Visualizing Fukushima: Determining the grounds for effective visualization of the Fukushima Daiichi Nuclear Power Plant Disaster

Kwanghoon Lee

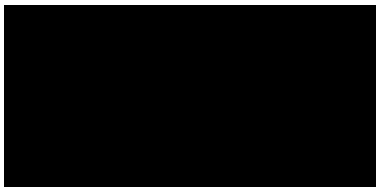
Thesis submitted for the degree of Doctor of Philosophy (PhD)

Department of Design
Goldsmiths, University of London

May 2019

Declaration of Authorship

I, Kwanghoon Lee, hereby declare that this thesis and the work presented in it is entirely my own. Where I have consulted the work of others, this is always clearly stated.

Signed: 

Date: 20th of May, 2019

Acknowledgement

First and foremost, I would like to thank my main supervisor, Terry Rosenberg. His academic support, constant contributions of ideas, patience, and kind consideration during my research process in both London and Seoul enabled to complete this thesis. I would also like to show my appreciation for my second supervisor, Martin Conreen.

I am eternally grateful for Professor Jonathan Freeman and Professor Ed D'Souza. Their advices were crucial in the improvement of my research.

It is difficult to express in mere words how much I have been in debt to my friend, Dr. Inki Kim. He is not only a lifelong best friend, but is also a reliable and knowledgeable mentor who greatly enabled my PhD programme. I also take great comfort in my friends and mentors in the fields of design, architecture, computer engineering, literature, and media: Jin Uk Lee, Aaron Kim, Dr. Bongjin Koo, Je Baak, Chase Yun, Professor Myungjin Baek, Professor Joonsoo Ha, and Sulki Jang. My many conversations with them always gave me invaluable inspirations and insights, and most crucially allowed to maintain some perspective during particularly difficult times.

Last but not least, I reserve the biggest thanks for my parents, brother, sister-in-law, and my loving wife.

Abstract

The vast amount of data and information now available in every aspect of modern society, otherwise called big data, has become a necessary resource to understand the trends of complex modern society. They have been largely controlled by the government and a few select major global companies and hence, have formed political hegemony. However, data and information is of course a meaningful resource which can change the world when it is open to the public and used appropriately.

To use the resource appropriately, Information visualization is an essential tool since it enables the finding of valuable trends amongst the large volume of data set and information. However, visualizations often lead to misunderstandings due to the various kinds of data and information and different possible interpretations depending on the diverse background of the people that are considering these visualizations. Moreover, these results are likely to have a negative impact on the world. Therefore, it is necessary to study the understanding of the visualization according to the background of the viewer.

In this context, this research investigated how visualizations of the Fukushima disaster in online newspapers are understood by people from various backgrounds such as their nationality, age, etc. The reason for studying the Fukushima disaster is that the characteristics of data, information, and visualization surrounding this one event are very similar to those of the contemporary world. This disaster needs to be understood with a wide range of data and information due to its multidimensional aspects such as politics, economy, society, environment, technology, etc. and so visualization is an essential tool to assist in that process. In addition, there is also the political hegemony of the Japanese government, and non-governmental organizations and the general public surrounding data and information. Still further, there are many problems which can be solved by using data and information as well (i.e. radiation contamination, present situations of evacuees, distribution of food from Fukushima, etc.). This one incident is therefore useful as a reflection of society in general, and from which one can understand the use of data and visualization in macroscopic modern society.

The reason for studying the visualization of online newspapers is that its main users are the general public. In addition, the most traditional and basic media format among the various visualizations' types in online newspapers is useful for sharing and spreading. In fact, the visualizations based on such type have been widely and actively shared through online media in relation to the Fukushima disaster. In particular, studying how visualization is understood by the general public from various backgrounds is

one of the most fundamental and significant areas in this field. This is because visualization has been used as a kind of universal language which transcends borders and boundaries across many people. Furthermore, the general public is the most direct subject that can change the world by understanding the given information and data through visualization. It is, therefore, important to look through their eyes and study their visualization use and understanding.

This study has collected many visual instances which have represented the data and information of the Fukushima event in order to analyze their components and to explore their understanding-related effects. The collected cases comprise of 236 visualizations used in online newspapers from 25 countries. These are countries where the radioactive fallout from Chernobyl and Fukushima has been detected by the IAEA and the CTBTO.

This study devised a framework to analyze the collected visual instances as well as to explore the principles in which understanding of visualization works. The framework is composed of several categories including a) source of data and information; b) main topic and purpose of visualization; and c) representation methods such as representational keys, types of visualization, metonymical and metaphorical expression. The framework was used not only in the analysis of collected visualization instances but also in the overall evaluation of understanding effects.

This study constructed visual materials by selecting predominant visualization forms in accordance with the result of the analysis. To conduct the interview, this study used semi-structured interview as the main methodology. This is because it was necessary to listen to the reasons for the different interpretations depending on the diverse backgrounds of the viewers. Thus, I designed a questionnaire composed of visual materials and open-ended questions which asked as to the understanding effects of visualization. The open-ended questions related to the reliabilities of the data sources of visualization, the level of understanding and the emotional impact of visualization, as well as the degrees of influence and change of perspective by those factors. The 113 participants who I encountered by random sampling were residents of Seoul, a major capital city which is close to the disaster area and in which many disaster-related issues have been often reported.

The results of the interviews were analyzed according to categories based on the participants' various backgrounds, i.e. region; age; whether or not the event still matters to them and their reasons for taking this position; and their existing perspectives on this event. In addition, by using the designed framework,

this research also explored the characteristics of the visual syntax in the visualizations which enabled such effects and changes

As a result of the study, there were various understanding effects according to various backgrounds and the categories of those. Put another way, the diverse backgrounds resulted in: various degrees of reliability on the source of data and information; diverse level of understanding of the components in visual syntax; various degrees of emotional stimulation which is a subsequent effect of understanding; and changes of perspectives. Nevertheless such effects were higher among the participants who were close to the impact of the catastrophe; whose nationalities were represented as influenced regions in visualizations; and those who had evident interests or concerns and the reasons for those.

Finally, this study provided guidelines for the field of the practice of visualization. In addition, it showed the possibility that visualization can work in a sociopolitical movement; and that the findings of this research can work seamlessly in combination with the principles of visualizations based on advanced technologies. Above all, this research is valuable in that it discovered the performance process and the consequences of visualization, which enabled these possibilities by investigating the understanding resulting from visualization according to the various backgrounds of many different people.

Table of Content

List of figures

List of Tables

Introduction

There have been a number of varied types of visual presentation to deliver information relating to the Fukushima disaster since its occurrence on 11th March 2011. There are traditional visual media such as photography and video that go some way in capturing and presenting the disaster scene, but notable other media includes information visualization representations including infographic and data-visualization. These techniques have been able to communicate a wider scope of information about the location, scale, condition, influence, etc. of the event.

In particular, people frequently exchanged communications surrounding the information of the event, sharing and spreading their views through online media such as blogs and social media sites. It is not difficult to find such visual materials across platforms such as Facebook, Instagram, Pinterest, etc. In addition, people tended to form the general public opinion through the posted visual images on those sites. These uses of information visualization regarding the event does not seem to be different from that of the aforementioned traditional media, at least at first glance. However, when taking the aspect of understanding into consideration, it is sometimes possible that the differing forms will produce different results. In other words, information visualization, which requires a process of interpreting the data or information encoded in visual components, is more likely to lead to misinterpretation, unlike photos and videos which tend to enable a more immediate recognition of realistic scenes.

There is a notable example of this with regard to use of visualization. The visualization below is a thematic map intended to visualize the simulated wave height formed by the 2011 Tohoku earthquake and tsunami [Fig.1].

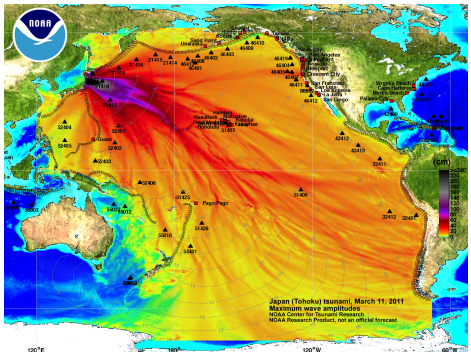


Figure 1. Japan (Tohoku) tsunami, March 11, 2011: Maximum wave amplitudes. NOAA (National Oceanic and Atmospheric Administration), 2011

This visualization case which was produced and released by NOAA (National Oceanic and

Atmospheric Administration of USA) in 2011 was quickly shared and spread across the world, and resulted in the formation of broad public opinions. This image was misunderstood by many people to be a map to indicate the spread of radiation contamination. Among these people, there were not only ordinary people who were anxious about radiation diffusion, but even experts such as scholars, reporters, writers, etc. The users of social media expressed their deep anxiety with comments on posts such as this visualization, with the resulting spread of these posts leading to a mistaken public view that radiation from Japan had hit America. Even specialists disseminated mis-informative articles and these were also shared among many people. Ethan A. Huff (2013), a writer for Natural News[1] posted this image and wrote that the radiation contamination was threatening the west coast of the US, using fearful and anxious tones on an online site named truth11.com[2]. Dr. Mark Sircus (2013), a writer and author in the field of medicine and health, also wrote that this was the worst image he had ever seen, and was in his eyes clear evidence proving the spread of radiation from Fukushima[3].

Clearly, not all people misinterpreted this visualization. There were other people who pointed out such misunderstanding, suggesting careful reading of this visualization was required. In addition, its modified version which corrected the misunderstanding appeared and was spread far and wide in an attempt to clarify any confusion [Fig.2][4]. Michael Smith (2014), a writer for Guardian Liberty Voice in the UK, criticized this problem, writing that this image was “one of several misleading maps being published on the internet”[5].

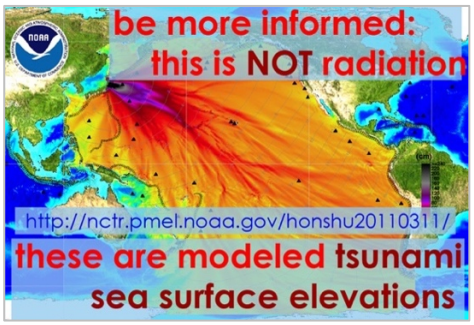


Figure 2. A different version modified based on NOAA’s original case by adding some sentences which corrected misunderstanding. Unknown creator

[1] Natural News is a US online news site related to health.

[2] http://truth11.com/2013/11/14/11-articles-on-the-global-threat-of-fukushima/

[3] http://northerntruthseeker.blogspot.co.uk/2013/08/the-fukushima-nuclear-disaster-news-you.html

[4] http://earthjay.com/?page_id=910

[5] http://guardianlv.com/2014/01/fukushima-radiation-fallout-rumors-debunked/

It is likely that there were various reasons behind the misinterpretation of the visualization by NOAA: a) majority of people's understandable concern and anxiety regarding radiation spread, b) the Pacific Ocean being shown covered by reddish hues, c) the description of the diffusing movement beginning from Japan, d) a lack of background knowledge that such type of visualization (using hue) has been employed to represent wave height, e) the fact that the data visualization was created and released by a supposedly reputable governmental organization in America regarding a situation where the Japanese government had announced that the radiation leak was perfectly blocked, etc.

These possible reasons were undoubtedly instrumental in causing confusion, especially given the viewers' diverse backgrounds such as their concerns regarding the event, their regional conditions, the degree of interest surrounding the event, etc. As a result, it is necessary to discover the relationships between the different interpretations according to the different backgrounds. This is because, as shown in the series of events relating to the visualization of the simulated tsunami, understanding is likely to be variable following consideration of only one type of visualization. In this situation, it is likely to result in behaviors which are dramatically different from the original purpose of the visualization.

