries, mainly in the eastern, north-eastern, and western regions; some countries in Asia and the Middle East; and among some ethnic groups in Central and South America and Eastern Europe. There may be girls and women in diaspora populations in North America, Australia, New Zealand and Europe who have undergone, or will undergo, FGM/C (World Health Organization, 2018, 2008).

The World Health Organization uses the term "female genital mutilation". "Mutilation" distinguishes the term from male circumcision and expresses the practice as a serious violation of women's and girls' rights, emphasizing its harmfulness and gravity (World Health Organization, 2018). Practicing communities and individuals may use the terms "female genital cutting" and "female genital mutilation/cutting" (World Health Organization, 2018). This research uses FGM/C to be consistent with the SDG indicator terminology.

FGM/C is carried out on girls of varying ages in different communities, traditions, circumstances, and cultural groups. Some girls undergo FGM/C before age five. Others are subject to it between the ages of five and fourteen, or before marriage (World Health Organization, 2018). The practice violates several human rights. If performed on a child, the practice violates the rights of the child; it violates human rights to health, security, and physical integrity of the person, and the right to be free from torture and cruel, inhuman, and degrading treatment. When the practice results in death, it violates the right to life (World Health Organization, 2008).

Members of communities that practice FGM/C, including women, often see the practice as a historical and cultural tradition, and support and continue the practice out of respect to elders in the community (World Health Organization, 2018). It is a social convention with rewards and punishments that perpetuate it, as perceived social benefits are understood to be higher than the disadvantages (World Health Organization, 2008). Communities may justify FGM/C as rite of passage into adulthood; a way of enhancing fertility; a necessity for acceptance in society; a requirement for marriageability; a way to ensure a woman's virginity, chastity, and faithfulness; a procedure for physical cleanliness and beauty, or spiritual purity; a reflection of femininity; and/or a stipulation of religion. But FGM/C is practiced among

Christians, Muslims, and Jews, predates Christianity and Islam, and is not mentioned in any major religious texts; it is not mandated by religion (World Health Organization, 2018, 2008).

Usually both men and women support FGM/C where it is widely practiced; people who disagree may face harassment, shunning, and condemnation (World Health Organization, 2008). Achia (2014) found in a survey of Kenyan women that age, region, rural-urban classification, education, religion, marital status, socio-economic status, and media exposure were also significantly associated with FGM/C. In Kenya, women from rural areas are more likely than women from urban areas to have undergone FGM/C and the prevalence rate varies by county –from 38 percent in Kajiado to 75.9 percent to Kisii in 1998 – and county is still a large unit for analysis (Ngianga-Bakwin Kandala et al., 2017).

There are also marked prevalence variations in age groups. Spatial modelling of within-country data can identify geographic clusters of FGM prevalence; government and stakeholder interventions could make use within-country spatial models to target these clusters (Achia, 2014) which are not visible or identifiable through SDG indicators where sub-national analysis can inform decision-making for specific interventions. Whereas a national statistic may appear to be decreasing, sub-national geographic trends may show a different reality with variations by county (Kandala et al., 2017). Spatial analysis of FGM/C prevalence in Ethiopia also shows geographic clusters, and that individual, demographic, economic, religious and cultural factors affect prevalence rate of FGM/C, which indicates the need for targeted social and geographic intervention (Setegn, Lakew, & Deribe, 2016).

Interviews with women living in Spain who had undergone FGM in their countries of origin in sub-Saharan Africa show that the practice continues from generation to generation due to social and family pressure, and is silenced for those same reasons; it is seen as normal (Ballesteros Meseguer, Almansa Martínez, Pastor Bravo, & Jiménez Ruiz, 2014) and there may be "cultural inertia" (N.-B. Kandala, Nwakeze, & Kandala, 2009, p. 784).

FGM/C is part of the cultural identity of women and girls where it is widely practiced and it may impart pride and community membership. Traditional and religious leaders, elders, healthcare providers, and others in power or authority often uphold the practice, and often so do older women who have been mutilated who become "gatekeepers of the practice, seeing it as essential to the identity of women and girls" (World Health Organization, 2008, p. 7).

The medicalization of FGM/C - when any healthcare provider performs it in private or public care – it is also is a violation of girls' and women's rights. Medicalization perpetuates and legitimizes the harmful act, regardless of the healthcare provider's beliefs, methods, or intentions (World Health Organization, 2018).

FGM is a traumatic intervention. The girl is usually held down while undergoing the procedure. Nearly all girls who undergo FGM have pain and bleeding. Immediate health problems such as infection are only documented if a girl goes to the hospital, so the actual extent of these complications is not clear (World Health Organization, 2008). Childbirth risks are significantly higher for women who have undergone FGM, which puts the newborns at risk. Babies of women who have undergone FGM have a higher death rate during and immediately after birth, with higher rates depending on the type of the mutilation (World Health Organization, 2008). Babies of mothers who have undergone one type of FGM are more likely to need resuscitation at birth and are at higher risk of perinatal death (World Health Organization, 2018).

FGM/C "reflects deep-rooted inequality between the sexes, and constitutes an extreme form of discrimination against women" (World Health Organization, 2008, p. 1). It is rooted in society, economics, politics, and culture, and reflects social control over women, perpetuating normative, unequal, and harmful gender roles (World Health Organization, 2008). The Member States of the United Nations agreed to declare FGM a violation of the human rights of girls and women. A UN interagency statement calls for the elimination of FGM (World Health Organization, 2008).

The FGM/C SDG indicator is a measure of SDG Target 5.3, which is part of goal 5, on gender equality (see Table 1). The indicator data is provided by national statistical offices and compiled by UNICEF. Data on this indicator has been collected in low and middle-income countries since the late 1980s, through household surveys. The computation method for the indicator is the number of girls and women 15-49 who have undergone FGM/C, divided by the total number of girls and women aged 15-49 in the population, multiplied by 100 (United Nations, 2018a).

Table 1: 5.3.2 – SDG indicator, target, and goal

SDG indicator	**SDG target**	**SDG**
5.3.2: Proportion of women and girls aged 15-49 who have undergone female genital mutilation/cutting, by age	5.3: Eliminate all harmful practices, such as child, early and forced marriage and female genital mutilation	5: Achieve gender equality and empower all women and girls

3. RESEARCH OBJECTIVE 1: OVERVIEW OF UNCONVENTIONAL THEMATIC MAP TYPES

3.1. Overview

The research questions are: what are characteristics of 'unconventional' thematic maps to represent SDG indicator data? How might a thematic map embody selected SDG indicator data?

The objective is to evaluate a range of thematic map types suitable for SDG data and how one might embody the data of SDG indicator 5.3.2 in one of these map types. Thus section is an overview of thematic map types and their uses, advantages, and disadvantages; the focus is on unconventional map types to visualize univariate SDG indicators, alone or with an equalizing variable, such as population.

The 'official' SDG indicator data is available and measured by country but not at a finer scale, as the targets and goals are global, to be achieved by each country. Usually the indicators measure a proportion of the population or of a sub-population. Others are binary distinctions or parity indices. Of the most common conventional thematic map types (choropleth, proportional symbol, dot, and isoline), the most suitable for a world or regional map of SDG data, depending on the indicator, would therefore be proportional symbol and choropleth.

Choropleth maps are widely used to represent social data, but if they display raw counts they do not portray the spatial pattern of the issue, since areas with higher populations can have higher counts than areas with smaller populations. Standardizing these counts by another variable, such as population, still makes it impossible to distinguish between areas with high rates and high population, and areas with low rates and low population (Roth, Woodruff, & Johnson, 2010). These maps can be misleading, since the size of each polygon represents the geographical area of the enumeration unit, rather than population size or other attribute that is relevant to the visualized statistic. As area and population are not necessarily related, a choropleth map may not always be the most suitable representation for social data. For these reasons this section reviews these maps types in addition to area cartograms: grid, necklace, tile, value-by-alpha, and pictorial symbol (isotype).

Other increasingly popular thematic map types, such as cartograms – where polygons are scaled according to an attribute such as population – also distort any of size, shape, angles, or topology, which may render the geography unrecognizable, limiting their usability. Tile maps simplify each polygon to a geometrical shape such as a square or hexagon while maintaining the overall shape of the region, distorting shape, geography and topology, but are becoming more common in the media. Less common alternatives are necklace maps and value-by-alpha maps, which do not distort shape or topology. This section describes strengths and limitations of these map types to inform the design of the SDG indicator maps used in the user study.

3.2. Area cartograms (value-by-area maps)

Cartograms are not new, but are an increasingly popular alternative to choropleths and other thematic map types. Area cartograms (hereon referred to as cartograms, as opposed to distance cartograms) are some solutions to the challenges of representing spatial phenomenon on choropleth maps.

These thematic maps proportionally distort the area of each input polygon by a related equalizing variable, such as population. The statistic of interest can then be shown in a choropleth (colour shading) layer atop the distorted polygons, and does not require standardization. Cartograms thus show both statistical and geographical information from which the user may gain insight into outliers, patterns, and trends. Especially suited for visualizing political and socio-economic data, cartograms appear often in media, textbooks, and blogs, and are increasingly popular in social, political, and public health applications (Nusrat & Kobourov, 2016; Roth et al., 2010).

Distortion of angle, area, shape, or distance is generally undesirable, but is an inevitable quality of any 2-dimensional map representing the earth's 3D surface. A cartogram conveys information through its deliberate distortion and use of both statistical and geographical information, perhaps more than a traditional choropleth map does (Döll, 2017; Dorling et al., 2006). For example, in visualizing climate change risk and population change, Döll (2017) found that a bivariate cartogram of the world conveys this information at a higher spatial resolution than would be normally possible with a conventional thematic mapping method. Sui and Holt (2008)'s paper at the intersection of critical cartography and the applications of cartograms in public health and epidemiology states that choropleth maps "can tell some of the most egregious visual lies ever encountered in mapping" (p. 4) and may also be comparatively limited for their usefulness in public health spatial analysis.

Like all maps, a cartogram has the power to influence. As Raisz (1934) notes: "its educational value is not limited to the schools: it may serve to set right common misconceptions held by even well-informed

people" (p. 294). Kaspar, Fabrikant, & Freckmann (2011) suggest that cartograms may be "provocative" but are "readable, understandable, and accepted by map readers" (p. 1). The Worldmapper project, an online resource, visualizes many global social and economic datasets by country on world cartograms, providing "an impartial, empirical view" from which global inequality emerges as a theme (Danny Dorling, Barford, & Newman, 2006, p. 758). Atlases may use cartograms for their shock factor and ability to show dramatic differences between areas, while in human geography cartograms are a more socially just form of mapping because they provide a more equitable representation of the world (Dorling, 1996).

3.2.1. Cartogram accuracy

Many algorithms exist for cartogram production with different results and usability. The four major types of area cartograms are rectangular, contiguous, non-contiguous, and Dorling, which are described below. For each type there are many algorithms to produce different results; none is ideal, because in distorting area, all cartograms compromise one or more of statistical, geographical, and topological accuracy (Nusrat & Kobourov, 2016).

Cartogram types vary in their topological, geographical, and statistical accuracy and no type is completely effective in minimizing all three. Topological accuracy describes how well the cartogram retains the original map's adjacencies between polygons. If and only if two polygons represented as neighbours in the original map are also neighbours in the cartogram, the cartogram preserves adjacencies and topology (Nusrat & Kobourov, 2016).

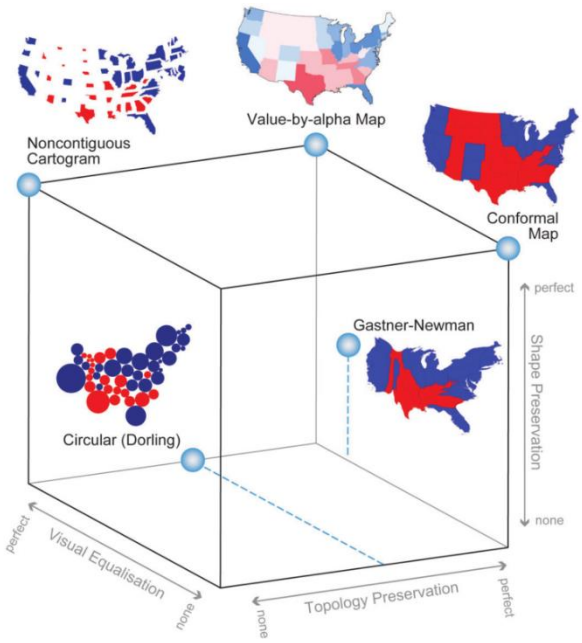

Figure 2: Cartogram[3] (Roth et al., 2010) shows the tradeoffs cartograms make in topology, geography (shape), and statistics (visual equalization).

Geographical accuracy describes to what extent the modified polygons in the cartogram resemble original map polygons in their shapes and relative position, which can be measured in various ways including curve similarity and pairwise distances (Nusrat & Kobourov, 2016).

Statistical accuracy describes the extent to which the modified areas on the cartogram represent the statistic or attribute they show, measured by the cartographic error – the relative distortion of each modified polygon from the desired statistic. The primary goal of many cartogram-generation algorithms is to minimize this error (Nusrat, Alam, & Kobourov, 2018; Nusrat & Kobourov, 2016).

Put another way, all cartograms compromise somehow between geography (shape), statistics (visual equalization), and topology (adjacencies), which are captured by the Cartogram[3] (cartogram cubed) visualization in Figure 2 (Roth et al., 2010).

3.2.2. Rectangular cartograms

Raisz (1934) introduced the rectangular statistical cartogram, which discards geographical shape by converting each region to a rectangle proportional to its value of the statistic of interest. By simplifying each polygon in this way, the cartogram becomes more of a "geographic design" or visualization than a map (Raisz, 1934, p. 292) which can help solve or understand distribution problems. Rectangular cartograms perform "sub-optimally" both quantitatively and qualitatively by user preference, which suggests that cartograms that greatly distort shape and relative position should be very carefully used (Nusrat et al., 2018).

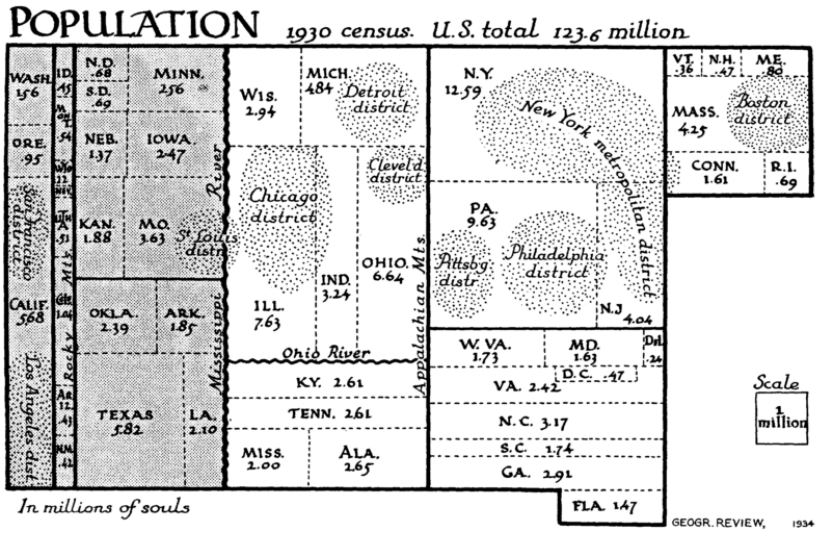

Figure 3: A rectangular statistical cartogram, where each rectangle represents a census unit or geographical division in the United States, sized proportionate to its population. Dotted lines represent metropolitan districts, also proportionate to population (Raisz, 1934).

3.2.3. Contiguous cartograms

Contiguous cartograms deform polygon areas but maintain adjacencies. These cartograms maintain statistical, topological, and geographical accuracy better than non-contiguous, rectangular, and Dorling cartograms (Nusrat & Kobourov, 2016).

Many methods and algorithms to create contiguous cartograms have been designed, the most popular (in journals and conferences) of which is from Gastner and Newman (2004). Their algorithm produces diffusion cartograms, which the authors describe as "elegant, well behaved, and useful cartograms" (p. 7499) that use a linear diffusion process to equalize population density across the cartogram, thereby preserving topology. The Gastner-Newmann cartogram's popularity is likely due to the availability of tools to create it, and its balance between statistical and geographical accuracy because it maintains shapes relatively well (Nusrat & Kobourov, 2016).

The Worldmapper project, for example, has produced over six hundred cartograms of the world using the Gastner-Newman method, visualizing topics social and economic data on topics related to pollution, poverty, and education, and more (Hennig, Pritchard, Ramsden, & Dorling, 2010). But to represent every country on the cartogram, missing values are estimated, or in the case of very small territories, omitted (Worldmapper, 2018; Dorling et al., 2006).

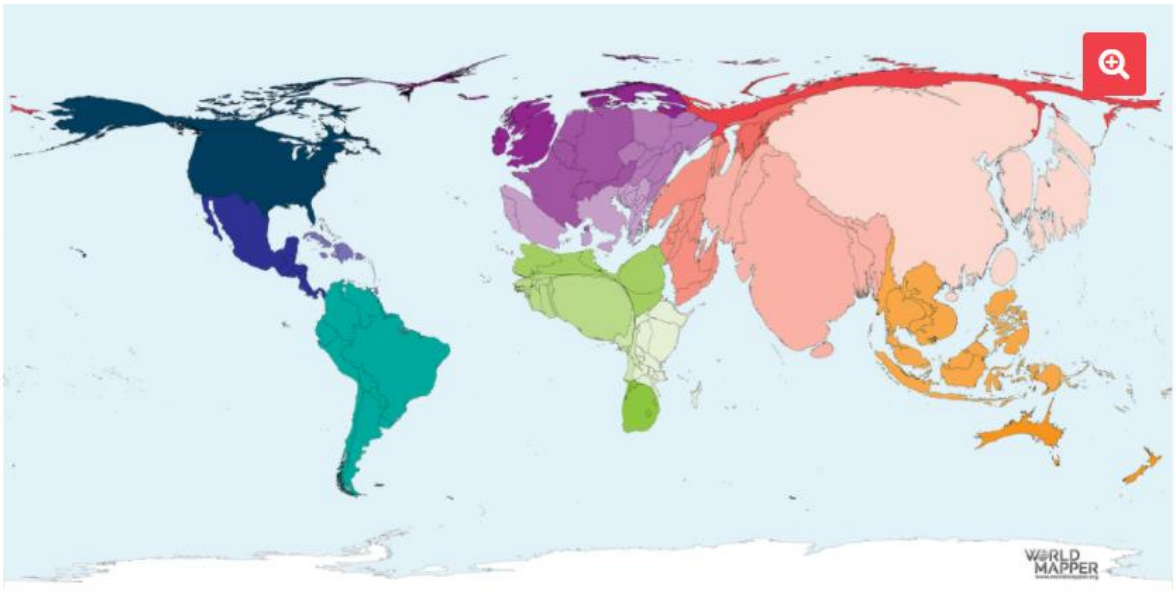

Figure 4: A Gastner-Newman cartogram of internet user worldwide by country in 2015 (Worldmapper, 2018).

3.2.4. Non-contiguous cartograms

Non-contiguous cartograms maintain statistical accuracy and shape, but not adjacency. Each undistorted polygon is independently resized, resulting in discrete polygons with gaps between them that renders recognition relatively uncomplicated for the user (Nusrat & Kobourov, 2016; Olson, 1976).

Non-contiguous cartograms which preserve the regions' centroids may also have overlap depending on the data value; in this case gaps, overlap, and individual regions' attributes may be more difficult to interpret. In non-overlapping, non-contiguous cartograms, regions shift to avoid overlap, causing distance distortion and not preserving centroids, but may make the regions and data easier to interpret (Demers & Bortins, 2002).