The issues surrounding understanding of information visualization serves as a starting point for my research questions. The field of information visualization has been evolving as a method which aids our understanding. However, the case of NOAA's visualization shows that visualization is likely to be misunderstood, leading to inappropriate decision making even though on the face of it, it neither depicts misinformation nor is there a lack of crucial errors in its representational method. Consequences such as these can occur at any time, and in the case of representing crucial information and data which are directly linked to our safety and life, such a result can cause serious and real problems.

1.1. Research questions

With such considerations in mind, the research questions can be organized as follows.

a) Which data and information of the Fukushima event have been communicated through visualization?

It is important to understand whether or not the existing visualizations of this event have already

represented information and data according to people's needs. There are two possible assumptions with respect to this importance and for the case of NOAA's visualization. If it is true that people have the required data or information surrounding radiation contamination in the Pacific Ocean, and there has been a lot of representations of those matters, it is probable that those visual forms are already well familiar to people. This will undoubtedly result in a reduced possibility of misunderstanding. Another factor is that if the reactors of the nuclear power plant in Fukushima did not explode, and people therefore somehow became indifferent to the contamination issue, NOAA's visualization could be understood as depicting another topic of data and information in this area.

b) Where is the data and information taken from? (i.e. the source of data and information)

It is highly possible that the named source, NOAA in this visualization instance, is one of the factors that could make people (even including the aforementioned specialists) attach an assumed reliability to that visual material and share it despite the misunderstanding that could ensue. This could be due to the contrast between the underlying mistrust of the Japanese government's concealment and downsizing of the disaster's situation, compared to the data that is openly available to the public by the governmental organization of America. If the above hypothesis is true, the source of data and information is closely concerned with understanding. This is because the identity of the source is likely to be a significant factor in determining the quality of information and data.

c) Do the existing instances of visualization of the Fukushima provide effective understanding to diverse people despite their varied backgrounds?

The NOAA's case showed that visualization can lead to misunderstanding despite a lack of fundamental fault in its expressional manner. Issues to be considered here should not be limited to the dimension of the visualization itself. It is necessary assess the true extent of effectiveness depending on the various backgrounds of viewers into account.

d) What influence does visualization of the Fukushima event have on viewers?

There is no doubt that this event was a significant catastrophe with effects felt all around the world, but it surely cannot be said that all people across the world are still and equally concerned about this event in their daily lives to an equal degree. There could easily be those who have felt

indifference in the first place, or have gradually forgotten this event due to there being almost no chance that they would ever in real life feel the influence of the disaster themselves. However, no one can be sure that such a disaster would never happen again, and when such a disaster could strike. Moreover, this event is still on going. Therefore, it is necessary to consider whether visualization of the event can play a role in changing the perspectives on this disaster for those who have previously downplayed this event. This is because that moment of reflection acts as a beginning point to change the world and becomes one of the valuable consequences of meaningful understanding of visualization as well.

1.2. General outline of the research

The ultimate goal of this research is to explore the understanding of visualization and its subsequent effects depending on the various backgrounds of diverse viewers. Its general outline can be described in four distinct parts.

a) Collection

This research collected and investigated 236 existing visualization instances which represented the information and data regarding the Fukushima disaster, taken from online journalism media from 25 countries across the world. Considering the countries which have been officially confirmed as suffering from the fall out of radioactive materials from the Fukushima disaster and the Chernobyl catastrophe (which is the most similar event to Fukushima), they are located in various geographical conditions in Asia, Europe, the Americas, and Africa. The reason for considering those regions is that it is more likely that there have been more evident concerns regarding the event from these places, and consequently more need for information and data regarding the event. The result is that there are more frequent and increased uses of visualization as communication methods.

b) Analysis

I disassembled and analyzed the various components of the collected visual samples which range from the sources of data and information to the representational manners. In addition, I designed and employed a framework for the process of not only the analysis but also the

investigation of their effects upon understanding. The framework comprised the categories including 1) source of data and information, 2) main topics of visualization (as relating to categories of information and data and the purpose of visualization), 3) Representational key (as the minimum unit of visualization), 4) Type of visualization (as an assembled form of the keys), and 5) Metaphor and Metonymy (as an aspect of linguistic expressions which aid understanding). These categories are based on theories from scholars in the fields of information and data visualization as well as from those experts in the linguistics. For the Representational key, the theories from Jacques Bertin, an expert in cartography and Colin Ware, a scholar in visual perception and visualization were referred; for the Type of visualization, the principles from Edward Tufte, a statistician and specialist in visualization field were consulted; and for the Metaphor and Metonymy, I referred to the discussions from George Lakoff and Mark Johnson, scholars in the domain of linguistics.

c) Investigation of understanding of visualization (Interview)

I interviewed 113 people by random sampling. These participants were ordinary people with diverse backgrounds including differences in nationality and age, all of whom resided within South Korea, and specifically Seoul where the on-going issues of the Fukushima event have been frequently exposed. This location was also chosen as it is relatively not distant from the disaster area and its influences. The reason for selecting from the general public (ordinary people) as the interviewees is because they represent those who are in most need of the information and data regarding the event and who are the very subjects who can change the world by understanding the resources, and sharing and spreading those. The information and data about the disaster should not be commodities kept only for certain fields or classes. Moreover, the principle targets of online journalism media are the general public itself.

In the interview, I used a questionnaire and visual materials. A semi-structured interview format was essential for this research due to the necessity of investigating their various results surrounding understanding, and the reasons for those. Further, the questionnaire was composed of open-ended questions which asked as to the credibility of the sources of data and information in the visual samples. The level of understanding those and their subsequent effects were observed, which included emotional stimulation; the influence of the visualizations such as

whether or not their perspectives on the event have been changed, etc were also scrutinized. In addition, these understanding-related effects were explored based on not only the interview materials but also the framework to look into visualization structures.

1.3. Reasons for undertaking the research

One of the main reasons for undertaking this exploration is that there are multidimensional aspects to the Fukushima disaster, leading to a limitation of understanding regarding this event when using a written language or traditional visual methods of journalism media. The multiple topics of the disaster include various matters such as damaged situations in various locations, radiation level, the influences of radioactive materials and radiation contamination, the circumstances of evacuation, diverse conditions for the evacuees and their states, and any other matters in political, social, economical, environmental situations, etc. Therefore, to understand this disaster fully, a wide range of data sets and information are essential, and visualization is the most effective and indispensable tool to understand those. Ultimately the manner of the understanding of the visualization can lead to certain behaviors which could be advantageous or disadvantageous in changing the existing circumstances.

For the reasons above, and reflecting the urgent necessity of this research, I believe there is a strong justification for this study by understanding the features of data and information, and visualization of those aspects in the contemporary world.

1.3.1. Data in the contemporary world

The data and information surrounding the Fukushima event cannot be collected or generated by one person alone, or by one research institution or one journalism media. This is due to the enormous scope and volume of the data and information available. This has made those pieces of information into resources, and produced divisions between those who control the resources as assets and others who strive to access and share them. This is personified by the confrontation between the State Secret Law legislated in Japan and the general public's demand for transparent information and data concerning the disaster. Therefore, there are political and economical hegemonies around the data and information,

drawing clear lines between the haves and the have nots. This socio-political feature is closely aligned with the characteristics of data and information in the contemporary world.

"Bigdata" is a term often used to represent the features of present-day data and information. The notion of bigdata is defined by attributes including a) Variety (diverse sources including traditional media as well as modern network-technology based media such as digital documents, websites, etc.), b) Volume (huge amounts of data and information which is currently measured in peta bytes but predicted to grow to zettabytes in the close future), c) Velocity (high speed of generation and storage which is too fast to analyze in real time), d) Variability (inconsistent conditions regarding the flow of data), e) Complexity (difficulty of constructing hierarchy, linking, matching, etc.), and d) Value (merit which can be beneficial to the fields of politics and economics by discovering social trends) (Kata, et al. 2013:404).

Such data and information have already been administered by governments and global enterprises across the world. For instance, the UK and USA governments have possessed bigdata as national property and have restricted its use in many cases. In order to establish and maintain their policies and govern socioeconomical activities, they have controlled the statistical data and information on certificates, laws, economics, death, crimes, even weather, etc. (Cuckler, 2010: 8-9). This control is also exerted by multinational corporations such as Amazon, Google, Microsoft, etc. who closely develop their own technologies and infrastructures to manage bigdata. It appears they have gradually and stealthily collected the data relating to our personal lives, resulting in perhaps useful analysis to promote greater convenience for those users, but also to benefit the corporations themselves and their huge profits (ibid.:6).

Bigdata and information have been tightly protected by the groups above, but it seems that bigdata and information prove their real worth when they are released. The general public and NGOs (Nongovernmental Organizations) now call for free access to those assets (ibid.: 8), since they can discover solutions which could make their existences better with the benefit of such data and information. For instance, there was a project which showed the usefulness of public data called "San Francisco Crime spotting". By accessing the data and information regarding the hotspots and nature of crimes in their local areas, the general public can be more informed as to where the problematic areas are and request greater police patrols in those areas (ibid.:8).

As wider public use of data and information is increasingly producing positive and effective results in social and financial dimensions, the governments of certain nations have begun to actively release data, rather than simply presenting improvement plans for specific problems. These changes have been prominent particularly in the US and the UK. For instance, they designed and provided services for sharing data in terms of various subjects including sanitary inspection scores of restaurants, availability of parking spaces in crowded cities, monitoring politician's activities and public services, various local problems, etc. (ibid.:8-9).

The instances above show one of the most crucial characteristics of data and information in the contemporary world: that is, the power to change the world.

1.3.2. Importance of visualization

The value of visualization is just as important as that of data and information in present-day society. This is because it is a direct method through which one can understand data and information, and one which enables the recognition of the patterns and structures of complex and enormous volumes of data sets and information. It is, after all, a tool to understand an inhuman volume and range of data and information with the perspective level of a human (ibid.: 10).

However, the importance of visualization is not restricted within the boundary of understanding itself. This is because, as a result of understanding, it improves decision making and changes attitudes of people towards certain problems (Retamero and Colkely, 2013: 392). It also leads to alterations in perspectives of people (Wattenberg in Kosara, et al. 2009: 2); and, in consequence, it contributes to the change of the world (Kosara, in ibid.: 2).

There are abundant examples of this theory being put into practice. Some of the aforementioned services of data sharing (to create better surroundings) by the governments and global enterprises have employed this visual manner to provide data and information, as well as the analysis of the results produced: Google Trend, FixMyStreet.com, San Francisco Crime Spotting project, etc. In these cases, visualization allows us to discover unknown facts (patterns or phenomena) which are difficult to identify easily in mere data sets themselves. In practical terms, this reflects the current generation of ever-increasing levels of new knowledge.

In addition, according to various research papers which explore the function and role of visual aids to deliver information regarding the medical risks to citizens and patients, visualization is an effective tool to improve the capabilities of understanding and decision making of those who have felt difficulty in understanding such health-related information (i.e., people who have low numeracy; persons who are short of medical knowledge but have relatively high ability to interpreting graphs; those of an older generation; the illiterate in a certain language (in which the information is originally presented); and patients who are at high risk) (Retamero and Colkely, 2013: 394). As this effectiveness is likely to reduce the health risks of patients and citizens, and help them to choose better medical treatment, this contributes to a real change across the world as well.

This function, which affects ideas, behaviors, and does result in real changes to the world, is a feature which visualization has long retained. It is of course possible to find how and when these such instances have played a role in history. [Fig.3] is one such example.

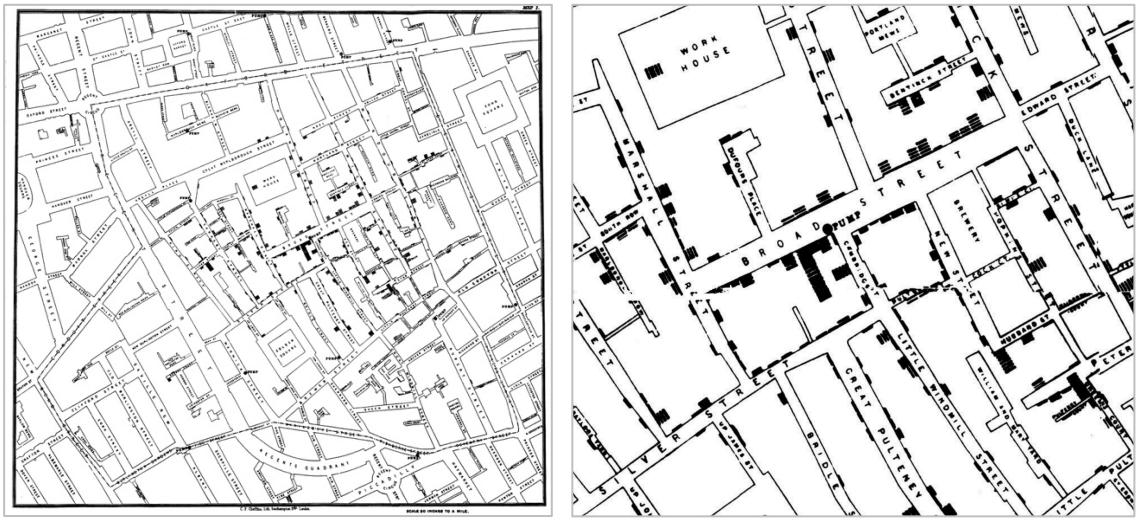


Figure 3. The Cholera map produced by John Snow in 1854 (the whole image and an enlarged part of it)

The map above, produced by John Snow who was a physician and an expert in anaesthesia and medical hygiene in the 19th Century, changed general attitudes towards cholera. The small bars on the map depict the number of deaths and we can see the group of the bars with the largest amount are located around the Pump (indicated in the center of the enlarged part on the right side of [Fig.3]). This enabled the discovery of the fact that the pump was the source of infection of cholera, against the previous belief that this disease was spread through aerial infection (Roger, 2013). Thus, this is a historically valuable visualization which changed the perspectives regarding the infectious disease,

cholera, and prevented its diffusion. As a result, visualizations such as these truly did contribute to the change in the world.

In addition, the role of visualization during WWII was one of the instances of such function and role. Visualization at that time played a crucial role in producing prompts that allowed for quick decision making in situations of both battle and evacuation. Graph expressions such as diagrams and charts were used to visually present data during the war, including radar, sonar and other visual technologies used as tools of the war (Drucker and McVarish, 2013: 238). Types using iconic visual artefacts such as infographics were presented as typical forms due to the necessity of codes, cryptograms and symbols, which were all required to be interpreted regardless of specific language (ibid.: 237). Consequently and as a stark example of a real effect on life and death, this contributed to save many people's lives during the war.

The cases above demonstrate that the power to change the world is one of the fundamental elements in information visualization.

1.3.3. Evolution of visualization across diverse media

The media of visualization have evolved in accordance with the advancement of production technology. Escaping from the form of traditional 2D-based graphical expressions typically used for printing, there has been an increase in the diversity in advanced types of media such as moving image (motion graphic), interactive media based forms, even the type using 3D objects, etc.

In particular, the software tools based on programming languages such as *Processing* and *C++* have the capability to transform data into color, shape, texture and even movement of elements in accordance with creators' intentions. They have also played an important role in spreading a new area of visual art such as digital interactive media art. It is evident that these technologies have contributed to the extension of not only expressional possibilities but also media types of the visualization.

Digital technology also has had an influence on the dissemination of visualization. Visualization has become suddenly and increasingly popularized through use of the digital apps which are readily available to almost anyone around the world. Apps such as *Google charts*, *Visualize.me,* and *Infogr.am* are common examples. Even though they are inappropriate in creating unique or originative

visualization forms, it is possible to easily utilize applied types of the traditional visualization by using those new apps.

In addition, digital technology has shifted the functionality of information visualization. In particular, the combination of the visualization and hypertextuality provides a function to lead users from and into other information through the interaction between them[6] In other words, information visualization is not only a graphic form which efficiently deals with information but also an interface to access further information.

It is not difficult to find the examples of visualization in the form of advanced media (screen media, etc.) based on the digital technologies. For instance, “Information is Beautiful[7]” established by David McCandless, a journalist and designer in the field of visualization, presents not only 2D based visualizations but also more dynamic forms such as interactive media. The subjects and types of data and information of those are various: this includes both quantitative and qualitative data and information relating to politics, economics, culture, society, etc. [Fig.4].

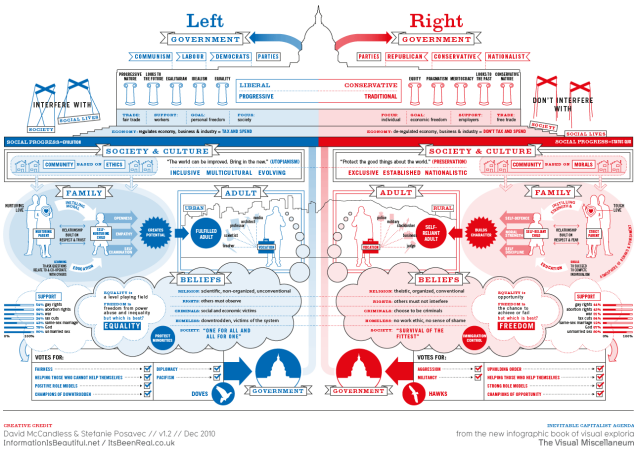


Figure 4. Left and Right. Created by McCandless and Posavec. 2010

In addition, “Visualcomplexity.com”, set up by Manel Lima who is a designer and author in the field of network visualization, has collected and introduced advanced types of visualization based on digital algorithms created by computer programming technology. These results show interesting dynamics and

[6] This functionality can be found in infographic articles of online newspapers. For example, refer to the link: http://usatoday30.usatoday.com/news/nation/smelting-lead-contamination#

[7] https://informationisbeautiful.net

exquisiteness which are created when the various digital algorithms deal with bigdata relating to networks of diverse realms in the online world [Fig.5].

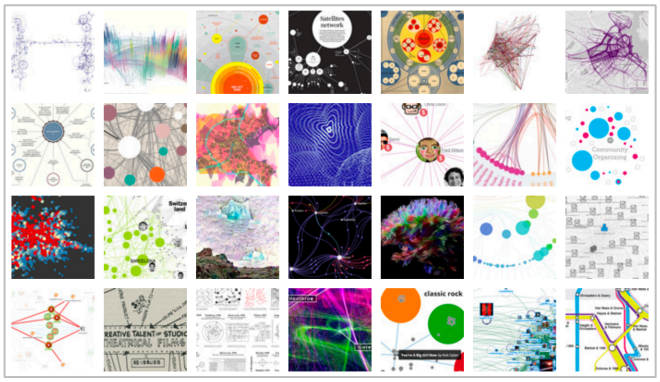


Figure 5. The collected visualization cases of network. Captured from Visualcomplexity.com.

Furthermore, the advanced types of visualization in contemporary society have been extending their domains to that of aesthetic value. “Wind Map” created by a collaboration between Martin Watternberg and Fernanda Viégas, scientists and artists in the field of data visualization, creates a remarkable aesthetic impression created by the elaborate thin lines which are the vehicles of wind. This is the first web-based artwork which MOMA (the Museum of Modern Art in New York) keeps as part of its permanent collection[8] [Fig.6].

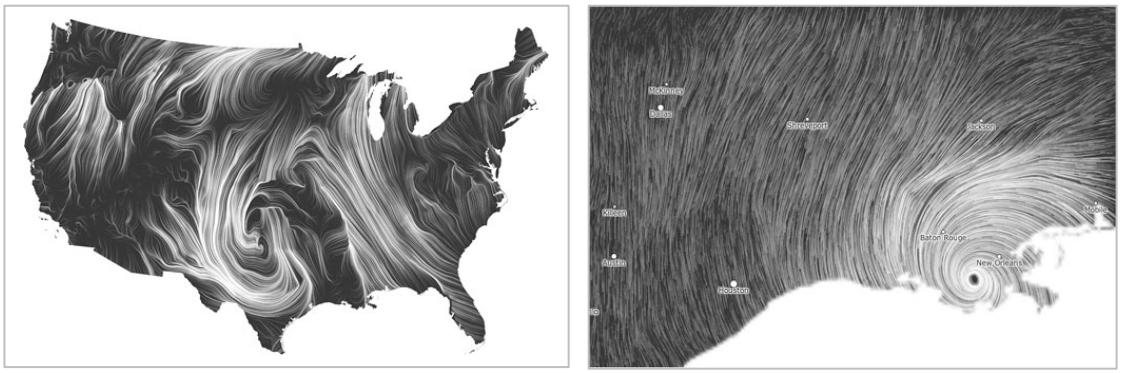


Figure 6. Wind Map. Created by Wattenberg and Viégas. 2012.

1.3.4. Particularity of visualizations in online newspaper

Despite the variety in the media types and genre of visualization, this research focuses on visualization instances which have been employed in online newspapers. The reason for considering

[8] http://www.bewitched.com/windmap.html

the journalism media is that one of the primary goals of this research is to investigate understanding and its surrounding effects upon diverse people from various backgrounds. The reason that I posed a question surrounding the misunderstanding around NOAA's visualization in the first place is based on the same context as well. The investigation of the use of visualization among the general public is very important since we have already confirmed that the visualizations became bold and powerful subjects to lead to change in the world when data and information were openly shared.

The necessity of exploration on the use of visualization and its effectiveness of understanding among the general public has long been highlighted by experts in this field. Robert Kosara, a scientist and expert in the field of visualization, wrote as follows (Kosara, et al. 2009:2)

> Visualization papers tend to assume a particular type of user who is hard to find in the real world: the domain expert. We need to find a way to talk to non-expert, interested people with average intelligence and computer skills. What do they want to learn? Where do they get their news? And how can we reach them?

In addition, Stephen Few, the founder and principal of Perceptual Edge, a consultancy of data visualization, pointed out the following (Few. 2008:2)

> Most data sense-making activities in the normal course of world affairs can be handled by a broad range of people using fairly simple visualization techniques. If you search for resources that teach and support data analysis, however, you'll find many books, courses, and tools that address the sophisticated needs of the few, but almost none that address the simpler needs of the many.

Their comments support the over-arching reason for this research.

The usual targets of journalism media are the general public and hence it is highly probable that the explanatory visualizations provided by those media are more frequently and easily used among the general public. This is in comparison to exploratory and relatively difficult visualizations designed by specialized research institutions or firms to handle a wide range of bigdata. Of course, there have been special newspapers which have reported on these events and trends in certain fields. However, the visualization instances investigated by this research were collected from diverse online articles

published by traditional newspaper media which have produced the type of printed daily newspaper.

In addition, there could be a concern that this research is unsuitable to the field of visualization in the contemporary world because the explanatory visualizations of online newspapers mainly rely on a very basic form of media, which is a 2D-based graphical expression in the type of still image. However, there are several reasons for exploring visualization based on this basic media type.

Firstly, the greatest number of visualizations in online newspapers have employed such fundamental media type. Of course, online newspapers have also used other forms of visualizations such as interactive media type, moving image, etc. but the chances of identifying specific instances with these advanced forms are much less than those of visualizations with the basic media form (This is a fact which was discovered during the process of collecting the visualization instances). Therefore, it is highly likely that the visualizations in the type of fundamental media have been predominantly popularized among the general public.

Another reason to continue exploring visualizations is that it is easier and more comfortable for viewers to share and spread visualizations with the type of 2D based still image. Other advanced media types (such as moving image and interactive media) are mainly provided by paid-for services, and it is probable that this service form has been an obstacle in sharing and spreading that information. In addition, it is more suitable to view those visualizations in the environment of a personal computer screen due to its large scale and diverse buttons pointing to various hyperlinks. On the other hand, the visualizations with basic media form can be employed and shared through both the PC and another media, the mobile-phone.