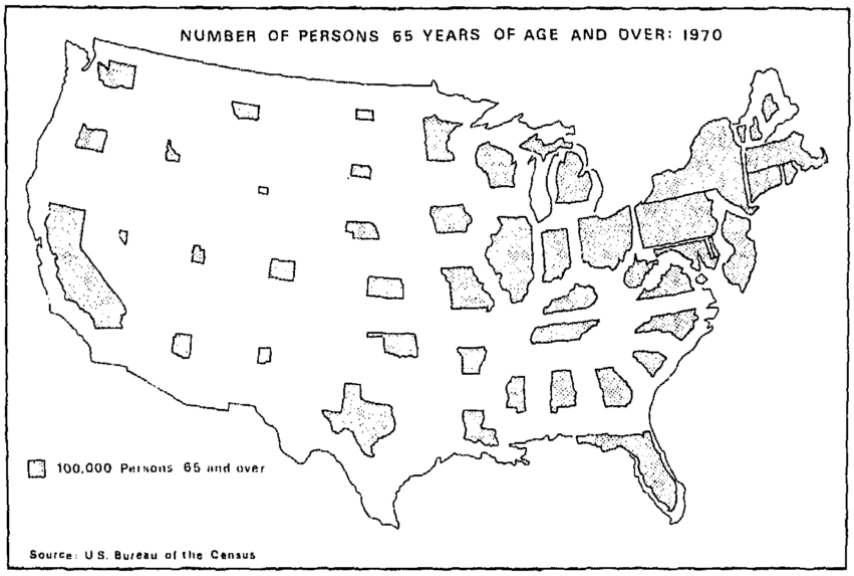

Figure 5: A non-contiguous, non-overlapping area cartogram of the United States where the size of each state is proportionate to its population aged 65 and older (Olson, 1976).

To create a non-contiguous cartogram Olson (1976) proposed that a high-density enumeration unit from the base map become the anchor unit, which remains the same size in the cartogram, and from which the other units scale and resize accordingly. The spaces between polygons become meaningful if the highest-density unit is used as the

anchor, because the gaps represent discrepancy between the density in the anchor and other units. Thus, as with other cartogram types, the difference between the cartogram and the original map conveys information. Since each polygon scales down in place, this method also preserves polygon centroids.

The size of any enumeration unit does not relate directly to the region's data, but depends on the data distribution across all regions. Some regions may become too small and unrecognizable, and the resulting "sparseness" or lack of contiguity and map feel may render a non-contiguous cartogram unpreferable, or difficult to interpret or comprehend. In a study of cartogram effectiveness, users performed well on some task types using non-contiguous cartograms but did not appreciate them as much as some other types of cartograms (Nusrat et al., 2018).

3.2.5. Dorling cartograms

Dorling (1996) created an algorithm to make circular cartograms, which abstract each polygon to a circle, the size of which represents the data value. The circles may touch, but not overlap, and thus they shift if necessary. Thus Dorling cartograms abandon both shape and accurate topology, but can have zero cartographic error. They are popular on the web, especially through d3 implementations (Nusrat et al., 2018; Nusrat & Kobourov, 2016) – see Figure 6.

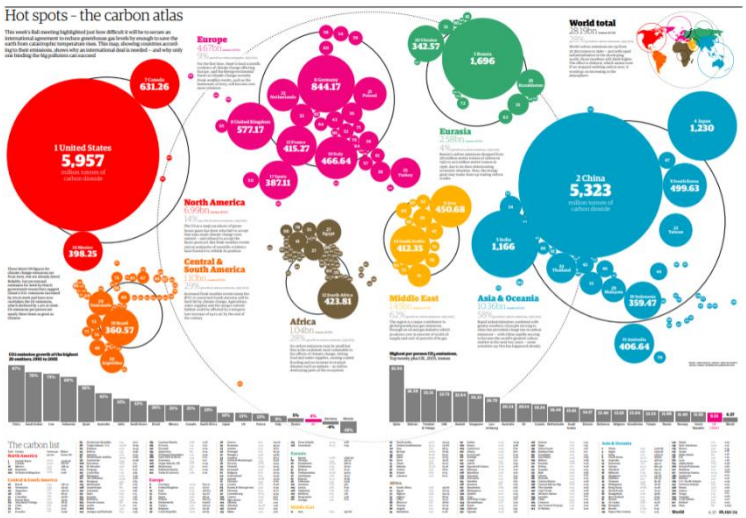

Figure 6: Circular cartogram published in The Guardian, showing countries as circles proportional to their carbon emissions (McCormick & Rogers, 2007).

Demers cartograms are similar to Dorling cartograms, but use squares instead of circles, which causes fewer gaps between regions (see Figure 7). While Dorling cartograms keep regions as close to their original location as possible, Demers cartograms often forego distance to preserve continuity between regions and visual cues (Demers & Bortins, 2002). Demers cartograms can be a special case of rectangular cartograms (Nusrat & Kobourov, 2016).

3.2.6. Mosaic cartograms

Sometimes confused with rectangular cartograms and tile maps, mosaic cartograms are configurations of multiple, congruent square, triangular, or hexagonal tiles connected at the edges. They have become popular in the media to show electoral and demographic data in the US and UK (Cano et al., 2015).

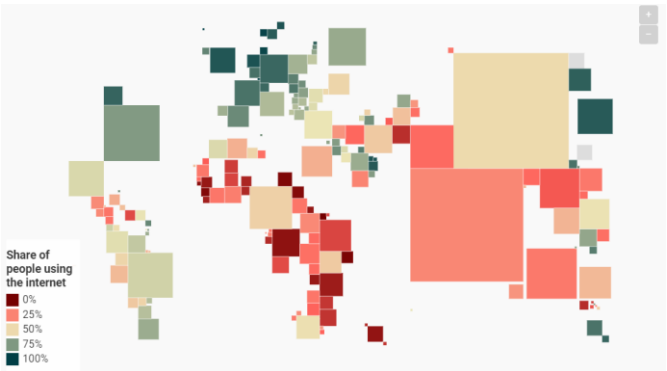

Figure 7: Demers-style cartogram of the world showing the share of people using the internet by country (Rost, 2018).

According to Cano et al. (2015), when mosaic cartograms are constructed with their methods, they can be a good alternative to rectangular cartograms; they maintain correct adjacencies and have very low or no cartographic error. These cartograms often maintain a schematized version of the input polygon's shapes, and allow users to accurately compare regions. The configuration of tiles represents the region, within which individual tiles represent the data (see Figure 8). So these maps require data that can be cast as small integer units, such as number of votes or people (Cano et al., 2015) – in general, data as absolute numbers, which is not the case for many SDG indicators.

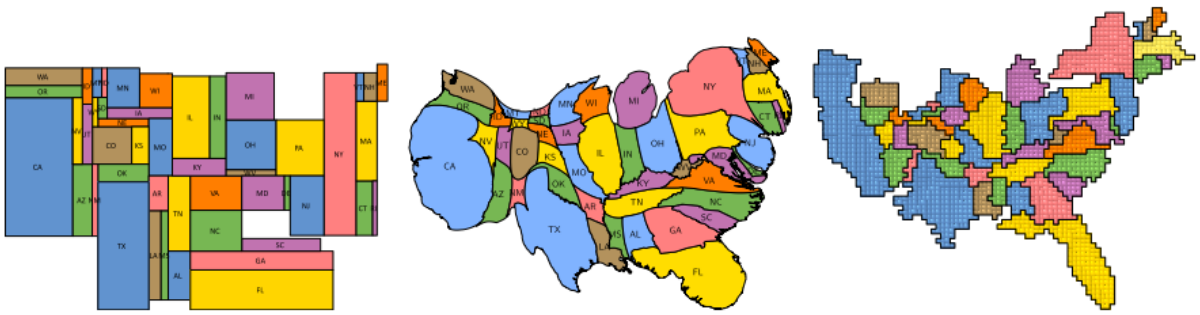

Figure 8: Rectangular, contiguous, and mosaic cartograms of the United States, showing businesses without paid employees. The mosaic cartogram uses one tile to represent 10,000 businesses (Cano et al., 2015).

3.3. Grid maps

A grid map, as described by Eppstein, Van Kreveld, Speckmann, and Staals (2015), is a simple spatially ordered treemap – a schematic representations of a geographic map where each map polygon corresponds to one aligned cell of the same size and orientation in a rectangular grid, for which "the main challenge is to find an association that allows a user to find a region in the grid quickly" (p. 101). The cells are associated with geographic regions in an optimised way (see Figure 9).

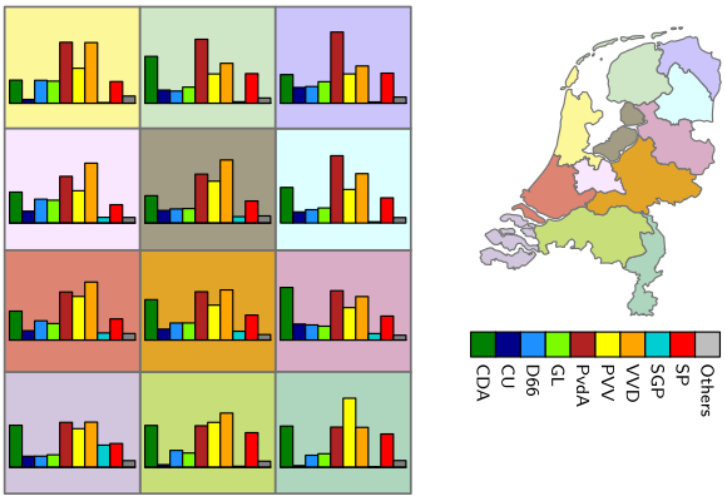

Figure 9: This grid map of the Netherlands shows the geographical map beside it, with the colour of each cell the same as the colour of the area it represents, overlaid with the data for election results in a bar chart (Eppstein et al., 2015).

All the polygons thus are squares of equal size and orientation, as in a mosaic cartogram (see next section), but they are all cells in a grid. In this way they are similar to tile maps, because all cells have the same weight on the map and the same space to show information, which may improve readability.

It is not likely that grid maps would be effective for use as world maps for SDG data because the shape and geography are completely distorted – but if exact geography and location are not the priority, then grid maps are one alternative for an abstracted map that provide each region with equal weight regardless of geographic area (Eppstein et al., 2015, p. 102).

3.4. Necklace maps

Speckmann and Verbeek (2010) propose the automated 'necklace map' as a novel thematic map type which overcomes some challenges that cartograms, choropleth, and proportional symbol maps present especially for small areas with large data values. The 2D input map is projected onto a 1D curve (the 'necklace') which encloses the boundary of the input map region such that each enumeration unit is mapped to a contiguous interval on the necklace and is represented by a symbol, usually a symmetrical shape, scaled proportionally to the data. Thus, the size and relative size of the symbol convey the data. A 'good' necklace map should preserve the spatial relationship between the symbol and represented region as much as possible; but it is more difficult to associate the symbol with the region than in other map types. Interactivity can mitigate this disadvantage (Speckmann & Verbeek, 2010).

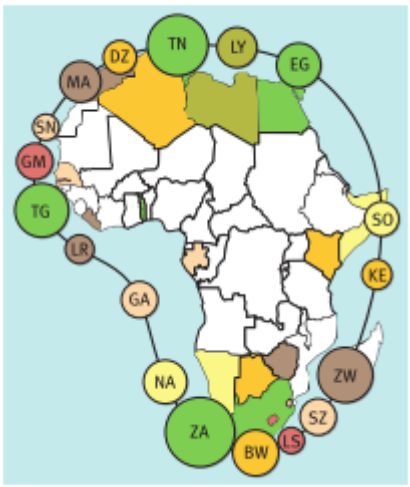

Figure 10: A necklace map of Africa showing the relative population of internet users in some countries (Speckmann & Verbeek, 2010).

A necklace map can have multiple and nested necklaces; multiple necklaces increases the chances that a symbol is placed near the region it represents and can be scaled to an appropriate size, and larger or clustered data sets may be better suited to be represented by multiple necklaces – but too many necklaces may cause too much clutter and loss of the structured appearance (Speckmann & Verbeek, 2010).

The necklace map is well-suited to visualize data disproportional to area, data that is only present for certain regions, and multivariate data (Speckmann & Verbeek, 2010) which could be beneficial in the case of SDGs and their indicators which are complex, interconnected, interdependent, and often incomplete (Speckmann & Verbeek, 2010).

The necklace map is uncluttered (compared to proportional symbol maps) but the necklaces show relative symbol size, and not absolute values, and thus values may not be distinguishable, especially as the proposed maps lack a legend (Speckmann & Verbeek, 2010).

3.5. Tile maps

Whereas the grid maps described above use one rectangular grid cell to represent an enumeration unit in a configuration that does not necessarily resemble the region boundary, tile maps (sometimes called tile grid maps, or even grid maps, but different from above) abstract each polygon to a single geometric tile in a configuration that retains local topology where possible, and thus somewhat resembles the original map and the user's mental model. Each tile is identical in shape and size, so this information is lost, but geographically large areas do not dominate or demand attention and smaller areas are equally visible. A tile map should map should preserve local relationships (topology), global position, and global shape where possible, but acknowledge that task-specific issues and users' previous knowledge also contribute to how they perceive geographic features and relationships. (Mcneill & Hale, 2017). Tile maps avoid the visual imbalance of choropleth maps and favour clarity over complexity when compared to cartograms, and work best for data where population is irrelevant (DeBelius, 2015).

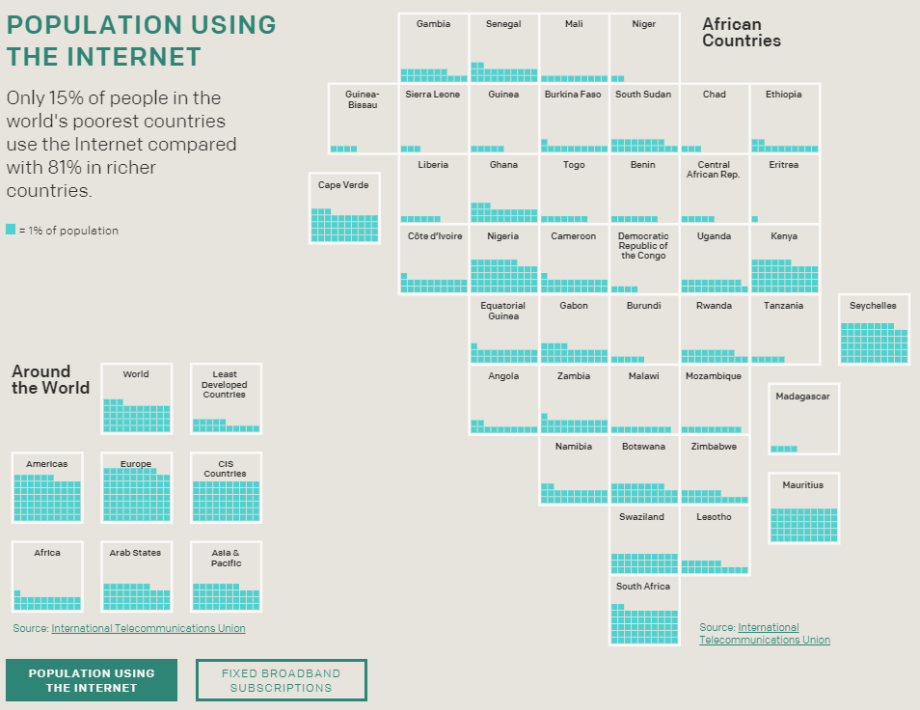

Figure 11: Tile map of Africa (ONE, 2018). Note some countries are missing. The statistic of population using the internet is shown through repeating squares

Tile maps may be still be suitable for SDG data to visualize the same indicator but tell a different story than choropleths and cartograms; different techniques can be used to show data atop the tiles, such as choropleth shading, symbols, or charts, such as in the "tile grid waffle chart map" (Schwabish, 2017b) from the ONE (2018) campaign to show how the internet can help end extreme poverty. This tile map shows the percentage of the population using the internet in some African countries, where the countries are represented by square tiles and each percentage point is a smaller square tile that takes up 1% of the area of the tile (see Figure 11). Figure 12 shows another example of a tile map of Africa, using a different basemap of square tiles. It shows deaths due to malaria in most African countries between 2000 and 2014; the data for each country is visualized as a time series graph on each tile (Richards, 2016)

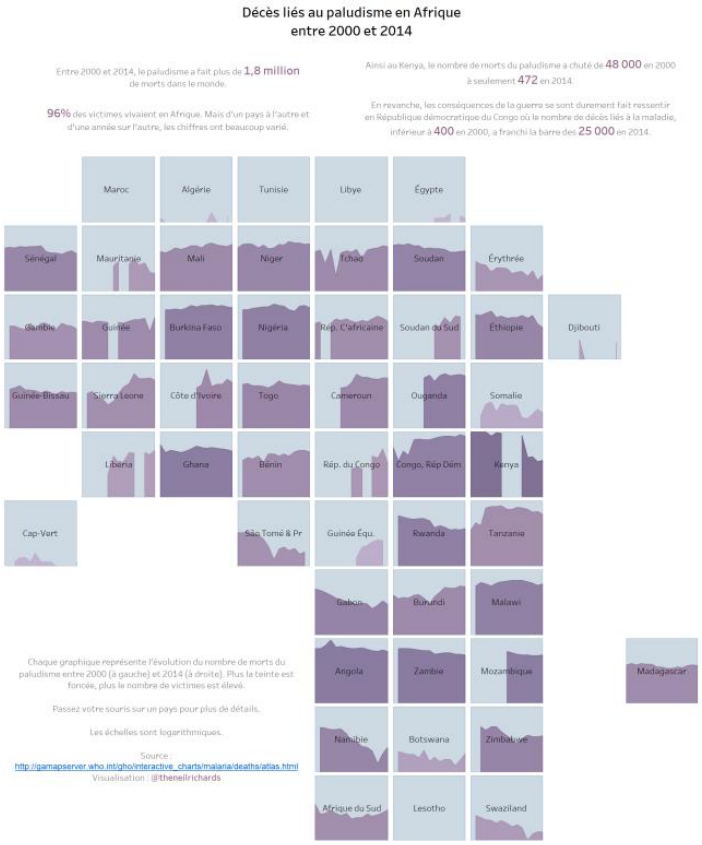

Figure 12: Tile map of Africa showing deaths due to malaria over time (Richards, 2016).

Tile maps are becoming more popular especially in the media, especially in the United States and are often animated or interactive (see, for example, Powell, Harris, & Cage (2014) in *The Guardian*, Berkowitz & Gamio (2015) in *The Washington Post*, and Tribou and Collins (2015) in *Bloomberg*). The uptake of tile maps is increasing, but Mcneill and Hale (2017) suggest their popularity is limited due to the lack of an automated procedure or tool to create them – several blog posts and websites discuss handcrafted tile maps (see DeBelius (2015)), with tutorials for how to create them in Excel, Tableau, or d3; the same maps tend

to be reused, which shows not a lack of demand but an effort required to produce them. Conversely, different designers and tools produce differing configurations and basemaps with inconsistencies in their geographies (see Figures 11 and 12 for examples of different tile basemaps of Africa). the above images show examples of different tile configurations for the same region. A popularized example of a world tile basemap available for free use, which has been reproduced and adapted for the study in this research, was made in Excel by Schwabish (2017). Given the inconsistencies in tile maps, Wongsuphasawat (2016) proposed quality metrics for tile maps based on how much they look like the original map, their topological accuracy, inaccuracy (invalid neighbours), misdirection (relative positions), and area or compactness (rows and columns).

To address and reduce the manual labour, required time, and inconsistencies in tile map production, (Mcneill & Hale, 2017) propose an algorithm to generate tile maps from raw shape data of contiguous areas, implemented in a browser-based application but this tool is not freely available yet to use.

Their algorithm creates and ranks several 'candidate' tile maps, allowing the user to select the most appropriate. The user can weight the criteria, and the total cost for each tile, as well as the cost per each criteria per tile, are displayed on the map, providing a semi-automated approach to tile-map creation so that "here, the automatic step does do all the hard work and the user need only browse the candidate tile maps" (Mcneill & Hale, 2017, p. 437).

Tiles representing states are usually square but hexagons, or circles may also be used. Square and rectangle tiles facilitate comparison across tiles due to their "rigid grid layout" and "from an aesthetic perspective, the clean, simple appearance of tile maps is notable" (Mcneill & Hale, 2017, p. 435). This visualization style allows for creativity in ways that others don't; some designers even use irregular but congruent shapes for the tiles, such as sheep (FlowingData, 2015).

Mcneill and Hale (2017) suggest the best tile map balances making and removing space and maintaining global shape, but that this balance will depend on geography and task. User studies can help understand how adjacency, relative orientation, global shape, and other properties relate to human judgements of the accuracy of tile maps, which will further depend on personal preferences and previous knowledge and experiences given "the subjective nature of the problem" (Mcneill & Hale, 2017, p. 442).