Therefore, it is appropriate to explore visualizations with the type of 2D-based still image because they are the most popularized types of visualization which have represented the data and information of the Fukushima event.

1.4. Purpose of the research

Taking all the discussions above, the purpose of this research can be organized as follows:

a) To investigate various components in visualizations of online newspapers such as sources of data and information, main topics, and visual syntax,

b) To explore how effective those are in effecting understanding among people with diverse backgrounds,
c) To examine the subsequent effects of understanding: whether or not the visualizations of the event can change the perspectives of the participants and how they lead to such alterations,
d) To evaluate whether the existing visualizations of the Fukushima event could contribute to ameliorating the circumstances surrounding the disaster, and
e) To suggest methodological guidelines which can be applied to the practical field of visualization.

2. Background

There are multidimensional issues to consider in relation to the Fukushima disaster: including political, social, cultural, technological, environmental, economical, etc. problems. In this chapter, there is a close analysis of the outline of, and notable issues surrounding this catastrophe from the aspect of data and information relating to the event.

2.1. The outline of the Fukushima event

2.1.1. Great East Japan Earthquake

The Fukushima disaster was caused by the magnitude-nine undersea earthquake off the Sanriku coast of Japan (Tohoku) on 11th March in 2011. This earthquake is commonly known as the Great East Japan Earthquake. The epicenter was 70 km east of the Tohoku Oshika Peninsula and at a depth of 29 km (Buerk, 2011). The magnitude of the earthquake was M9.0 to M9.1, which was the fourth strongest earthquake recorded since the beginning of modern earthquake observation in 1900 (United States Geological Survey (USGC), 2011). Due to the Great East Japan Earthquake, Honshu moved 2.4m to the east, and the Earth rotation axis moved about 10cm-25cm (Chang and Chai, 2011).

After the earthquake, a powerful tsunami occurred. A tsunami 40.5m high hit Miyako City, Iwate Prefecture in the Tohoku region, and in Sendai City a tsunami struck inland 10km from the sea shore (Buerk, 2011) [Fig.7]. In addition, there were numerous strong aftershocks whose magnitudes were higher than M6 all the way up to 2016 (東北地方太平洋沖地震, 2012). [Fig.8] charts the large number of aftershocks in 2011.

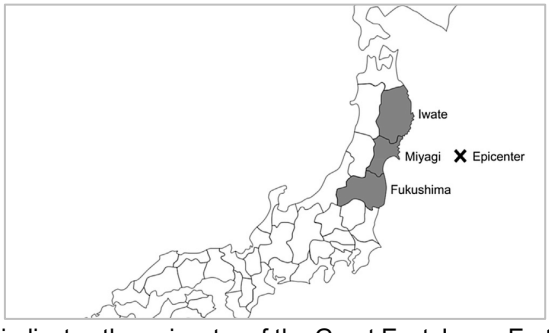


Figure 7. Map of Japan which indicates the epicenter of the Great East Japan Earthquake. The earthquake most

severely impacted Iwate, Miyagi, and Fukushima Prefectures (Kikuya et al., 2017).

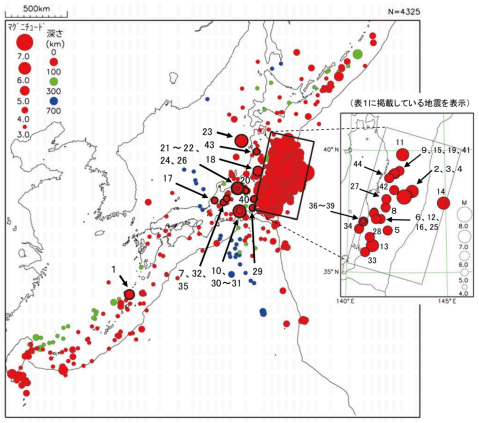


Figure 8. The map which shows aftershocks distribution (the earthquakes over M3.0) in March 2011 (JMA, 2011)

This earthquake was recorded as a natural disaster that caused the largest number of casualties in Japan since the Pacific War. [Table 1] shows the major damaged regions and the number of their casualties.

Prefecture	The number of death	The number of missing
Miyagi	10,555	1,234
Iwate	5,133	1,123
Fukushima	3,730	225

Table 1. the most severely damaged prefectures and their casualties

The Great East Earthquake affected not only Japan but also various other countries. An hour and 45 minutes after the earthquake occurred, the Pacific Tsunami Warning Center issued an earthquake tsunami warning in Hawaii[9]. In addition, it issued tsunami alerts to 50 countries and regions around the Pacific Ocean including America, Chile, Russia, New Zealand, Canada, Philippines, Indonesia, New Zealand, etc. (Kyodo News, 2011.; NOAA, 2011; News24, 2011; The Jakarta Post, 2011; and AP News, 2011).

2.1.2. The Fukushima Daiichi Nuclear Power Plant accident

The tsunami stemming from the Great East Japan Earthquake damaged several nuclear power plants in Japan, with the most extremely damaged one being the Fukushima Daiichi Nuclear Power Plant. When the earthquake occurred, nuclear reactors No.1, 2 and 3 of the Fukushima Daiichi Nuclear Power

9 "Warning Statement". Pacific Tsunami Warning Center. 2011.

were automatically shut down. About 50 minutes after the earthquake, however, a tsunami 15m high hit the power plant. It exceeded 5M, which was the maximum height of tsunami that this power plant was designed to withstand. The emergency diesel generator which was installed in the basement was flooded and stopped, and all electric facilities in the power plant were also damaged. The Fukushima Daiichi Nuclear Power Plant was blacked out without any power to ensure the reactors' safety, which action made it impossible to operate the cooling water pumps for reactor cooling. As a result, the cooling water rapidly evaporated and the internal temperature and pressure of the reactor dramatically was elevated. Finally, a hydrogen explosion occurred at the reactors Unit 1 (12th March), Unit 3 (14th March) and Unit 4 (15th March) and this finally triggered the release of radioactive material to the atmosphere (Kyodo News, 2011) [Fig.9].

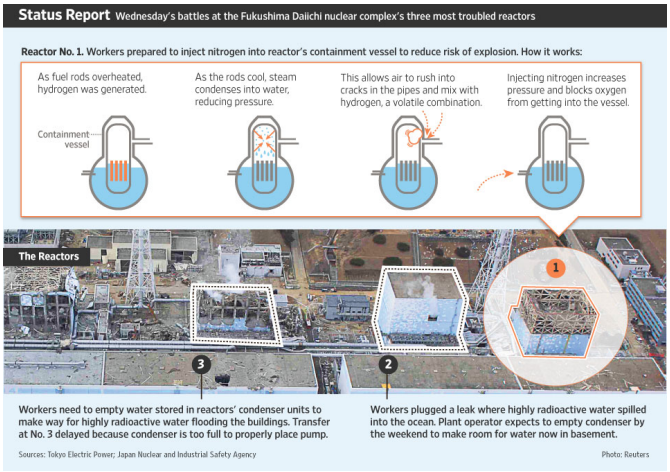


Figure 9. Status Report 2011. The Wall Street Journal. 2011

Emanating from the Fukushima Daiichi Nuclear Power Plant, about 60 billion becquerels of Caesium-137 and Strontium-90 per day had been released to the Pacific Ocean by 2013 (Lee, 2013). Moreover, from the day immediately following the Fukushima accident up to 7th of April, 100 trillion becquerels had been leaked out per day to the Pacific Ocean (Yoo, 2013).

Nevertheless, TEPCO (Tokyo Electric Power Company) has consistently adhered to its stance that there has been no problem since the concentration of contaminated water is supposedly below the standard level (Yoo, 2013). This attitude has been observed from not only TEPCO, but also from the Japanese government, who have downplayed the predicament. Together, they announced that the amount of Caesium-137 released from Fukushima Nuclear Power Plant Units 1 to 3 in 2011 were 15,000 tera becquerels, equating to 168.5 times that issued from the Hiroshima Atomic Bomb (89 tera

becquerels from the Little Boy Bomb) (Jeong, 2011). On the other hand, the Norwegian Atmospheric Research Institute estimated that the amount of Caesium-137 leaked in the same year was 36,000 tera becquerels (Jeong, 2011).

After the explosions of the reactors, the Japanese government designated an exclusion zone of 20 km radius from the nuclear power plant and prohibited residents and other people from entering that area (Cheon, 2011). However, the Japanese government finally added a radius of 20 to 30 km from the power plant as an evacuation zone. In addition, and dependent on the direction of the wind, some areas about 40 km away from the power plant were also seriously polluted with radioactivity, and hence the residents of those areas were ordered to evacuate as well [Fig.10] (Takano, 2017).

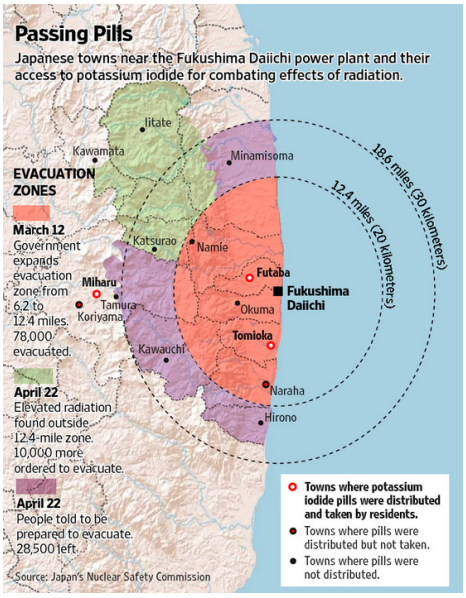


Figure 10. Shaky Ground. The Wall Street Journal. 201

As a result, about 81,000 people were forced to evacuate, and about 165,000 people became evacuees when also counting those who left their homes voluntarily (ibid.).

2.1.3. The cause of the Fukushima event

As confirmed so far, the Fukushima event is a truly multi-dimensional and multi-layered one and thus it is necessary to understand this disaster using a wide range of data sets and information. Put another way, it is highly probable that the multidimensionality leads to difficulty in understanding, and moreover, the understanding can differ depending on whether or not there has been transparent and sufficient

data provided, together with information regarding such multidimensional aspects of this catastrophe.

Nevertheless, the Japanese government has undoubtedly concealed and manipulated the data and information. It is not difficult to find evidence of this. At the International Olympic Committee (IOC) plenary address to select the 2020 Olympic venue, Prime Minister Abe announced that the radioactive contamination of the Fukushima nuclear plant was completely ceased (Park, 2013).

[Fig.11] below is also part of the evidence. This visualization, which was published by DER SPIEGEL, a German news magazine media, pointed out the trace of data manipulation by the Japanese government.

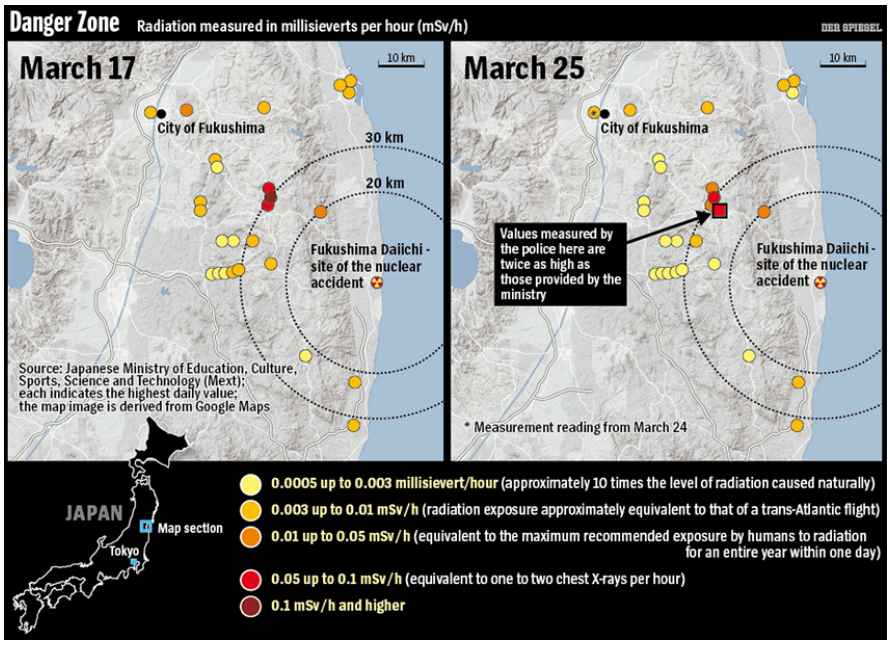


Figure 11. The danger zone. DER SPIEGEL. 2011

In addition, by manipulating the data of the radiation level, similar to the instance above, the government and local communities have been persuading residents to return to the evacuation zone. According to an interview with a resident in Itatemura by Satoshi Takano, a Japanese student in MPA and journalist, the government has not accurately delivered information to the evacuees and the levels of radioactivity measured by the government have been 20-30% lower than those produced by the residents themselves. Despite this treacherous situation, the Japanese government has persuaded them to return home (Takano, 2017).

In addition, according to Greenpeace research (2018), high radioactive contamination levels in Itate and Namie near the Fukushima power plant, which was included in the exclusion zone, were expected

to continue until the middle of the 21st century. Nonetheless, these towns were excluded from the exclusion zone in 2017 by the Japanese government (Greenpeace, 2018).

Moreover, the Japanese government passed a bill to prohibit the access and collection of data and information, called the State Secrets Law, in 2013. The list of the SDS (Specially Designated Secrets) contains a lot of items, but the most relevant sections with regard to the Fukushima event is as follows[10]:

Item (iii) Prevention of Designated Harmful Activities (e.g. Counterintelligence)

(a) Measures to prevent Designated Harmful Activities or thereto relevant plans or research

(b) Important information collected on the protection of lives and bodies of people, or information collected from foreign governments or international organizations in relation to prevention of Designated Harmful Activities

(c) Collection and organization of information listed in (b) or the capacity to do so

(d) Cryptology used for prevention of Designated Harmful Activities

The problem here lies in the fact that the scope of Designated Harmful Activities is ambiguous: counterintelligence is just one example. In these circumstances, if information and data about the situation of the Fukushima event are deemed important for Japan's security, collecting or releasing that particular information is now deemed a violation of this law.

Against this backdrop, the movements of nongovernmental organizations and citizens to collect and generate data and information have nevertheless persisted. Greenpeace was the first organization who conducted an independent measurement of radioactive contamination in and around Fukushima. Since March 2011, its members have measured radiation levels at 1 meter per second by using a vehicle or walking around (Greenpeace, 2018: p.5 and 8).

In addition, there is Safecast, another international non-governmental organization which has measured radiation contamination. The members of this organization have also directly collected radioactive pollution data and opened those in real time by using visualization through their online-site

[10] https://en.wikipedia.org/wiki/State_Secrecy_Law

named "realtime.safecast.org".

The Fukuichi Project was founded by people with the same purpose as those organizations above. The measurement unit of radioactive contamination of the Japanese government is usually 1 square kilometer, and in the case of a city area, it is 500 square meters. On the other hand, the Fukuichi Project is more detailed, using 75×100 square meters (Takano, 2017).

The kinds of data which have been generated and collected are not limited to the field of radiation contamination. There are various subjects of data and information such as the current situation of the evacuees and their population change, the trend of deaths relating to the Fukushima power plant accident, monitoring of the trade and distribution of Fukushima fisheries, etc.

The collection of data and information in these various fields is being conducted by many individuals, journalists, and organizations. Given this deep national and international interest, data and information regarding this disaster is likely to increase further, unless the diverse problems of this complex and long-lasting disaster are finally resolved. Therefore, it is valuable and suitable to investigate visualization as a tool to understand the Fukushima disaster and this is therefore one of the most important reasons for undertaking this research.

3. The framework

The analysis element following on from the collected cases is a fundamental process with which to discover the causality of the effect of information delivery and the tendencies of the production and use of visualization cases. Further, this is an essential preliminary phase to undertake before one is able to suggest the strategies of visualization to promote effective understanding. In order to perform such valuable analysis, this research utilized a framework which enabled such exploration by applying consistent norm and logic.

The framework was used as a tool to look into the effects of understanding which stemmed from micro- and macroscopic components in the visual language. In other words, the framework was utilized to explore the understanding effects of the smallest units, namely visual elements as well as the types of structures composed in the overall piece. In addition, the framework was employed to investigate linguistic effects which aid understanding, such as metonymycal and metaphorical expressions. The reason behind the study of those targets was that these methods of linguistic expressions coexist in the system of visualization. In the structure of visualization, there has been metaphorical representation in which specific objects are expressed by certain methods to represent different kinds objects, based on the similarity between those individual pieces. Furthermore, there can be seen metonymical expression which employs the part of a main object or uses other substitutes (such as indexical signs, symbolic signs, etc.) to indicate its features on the basis of the correlation of those elements.

The framework for analysis is thus designed to encompass the exploration of the disassembled fragments of visualization as well as the effect of understanding derived from the synthesis (combination) of those.

3.1. The composition of the framework

The framework is based on three main categories: a) representational key, b) types of visualization and c) metaphorical and metonymical expressions. They are further explained in the table below [Table 2].

Representational key		Type of Visualization	Metaphorical and Metonymical expression	
Arbitrary	Point Line Bar Shape (Geometry: Circle / Triangle / Quadrangle / etc.) Position Length Scale Color (Tone / Hue / Saturation / Brightness) Texture	Statistical Graphics (Bar chart / Pie chart / Line chart / etc.) Map Table Technical drawings (Plan / Cross section / Process graphic / etc.)	Metaphor	Heat (Thermography) Moisture (Precipitation) Pressure (Iso-Bars) Flow (Air / Ocean / etc.)
Non-arbitrary	Visual signs (Iconic / Indexical / Symbolic) Shape (Figurative) Photograph Text		Metonymy	Extracted detail (Object) Replaced object ( ) Location (Region: / Country: / Multiple countries: / World)

Table 2. The composition of framework

3.1.1. Representational key

The category of representational key includes the basic visual components which represent the smallest unit of data set and information. They perform a similar function to words since they are visual substitutes indicating the subjects of data and information or describing qualitative or quantitative conditions of the subjects. In other words, they function as nouns (or pronouns), identifying the subjects, or can also be compared to adjectives (or verbs) describing the quantity, change, shape, movement, etc. of those components.

The components can be both arbitrary or non-arbitrary but the elements of the two different categories coexist in many cases. The arbitrary key includes geometrical figures and colors which are assigned

on the basis of the rules or codes in the system of visualization rather than the similarity or correlation with the subjects. They therefore demand to be learned[11] and to be interpreted in some cases. On the other hand, the non-arbitrary components have morphological, causal, symbolic, etc. relationships with the subjects or the contents of the data set and information. They can therefore be interpreted more easily, with less reliance placed upon learning. For instance, there are visual artifacts describing figurative shapes, iconic signs such as pictogram, indexical signs including arrows, etc.

Visual elements which are included in the arbitrarily representational key have been studied by a number of researchers and there are two notable publications in this field: *Semiology of Graphics* (Bertin, 1967) and *Information Visualization: Perception for Design* (Ware, 2012). In his work, Jacques Bertin, a French scholar in the field of cartography, (1967) divided the visual components of information graphics into seven categories including position, size, shape, value, hue, orientation, and texture. He explored a strategy of how to apply those elements in some kind of order so as to increase the effect of visual cognition and to stress-test the information. The various kinds of representational key of the framework are based on these 7 classifications. In addition, Colin Ware, an expert in the domain of data visualization and cognitive science, investigated the cognitive effectiveness of a wider range of basic visual elements (2012). He categorized those into two groups – arbitrary and sensory codes – and discussed the possible methodologies to apply those methodologies effectively based on the principles of the system of sight and visual cognition.

The common ground between these two great achievements by Bertin and Ware is that they focus on the methodology of representation grounded on the principles regarding the system of visual perception of human. Hence, their theories focus on universal visual language regardless of the topics or subjects of data and information.

Contrary to the above, this research explored whether the components of the representational key had been utilized to bring about effective understanding of the specific subjects (main topic of data or information), namely the multidimensional aspects of the Fukushima event. In other words, it studies whether the visual elements were used appropriately in order to help viewers clearly understand the

[11] In cases of complicated statistical charts employing the types of multivariate visualization, viewers need to know how to interpret the structures. In addition, understanding the legend of thematic maps and using that guide to assist interpretation can be included as part of the learning process as well.

multidimensional aspects of the disaster. The reason for this analysis is that such basic units form the crucial factors to create the effects of metaphor or metonymy in visualization. The components contain their own semantic elements of data and information but those effects by their synthesis are most likely to lead to the association with other subjects which are relevant or irrelevant to the contents of data set and information. In addition, the risks and the potential for any such misinterpretation could promote or disturb the understanding effect of visualization. The misunderstanding of NOAA's visualization of the tsunami simulation represents one such instance of one of the potential negative consequences.

Therefore, the constituents of representational key are explored in order to understand not only the cognitive effects resulting, but also their potential to lead to positive metaphorical and metonymical effects.

3.1.2. Type of visualization

The types of visualization are specific forms constructed by the assemblage of the elements of the representational key, and they are similar to the structures of the syntax of visualization. These organizations lead to understanding of the data set and information. This is because they are the forms which enable comparison or contrast, perception of spatiotemporal changes, investigation of patterns in whole and in parts, etc.

The types can be categorized into two groups, as forms composed of arbitrary and non-arbitrary representational key. For instance, there are statistical charts (i.e. bar charts, pie charts, etc.) in the former, with the styles of technical drawings based on figurative shapes an example in the latter category. This dichotomous approach is possible in the types of visualization but they usually coexist in most other cases. For example, in the form of thematic map which displays statistical data by region, the arbitrary elements, such as circles displaying the statistics, are located on the map, which is one of the non-arbitrary components [Table 3].

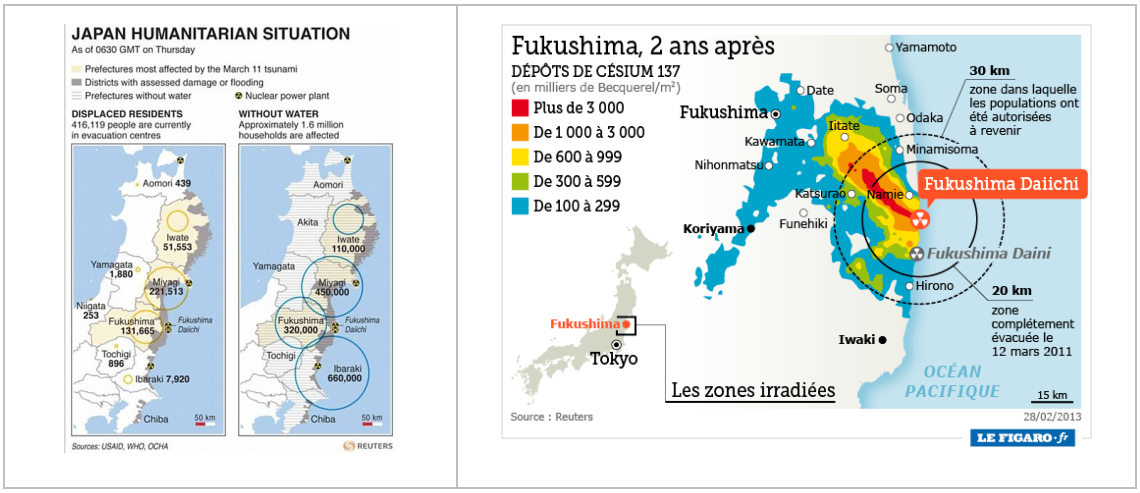


Table 3. The examples of the combination of arbitrary and non-arbitrary keys. (Left: JAPAN HUMANITARIAN SITUATION, REUTERS, 2011. An example of the combination of the arbitrary and non-arbitrary components / Right: Fukushima, 2 ans après Dèpôts de cèsium 137 (Fukushima, two years after the accumulation of Caesium-137). Le Figaro. 2013)

There are an increasing number in the list of available types of visualization and so it is not easy to categorize all of those. However, it can be more helpful to classify them according to the functions of visualization: to deal with statistical figures, to indicate the physical condition of subjects, and to narrate the change or process. In the framework, the statistical graphics and table, in which numeric figures are arranged, can be included in the first function; the map, photograph, plan and cross section can be categorized in the second function; the process graphic and multiple photos and drawings with descriptive role can be located in the last function [Table 2].