3.6. Value-by-alpha maps

To address the limitations of all cartograms caused by distortion, (Roth et al., 2010) suggest value-by-alpha maps as an alternative thematic mapping technique. Value-by-alpha maps visually equalize the basemap by varying the alpha channel (translucency) instead of the area of each enumeration unit according to an equalizing variable, preserving geography, and thus preserving both shape and topology. Larger alpha values mean higher opacity and less transparency, so enumeration units with low values of the equalizing variable disappear into the background, and areas with high values stand out.

Using the choropleth shading technique, another variable can be layered onto the visually equalized basemap. Comparison between value-by-alpha maps is easier than between cartograms because size, shape, and topology are constant. These maps allow for smaller and more numerous enumeration units than cartograms (Roth et al., 2010) (if the data are available on that scale).

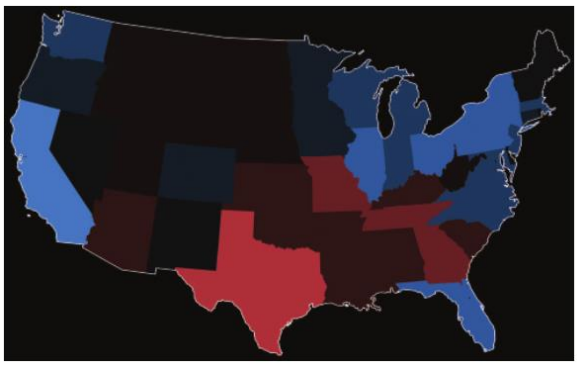

Figure 13: This value-by-alpha map shows the results by state of the 2008 USA presidential elections, with state population as the equalizing variable (Roth et al., 2010).

Cartograms are effective for emphasizing few and extreme geographic disparities, whereas value-by-alpha maps are better to portray a more holistic view of complex or subtle spatial phenomena. They are not ideal for users to make numeric estimates about the equalizing variable, because it is easier to estimate value from size (as in a cartogram) than from other visual variables (Roth et al., 2010). One study comparing usability of cartograms, value-by-alpha maps, and proportional symbol maps found that value-by-alpha maps are as effective and efficient as cartograms but less so than proportional symbol maps, and that users prefer proportional symbol maps and value-by-alpha maps to cartograms – probably in part because cartograms are less familiar or common in the culture of the participants in the study (Gao, Li, & Qin, 2018).

3.7. Pictorial symbols

In the 1920s Otto and Marie Neurath and Gerd Arntz created an international picture language to visually represent social facts to uneducated, working-class populations which came to be known as Isotype (International System Of TYpographic Picture Education). The aim was to provide a visible, tangible, and easily and universally understandable form to political and social ideas (Blau, 2006; Haroz, Kosara, & Franconeri, 2015). These pictorial statistics used simple, minimally coloured symbols or icons as units representing fixed quantities, repeated in specific configurations, with some verbal explanation to portray the data in a striking and interesting way – a "modern hieroglyphics" (Neurath, 1974; Haroz et al., 2015). The system is not widely used anymore for information visualization (Mayr & Schreder, 2014) and has been largely dismissed in data visualization and HCI but Arntz's highly recognizable symbols are still used in traffic icons, signs, and warning labels (Haroz et al., 2015).

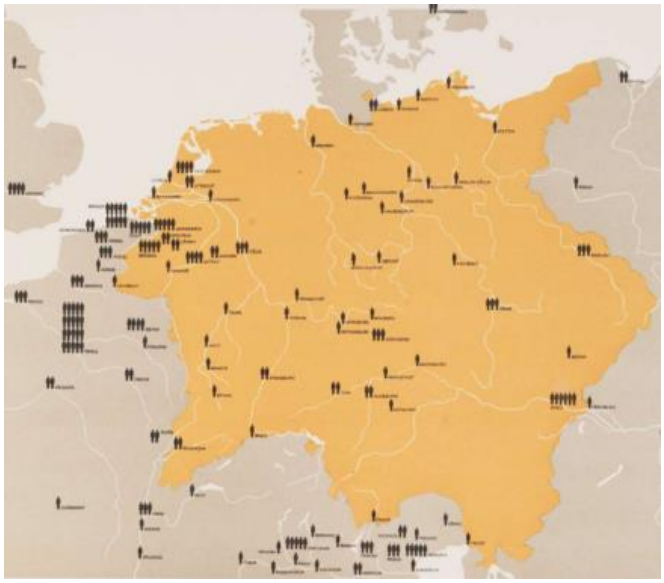

Figure 14: An isotype map, shown in (Mayr & Schreder, 2014).

The aim to make information pictorial and therefore more easily and universally accessible is admirable, but is also a positivist, a rational and scientific approach to visual rhetoric that considers readers to be universal in their interpretation (Kostelnick, 2007). As the creators came to realize as their work became more international, what was applicable in one context and "international for western man only" was not always immediately understood or recognized in another, for example in Nigeria (Neurath, 1974, p. 147).

3.8. Embodying the data

Feminist cartography adopts an epistemology of embodiment and acknowledges different modes of production, cartographic media, and "geometries of experience" (Huffman 1997, p. 267). D'Ignazio and Klein (2016) outline a framework for feminist data visualization, of which one principle is to "legitimize embodiment and affect" (p. 3) and to validate the experiences that arise from sensations and emotions as valid ways of knowing, equally important as more quantitative knowledge, understanding, and experience. Dragga & Voss (2001) write about the need to humanize technical illustrations, to bring sensitivity to the human aspects of statistical graphics because they are "never objective representations of reality, but socialized constructions of multiple subjective interpretations of available filtered evidence" (p. 266). By "omitting the human misery" (p. 266) a visualization distorts reality and escapes the statistics, indifferent to the human condition it portrays. Pie graphs, maps, bar charts, and other visualization types may neutralize human fatalities, injuries, and other grievances. In pictographs, pictures or images are conventionally used to make visual information engaging and accessible, but not out of ethical or humanistic concerns (Dragga & Voss, 2001).

Dragga & Voss (2001) suggest "appropriate" pictographs (rather than photographs of disfigured humans) as one method visualize the human condition in a thoughtful way in a technical visualization. If to embody data is to make it tangible or visible, and if communicators should seek to "humanize the visual display of information" (Dragga & Voss, 2001, p. 269) then one way to do so in maps depicting SDG indicator 5.3.2 is to create and use a distinguishable pictorial icon or symbol to express the data, rather than only a visual variable, such as colour, which was used in the choropleth map.

Based on the thematic map types discussed in this chapter, one way to embody the data be to combine a pictorial symbol or icon, with the tile map in the style of Figure 11 from the ONE (2018) campaign which uses a smaller tile within each square to classify 1% of the population. A meaningful or appropriate symbol, instead of an abstract square, could represent the data and the issue while challenging traditional definitions of a map. The creation and application of this map are discussed in Chapter 4.

3.9. User studies

This section reviews recent studies evaluating aspects of usability - effectiveness, efficiency, and/or satisfaction – of cartograms and other thematic map types, and studies of emotions that maps evoke.

3.9.1. Cartogram usability studies

Kaspar, Fabrikant, and Freckmann (2011) found in their study on spatial inference making with contiguous value-by-area cartograms that effectiveness (accuracy of responses) and efficiency (speed of responses) depends on task complexity and the shapes of enumeration units. For simple tasks, cartograms are as effective and efficient as combined choropleth and graduated symbol maps. Overall, however, a choropleth map with graduated symbols was more efficient and effective than the cartograms when analyzing census population data. Participants had difficulty answering complex questions, especially when integrating two visual variables (colour and size), but performed equally well with cartograms and choropleth maps on complex tasks when enumeration units were irregular shapes.

In their study with metrics-based, task-based, and subjective evaluations of the effectiveness of four cartogram types, Nusrat, Alam, & Kobourov (2018) compared the effectiveness of Dorling, rectangular, contiguous, and non-contiguous cartograms. Users who were familiar with cartograms took longer to perform tasks, possibly because of deeper engagement. Overall, rectangular cartograms performed

distinctly worse than the others; the authors suggest this difference may be due to severely distorted regions and relative positions. Non-contiguous cartograms performed well on metrics- and task-based evaluations but did not rank as well in users' subjective preferences and attitudes, likely due to lack of contiguity. Contiguous and Dorling cartograms performed well on all evaluations.

Comparing the usability of two types of value-by-alpha maps (black background and white background), bivariate cartograms, and bivariate proportional symbols maps, Gao, Li, and Qin (2018) found value-by-alpha maps and bivariate area cartograms to be nearly similar in effectiveness and efficiency, but value-by-alpha maps were significantly less efficient and effective than bivariate proportional symbol maps. Users preferred value-by-alpha maps and bivariate proportional symbol maps equally, over bivariate area cartograms; the cartogram "was abandoned because it was not common enough in the culture of the subjects" (Gao et al., 2018, p. 14).

Sui and Holt (2008) explored the effectiveness of cartograms as analytical and visual tools in public health applications given the field's low "cartodiversity" (p. 4). They embrace cartograms through a synthesis of three paradigms of maps: maps as images, maps as models or computational tools, and maps as social constructs, and conclude that "a comprehensive understanding of cartograms must include cognitive, analytical, and critical dimensions" (p. 3). They believe that cartograms heighten users' sensitivity to critical aspects of maps and mapmaking, reminding users that maps are consciously human made; "the use of cartograms vividly demonstrates that maps are neither the world nor an objective record of our world experience, but, rather, a means whereby we come to understand aspects of it…because cartograms transform space in many interesting ways, they may have a significant impact on our view of reality" (p. 15).

3.9.2. Subjective responses to maps

In an evaluation of value-by-area cartograms, Dent (1975) used semantic differential scales to test reader attitudes and responses towards the maps. These qualities categorized as general attitudes ("valuable/worthless", "truthful/misleading", "good/bad", etc.); appearance ("complete/incomplete", "innovative/conventional", etc.); and readability ("easy to read/difficult to read", "communicates idea/does not communicate idea", etc.) (p. 163). The technique was relatively new in cartographic research at the time and had not been applied to cartograms. Nusrat et al. (2018) used this technique in their comparison of the effectiveness of cartograms to measure attitudes. A similar technique is applied in the study in this research. Gilmartin (1978) found "subjects are able to respond subjectively to maps" (p. 138) and that the semantic differential technique, in gauging user reactions to thematic maps, is sensitive to perceived differences in design characteristics between maps.

3.9.3. Emotions and data visualization

Harrison, Chang, and Lu (2012) found that affective priming can influence graphical perception and visual judgement. In the study, participants were given either a positive or negative story to read before performing graphical perception tasks involving quick visual judgements. The findings suggest significant differences in graphical perception abilities between groups, where participants with positive priming generally performed better than those with negative priming, though negative priming also affects performance. They note that priming may unintentionally occur if data content is already strongly emotional or high stress.

In the Seeing Data project, Kennedy and Hill (2017) asked participants focus groups of non-experts to evaluate visualizations from the media. Participants experienced significant emotional reactions and feelings in engaging with both the data and visualizations, including the subject matter, design and style, source, and their own ability to make sense of the visualizations. The authors argue that emotions matter – that rational reactions are insufficient to describe everyday engagement and experiences with data, and that emotions are vital in understanding "the social world of data" (p. 13).

3.9.4. Emotions evoked by maps

Research on affective and emotional properties of thematic map types is limited. Some research has looked at emotional responses to aesthetic properties of maps. Colour is a highly emotional visual variable and some recent research in cartography has reviewed some of its emotional and associative properties (Weninger, 2015). Fabrikant, Christophe, Papastefanou, and Maggi (2012) asked how human emotion and affect interact with cognition and perception of spatio-temporal inference making with visuo-spatial displays. They used mixed methods to capture human emotive responses to topographic maps with various colour schemes, and found that emotional responses can validate using unconventional colour schemes on topographic maps.

Skarlatidou, Wardlaw, Haklay, and Cheng (2011) studied users' emotional responses to colours on maps, focussing on trust, to better understand what and how attributes of Web GIS applications influence the trust perceptions of non-expert users. In one study, participants rated eight basic emotions including trust on Likert scales for each of four thematic maps. Results indicated that users found separating emotional responses to the colours and subject matter difficult to separate. Results of other studies indicate that interface design can improve users' trust.

Gilmartin and Lloyd (1991) studied the effects of world map projections and distances on users' emotional involvement with places on the maps. Their results support the hypotheses that higher distance is related to lower emotional involvement and that females express higher emotional involvement than males. They suggest these findings are significant in understanding the importance of how maps communicate to readers about places around the world – maps in schools and the media that use projections which exaggerate global distances may contribute to people being less interested in some places than others.

Barford (2017) used world cartograms and visualizations depicting inequality with individuals from the UK, Mexico, and Kenya to understand emotional responses to inequality. The visualizations influence the discussion and users' perceptions – for example, she notes the users from Kenya seeing a cartogram where Kenya is hardly present as amusing: "that Kenya is not visible on a map of high earnings could be funny due to a similar combination of ridiculousness and powerlessness. Firstly, seeing one's country missing from a world map is bizarre. Unexpected occurrences or actions are often used to provoke laughter, and this map had the same effect" (p. 33).

Döll (2017) suggests cartograms about climate change and its impacts could trigger emotions, particularly "moral emotions" because "visualizations of human exposure may be expected to lead to emotions such as compassion for those that are shown to be affected by potential negative impacts" (p. 1192). Döll (2017) calls for empirical studies on the capability of cartogram types to trigger moral emotions while conveying complex information.

Van Lammeren, Houtkamp, Colijn, Hilferink, & Bouwman (2010) found that visualization techniques influence users' perception of the quality of the visualized environments, which cannot be deduced directly from the visualizations, but are construed from memory and associated affect. Their study comparing 2D and 3D visualizations of land use planning scenarios found users of the 3D visualization had more positive perceptions and higher affective appraisals of environmental quality.

3.9.5. Symbols, icons, and pictographs

Haroz, Kosara, and Franconeri (2015) found that pictographs tempt readers to inspect a visualization more closely and can help them remember information during challenging tasks. Boy et al. (2017) studied whether anthropographics (representations of abstract data with icons of people) elicit empathy in users, for example in information visualizations of human rights and humanitarian atrocities, and found that the outcomes were similar to those from standard charts. They suggest that when graphics are part of an emotive narrative, they can "afford to be abstract" (p. 5471) but that anthropographics are not detrimental and their potential should be further explored, for example for attracting users' attention and drawing them into a narrative.

4. RESEARCH OBJECTIVE II: USER STUDY

The overarching research question in this study was: how are users' emotions and attitudes affected by engaging with thematic maps and an SDG indicator about female genital mutilation?

The objective of this study was to measure users' affective states before and after they viewed three thematic map types portraying the same indicator, and to collect information on self-reported emotions, task responses, attitudes, and comments towards the map types and data.

The three map types are choropleth, cartogram, and repeated icon tile map. The data set is SDG indicator 5.3.2, "the proportion of women and girls aged 15-49 who have undergone female genital mutilation/cutting" from the SDG 5, to "achieve gender equality and empower all women and girls) (United Nations, 2017).

Table 2: The map types and data tested by each user.

Visualizations tested with each user	*Map type*		
	Choropleth	Tile map with icon	Cartogram
SDG indicator	5.3.2.	5.3.2	5.3.2

This indicator was chosen because it is (to this researcher) unsettling and striking, which may make it more emotionally probing. It was also chosen to draw attention to an issue affecting women and girls that is not commonly discussed in western countries and of which not all people are aware. To focus on the affective properties of the maps rather than the indicator alone, participants were not given any other information about FGM/C.

Information on affect and emotion was collected through PANAS and users' comments to open-response question. Tasks for each map were multiple-choice questions. Information on participants' attitudes towards map types was collected through Likert scales to rank map qualities and through open-response questions. Demographic information and prior knowledge about FGM was collected through multiple choice questions and open-repsonse questions (see Table 3 for a summary of these methods).

Table 3: The data collected and methods used in the online survey.

Data collected	*Affect and emotion*	*Task responses*	*Attitudes*	*Demographics and prior issue knowledge*
Collection method	PANAS, comments	On-screen visualization-based tasks (multiple choice questions)	Likert scale ratings of map attributes, comments	Multiple choice questions, comments

4.1. Data and visualizations

The visualized dataset was was indicator 5.3.2, the proportion of women and girls aged 15-49 who have undergone female genital mutilation/cutting. The data is available from the UN SDG Global Database for 27 African countries, Yemen, and Iraq. Since data is mostly available for countries in Africa, maps of Africa were produced for the study. The shapefile of country borders and population are from Natural Earth (Natural Earth, 2018) and did not account for contested borders.

Table 4: Data, and their sources, used to create the maps for the study.

Data	**Description**	**Source**
Country borders	Shapefile of the world – 2018 country borders	Natural Earth
Population	Country populations – used for cartogram creation/distortion	Natural Earth
SDG Indicator 5.3.2	Proportion of women and girls aged 15-49 who have undergone female genital mutilation/cutting	SDG Global Database

4.1.1. Data limitations and quality

FGM prevalence and type varies within and between countries and regions. For many countries subnational data is available, but this level of detail is outside the scope of SDG indicator data, as SDG data is available per country. Thus the maps in this research and data do not show spatial or ethnic prevalence variation within countries, though this data may be available from other sources. The indicator is the proportion of women aged 15-49 who have undergone female genital mutilation/cutting. But FGM primarily happens to girls between ages zero and 15 (World Health Organization, 2008); in half the countries with data, majority of girls who undergo FGM are mutilated before age five; but in most countries more middle-aged women than adolescents have been subjected to FGM/C (UNICEF, 2013).

Thus, the SDG indicator does not show the current prevalence in children. Furthermore the WHO identifies four types of FGM (World Health Organization, 2018) according to the extent of the mutilation/cutting, and the SDG indicator does not disaggregate according to type of FGM.

The data are not complete. The map titles indicate that the data is from 2004-2016, because in the SDG indicator dataset, each country had one data point from a year in that range. So the maps are showing inconsistent data. Data in the dataset is also only available for the African countries indicated on the maps and Yemen and Iraq, though FGM has been reported to occur elsewhere.

4.1.2. Maps types used in the study

The user study in this research presents users with three map types: cartogram, contiguous cartogram, and tile map with repeating icons. The choropleth (see Figure 15), a standard thematic map, is used mainly as a baseline or comparison because its wide use and general familiarity. The choropleth map was made with ArcMap and Adobe Illustrator. The colour scheme is from Color Brewer (Brewer, Harrower, & The Pennsylvania State University., 2013).

A cartogram was used because of its popularity. Among cartogram types, users seem to prefer contiguous and Dorling cartograms, possibly due to their familiarity from media. Users also show higher performance on tasks with these types of cartograms (Nusrat et al., 2018). The study used a contiguous Gastner-Newman cartogram with countries distorted by population and coloured, as in the choropleth technique, according to the statistic of interest. The population cartograms were made with the cartogram geoprocessing tool installer for ArcGIS by contributor CarolAPL, available on the ArcGIS website. The tool creates density-equalizing (contiguous) cartograms based on the Gastner-Newman algorithm (CarolAPL, 2016).

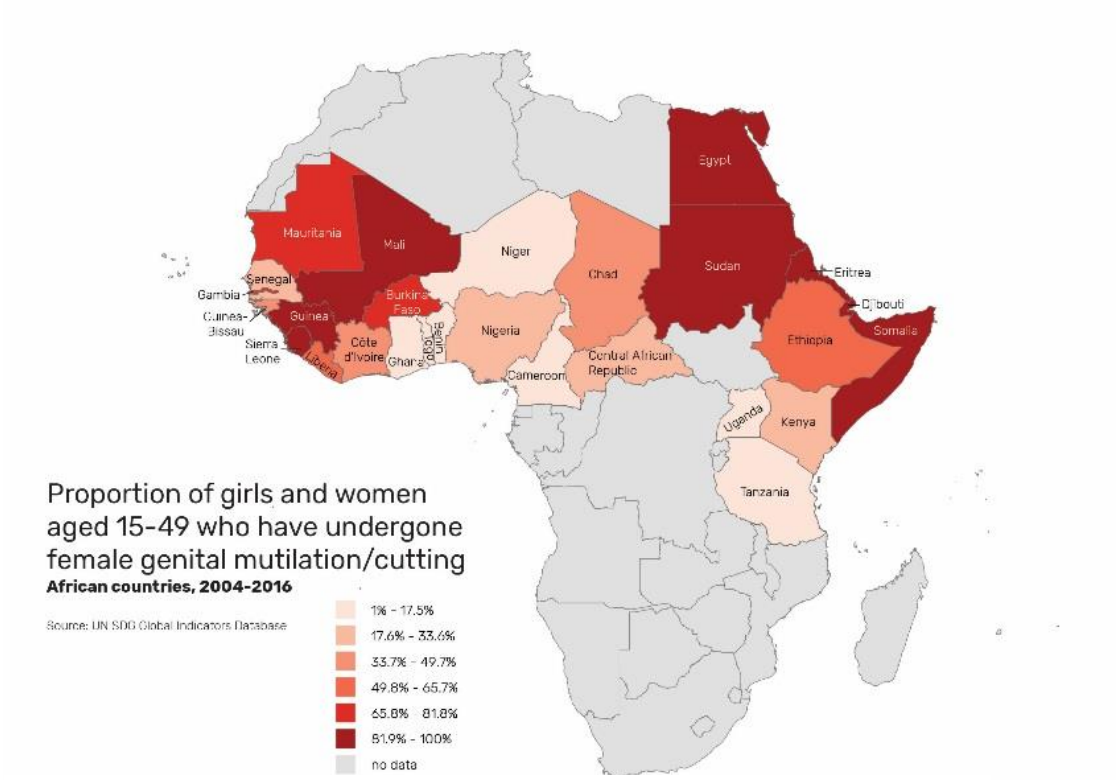

Figure 15: The choropleth map used in the study.

The tile map with repeating icon combines ideas from the tile map, the "tile grid waffle chart" and isotype repeating symbols, to produce a map in which the data is embodied through a scissors symbol that may draw attention to the actual issue rather than abstracting it to a colour or geometric shape.

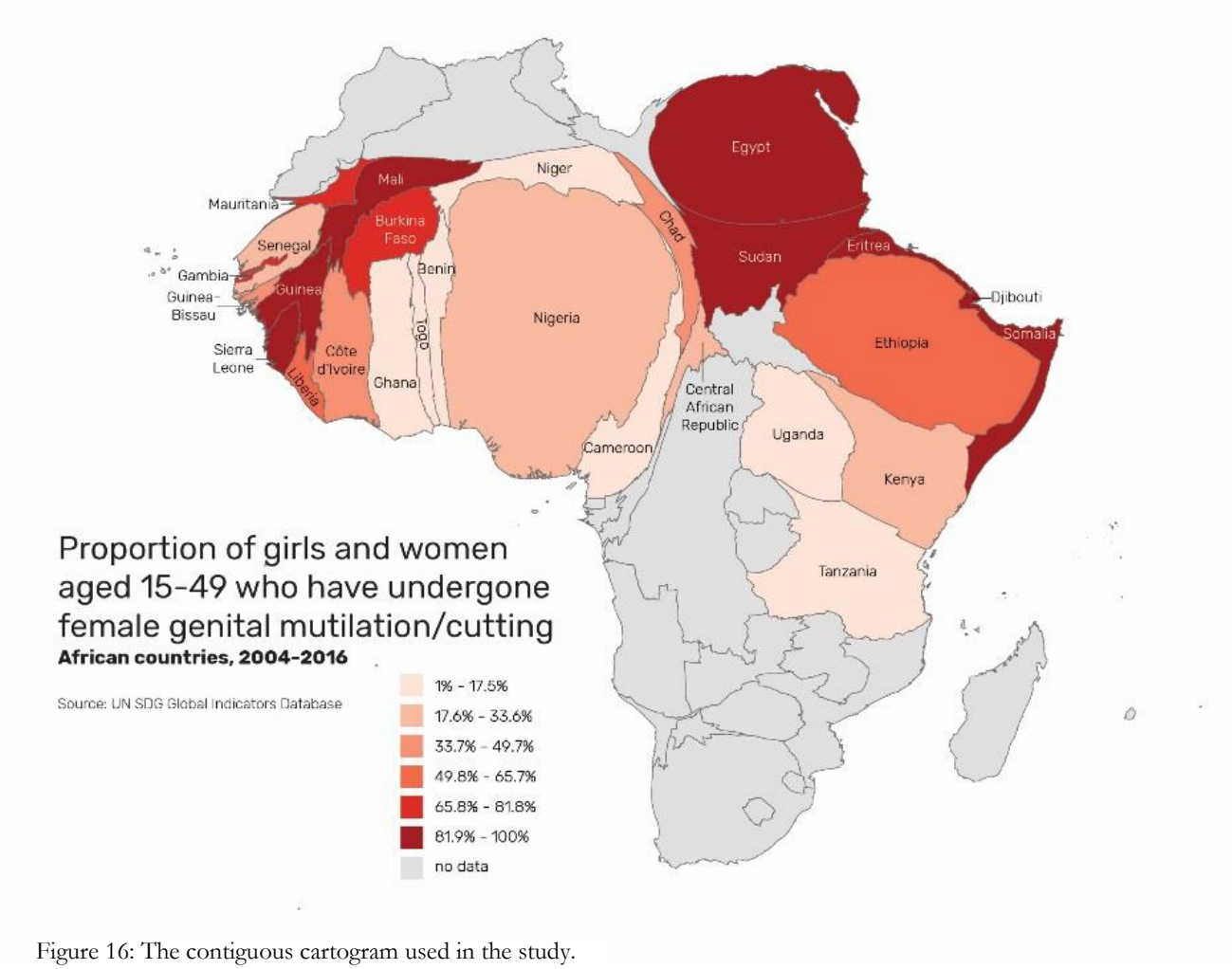

Figure 16: The contiguous cartogram used in the study.

The tile map in this study is inspired in part by one participant's work at the SDG DataViz camp at the University of Twente's Design Lab from 28 May to 1 June, 2018. Facing the challenge of geographically (or quasi-geographically) visualizing SDG data in cartogram and/or repeating symbols, one participant, Marieke Abbink, adapted an existing square tile map of South America from Schwabish (2017) to visualize SDG indicator 5.5.1, the proportion of seats held by women in national parliaments by designing and repeating an icon. She created an icon to represent women in parliament.

I adapted this idea for this study by recreating the base tile map in Illustrator and rearranging some tiles, i.e. those representing island countries. I designed the scissors icon in Illustrator by adapting a scissors icon in the Maki icon set (Mapbox, 2018).

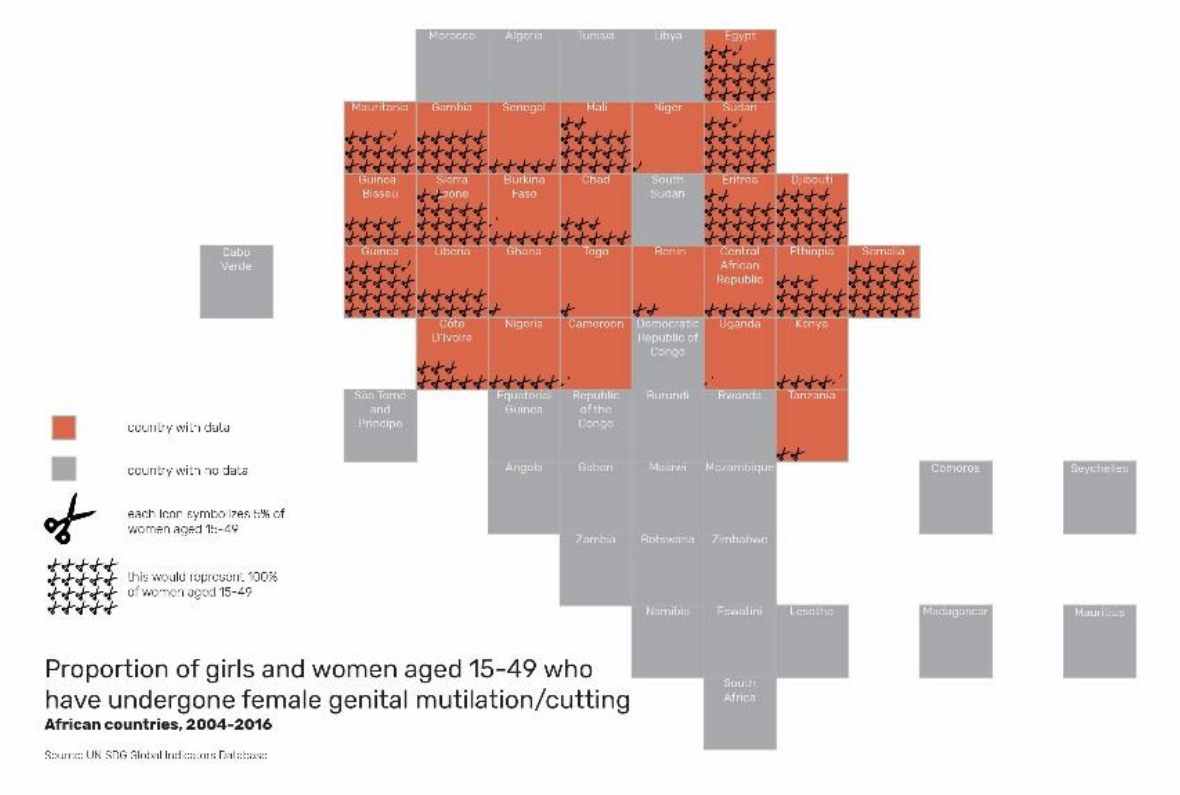

Figure 17: The repeating icon tile map used in the study.

4.2. Methods and procedure

The online survey was designed with SurveyMonkey because the Geo-Information Processing department at ITC has a subscription to the service and prefers to keep surveys and data centralized through it. The survey was open for approximately 2 weeks and took approximately 20 minutes to complete.

The survey opened with an introduction about the study on the first page. On the next page the participant completed the first Positive Affect and Negative Affect Schedule (PANAS) as the baseline self-report of affect (emotion). The third page provided information about the map types with example map images of each map type. The fourth page introduced the dataset and indicator 5.3.2 and had an open question to gauge the user's prior knowledge or awareness of female genital mutilation/cutting. The fifth page showed any of the three maps with two multiple-choice tasks (the maps were presented in random order throughout the study). The user was requested to take a minute to explore the map before completing the two tasks below the map image. On the sixth page the participant completed the second PANAS. The next four pages alternated between the two remaining maps/tasks and two PANAS. On the eleventh page, the participant was shown the three maps together, and rated each map separately by marking seven qualities on a 5-point scale from "strongly disagree" to "strongly agree" and any additional comments. This page also asked two open-ended questions referring to all the maps together about participants' emotions experienced through the study and what questions they had from the maps. The last question page had a brief demographics questionnaire about gender, age range, nationality, country of residence, occupation or field of study, and experience in a geo-related field. Screenshots of the full study are in the Appendix.

The participants viewed the maps in random to counter potential learning bias or any effect that a particular viewing order might have, which could affect users' responses to tasks and PANAS. Though

they completed PANAS four times only the first and last were analyzed due to a limitation in SurveyMonkey's randomization feature which does not record the order of maps each participant saw, so each PANAS could not be associated or identified with a particular map.

Table 5: Structure of the online survey.

Survey structure		
Page	**Content**	**Format of questions/responses**
1	Introduction to the study	N/A (text only)
2	PANAS form	20 rows of Likert scale rankings
3	Information about map types with examples	N/A (text and images only)
4	Information about data set and issue engagement/awareness questions	1 open comment
5	Map #1 with tasks	2 multiple choice tasks
6	PANAS form	20 rows of Likert scale rankings
7	Map # 2 image with tasks	2 multiple choice tasks
8	PANAS form	20 rows of Likert scale rankings
9	Map #3 image with tasks	2 multiple choice tasks
10	PANAS form to complete	20 rows of Likert scale rankings
11	Attitude questions and comments	7 rows of Likert scale rankings and 1 comment box, for each of 3 map types; 2 open, summary questions
12	Demographics questions	Four multiple choice and two open comment questions

A convenience sample of participants was recruited through snowball sampling, email and Twitter. Invitation emails were sent to some students and faculty at the ITC and the Erasmus Mundus Cartography MSc. program, and members of the International Cartographic Association's Commissions on Cognitive Issues in Geographic Information Visualization; Use, User, and Usability Issues; and Visual Analytics. One professor at ITC also tweeted the study link. Participants did not receive compensation.

4.3. Data collection

4.3.1. Self-reported affect: Positive Affect and Negative Affect Schedule (PANAS)

The 10-item PANAS are self-reporting scales comprising two terms from each of five triads where the subjects rate each adjective on a five-point scale according to how they feel during the specified time frame. When used in a short-term time frame, such as "right now" or "today", the scales also are "sensitive to fluctuations in mood" (Watson et al., 1988, p. 1069). PANAS has been found to be reliable and valid for measuring positive and negative affect (Watson et al., 1988) and demographic variables have been found to have "only very modest influences on PANAS scores" (J. R. Crawford & Henry, 2004, p. 245). Participants completed PANAS four times: once at the beginning of the study (page 2) and again after using each of the three maps.

4.3.2. Tasks

Participants were asked to take one minute to observe each visualization before completing the tasks. The tasks were designed for users to engage with the map content and design, more than to test map usability. Tasks were limited to two closed-response, multiple-choice questions per map to minimize participant fatigue. The specific wording of the tasks for each map can be seen in the screenshots of the survey, in the Appendix.

To avoid participant fatigue and given the nature and overall objective of the study, the tasks were not designed to be cumbersome, numerous, or difficult, but to engage users with the maps and data. The tasks were consistent for the maps and combined aspects of locate, find top-k, and compare tasks from the task taxonomy (Nusrat & Kobourov, 2015). The first task named a specific country and users to find the proportion of women and girls aged 15-49 who had undergone FGM/C there, with four answer options. The second question asked users to select from four countries the one with the highest or lowest proportion.

These tasks drew in part from the taxonomy of cartogram tasks proposed by Nusrat and Kobourov (2015), a framework of ten analytic cartogram task types, which are adapted from multiple cartography and information visualization task taxonomies, and which can be used for evaluating various cartograms. While they do not discuss tile maps, this study extends these task types to the tile maps because tile maps also distort area by making all regions equal, thereby also distorting topology; and for consistency, to the choropleth maps.

4.3.3. Attribute ratings and attitudes

On page 11, users ranked the following qualities on Likert scales from "strongly disagree" (1) to "strongly agree" (5), with 3 as "neutral": *interesting, truthful, symbolizes information well, shows relative values clearly, easy to understand*, and *emotional*. This information was used to collect subjective information on attitudes and preferences towards the maps.

This method was adapted from the semantic differential technique used by Nusrat, Alam, and Kobourov (2018) in their evaluation of cartogram effectiveness, which has been used by others to evaluate cartograms and thematic maps (Dent, 1975). Semantic differential and Likert scales are prominent verbal scales (Agarwal & Meyer, 2009). The semantic differential technique uses pairs of opposite words or phrases on a scale, on which users select the position that represents their attitude (Nusrat et al., 2018). Due to limitations in SurveyMonkey functionality a Likert scale was used as an adaptation of the semantic differential technique, with some adjectives borrowed from Nusrat et al. (2018).

Participants could supplement their ratings of each map type's attributes with comments about the map. They also answered two open-ended questions on page 11:

1. Looking back at your thoughts and feelings during this study, what emotions did you experience while viewing these maps and the issue they portray?
2. Looking back at your thoughts and feelings during this study, what questions do you have from the maps?

These questions probed users to elaborate on their emotions that PANAS captured, and allowed them to share additional information about their experiences during the survey.

4.3.4. Participant information

On page 4, participants indicated whether they had used each of the three map types, and about their familiarity with the issue of female genital mutilation/cutting. On page 12 they completed a demographics questionnaire about their gender, age, nationality, country of residence, field of study or occupation, and background in geo-related fields.

4.4. Results

4.4.1. Participant information

64 people participated in this study, of which 55 completed it, in that they reached the end of the survey. The results and findings here and in Chapter 5 draw only from these 55 responses.

All but one participant responded about their gender. 27 (half) identified as female; 26 (48%) identified as male and one (2%) chose the response "I prefer not to answer". Half the respondents were between 18 and 34, and half were over age 34. The largest group was age 25-34, with 25 participants.

All participants had used choropleth maps before. 48 (87%) had used cartograms before, and 22 (41%) had used tile maps before. 54 participants were from 23 nationalities living in 14 countries, with the highest numbers living in Germany (17) and the United States (9).

53 participants responded to the question about their occupation or field of study. Of these, 28 participants mentioned a professional or educational background related to cartography, geovisualization, geomatics, geography, or GIS. Nine mentioned being researchers, lecturers, or professors. 43 participants mentioned higher education or work experience in a geo-related field, such as cartography and GIS.

4.4.2. Familiarity with FGM/C

47 participants answered the open-ended question "What do you feel, know, or think about female genital mutilation/cutting?" Their responses were thematically coded using the following codes that emerged from themes in their responses: neutral, culture, unaware, Africa, human rights, women/girls, detail, against the practice, negative emotion/feeling. Several responses were assigned more than one code. The majority of responses indicated they felt something negative, such as sadness, anger, or humiliation, and/or that they disagreed with the practice or thought it was wrong. Three of the respondents indicated that they did knew nothing or very little, while the others all indicated some knowledge or feeling against it. The codes assigned to these comments were: neutral, culture, religion, unaware, Africa, human rights, women/girls, detail, against the practice, and negative emotion/feeling. The breakdown of the codes by comments is in Figure 18.

The 'detail' code was assigned to responses that addressed the issue in several words and expressed some more thought than most of the answers which were very brief and only a couple words. For example, 'detail' was assigned to this response, from Participant #3:

"Feel: It is a horrific practice; absolutely unacceptable. Know: There are regional clusters where female mutilation is acceptable. I have read several reports that focus on incidents and practices in Africa. Think: I don't want to think about it, and that probably is a negative in terms of global citizenship. I do think at times external interventions/ development relief are not as effective as they could be"

The above response was also coded Africa, against the practice, and negative emotion/feeling.

While many responses indicated a negative feeling towards the practice, only those that actually suggested the practice itself was wrong, abhorrent, or a similar word were coded as 'against the practice', while those indicating a negative emotion were coded with 'negative emotion/feeling'.

For example, a response that was coded with "against the practice" and "human rights" was "it hurts, its wrong, its inhuman, results into lifelong disability" while coded only as "negative emotion/feeling" was the response "nervous, disturbed".

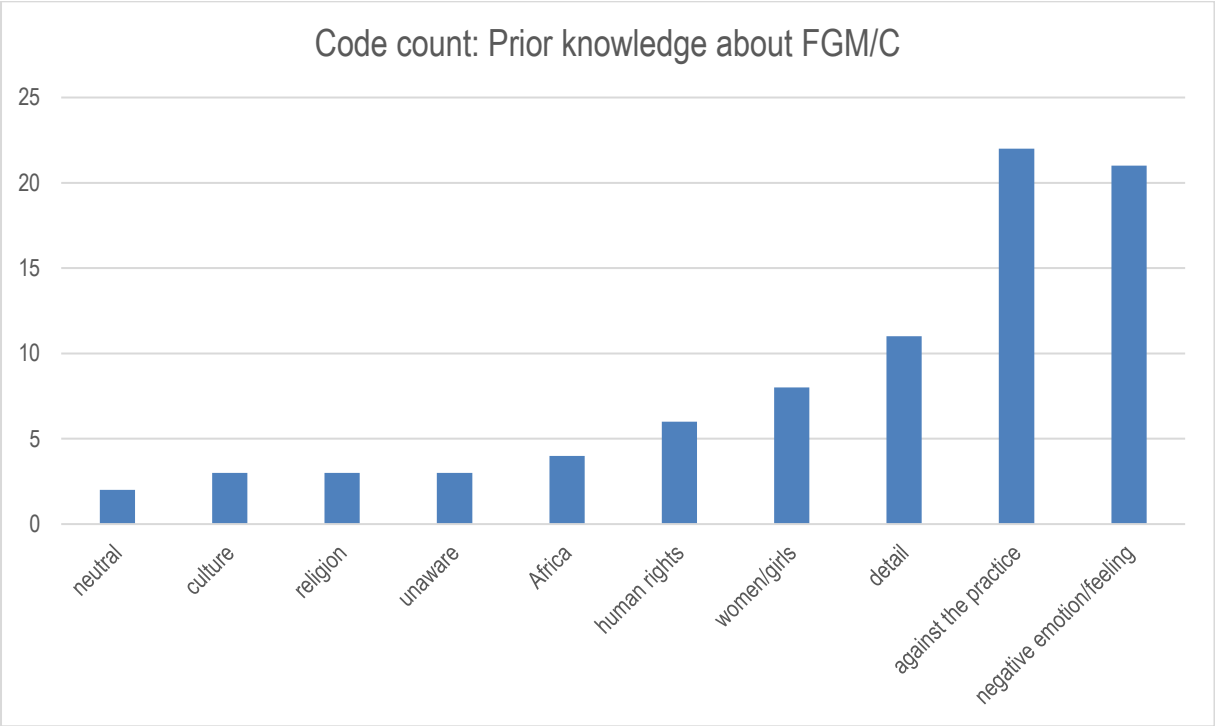

Figure 18: The code count for all users for the open-ended question, "What do you feel, know, or think about female genital mutilation/cutting?"