This categorization is based on the perspective from Edward Tufte, a scholar in data visualization and a statistician, and in whose work he approaches visualization. According to Tufte, the forms of information visualization can be listed under three categories: visualization of numbers; visualization of nouns; visualization of verbs. The visualization of numbers includes a graph for quantitative data and information; the visualization of verbs involves the representation of process and relational graphs; the illustration of object and map-based forms can be situated in the visualization of nouns (Tufte, 1997).

As aforementioned, there are various possible combinations between those distinct features above in many cases. In addition, each of those dealt with different categories of information. Therefore, the analysis of the types under scrutiny aims to understand the tendencies of the combination between not only the diverse elements of representational key but also the different types of visualization. In addition, it seeks to grasp the patterns of unions between the types and the contents of the data set and information.

3.1.3. Metaphorical and metonymical expressions

Metaphor is a way of describing a specific subject from the perspective of other things displaying similarities (Lakoff and Johnson, 1980: 84). In addition, metonymy is a way of designating a subject by using a different or related thing which has a similar relationship with the subject (ibid.: 76). These are not confined to mere linguistic expressions but have existed in the system of visualization. Examples of metaphorical expressions can be found in the cases of maps representing the dispersion of accumulated Caesium-137. Some of those utilize the hue of a visible ray which has been commonly used to display heat in the system of thermography. As the domains of high temperature are indicated by a warm color range, and those of low temperature are displayed by cold color range in the thermography, the Caesium accumulation map indicates the realms of a large amount of Caesium-137 by using warm colors, with the low levels of the accumulation being represented by cold colors for contrast [Fig.12].

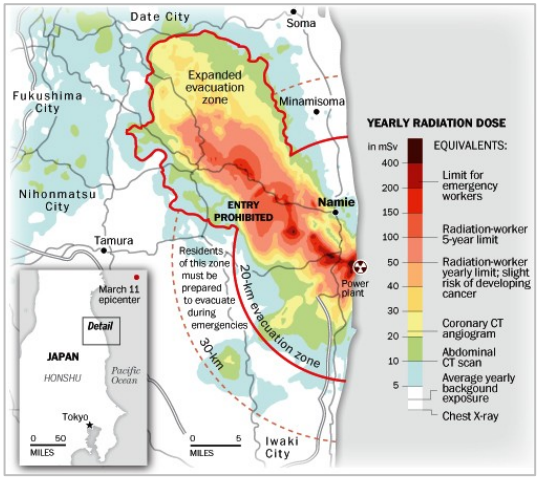


Figure 12. Off-limits. The Washington Post. 2011.

Such expression style is not deployed without any context. Through the experiences of using weather map or body heat map with the displaying methods above, we recognize that the warmer color range sections represent some sort of tense situations, or are used to display warning and caution. The Caesium accumulation map delivers information in the same way: the colors in the map let us understand the quantitative information of the accumulated radioactive material and at the same time, emphasize the seriousness inside the realms indicated by the warm color range. In this case, this technique is a form of understanding by using the expressive technique of another subject, namely heat.

This process can be exemplified in the notion of conceptual metaphor by Lakoff and Johnson. Their comments below strongly support the fact that such expressional method can be included in metaphorical expression.

> Do we systematically use inference patterns from one conceptual domain to reason about another conceptual domain?
>
> The empirically established answer is "yes." We call that phenomenon conceptual metaphor, and we call the systematic correspondences across such domains metaphorical mappings (ibid.: 247).

This research, therefore, analyzes metaphorical representations in the existing visualization cases. The categories of possible metaphors which the framework includes are: the Heat of thermography, Moisture of precipitation map, Pressure of Iso-bars map, Flow of wind map and ocean flow map, etc. The analysis focuses on the combination between those metaphorical objects and the subjects of data and information which are remote from the objects.

Another technique, metonymical expression, has also often been used in visualization. For instance, there are visual substitutes for the subjects of data and information in the cases of the visualizations of the Fukushima event as per the table below [Table 4.].

Subject	Substitute
Nuclear power plant	Symbolic sign of radiation
Wind	Arrows
Moving path of radioactive materials	Moving path of tuna or pollack
Country	Border on map

Table 4. The instances of subjects and their visual substitutes

Such replacements are not arbitrary. This is because the substitutes are selected based on associations (correlations) between the subjects[12]. The symbolic sign of radiation is a representative and essential part to indicate the fundamental energy of a nuclear power plant; the arrow is an indexical sign used to display the causality of the movement of wind; the tuna and pollack are the mediators of

[12] In this research, the designation by using arbitrarily representational keys such as geometric or abstract figures are not included in the category of metonymy.

radioactive materials, hence act as delegators of the movement of possible risk; and finally, the countries are represented by geographical shapes instead of any other multidimensional aspects.

The framework thus analyzed the varieties of visual substitutes through the metonymical elements including Extracted detail, Replaced object, Location, etc., while aiming to understand how the metonymy has been used in the cases representing the Fukushima event.

The reason for the investigation of the expressions above such as metaphor and metonymy is that they are the factors which affect understanding, based on the familiarity stemming from the experience of using the visualizations. In the cases representing the Fukushima accident, the wave-height visualization by NOAA, as aforementioned, is one example of its use. It is highly possible that the metaphorical expression, namely employing the technique of thermography, is one of the crucial factors that can drive misunderstanding[13]: rather than the height of tsunami, radiation dispersion might be more easily inferred from these methods. With regard to the metonymical expression, it is highly probable that the reason for the general public's anxious reactions (triggered by understanding) follows the consideration of the tuna (or pollack), a common and popular food in our experiences. Therefore, the exploration of both techniques of visualization can be a good was of revealing the important aspects of visualization linked to understanding.

3.2. The structure of the framework: the matrix for analysis

To systematically analyze various cases of visualization, it is necessary to organically structuralize the aforementioned categories. The constructed framework can be visualized as below [Table 5].

[13] A notable point here is that the general type of wave-height map has been composed of this metaphorical expression, i.e. the hue of thermography. It is highly probable that the misunderstanding was caused by multiple factors including unfamiliarity with the type of wave-height map, as well as the intense shape which reminds the viewer of strong dispersion from Japan, etc.

Theme of Vis. ( ) / Subjects of Data and Information ( )																															
				Types of Vis.									Rhetorical expression																		
				Statistical Grahpics				Map	Techincal drawings				Metaphor							Metonymy										
				Bar chart	Pie chart	Line chart	etc. ( )		Plan	Cross section	Process grpahic	etc. ( )	Heat (Thermography)	Moisture (Precipitation)	Pressure (Iso-Bars)	Flow			etc. ( )	Extracted detail ( )	Replaced object ( )	Location				etc. ( )					
																Air	Ocean	etc.				Regions ( )	Country ( )	Multiple countires ( )	World					
Representational Key	Arbitrary	Point																													
		Line																													
		Bar																													
		Shape	Circle																												
			Triangle																												
			Quadrangle																												
			etc.																												
		Position																													
		Length																													
		Scale																													
		Color	Tone																												
			Hue																												
			Saturation																												
			Brightness																												
			etc.																												
		Texture																													
	Non-arbitrary	Signs	Iconic																												
			Indexical																												
			Symbolic																												
		Shape (Figurative)																													
		Photograph																													
		Text																													

Table 5. The structure of the framework: the matrix for analysis

The framework initially categorized the contents of visualization including the topics and subjects. Next followed a careful classification of the disassembled smallest units, namely the elements of representational key. These were then arranged in a vertical direction. Subsequently, the types of visualization constructed were analyzed and placed along the horizontal axis. Finally, the metaphorical and metonymical uses were investigated and the list for those was located as part of an extension of the horizontal line.

In this structure, the results following an in-depth analysis of the categories above were revealed in the form of organically linked patterns: the interconnection of the subjects of data and information, the elements of representational key, the types of visualization composed by those, and the metaphorical and metonymical effects derived from their combinations. Put another way, this framework enables the

investigation of not only each of the categories but also the relationship between those as below [Fig.13].

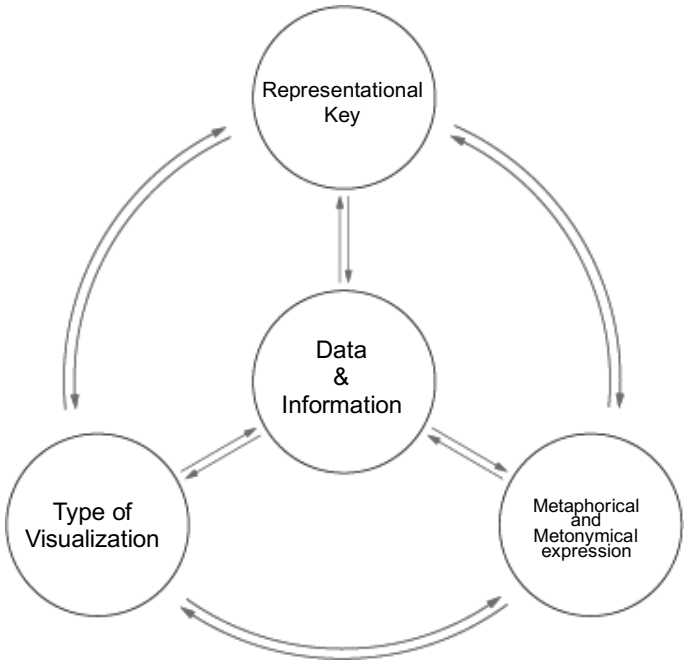


Figure 13. The relationship between the categories which compose the framework

The patterns observed also helped to discover the structural characteristics of the cases which interviewees can easily understand and in turn, could provide key clues behind the causes which trigger the understanding effect. This framework, therefore, was utilized to suggest for better strategies for the effective construction of visualization not only on the process of analysis but also the steps to be taken and the lessons to be learned after the analysis.

4. Analysis of the Visualization Samples

This research analyzed 236 visualizations, from which there presented various issues with respect to the Fukushima accident. The framework of analysis outlined in Section??? was employed across the selection. The visualizations were selected from both the years between 2011 and 2016, and also from the journalistic media of 25 countries. Of the countries selected, twelve were directly affected by the Fukushima accident, and fourteen affected by the Chernobyl disaster[14]. The reason for selecting nations affected by Chernobyl is that Chernobyl was an accident that was most analogous to Fukushima; both were centerd on a nuclear power plant, and both resulted in significant radiation fallout. The visualizations of both 'disasters' needed to capture and communicate similar complex and shifting data sets and human narratives leading to similar effects on its readers – inciting feelings of disbelief, fear, sympathy, sadness and so on.

The twelve 'Fukushima countries' included those reported by CTBTO (Comprehensive Test Ban Treaty Organization) to be amongst those most affected by radiation fallout from the disaster on the 12th March 2011 – one day after the event. The CTBTO assembled data from radiation sensors across the globe and monitored the radiation spread at that time. The CTBTO suggested that the 12 nations most endangered by the radiation dispersion were: Australia, Canada, China, Fiji, Japan, Korea, Malaysia, Mexico, Mongolia, Philippines, Russia, and the USA (Krysta and Coyne, 2012).