4.4.3. PANAS

PANAS consists of two 10-item mood scales to measure positive affect (PA) and negative affect (NA), where PA reflects how enthusiastic, active, and alert a person is. Low PA is distinguished by sadness and lethargy. NA reflects distress and unpleasurable mood states and engagement, such as anger, fear, guilt, and nervousness. Low NA is characterized as a state of calmness and serenity (Watson et al., 1988).

To complete PANAS, the subject ranks to what extent they feel each of the twenty words on a scale from 1 (very slightly or not at all) to 5 (extremely). Completion of each PANAS scale was required to proceed in

the survey, so all 55 participants completed them. This figure shows the weighted average for each affect term in the PANAS at the beginning of the survey ("before"), and after exposure to all maps ("after"). The terms are arranged by decrease, from lowest (negative decrease, i.e. increase) to highest. All the negative affect terms had the lowest decrease – some increased (from hostile to distressed) while all PA terms decreased (alert to interested). Attentive and interested also showed comparatively high drops.

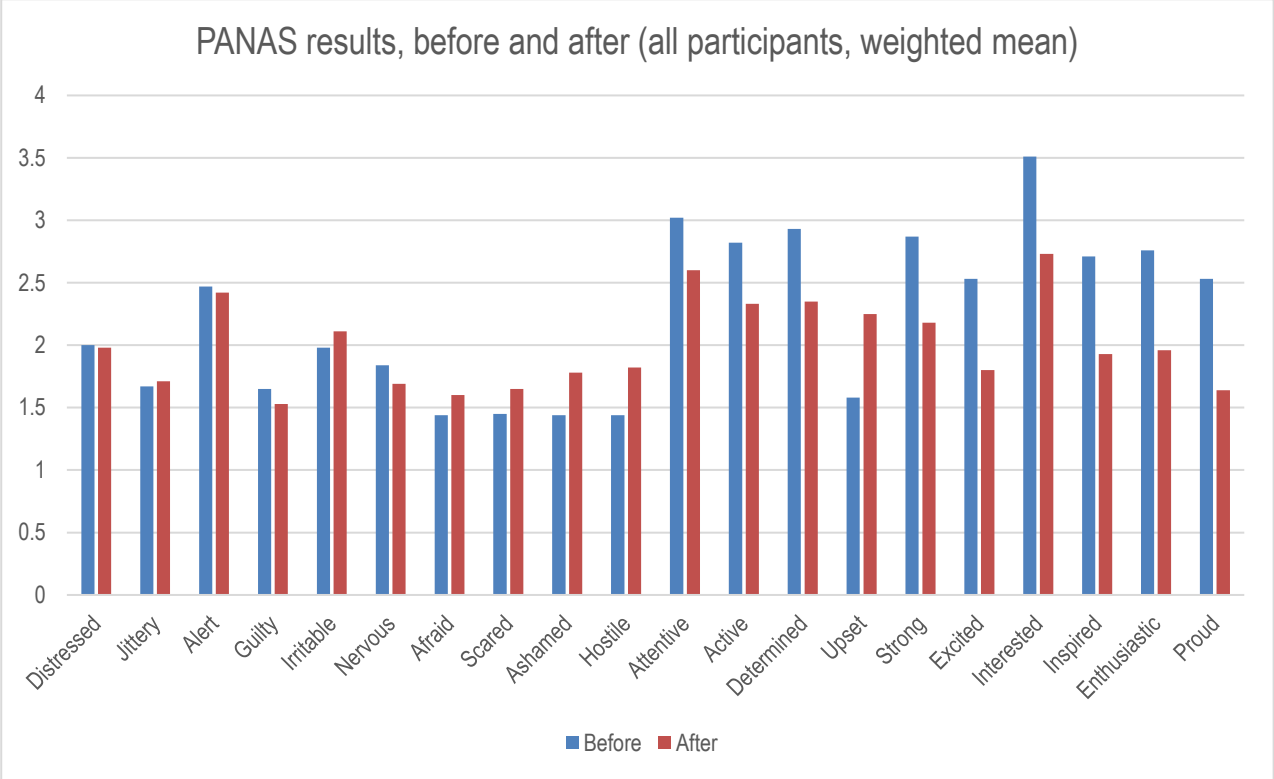

Figure 19: Arranged according to the "weighted average before" from highest to lowest, this chart shows the before and after responses to each PANAS word. Participants rated to what extent they felt each word from 1 (very slightly or not at all) to 5 (extremely).

Positive affect and negative affect are tallied by summing the respective scores for the PA words in PANAS (interested, excited, strong, enthusiastic, proud, alert, inspired, determined, attentive, active) and the scores for the NA words (distressed, upset, guilty, scared, hostile, irritable, ashamed, nervous, jittery, afraid). These sums can range from ten to fifty, where higher scores of PA or NA indicate higher levels of PA or NA respectively, and lower scores indicate lower levels. The creators of PANAS found the mean momentary PA mean to be 29.7 and mean momentary NA to be 14.8 (Watson et al., 1988). In this study, the 'before' mean PA was 28.15, and 'after' mean PA was 21.94, while 'before' mean NA was 16.49 and 'after' mean NA was 18.12 (see Figure 20) – all of which are lower than the abovementioned means and show a decrease in PA and increase in NA between the beginning of the study (before participants saw the maps) and after they saw all the maps.

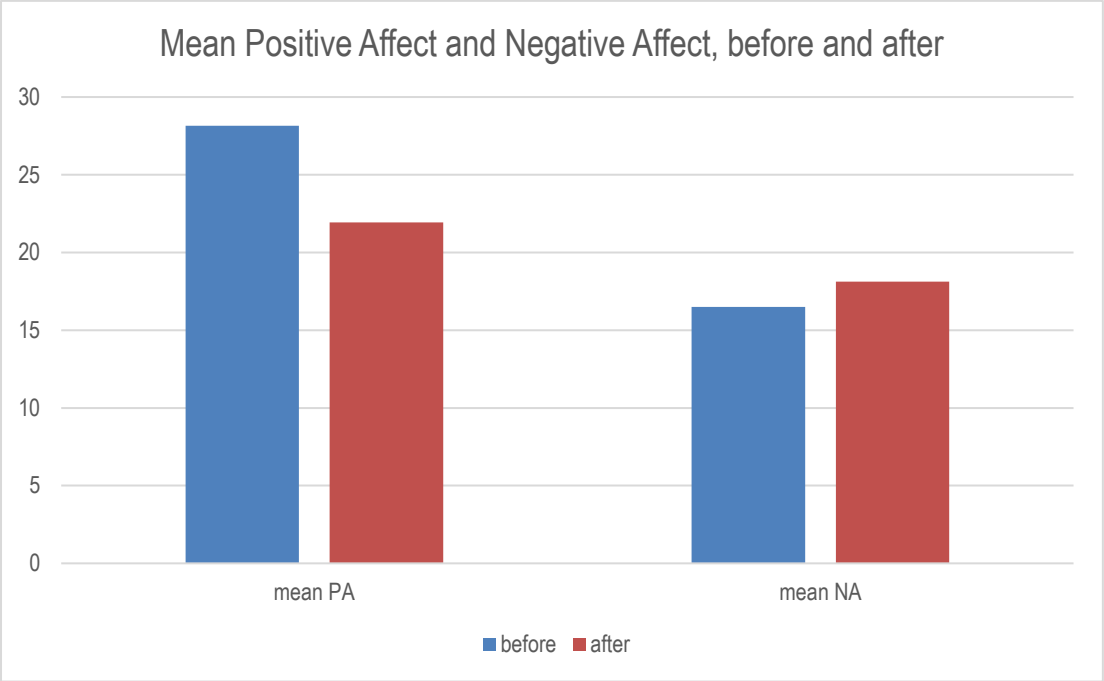

Figure 20: Positive affect and negative affect before and after viewing the maps. PA decreased, while NA showed a small increase.

The figures below show a distinct decrease in the weighted mean response (as opposed to mode, above) for positive affect terms: on average, participants were notably less excited, proud, inspired, enthusiastic, active, strong, determined, attentive, and interested, by the end of the study, and somewhat more hostile, ashamed, afraid, scared, upset, and irritable.

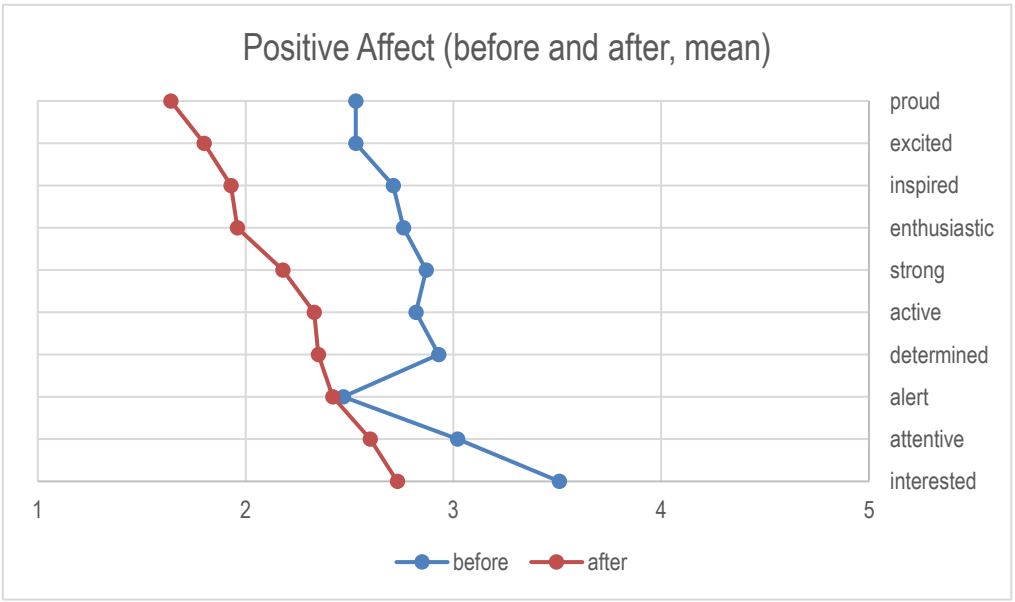

Figure 21: Mean results for each positive affect term, before and after.

In response to the open-ended question that asked about thoughts, feelings, and emotions experienced during the study, 21 of the forty responses indicated a negative emotion towards or from the maps or

data, such as sadness, anger, annoyance, and distress; the average PANAS scores for negative affect show an increase (see figure below) which reflects this emotional impact. Several users mentioned their interest or curiousity was piqued, and/or they were surprised or shocked about the indicator/dataset. However, the average score for 'interested' decreased overall in PANAS, which could indicate that users less interested due to the study itself (from fatigue), or the maps.

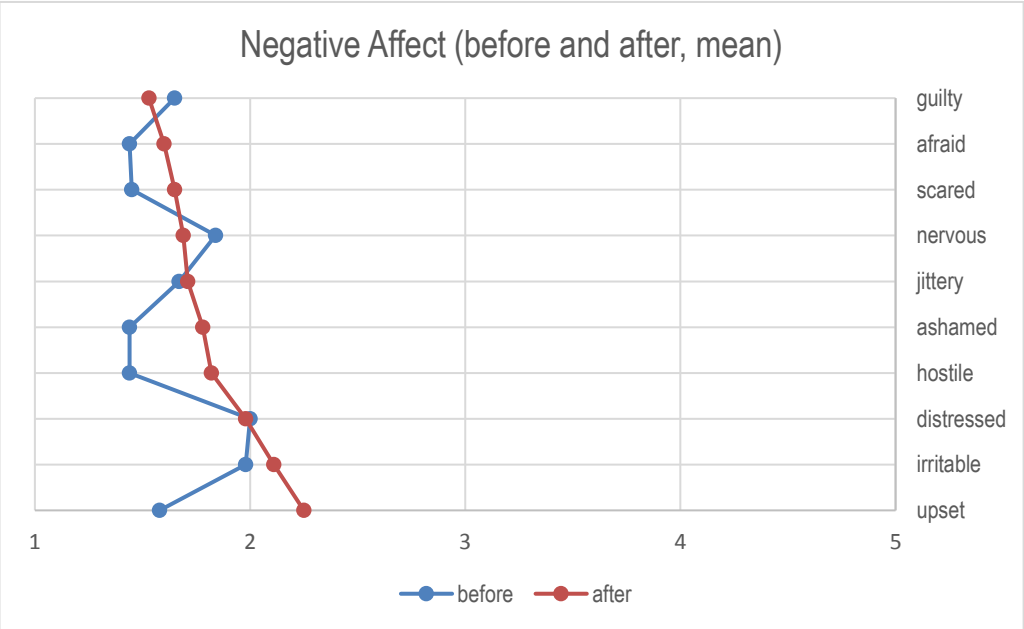

Figure 22: Mean results for each negative affect term, before and after.

4.4.4. Task results

For all six tasks, the average score for correct responses was 95%, with the lowest score at 50%, and both the median and highest score at 100%. 41 participants (75%) achieved between 91% and 100% correct responses, 11 participants (20%) scored between 81% and 90%, two participants (3%) scored 61%-70%, and one (2%) scored 50%.

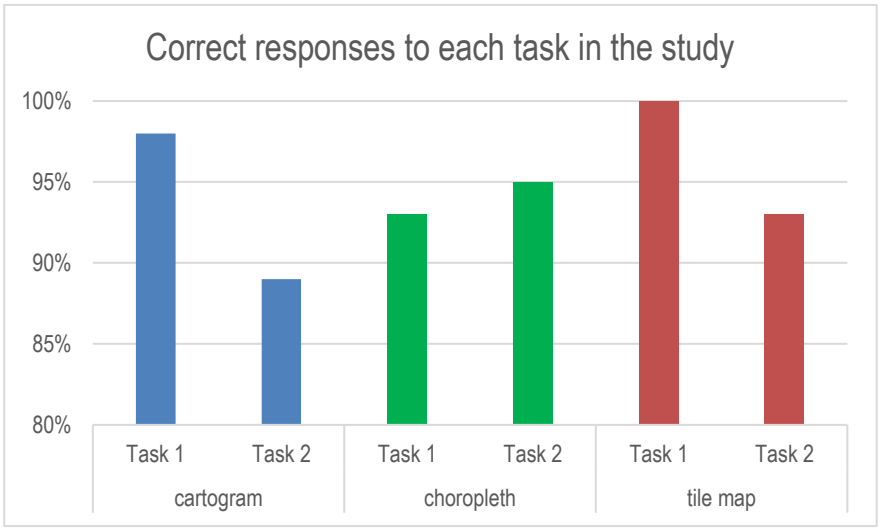

Figure 23: Correct response rates for each task in the study.

Choropleth Task 1: What is the percentage of women and girls aged 15-49 who have undergone female genital mutilation/cutting in Somalia?

Response: 51 respondents (94%) answered correctly. 3 respondents answered incorrectly. 1 person skipped this question.

Choropleth Task 2: Which of the following countries has the highest proportion of women and girls aged 15-49 who have undergone female genital mutilation/cutting?

Response: 52 respondents (95%) answered correctly and three respondents answered incorrectly.

Cartogram Task 1: What is the percentage of women and girls aged 15-49 who have undergone female genital mutilation/cutting in Egypt?

Response: 55 respondents (all but one, 98%) responded correctly.

Cartogram Task 2: Which of the following countries has the highest proportion of women and girls aged 15-49 who have undergone female genital mutilation/cutting?

Response: 49 respondents (89%) answered correctly; the remaining six participants were split between two incorrect responses.

Tile map Task 1: What is the percentage of women and girls aged 15-49 who have undergone female genital mutilation/cutting in Tanzania?

Response: All participants answered correctly.

Tile map Task 2: Which country has the highest proportion of women and girls aged 15-49 who have undergone female genital mutilation/cutting?

Response: 51 participants (97%) answered correctly, and the other four responses were split between the three incorrect answer choices.

4.4.5. Map ratings

Table 6: Ratings for map qualities on Likert scales.

Ratings for map qualities	
Strongly disagree	-2
Somewhat disagree	-1
Neutral	0
Somewhat agree	1
Strongly agree	2

All participants completed ratings for the cartogram, choropleth, and tile map. They rated each quality from Strongly Disagree to Strongly Agree, which translates into a 5-point scale from -2 (strongly disagree) to 2 (strongly agree), with 0 as neutral.

Participants seemed, on average, to prefer the choropleth map, followed by the tile map, and then the cartogram. The average of the mean ratings across the qualities for was 0.98 for the choropleth, 0.48 for the cartogram, and 0.62 for the

tile map. The mode ratings for these responses differ, as shown in the figure below. The following sections explore comments on each map type.

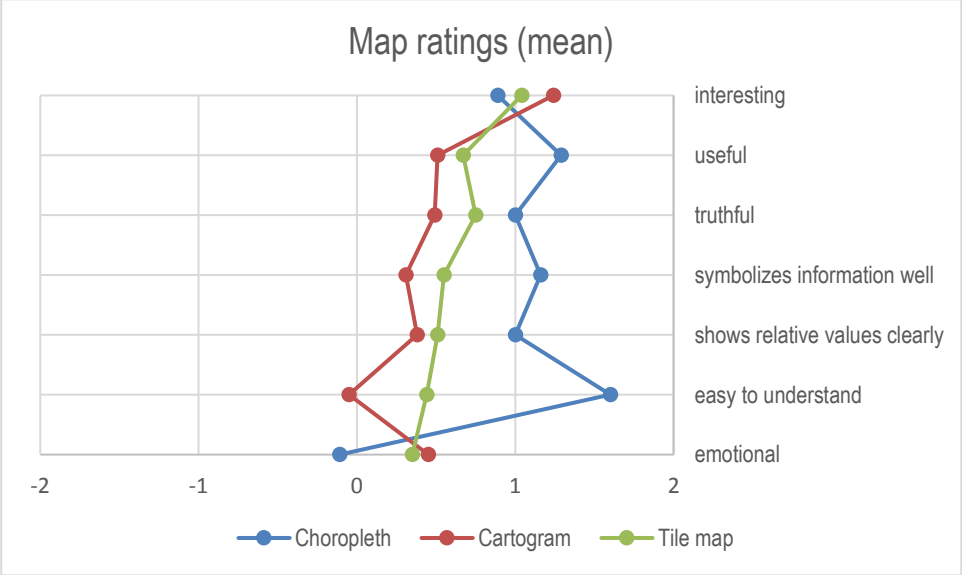

Figure 24: Map ratings (mean): Participants 'rated' the above qualities for each map from strongly disagree (-2) to strongly agree (2).

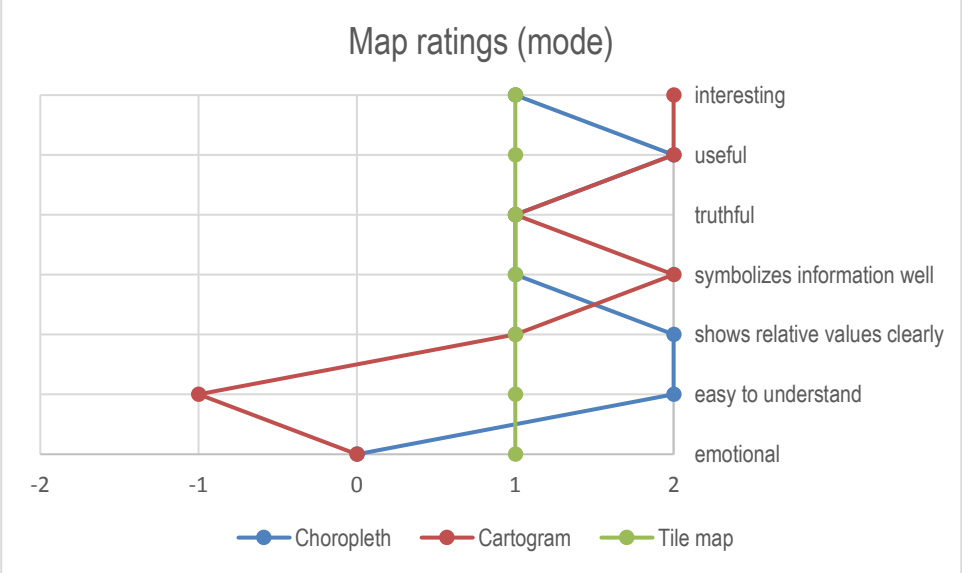

Figure 25: Map ratings (mode): Participants 'rated' the above qualities for each map from strongly disagree (-2) to strongly agree (2).

4.4.6. Comments on map types

Participants could comment on their ratings, thoughts, and feelings, for each type of map. A set of codes based on common themes was applied to the comments. Many comments have more than one code.

There were 24 comments on the choropleth map, 27 comments on the cartogram, and 28 comments on the tile map, the code counts for which are shown in Figures 27-29. The responses were assigned the following codes: map qualities (boring, traditional, neutral); map appearance/design (symbol/icon, colour); geography (borders, shape); emotion; critique; usability (easy to use, hard to read, need time/closer look, familiar, unfamiliar); positive response (interest); negative response; neutral response; mixed response; data; indicator.

The 'data' code was assigned to responses mentioning the statistics, attributes, or data while the 'indicator' code was assigned to responses that discussed the data in a more subjective way.

Of the 24 comments on the choropleth map, 8 mentioned that it was easy to use; often this was linked to its familiarity or wide use: "simple, seen so many times before, that's why one probably doesn't spend too much time looking at it". Four mentioned emotions, in all cases linked to colour – some suggested that the colours and topic were both emotional, but another suggested that the map "should be shown with way more emotions, not just scheme of colours".

Overall the choropleth seemed to evoke reflection on the data and usability of the map more than the indicator issue. Three people mentioned it was boring, a word which did not appear in the comments on the tile map or cartogram.

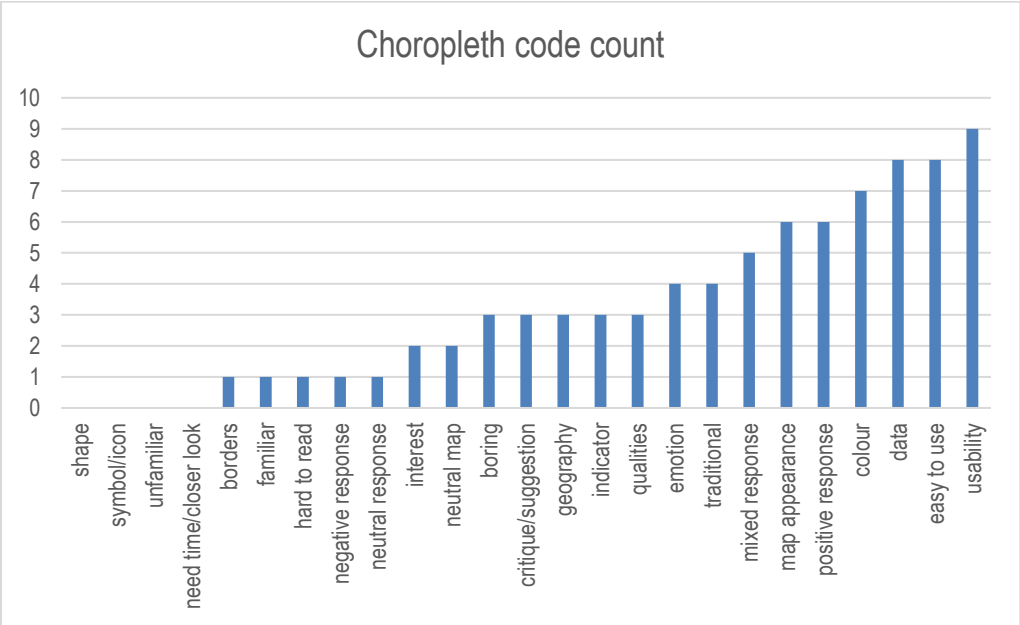

Figure 26: Code counts for comments on the choropleth map.

Generally, users did not deem the tile map as easy to read, rather that it required more time and a closer look: "it took quite some time to read the legend, to read all the tiles, and then to see". All eight comments about its usability (how participants felt towards its difficulty or the time needed to peruse it – its effectiveness or efficiency) mentioned needing more time, a closer look, or that the map was hard to read. One comment that mentioned it was hard to read did mention that it was also "useful for determining the percentage of women affected in any particular country" and that it was "easy to understand at a glance, but harder to navigate" due to distortion. One comment that mentioned "easy to read" (but was not

coded as a usability comment) noted that the tile map made "it easy to understand the phenomenon proportions".

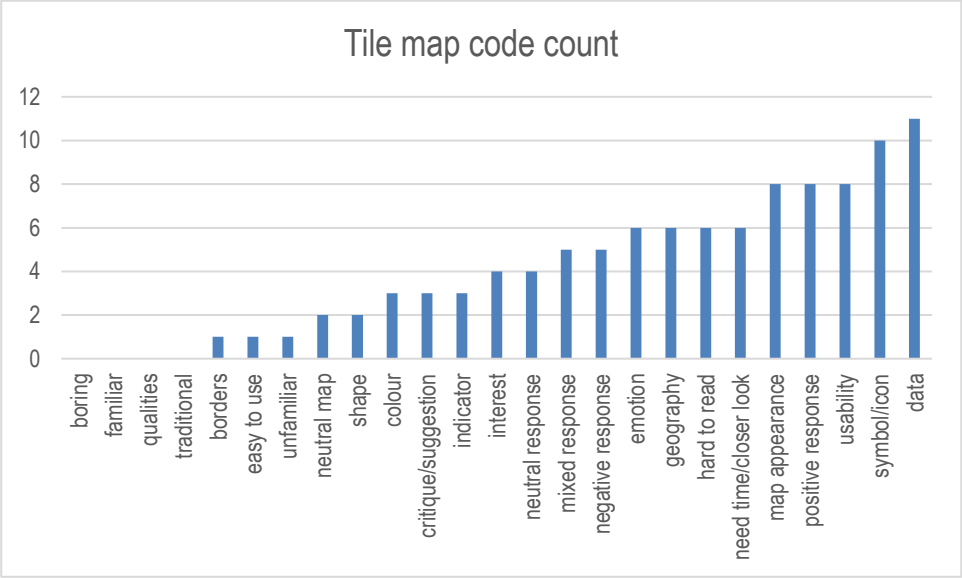

Figure 27: Code counts for comments on the tile map.

Together, mixed, neutral, and negative responses outweighed the positive responses to cartograms. But positive responses indicated the map was good because it showed more information or was easy to understand: "it provides the population as well as the statistic. Most informative map that shows quality as well as quantity".

Although the study provided a brief explanation that in the cartogram the countries were distorted by population, some participants thought the map showed the same statistic twice, through distortion and colour: "here, the relative size of the countries is used to show the same information as with the colours. By that, the message is doubled/duplicated, and probably causing more emotions", while one asked, "Why is the same topic visualised twice?!?". Others suggested the map would be more emotional or effective if the proportion of affected women and girls was used to distort the country sizes, rather than population.

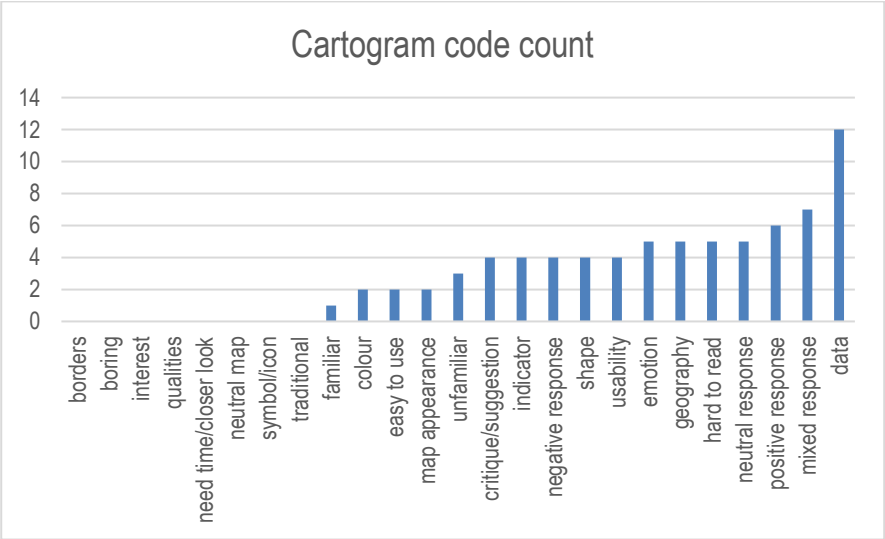

Figure 28: Code counts for comments on the cartogram.

4.4.7. Open-ended responses

40 people answered the first question, "Looking back at your thoughts and feelings during the study, what emotions did you experience while viewing these maps and the issue they portray?" The responses for this question were thematically coded as map vs. issue (4), interest (7), surprise/shock, not really emotional (9), and negative emotions (21).

The "map vs. issue" code was assigned to responses that differentiated between the indicator/issue/data, and the visualization (the map). For example: "I just feel emotions looking at the maps, emotions on the visual part, instead of emotions concerning the content" (Participant #48) and "It's a sad topic but the maps just show the data" (Particpant #10). All these responses also received the "not really emotional" code, but as did others that did not mention the visualizations specifically, such as "Not much. I feel bad for the girls and women in these countries if they don't want to be mutilated" (Participant #23) and "not sure, analytical?" (Participant #6).

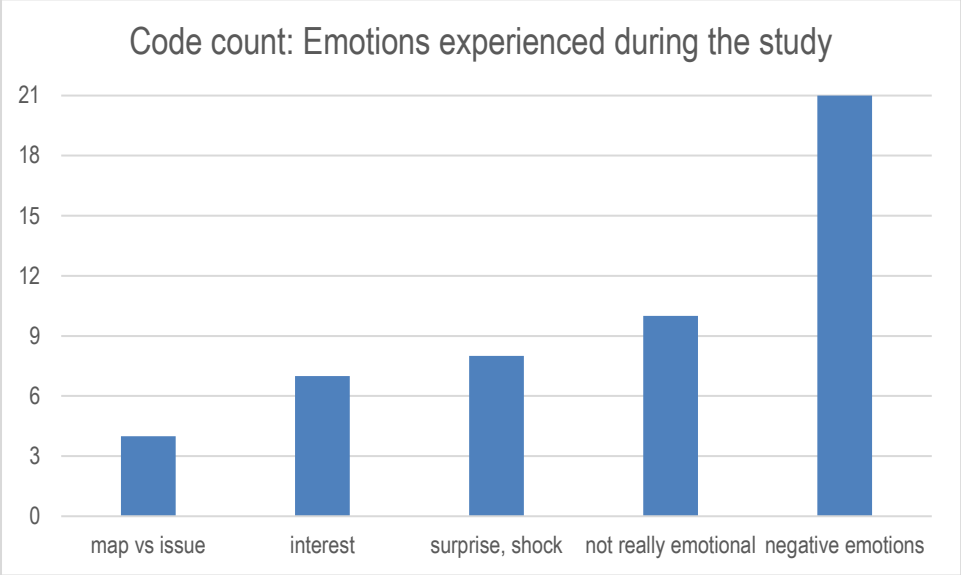

Figure 29: Code counts for responses to "Looking back at your thoughts and feelings during the study, what emotions did you experience while viewing these maps and the issue they portray?"

30 people responded to the question, "Looking back at your thoughts and feelings during this study, what questions do you have from the maps?" This question's responses were coded with more information (5), map design and type (7), none/other (8), and data (8). Responses were coded with "data" if they questioned the sources, quality, availability, or some other quality of the data. For example: "why are there so many countries with "no data"? (Participant #55) and "are there absolute numbers?" (Participant #50) while those with the tag "more information" ranged from "Why?" (Participant #2) to "Are there different reasons for Northern, Western, and Eastern Africa? I assumed mutilation was fuelled in part by conservative religious beliefs, but am less certain about the role of religion based on the religious diversity in the three main clustered regions. Perhaps instead the driver is education, poverty…?" (Participant #3).

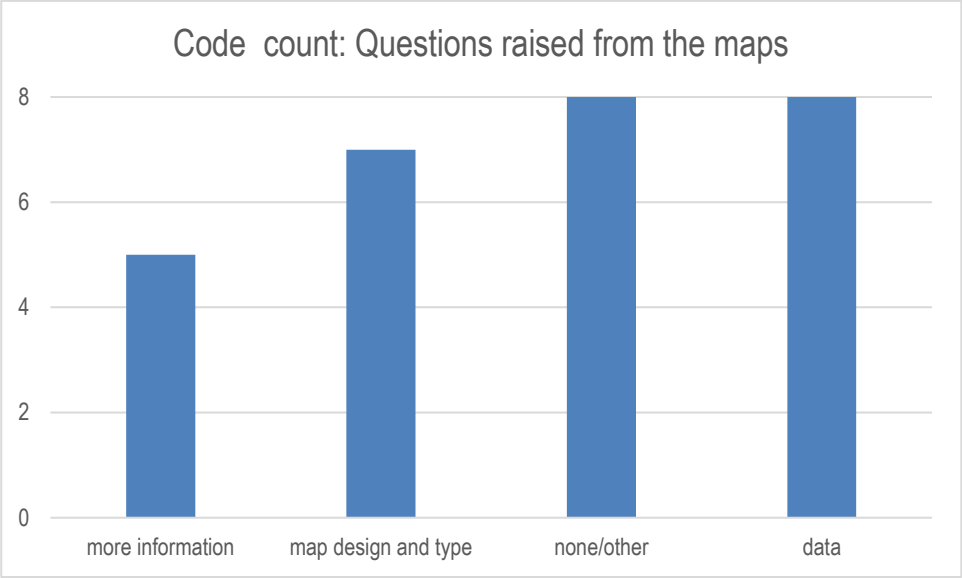

Figure 30: Code counts for responses to "Looking back at your thoughts and feelings during this study, what questions do you have from the maps?"

5. DISCUSSION

5.1. Overview

The results of this study show that thematic maps of the striking SDG indicator 5.3.2 on the proportion of women and girls aged 15-49 who have undergone FGM/C in African countries can and do evoke emotional responses, but to the extent that the exceptions – the minority of responses – which indicated no or little emotional responses to the issue and/or maps, or which equated the data to facts, separate from a human or emotional experience – are points of interest in the findings. In this study the participants were not given any other information about FGM/C. The study thus focused on the affective and other responses to the thematic map types – but, as the following discussion highlights, the effects of the data and the maps cannot truly be separated or viewed in isolation.

Preston (2008) differentiates between mapping techniques that intentionally and unintentionally evoke emotional responses, contending that the latter shift power from the map author to the map reader. The thematic maps in this study had some "emotional intent" (Preston, 2008, p.8) because they depicted a striking and unsettling data set (to this researcher) and an issue that many find disturbing and yet distant, though not all participants in the study were aware of the issue. The maps were intentionally striking: the scissors symbol in the tile map (to embody the data) indicates the act of cutting – a form of injury – even to someone unaware of female genital mutilation/cutting but who has read the title of the map; and the orange and reds are intense colours that attract attention.

Most participants mentioned negative emotions in their responses to the questions about emotions experienced through the study. The average score for Positive Affect across users after viewing the maps was lower than before viewing the maps. It is possible that these differences are due to the nature of the study itself, and its length and questions, which may have caused fatigue; as one respondent (Participant

#7) indicated in the open responses, "the maps were fine; the emotion questions were irritating". However, the differences may also be due to emotional responses evoked the map types and the indicator.

But perhaps the most interesting finding overall is any lack of an emotional response for some of the respondents, or a more general emotional reticence – or, perhaps, an emotional denial, or genuine lack of emotional involvement. This, despite the jarring data, the visual conventions or design choices in the maps, or the acknowledgement that the issue or data might be striking – whether to the participant or to someone directly affected – but that the maps themselves did not convey this message. This section delves into themes that emerge from this observation: distinction between the issue or data FGM/C and the map types, visual conventions and choices, responses based on the map types; maps as objective and neutral visualizations; and maps as separate entities from the data they convey.

5.2. Visual conventions and design choices

Quantifying an issue enables the "viewing of phenomena from afar" (Kennedy & Hill, 2017, p. 14) – what Haraway (1988) calls "the god trick of seeing everything from nowhere" – distancing users, viewers, and consumers from the people or concepts to whom the data refer, furthering them from awareness and sensitivity to those people, without whom the data would not be. But Kennedy & Hill (2017) also argue that visualizations may reduce this distance and evoke emotions that may connect viewers with the subjects of the data. The maps in this study were not intentionally designed to be as overtly persuasive as propaganda maps (Muehlenhaus, 2012), but made use of both visual conventions that may imbue a perception of neutrality (Kennedy, Hill, Aiello, & Allen, 2016), or cause desensitization, and visual variables and elements which draw attention to the indicator: a conspicuous, striking symbol (scissors) and red-orange colour scheme. The maps were not neutral – no map is.

Maps have long been viewed as objective and neutral (Kitchin & Dodge, 2007) and authoritative; so to present an emotional data set in map form raises questions about how maps and data work together or separately to evoke conflicting or compatible emotions. Four participants noted a discrepancy in the final open question between the emotional 'value' of the map topic and the actual maps. For example: "it's a sad topic but the maps just show the data" (Participant #10) and again, Participant #11: "No different emotions from when I started. Although it is a very emotive issue it feels far away… while clear, the maps themselves are quite clinical…". Visual conventions influence and socialize the design and perception of statistical graphics (Dragga & Voss, 2001). Kennedy et al. (2016) discuss the conventions that imbue visualizations, and users, with the impression of objectivity and neutrality: 2D viewpoints, clean layouts, geometric lines and shapes, and the mention of data sources. The maps in this study employed these conventions; the tile map, especially, conveyed a geometric quality – but at the same time, an alternative representation of space (Huffman, 1997). It is possible that these choices influenced one user's perception of the maps as "clinical" (Participant #11). This participant explained that though the issue was emotive, her emotions were not different from the beginning of the study, and that the issue felt far away and less emotionally influential than immediate personal issues. This reaction raises the question: would a more emotive, less clinical, and more visually persuasive map be desirable and/or influential? Hill, Kennedy, & Gerrard (2016) found that designs that fail to adhere to visual conventions and professional standards may be judged derisively and critiqued for poor execution, and that gendered derision is so entangled with legitimate criticisms that it has become normalized. Some participants did critique the maps or offer suggestions on how to improve – some for usability, while others to make the maps more emotional. For the former, Participant #50 critiqued and questioned the tile map's cartographic conventions and

intentions: "…why are the country labels as well as title smaller than on the other two maps?, all countries have the same visual weight/impact – is this the author's goal? … map author data is missing …" and for the latter, Participant #23 said, "Brighter, fresh-blood red would have been more emotional and had more of an impact on me, probably."

The subjective and geographic distances of Africa may have influenced participants who expressed little emotional involvement, since people are less concerned with events in distant places, and cartographic design choices such as projections can influence the perception of distance and affect emotional involvement in the place (Gilmartin & Lloyd, 1991). Only three participants mentioned being nationals of African countries (two from Egypt, one from South Africa) and one person mentioned current residence in an African country (South Africa).

Participant #48 noted, "I am not familiar with the topic, I think that is why it didn't give me an emotion…I just feel emotions looking at the maps, emotions on the visual part, instead of emotions concerning the content". This comment too indicates that design choices can influence users' emotions but that they can, somehow, be distinct from the topic or data that the map portrays. Also noting the gap between the maps and the issue, Participant #47 wrote that "the issue itself is highly emotional. None of the maps however transported this feeling to me. I was rather de-emotionalized by the maps", and said that concentrating on completing tasks correctly detracted from the emotional experience, and that the less familiar map types – cartogram and tile map – slightly increased attention and emotion due to their novelty.