By way of comparison, a report from the IAEA ((International Atomic Energy Agency) determined that the 14 nations most affected by the Chernobyl fallout were Austria, Belarus, Bulgaria, Finland, France, Germany, Greece, Italy, Norway, Russia, Spain, Sweden, UK, and Ukraine. One point to note when comparing these lists is that Russia appears in both the Fukushima and Chernobyl lists.

The journalistic media from which the visualization was selected were mainly composed of daily newspapers. These were selected in sequential order according to volume in circulation,[15] and the collected cases represented the instances of visualization released onto their online-newspaper sites.

However and to offer a more complete view, one should note that not all those countries are included in this circulation data. Thus, in when considering the excluded nations, the newspapers were selected

[14] Across both lists, Russia stands alone as the one country which was affected by both disasters.
[15] The circulation data was sourced from IFABC (International Federation of Audit Bureau of Circulations): the data of National Newspapers Total Circulation (IFABC, 2013)

based on the information available from the WiKipedia entries, using keyword searches based on 'lists of newspapers' in each of the countries. In addition, in cases where countries did not have available in their daily newspapers information-visualization articles, alternative online news portals or online newspapers which did release visualization instances were selected instead.

The table below presents the list of countries, selected newspapers and the number of collected cases [table 6].

Country	Related disaster	Selected newspapers	Number of cases
Australia	Fukushima	The Sydney Morning Herald, Daily Telegraph (Australia), The Australian, etc.	9
Austria	Chernobyl	Die Presse, Der Standard, kleinezeitung, etc.	10
Belarus	Chernobyl	Komsomolskaya Pravda, etc.	8
Bulgaria	Chernobyl	Capital, etc.	6
Canada	Fukushima	National Post, etc.	13
China	Fukushima	China Daily, The Mirror, Ifeng, etc.	10
Fiji	Fukushima	none	0
Finland	Chernobyl	Iltalehti, Mtv, etc.	4
France	Chernobyl	Le Figaro, Le Parisien, Libération, etc.	14
Germany	Chernobyl	Die Zeit, Süddeutsche Zeitung, Bild, etc.	20
Greece	Chernobyl	Kathimerini, Ethnos, To Vima, etc.	5
Italy	Chernobyl	la Repubblica, Il Sole 24 Ore, Il Giornale, etc.	8
Japan	Fukushima	Yomiuri Shimbun, Asahi Shimbun	20
South Korea	Fukushima	Chosun ilbo, Dong-A ilbo, Joong-Ang ilbo	13
Malaysia	Fukushima	Berita Harian, The Borneo Post, Sinar Harian, etc.	7
Mexico	Fukushima	Milenio, La razon, El Pais, etc.	7
Mongolia	Fukushima	N news	1
Norway	Chernobyl	Verdens Gang, Dagbladet	7
Philippines	Fukushima	Philnews	3
Russia	Fukushima, Chernobyl	Kommersant, Rossiyskaya Gazeta, Komsomolskaya Pravda, Ria, etc.	12
Spain	Chernobyl	El País, Faro de Vigo, AEl Periódico de Catalunya, ABC, etc.	11
Sweden	Chernobyl	Aftonbladet, Dagens Nyheter, Aftonbladet, etc.	8
UK	Chernobyl	The Daily Telegraph, dailymail, The Guardian, The Independent, etc.	14
Ukraine	Chernobyl	Komsomolskaya Pravda(Ukraine), Sevodnya, etc.	7
US	Fukushima	The New York Times, USA Today, The Washington Post, The Wall Street Journal, etc.	18

Table 6. The selected countries, newspapers, and the number of the collected cases

Collecting the cases was performed by online search. The process involved a) selecting a target country for collection by Advanced Search, b) accessing the websites of the selected nation's newspapers and c) searching the cases by keyword regarding the Fukushima disaster. The keywords in English are "Fukushima", "Fukushima nuclear power plant", and "Fukushima disaster". In cases

where the dominant language is not English, the keywords were translated into the local own languages and deployed.

The maximum number of the cases assessed was limited to 20 per nation. In addition, where there were multiple instances which were represented by the same topics by using similar types of visualization, the number of the cases to be analyzed was further restricted to 5 per country. The reasoning for this limitation is so as to avoid any unnecessary overlapping of instances, and to obtain a range of diverse instances as part of the analysis.

4.1. Issues concerning information and data from the collected cases

The collected cases of visualization deal with 37 topics. These diverse topics can be sorted into 4 categories below [Table 7].

Radioactivity issues	Technology issues	Social issues	Natural disaster issues
Radioactivity-diffusion process	Reactors conditions	Exclusion and evacuation zones	Tsunami
Radioactivity-accumulation level	NPP conditions	Evacuation	Great East Japan Earthquake
Radiation illness	General structure of reactors	Population of neighborhood areas of Fukushima	Similar natural disasters
Radioactivity-exposure influence	Meltdown process	Number of casualties	Potential similar disasters
Similar radioactive disasters	Condition of a specific reactor	Conditions of damaged regions	
NPP accident levels	Reactor explosion process	The spread of population of Japan	
Level of radioactivity (Air)	Fuel rod	Suicide rate of Japanese	
Discovery of mutated insect	Safe structure of reactor against wave	Population of evacuees	
Seafood investigation	Problems of ice wall	Data manipulation of Japanese government	
Detection of strontium	Contamination control		
Permissible level of radioactivity of food	Potential NPP accidents		

Table 7. The issues of collected cases and their categories

Among these four categories, the one relating to technology issues produces the largest number of cases. The statistics on frequency of the categories is as below [Fig.14].

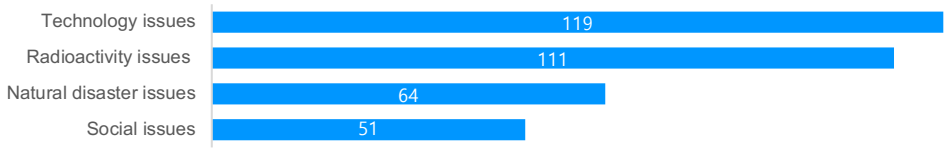


Figure 14. The number of the cases in each of the categories of the main issues

Based on the categories above, the sections below expand upon the analysis of the collected cases. In addition, the descriptions of the analysis of overall tendency and the patterns depending on geographical conditions will continue to be studied in turn.

4.2. The analysis of the instances of visualization in the category of the radioactivity issues.

When considering cases representing the radioactivity related issues, the largest number of topics covered is the process of spread of radioactive materials: namely via various vehicles of radioactive materials and their routes [Fig.15].

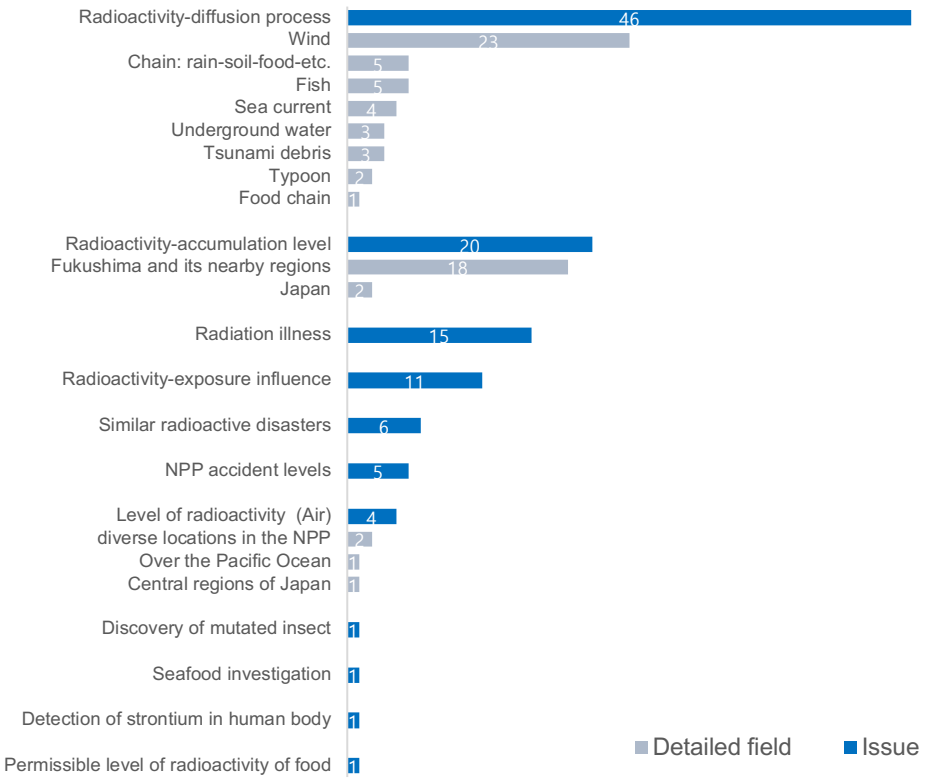


Figure 15. The statistics of the topics in the category of the radioactivity issues

The analysis of the cases which illustrate the radioactivity topics can be demonstrated in the table below [Table 8].

Issues	Detailed field	Representational key (A: Arbitrary / N: Non-arbitrary)	Types of Vis. (M: Map / C: Chart / T: Technical drawing)	Metaphor and Metonymy (Mp: Metaphor / Mn: Metonymy)	Number of the cases
Rad.(Radioactivity)-diffusion process Rad.(Radioactivity)-diffusion process	wind route wind route	N(Shape+Arrow)	M(Japan)+Arrow	Mn(Map+Indexical sign)	9
		A(Hue)+N(Shape+Arrow)	M(World)+Hue+Arrow	Mn(Map+Indexical sign)	6
		A(Hue)+N(Shape)	M(World)+C(Color plot)	Mn(Map)+Mp(Heat)	5
		A(Hue)+N(Shape+Arrow)	M(Korea, Russia, Japan)+Hue+Arrow	Mn(Map+Indexical sign)	3
	Fish(mainly tuna) route	N(Shape+Arrow)	M(The Pacific)+Arrow	Mn(Map+Indexical sign+Extracted detail)	5
	Chain: rain-soil-food-etc.	N(Shape)	T(Process graphic)	Mn(Extracted detail)	3
		N(Shape)	T(Landscape description)	Mn(Extracted detail)	2
	Sea current	N(Shape+Arrow)	M(The Pacific, Korea, Japan)+Arrow	Mn(Map+Indexical sign)	4
	Underground water	N(Shape+Arrow)	T(Plan)+Arrow	Mn(Extracted detail+Indexical sign)	3
	Tsunami debris	A(Texture)+N(Shape)	M(The Pacific)+Texture	Mn(Map)	1
		A(Hue)+N(Shape)	M(The Pacific)+C(Color plot)	Mn(Map)+Mp(Heat)	1
		N(Shape+Arrow)	M(The Pacific)+Arrow	Mn(Map+Indexical sign)	1
	Typoon	N(Shape+Arrow)	M(Japan)+Arrow	Mn(Map+Indexical sign)	2
	Food chain	A(Triangle)	C(Pyramid chart)	-	1
Rad.-accumulation level (soil)	Japan	A(Hue)+N(Shape)	M(Japan, Damaged area)+C(Color plot)	Mn(Map)+Mp(Heat)	2
	Fukushima and its nearby regions	A(Hue)+N(Shape)	M(Japan, Damaged area)+C(Color plot)	Mn(Map)+Mp(Heat)	13
		A(Circle, Size)+N(Shape)	M(Damaged area)+C(Bubble chart)	Mn(Map)	2
		A(Circle, Hue, position)+N(Shape)	M(Damaged area)+C(Scatter plot)	Mn(Map)+Mp(Heat)	2
		A(Bar)+N(Shape)	C(Bar chart) by M(Damaged area)	Mn(Map)	1
Radiation illness	Body and organs	N(Shape)	T(External description+Cross section)	Mn(Extracted detail)	15
Rad.-exposure influence	Effect by exposure level	A(Bar)	C(Bar chart)	-	4
		A(Circle, Size)	C(Bubble chart)	-	3
		A(Line)	C(Line chart)	-	1
		A(Bar+Hue)	C(Bar chart)	Mp(Heat)	1
		A(Size)+N(Symbolic sign of Rad.)	C(Bubble chart)	Mn(Symbolic sign)	1
		A(Geometry Figure)	C(Pyramid chart)	-	1
Similar radioactive disasters	Similar accidents in the past	N(Shape)	Photograph	Mn(Extracted detail)	3
		A(Bar, Hue)	C(Bar chart)	Mp(Heat)	2
		A(Hue)+N(Shape)	M(Europe)+C(Color plot)	Mn(Map)+Mp(Heat)	1
NPP accident levels	Scale of accidents by the level	A(Bar, Hue)	C(Bar chart)	Mp(Heat)	5
Level of Rad.	diverse locations in the NPP	A(Line)	C(Line chart)	-	2
	Over the Pacific Ocean	A(Hue)+N(Shape)	M(The Pacific)+C(Color plot)	Mn(Map)+Mp(Heat)	1
	Central regions of Japan	A(Line)	C(Line chart)	-	1
Discovery of mutated insect	Mutated butterfly and location	N(Shape)	M(Japan)+T(External description)	Mn(Extracted detail)	1
Seafood investigation	Kinds of the seafood	N(Shape)	T(External description)	Mn(Extracted detail)	1
Detection of strontium	Level of strontium	A(Line)	C(Line chart)	-	1
Permissible level of Rad. in food	Permissible level of Rad. by food	A(Bar)+N(Shape)	T(External description)+C(Bar chart)	Mn(Extracted detail)	1