The novelty or perceived limitations of some map types – the cartogram and tile map – were for some users a hindrance, indicating resistance to a non-familiar or untraditional, non-scientific map beyond the familiar, traditional, scientific, western intellectual idea of an objective map. But in a feminist critique of cartography, Huffman (1997) writes that feminist cartography adopts an epistemology of embodiment, acknowledging different cartographic media and modes of production, and cites cartograms as maps that use alternative geometry which emphasize ways of ordering and measuring space beyond Euclidean geometry. Cartograms are an example of how people can accommodate new map types and they may enable readers to compare relationships across units better than "maps that show the basically irrelevant physical area of the units" (p. 276). This novel or alternative approach to the geometry of geography would then also apply to the tile map, which distorted shape and represented each country with equal weight as a congruent square.

5.3. The tile map

Tasks were implemented in the study to increase user engagement with the maps. The tasks may have induced emotions that were not related specifically to the maps or data; as Participant #47 commented, "the maps had me concentrate on reading/understanding them and detecting the correct information…I did not have the actual issue in mind". Despite the distortions in the tile map's geography (area shape and size) and topology, the average success rate across the two tasks was highest for this map type, at 97% (compared to 94% for both the choropleth and cartogram). From the user comments on the map types, perhaps the time and extra effort required to look on the tile map contributed to more care taken when responding to the questions; or perhaps the tile map was easier to read.

Though pictographs may be statistically or visually redundant – "chartjunk" as termed by Tufte (Kostelnick, 2007) – they are not emotionally redundant (Dragga & Voss, 2001). McCleary (2003) frames a

similar concern in grappling with how to visualize human suffering or injury: "there is no mechanical, no manufactured cartographic solution that will convey the horror of catastrophe and calamity…how does one create displays that capture the minds and emotions of the map user?" (p. 1827). Haroz et al., (2015) found that pictographs invite users to engage with a visualization more closely.

The responses to the repeating icon tile map in this study reflect this finding to some extent, but perhaps for some because they were difficult to read and required more attention to decipher, and for others because the symbol was interesting and stimulating. Ten of 28 comments on the tile map mentioned the scissors icon that represented the data, and nine of these mentioned that in some way it was a good choice – that it conveyed the seriousness or emotion of the issue in some way, or made the map more "interesting". For example, Participant #8 said "the pictorial symbol, a scissor, helps to show the seriousness of the situation explicitly" and Participant #23 wrote "I like the scissors. A knife may have been even more effective, as a knife is more brutal". Others commented ambiguously: "symbols may be less precise but may allow a directer (sic) connection to the displayed data (if chosen well)". Conversely, one person noted that the tile map provided information well, but was geographically confusing and the scissor symbols were small and hard to see.

Several commented that the tile map was a neutral representation of the data: "it gives equal weight to all countries and includes a neutral representation of the rate" (Participant #22) or "seems more neutral in some ways than the other two" (Participant #9) – perhaps due to the geometry (squares) and thus visual conventions, discussed above. Several found it the map type unfamiliar, requiring more time and effort to use, which could be either a hindrance or an invitation to engage further: "Different map not very common. Not very good. Requires more attention and reading to understand the data" (Participant #21).

Some of these comments expressing discomfort or disdain for an unfamiliar map type evoke Huffman's (1997) note in a feminist critique of cartography of the limitations of the cognitive category and definitions of a Western map as ones that "make visible a global political world we recognize and understand" (p. 259) and that reflect a "transparently knowable physical world" (p. 259), meanwhile failing to recognize other images of the world as maps that do not fit these familiar scientific or strict boundaries. The author argues that "expanding the boundaries of what we acknowledge as maps is central to facilitating a feminist critique of masculinism in Western cartography, and to grounding a specifically feminist critique of masculinism in practice that acknowledges gendered bodies in mapping and explores new modes of cartographic representation" (p. 259).

A few participants asked, in the final open-ended question, about where and when the map types are used. Two responses about the tile maps stand out: "Where do people use the tile map? Where could that be useful?" and "Who in the world would ever use tile maps? Yuk". This reluctance to accept the maps may be explained by how the that tile maps are increasingly popular in the media and perhaps less so in industry and academia, and that most participants were professionals in a geomatics-related field. This is a generalization and would be interesting to validate with larger, more diverse sample size, but is a reminder of work by Fabrikant et al. (2012) that found that "cartographic expertise triggers emotional responses to unusual colour schemes in predictable ways" (p. 5) in a study of emotional responses to different colour schemes used on topographic maps.

In response to the question about emotions experienced while looking at the maps and the issue they portray, ten of the thirty responses expressed limited or no clear emotions, from "It (sic) just facts"

(Participant #14) to "Emotions? I can't say precisely how many and are the emotions I can feel looking at a map" (Participant #17). Prior knowledge of the indicator had some influence in users' emotional reactions: one participant said, "I am not familiar with the topic, I think that is why it didn't give me an emotion" but that they felt some emotions towards the map's visual aspects, but not the content. Four participants, two male and two female, had indicated initially that they were unaware about FGM/C, and/or had an unemotional response towards it. Only one was both unaware and did seem affected: "it is horrible, I didn't know it existed!!!".

The above comments on the data as "just facts" suggest that some respondents believe that data are just numbers, and view them as dissociated from the humans – the women and girls – they represent. The numbers come across as impersonal, and objective; but as Hill et al. (2016) write, data are not neutral, but are shaped in particular ways. Feminist critique questions the objectivity of data. Users who identify the data as facts are not necessarily intentionally sexist, but perhaps culturally embedded norms – for example, the very idea that data are neutral – influence assessment of the maps. From participants' comments, it seemed some were keen to distinguish or express their emotions while others were adamant that they did not experience emotions – perhaps, as most of the participants were experts in cartography, there was some doubt towards the validity or truthfulness of emotional experiences evoked by maps. Perhaps the study should not have been explicitly titled "maps and emotions" to avoid biasing perspectives for this reason. On the other hand, some users distinctly mentioned emotions in their comments on map types, even though the question addressed several attributes about the map types and not only their emotional qualities.

Six comments on the tile map mentioned emotions – again, possibly because the word was in the title of the survey – with mixed comments. Two suggested that the tile map was unemotional or relatively less emotional: "this map is completely unemotional but it forces its reader to involve into content reading and understanding" (Participant #33), distinguishing again between the map itself and the issue presented, because this participant also said in another comment, "I'm very annoyed with how women are treated at some parts of the world and I think that there should be way more maps" to raise more awareness.

Participant #20 said about the tile map, "This map reminds of a data list, where the numbers are placed in a somehow geographical way. It certainly causes less emotions than the other map types do", thereby comparing the map to something that is not a map – which may imply that maps can provoke emotions, but visualized lists – at least in this way – for this user, do not. Some indicated it was relatively more emotional: "the scissor icons make it emotional" and "the symbols chosen to represent the percentage of women is shocking and illicits and a strong negative emotional response".

5.4. The cartogram

The cartogram had the lowest correct response rate at 89% for one task. As Roth, Woodruff, and Johnson (2010) note, cartograms' distortion complicates basic tasks and therefore limits their use, which is a possible explanation for the task results. Users also found cartograms least preferable based on the qualities they rated. But several researchers call attention to the potential of cartograms to probe deeper engagement and thought with the map or to elicit moral emotions (Döll, 2017; Sui & Holt, 2008) and to draw attention to how "maps are thought experiments with significant effects on how we think about reality" (Sui & Holt, 2008, p. 16).

Döll (2017) says that cartograms trigger some kind of emotion, increase viewer attention, and may augment knowledge transfer as a result; the visualization of human exposure to climate change in a cartogram might cause compassion for those negatively affected. As Sui and Holt (2008) argue, it is necessary to understand thematic maps from more than one dimension, and they propose a framework to study the cognitive, analytical, and critical dimensions of cartograms. Taking this a step further, from the results of this research I would extend this framework to more thematic map types and include in or alongside the critical dimension the affective or emotional component of maps.

Although "cartograms are popular because they distort reality and 'shock' readers, providing an unusual and provocative perspective on an often commonplace topic" (Roth, Woodruff, and Johnson, 2010, p. 138) the cartogram did not seem to impart a strong emotional message or reaction. It may be the indicator topic was more provocative while the perspective (map type) was commonplace or familiar. Participants who mentioned emotion did so in a mixed way, indicating that the duplicate data (as they perceived it) may have caused stronger emotions, while others did not think that the map could show more emotion than the choropleth: "I do not think that the sizes of the countries on this map can provoke some feelings other than those caused by choropleth map"; and "the slightly negative emotional aspect I experience here does more refer to the difficulty to read choropleth maps, rather than the content it displays".

The four negative responses to the cartograms hinged vaguely on their appearance and distortion, calling to mind issues mentioned above about unfamiliar map types and visual conventions: "they show the polygons in an unfamiliar way" (Participant #6); "looks like an inflamed pancreas" (Participant #23). And whereas the choropleth was sometimes described as "boring", "neutral", or "traditional" because of its familiarity and wide use, nobody mentioned these words in their comments on the cartogram, even though it also did not explicitly elicit any impressions of novelty (as the tile map did) in the comments either.

5.5. Affect/emotion and engagement

Any lack of emotional response to the issue did not seem to depend on gender – five responses coded as 'not really emotional' were from people who identified as female, and five were from people identified as male. But those who did express emotions, expressed them differently. An interesting comparison may be drawn between responses of the 22 female respondents and 19 male respondents to the question "looking back at your thoughts and feelings during this study, what emotions did you experience while viewing these maps and the issue they portray?" There was an overall qualitative difference in their response types and content. Responses from males were usually remote, one word answers or lists of one-word emotions, or non-emotional, whereas responses from females were more engaged and used the word "I" in their responses. A selection of male responses that characterize the overall responses: "Anger, guilt, shock, sadness", "interesting", "Ashamed", "nothing decisive", "distressed, scared, and upset", "Emotions? I can't say precisely how many and are the emotions I can feel looking at a map", "Not much. I feel bad for the girls and women in these countries if they don't want to be mutilated".

A selection of characteristic female responses shows a more engaged response: "Anger was the feeling that I have experienced the most", "It made me very sad to see the large percentages. I thought this practice was being eradicated", "I always felt scared", "not sure, analytical?", "sadness", "not too many, it's a sad

topic but the maps just show the data", "shock, empathy, anger, indignation, and curiosity", "negative feelings associated with the theme".

While certainly both groups had several one-word responses or lists of single words – perhaps a reflection of the multiple PANAS scales consisting of 20 single words – female emotional interest seemed greater. By the end of the study, eight participants who identified as female (8) had questions about the reasons and factors behind FGM, compared to only three male-identified participants (insert examples or explain further).

This observation brings to mind feminist critiques of the disembodied knowledge and power; traditional geography construes male experience as synonymous with human experience, denying women's experience (Huffman, 1997). The lived experience of these women, reduced to data – colours or symbols – does not convey emotion or empathy to several respondents in the study – notably among more male respondents. This could reflect how the western intellectual and cartographic tradition has historically disembodied knowledge: "by denying its own gendered embodiment, the master subject defines everything in reference to its disembodied and ungendered self, while simultaneously defining and differentiating itself against that which it is not, the embodied and gendered female other" (Huffman, 1997, p. 256). "Masculinist biases in geography have created a decided absence of thematic maps that represent women's spaces and experiences" (Huffman, 1997, p. 270) whereby "women's experience, not fitting the male model, is trivialized, denied or distorted" (Kitzinger & Wilkinson, 1997, p. 566).

In general the questions users had after viewing the maps could be categorized into two themes: i) some users questioned or mentioned the quality, source, or extent of the data, given that most countries shown did not have data, and ii) others were interested in the issue and the causes, underlying factors, political, social, or religious contexts, or other information about FGM that could be added to the maps. The questions mostly indicate some interest and piqued curiousity to learn more and think critically about the mapping process (especially the data) and the issue beyond the glimpse that the maps provide.

5.6. Limitations and areas for future research

This research sought to employ some methodological principles of feminist cartography outlined by Huffman (1997), with a focus on gender issues in the map content and research questions engaging with emotion and affect as legitimate experiences and ways of knowing (D'Ignazio & Klein, 2016). However, it does not engage directly with the women whose experiences are portrayed in the data. It is unknown if any of the participants in the study have been involved with FGM/C. And, as Kitzinger and Wilkinson (1997, p. 568) write: "these data are troubling because we do not want simply to act as an amanuensis or conduit for these women's experiences; indeed, we do not think that merely representing these women's views to the world as data which 'speak for themselves' constitutes feminist research".

Emotional responses to maps could be explored and measured through many other methods; facial expressions, electrodermal activity, and other indicators might cause participants less fatigue than PANAS. The use of wearable biosensors that collect physiological information can be an "objective" way to measure emotional responses that might complement or supplement – perhaps also contradict – self-

reported affect through scales such as PANAS. Semi-structured interviews with participants might also solicit more detailed information about their experiences during the survey.

The participants in this study were mostly familiar with maps and/or studying or working in a geo-related field. Future studies could extend this research to participants who may be less familiar with maps. Though a convenience sample was recruited in the interest of time, an ideal target group would be of a wider range of occupations and fields of study, beyond geomatics and academia. The maps designed for this survey targeted the public – consumers of news or other media – and not specifically cartographers or academics. The expertise of the participants may have affected the results.

Participants viewed the maps in random order through SurveyMonkey's randomization feature, to counter potential learning bias from seeing the maps in a particular order, which could affect responses to tasks and PANAS. But a limitation in the Survey Monkey license makes it impossible to see in which order participants viewed the maps after randomization, meaning in analyzing the results, a particular PANAS could not be associated with a particular map. To account for this limitation only the first and last PANAS were used, to compare users' initial and post-map affective states (i.e. before and after they viewed the maps, rather than how their states changed after each map type). Future research could use a different tool or account for randomization differently.

Nusrat et al. (2018) studied the effectiveness of cartogram types and suggested that enjoyment is one under-explored factor of cartogram engagement. Though it is studied extensively in psychology and has piqued interest in visualization research, there is little exploration in the context of cartogram. Extending this beyond cartograms, further research could explore enjoyment (or lack thereof) as a usability factor along with emotional responses related to different thematic map types and SDG data sets or indicators.

The emotional influences of design choices and visual variables, such as colour, were not accounted for in this study in isolation. The colour schemes and design were fairly consistent across the three maps, but future research could isolate for selected variables to account for emotions that different visual variables evoke, in addition to design choices and design conventions (typography, layout, etc.). Other cartographic decisions may play a role in the user's emotional experience, such as choice of map projection.

In their research on the influence of affective priming on graphical perception, Harrison, Skau, Franconeri, Lu, & Chang (2013) note that strongly-emotional content may influence graphical perception. This study intentionally chose a striking, potentially emotional topic – female genital mutilation – which may have affected participants' task performance due to affective priming. In the future, a factorial study could compare affective responses to each thematic map type and to different data sets that are more and less emotional, to compare factors independently.

Further research could explore in a factorial design the separate perception of thematic map type, but also data or SDG indicator, on emotional responses. This study initially sought to explore both map type and data set as independent variables (the second data set being the proportion of seats held by women in national parliaments in African countries) in a within-subject design, but the second data set was later removed to minimize participant fatigue and the length of the survey.

Future research can look at how interactivity may invoke emotional responses in users through additional data, information, or design. This study used static maps because interactivity between map and

visualization styles differs, which would add another factor to the study and go beyond the initial scope of this research. For example, interaction (zoom, panning, hovering, etc.) with a tile/repeating icon map is different from that of a choropleth map. Interactivity could also cause confusion, frustration, or other emotional arousal which might affect the data collected. In the future, a study to explore users' affect and emotion and physiological responses to SDG data (as a case study) using interactive maps could be useful. Conversely, on-screen maps may have presented some limitations for users, for example depending on their screen size, resolution, and variations in colour.

6. CONCLUSION

In this research I reviewed different thematic map types suitable for an SDG indicator of female genital mutilation/cutting prevalence in a choropleth map, contiguous cartogram, and pictorial icon tile map. An online survey collected information on participants' affective states before and after looking at these three thematic maps, and users' emotional responses, attitudes, and preferences towards the maps. On average, users' positive affect decreased during exposure to the maps and many users commented after viewing all the maps that they had experienced negative emotions during the study. Some users commented that they experienced few or no emotions because the maps were just portraying data, and suggests that some see maps, regardless of the data they portray, as objective, neutral, and incapable or inappropriate media for emotional messaging, whether intentional or not. Given that the indicator is about female genital mutilation it suggests a possibility that women's lived, physical experience – outside the traditional historically mapped realm of disembodied, ungendered experience – is too unfamiliar, far or not significant enough to elicit emotion or more attention, which denies or trivializes their experience. But more research is needed to distinguish between how multiple factors might influence affective and emotional responses, and attitudes: users' prior knowledge and experience with the issue, data quality and completeness, cartographic and design conventions and decisions, subjective and geographic distance, indicator issue, and thematic map types. Future research could study which factors increase or detract from emotional involvement with maps, place, and data.

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APPENDIX

Screen captures from the online survey

Page 1: Introduction to the survey

Maps and Emotions Study

This study is part of research for a master's thesis which explores emotions evoked by geographic data and maps.

You will be asked to answer a few questions based on some maps, and your emotions after viewing each one. You are not being evaluated on your responses or your geographic knowledge.

There is no rush to complete the study. It should take about 20 minutes. Participation is voluntary and you may discontinue your participation at any time by exiting the survey.

No self-identifying information will be collected for this study. The results of the study will be used to write a master's thesis. Please email Britta (b.a.ricker@utwente.nl) or Natasha (n.pirani@student.utwente.nl) if you would like to read the results.

By continuing, you are consenting to participate in this study.

Thank you very much for your time!

Page 2: PANAS

This scale consists of a number of words that describe different feelings and emotions. Read each item and then list the number from the scale below next to each word. Indicate to what extent you feel this way right now, that is, at the present moment.

	Very slightly or not at all	A little	Moderately	Quite a bit	Extremely
Interested	○	○	○	○	○
Distressed	○	○	○	○	○
Excited	○	○	○	○	○
Upset	○	○	○	○	○
Strong	○	○	○	○	○
Guilty	○	○	○	○	○
Scared	○	○	○	○	○
Hostile	○	○	○	○	○
Enthusiastic	○	○	○	○	○
Proud	○	○	○	○	○
Irritable	○	○	○	○	○
Alert	○	○	○	○	○
Ashamed	○	○	○	○	○
Inspired	○	○	○	○	○
Nervous	○	○	○	○	○
Determined	○	○	○	○	○
Attentive	○	○	○	○	○
Jittery	○	○	○	○	○
Active	○	○	○	○	○
Afraid	○	○	○	○	○

Page 3: Information about the thematic map types

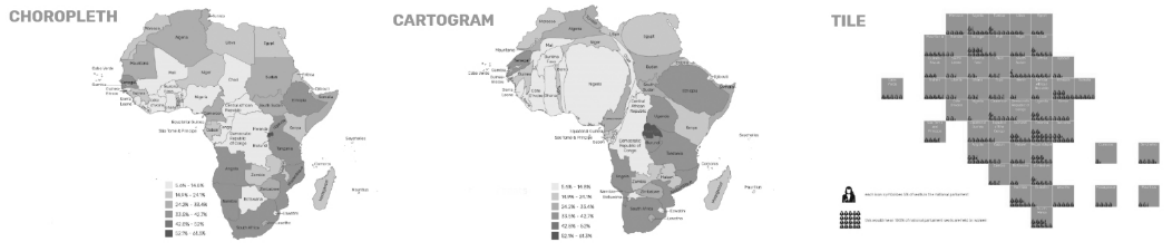
In this study you will see three types of maps showing African countries (because the data is available for these countries).

1. **Choropleth map**: The size and shape of the countries represents their real geography and area. The colour of each country represents a value which can be read from the legend.

2. **Cartogram**: The size of each country is shown proportional to its population, rather than its geographic area. Thus, countries with larger populations appear larger, and countries with lower populations appear smaller. The colour of each countries represents a value which can be read from the legend.

3. **Tile map with icons**: Every country is a square of equal size which contains an icon that repeats to symbolize the value of the data, which is explained in the legend. Each country has the same space on the map, but in the graphic countries do not necessarily border the countries they neighbour in reality.

Examples of the map types in this survey



Have you used these map types before?

	Yes	No	Maybe
Choropleth	○	○	○
Cartogram	○	○	○
Tile map	○	○	○

Page 4: Open question about awareness

In this questionnaire you will see several different visualizations that show an indicator from the United Nations' Sustainable Development Goal #5, to achieve gender equality and empower all women and girls:

The proportion of women and girls, aged 15-49, who have undergone female genital mutilation/cutting.

The following question may be sensitive; please note you can leave the study at any time.

What do you feel, know, or think about female genital mutilation/cutting?

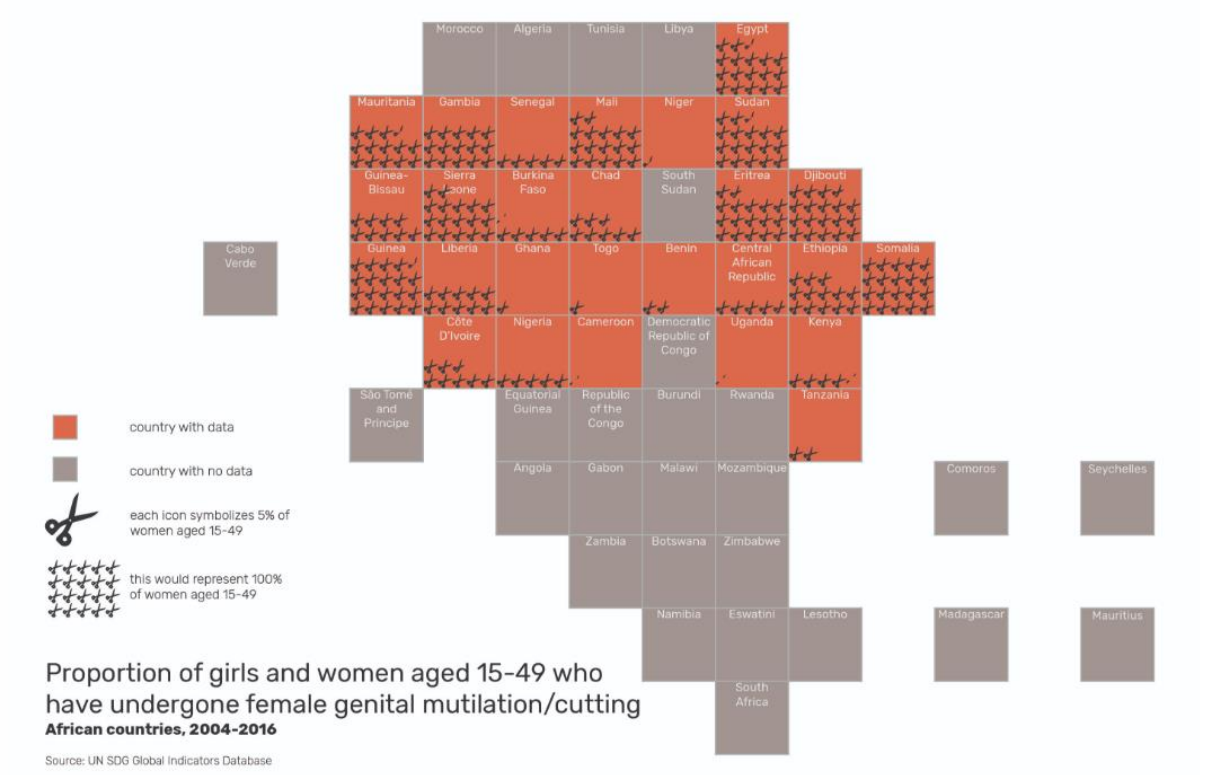
Page 5: Information about the first map type, the map, and two tasks (e.g. tile map):

Tile map with icons

Take a minute to look at the map before answering the questions below.

Reminder:

Every country is a square of equal size which contains an icon that repeats to symbolize the value of the data, which is explained in the legend. Each country has the same space on the map, but in the graphic countries do not necessarily border the countries they neighbour in reality.



What is the percentage of women and girls aged 15-49 who have undergone female genital mutilation/cutting in Tanzania?

- 80%
- 10%
- 50%
- No data

Which country has the highest proportion of women and girls aged 15-49 who have undergone female genital mutilation/cutting?

- Somalia
- Egypt
- Sudan
- Djibouti

Page 6: PANAS

This scale consists of a number of words that describe different feelings and emotions. Read each item and then list the number from the scale below next to each word. Indicate to what extent you feel this way right now, that is, at the present moment.

	Very slightly or not at all	A little	Moderately	Quite a bit	Extremely
Interested	○	○	○	○	○
Distressed	○	○	○	○	○
Excited	○	○	○	○	○
Upset	○	○	○	○	○
Strong	○	○	○	○	○
Guilty	○	○	○	○	○
Scared	○	○	○	○	○
Hostile	○	○	○	○	○
Enthusiastic	○	○	○	○	○
Proud	○	○	○	○	○
Irritable	○	○	○	○	○
Alert	○	○	○	○	○
Ashamed	○	○	○	○	○
Inspired	○	○	○	○	○
Nervous	○	○	○	○	○
Determined	○	○	○	○	○
Attentive	○	○	○	○	○
Jittery	○	○	○	○	○
Active	○	○	○	○	○
Afraid	○	○	○	○	○

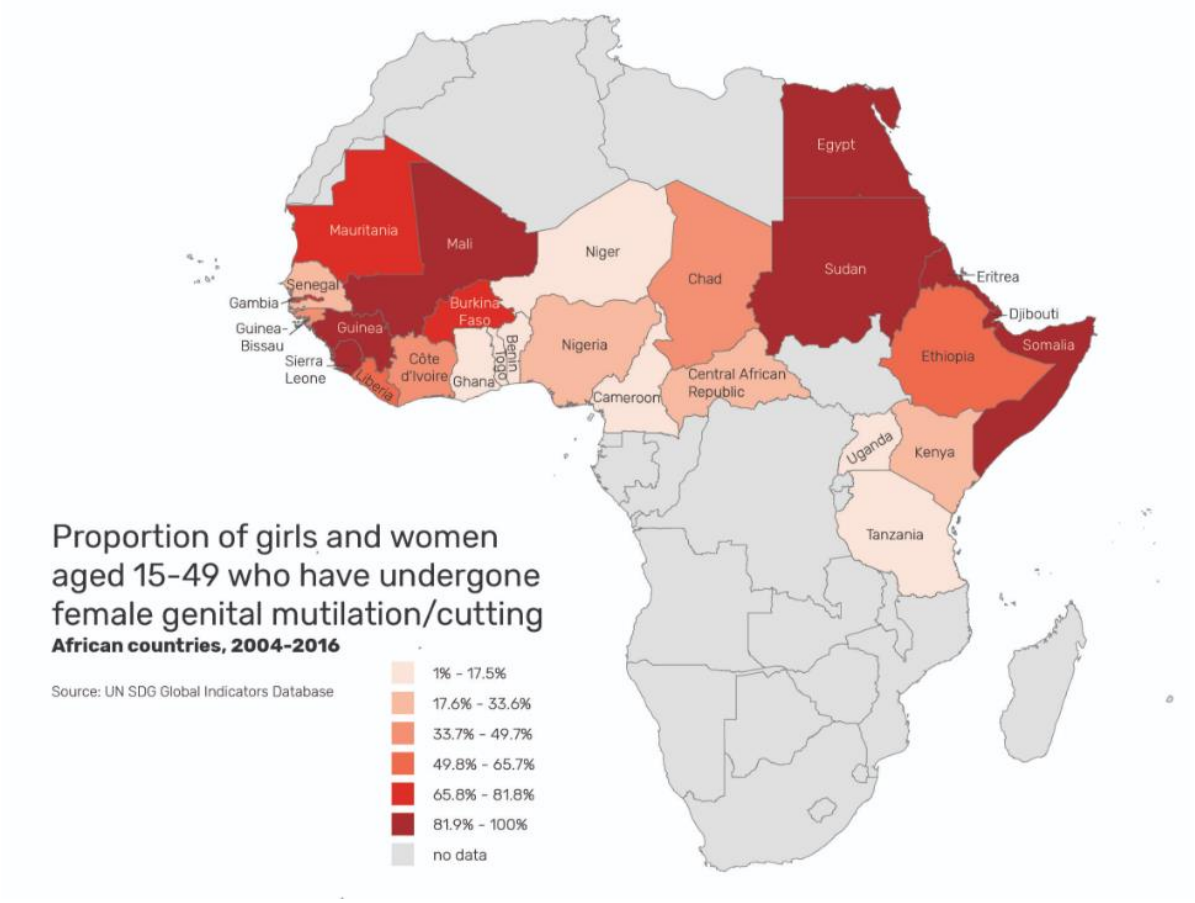
Page 7: Information about the second map type, the map, and two tasks (e.g. choropleth map):

Choropleth

Take a minute to look at the map before answering the questions below.

Reminder:

The size and shape of the countries represents their real geography and area. The colour of each countries represents a value which can be read from the legend.



What is the percentage of women and girls aged 15-49 who have undergone female genital mutilation/cutting in Somalia?

- ◯ 49.8% - 65.7%
- ◯ 81.9% - 100%
- ◯ 65.8% - 81.8%
- ◯ No data

Which of the following countries has the highest proportion of women and girls aged 15-49 who have undergone female genital mutilation/cutting?

- ◯ Tanzania
- ◯ Burkina Faso
- ◯ Sudan
- ◯ Central African Republic

Page 8: PANAS

This scale consists of a number of words that describe different feelings and emotions. Read each item and then list the number from the scale below next to each word. Indicate to what extent you feel this way right now, that is, at the present moment.

	Very slightly or not at all	A little	Moderately	Quite a bit	Extremely
Interested	○	○	○	○	○
Distressed	○	○	○	○	○
Excited	○	○	○	○	○
Upset	○	○	○	○	○
Strong	○	○	○	○	○
Guilty	○	○	○	○	○
Scared	○	○	○	○	○
Hostile	○	○	○	○	○
Enthusiastic	○	○	○	○	○
Proud	○	○	○	○	○
Irritable	○	○	○	○	○
Alert	○	○	○	○	○
Ashamed	○	○	○	○	○
Inspired	○	○	○	○	○
Nervous	○	○	○	○	○
Determined	○	○	○	○	○
Attentive	○	○	○	○	○
Jittery	○	○	○	○	○
Active	○	○	○	○	○
Afraid	○	○	○	○	○

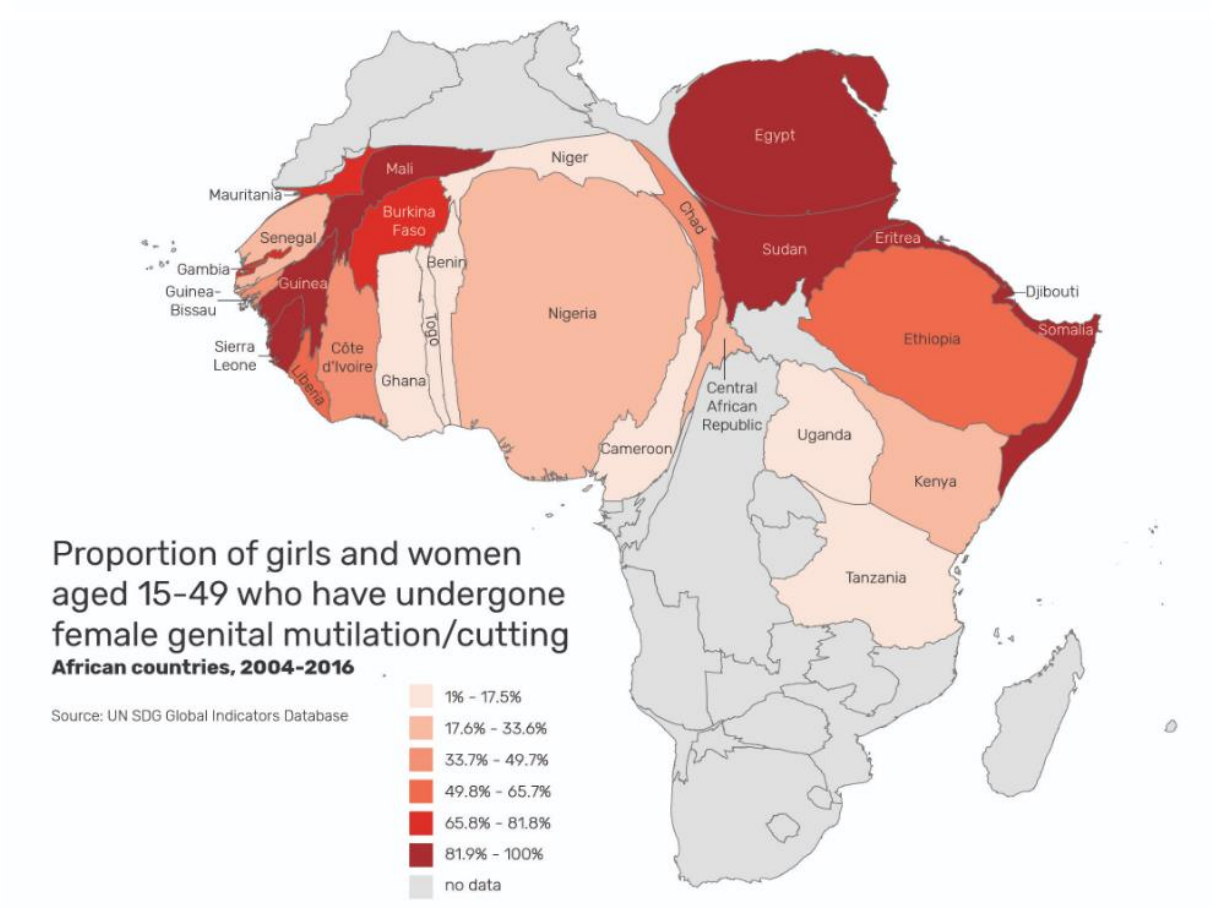
Page 9: Information about the third map type, the map, and two tasks (e.g. cartogram):

Cartogram

Take a minute to look at the map before answering the questions below.

Reminder:

The size of each country is shown proportional to its population, rather than its geographic area. Thus, countries with larger populations appear larger, and countries with lower populations appear smaller. The colour of each country represents a value which can be read from the legend.



What is the percentage of women and girls aged 15-49 who have undergone female genital mutilation/cutting in Egypt?

- 49.8% - 65.7%
- 65.8% - 81.8%
- 81.9% - 97.9%
- No data

Which of the following countries has the highest proportion of women and girls aged 15-49 who have undergone female genital mutilation/cutting?

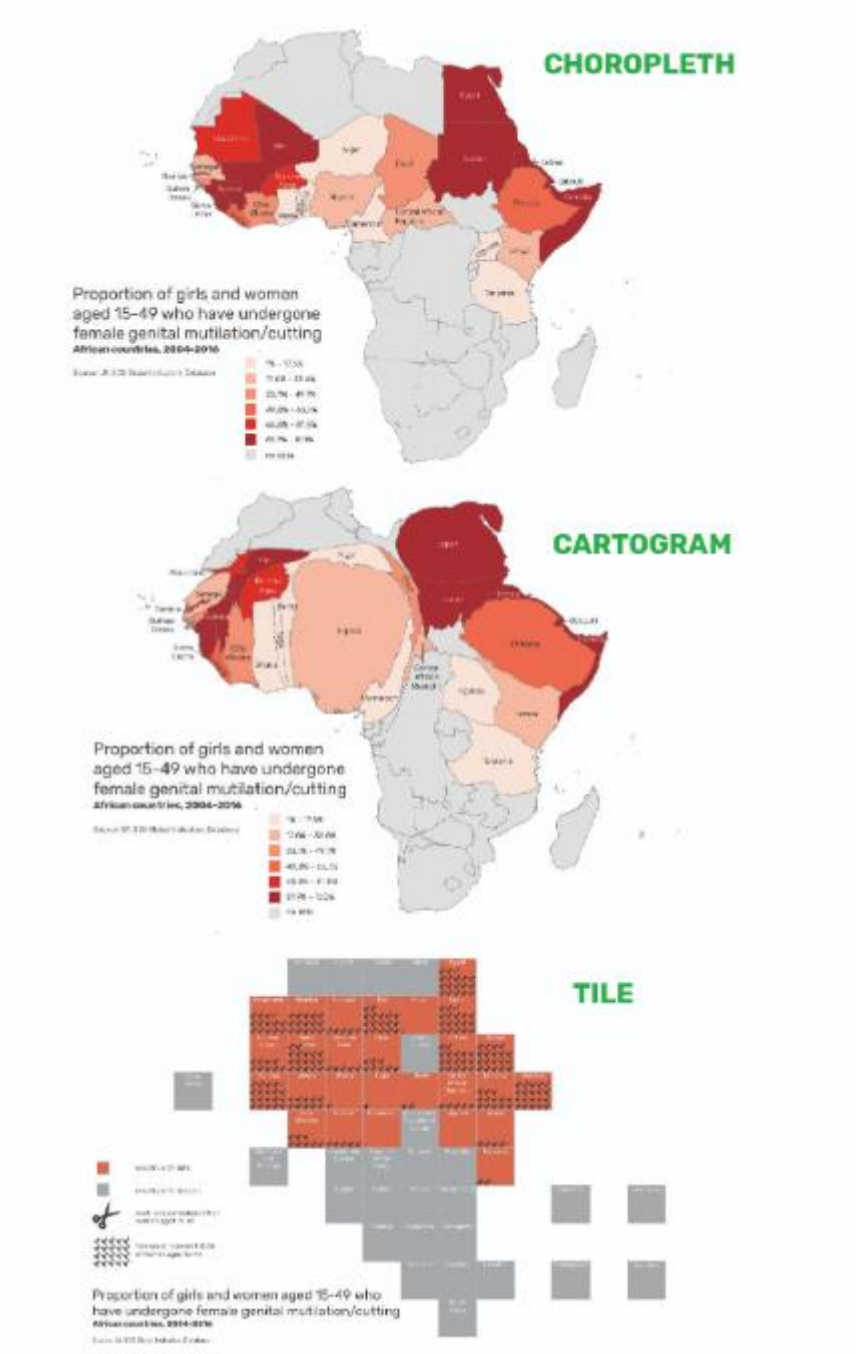
- Nigeria
- Ethiopia
- Mali
- Central African Republic

Page 10: PANAS

This scale consists of a number of words that describe different feelings and emotions. Read each item and then list the number from the scale below next to each word. Indicate to what extent you feel this way right now, that is, at the present moment.

	Very slightly or not at all	A little	Moderately	Quite a bit	Extremely
Interested	○	○	○	○	○
Distressed	○	○	○	○	○
Excited	○	○	○	○	○
Upset	○	○	○	○	○
Strong	○	○	○	○	○
Guilty	○	○	○	○	○
Scared	○	○	○	○	○
Hostile	○	○	○	○	○
Enthusiastic	○	○	○	○	○
Proud	○	○	○	○	○
Irritable	○	○	○	○	○
Alert	○	○	○	○	○
Ashamed	○	○	○	○	○
Inspired	○	○	○	○	○
Nervous	○	○	○	○	○
Determined	○	○	○	○	○
Attentive	○	○	○	○	○
Jittery	○	○	○	○	○
Active	○	○	○	○	○
Afraid	○	○	○	○	○

Page 11: Images of all maps, Likert scale questions to rate qualities of each map (same qualities per map, thus only one example shown here), and open questions:



Please rate the choropleth:

	Strongly disagree	Somewhat disagree	Neutral	Somewhat agree	Strongly agree
Interesting	○	○	○	○	○
Useful	○	○	○	○	○
Truthful	○	○	○	○	○
Symbolizes information well	○	○	○	○	○
Shows relative values clearly	○	○	○	○	○
Easy to understand	○	○	○	○	○
Emotional	○	○	○	○	○

Please comment on your ratings, thoughts or feelings about this map:

Looking back at your thoughts and feelings during this study,

What emotions did you experience while viewing these maps and the issue they portray?

What questions do you have from the maps?

Page 12: Demographics questions (gender, age, nationality, country of residence, field of work or study, and geo-related experience; closing message):

What gender do you identify with?

- ○ Female
- ○ Male
- ○ Other
- ○ Prefer not to answer

What is your age?

- ○ 18 to 24
- ○ 25 to 34
- ○ 35 to 44
- ○ 45 to 54
- ○ 55 to 64
- ○ 65+

What is your nationality?

Where do you live?

What is your occupation or field of study?

If you have experience in a geo-related field (for example, geography, geomatics, cartography, etc.), please describe it briefly.

Thank you for your time and participation!

For more information about this study, please contact Natasha (n.pirani@student.utwente.nl) or Britta (b.a.ricker@utwente.nl).