Table 8. The analysis of the cases representing radioactivity issues

The major factor to consider here is the wind and its routes and directions, a major contributor to the process of the radiation spread. There are 23 cases which deal with diffusion by wind. These instances

attempt to predict the spread of radioactive contamination by studying the directions or routes of winds from Japan to neighboring countries or further across the world. Wind is mainly represented by an arrow, a non-arbitrary key, and this representation is displayed in combination with the type of map. In such cases, due to the features in the map and given that the arrow sign is an indexical one, those cases mainly use the effect of metonymy. In addition to the 18 instances of such expression, there are 5 other different examples which represent the wind: those employing the colors of the hue of the type more commonly found in heat maps (thermography). In these cases, the domains of the winds and their strengths are replaced by using shades of colors and they are represented as a type of thematic map as well.

The second largest issue is that of radioactivity-accumulation level. There are 20 cases which depict this information. They usually represent the quantitative data of Caesium-137 gathered in the soil since the explosion of the Fukushima nuclear power plant. The main representational key employed here is hue, an arbitrary key. The type of color plot used here is a composition of hue, together with the form of map which generally displays the exclusion and evacuation zones, or even the whole domain of Japan. Most of those cases employ the hue which is similar to that of a heat map (thermography) and hence, they also bring about a metaphorical effect. [Fig.16]

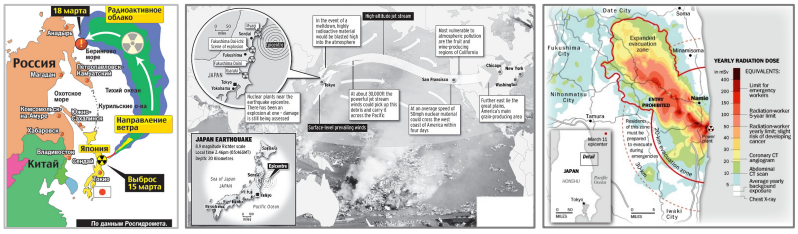


Figure 16. The instances which deal with wind, a process of radioactivity diffusion and the condition of radiation accumulation. The left case uses colors to indicate the realm of the wind (Left: Komsomolskaya Pravda (Russia). 2011. : Росгидромет: «К 18 марта зараженное облако может приблизиться к Камчатке».(Roshydromet: "By March 18, contaminated cloud can come close to Kamchatka."). / middle: Dailymail (UK). 2011. America on radiation alert: Japan faces world's worst nuclear accident since Chernobyl as experts warn fallout may reach U.S. / right: The Washington Post (US). 2011. Yearly Radiation Dose.)

The major representational key visible here is shape which is a non-arbitrary key. There are 85 cases which mainly employ shape, which includes 57 cases of maps, 15 instances describing the body and organs to explain radiation illness, and 5 examples of simple drawings of rain, soil, crops, mutated insects, fishes, etc.

On the other hand, there are 48 cases which use arbitrary keys. Among them, hue comprises the largest number, 39 cases. The hue combines with the type of map in 28 cases and that of bar chart in 17 instances.

The largest number of types observed is that of map and 60 cases employ this style. Further, the major key involved in this type is the arrow, a non-arbitrary key which delivers information concerning the routes of the wind (20 cases), the moving paths of fish (5 instances), the sea current (4 cases), the flow of tsunami debris (1 example), etc. The second most frequent type is chart which can be found in 57 cases: color plot in 23 cases to exhibit the level of radioactivity-accumulation (15 cases), the realm of the wind (5 cases), and that of tsunami debris (1 case), etc.

With regard to the metaphor and metonymy, the majority of the cases of which there are 89 instances, use metonymical expression including 59 cases of map, together with 29 cases of other extracted details such as fish movement, human body and organs, rain, crops, soil, etc. In the case of metaphor use, there are 39 cases which employ the metaphorical expression of heat map, since they use the hue of thermography. This expression is used mainly to display the level of radioactivity accumulation and the realms of the wind which are the vehicles by which radioactive contamination is most commonly spread.

To sum up and when considering all the collected instances which represent radioactivity issues as a whole, the largest number of the topics covered relates to the process of radioactivity spread. The heaviest use of representational keys is shown by the arrow, a non-arbitrary key to depict wind and its routes and directions. The most frequent type of visualization is thematic map, and the use of metonymy is far more dominant than that of the metaphor due to a majority of the cases preferring to employ the map type.

4.3. The analysis of the cases which represent the technology issues

In the category of technology issues, there are 74 cases of visualization and the topics and their detailed fields are as below [Fig.17].

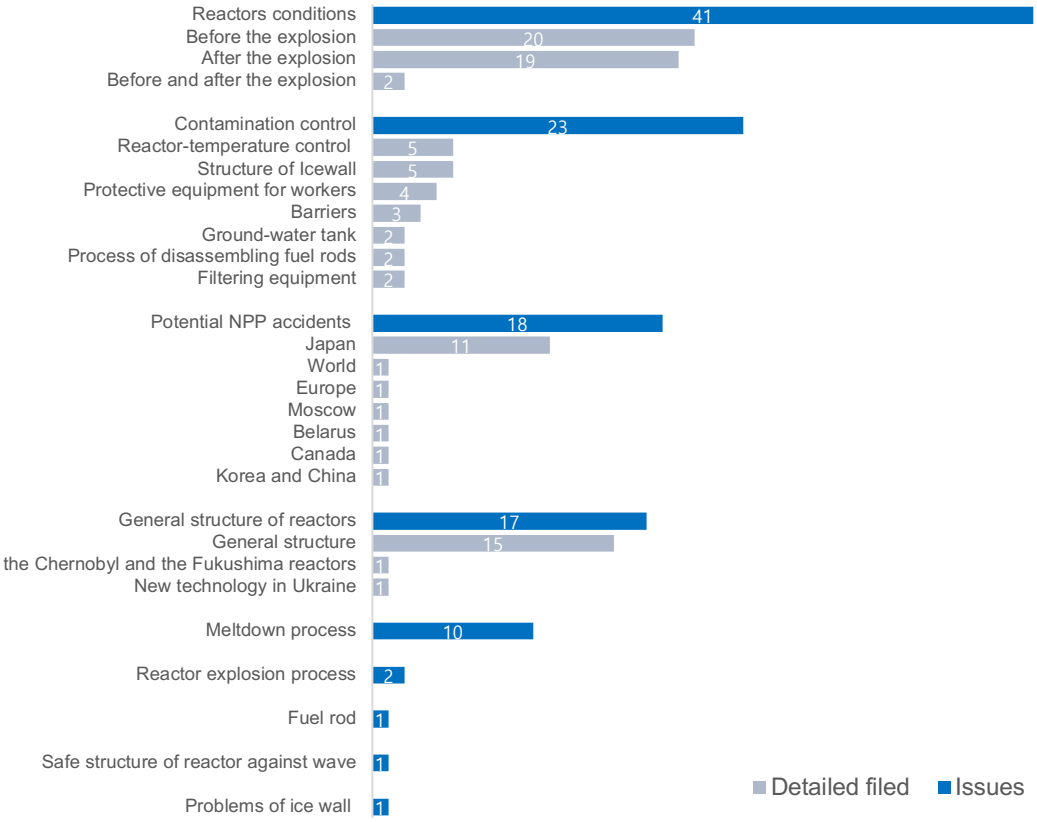


Figure 17. Statistics relating to issues in the category of the technology topics

The largest number of visualized objects found here is that of the condition of the reactors of the Fukushima nuclear power plant before the explosion, which can be found in 20 cases. Even though there are various topics in this category such as efforts to prevent contamination spread, the locations of potential NPP disasters on the globe, etc., information in terms of the actual reactors of the Fukushima NPP and even the reactor-related things such as the meltdown, general structure of reactor, etc. are represented far more than other information and data.

The analysis of the instances which exhibit technology issues can be summarized in the table below [Table 9].

Issues	Detailed field	Representational key (A: Arbitrary / N: Non-arbitrary)	Types of Vis. (M: Map / C: Chart / T: Technical drawing / P:Photograph)	Metaphor and Metonymy (Mp: Metaphor / Mn: Metonymy)	Number of the cases
Reactors conditions	Before the explosion	N(Shape)	P(Plan)	Mn(Extracted detail)	9
		N(Shape)	T(Plan)	Mn(Extracted detail)	6
		N(Shape)	T(Cross section)	Mn(Extracted detail)	5
	After the explosion	N(Shape)	T(Plan)	Mn(Extracted detail)	13
		N(Shape)	P(Plan)	Mn(Extracted detail)	3
		N(Shape)	T(Cross section)	Mn(Extracted detail)	2
		N(Shape)	T(Plan)+Motion	Mn(Extracted detail)	1
	Before and after the explosion	N(Shape)	P(Plan)	Mn(Extracted detail)	1
		N(Shape)	T(Plan)	Mn(Extracted detail)	1

Contamination control	Reactor-temperature control (reactors)	N(Shape)	T(Cross section)	Mn(Extracted detail)	2
	Reactor-temperature control (reactors+helicopter+water, etc.)	N(Shape)	T(External description +Cross section)	Mn(Extracted detail)	2
	Reactor-temperature control (reactors+cooling system)	N(Shape)	T(Cross section)	Mn(Extracted detail)	1
	Structure of ice wall	N(Shape+Arrow)	T(Cross section+Process graphic)	Mn(Extracted detail +Indexical sign)	4
	NPP & ice wall	N(Shape)	T(Cross section+Plan)	Mn(Extracted detail)	1
	Anti-contamination suit	N(Shape)	T(External description)	Mn(Extracted detail)	2
		N(Shape)	P	Mn(Extracted detail)	2
	Reactor & barriers	N(Shape+Arrow)	T(Cross section+Process graphic+Plan)	Mn(Extracted detail +Indexical sign)	2
	NPP & barriers	N(Shape)	T(Plan)	Mn(Extracted detail)	1
	Ground-water tank	N(Shape)	T(Plan)	Mn(Extracted detail)	1
		N(Shape)	T(Cross section)	Mn(Extracted detail)	1
	Disassembly of fuel rods (Fuel rods)	N(Shape)	T(Cross section+Process graphic)	Mn(Extracted detail)	2
	Filtering equipment (machine)	N(Shape+Arrow)	T(Cross section+Process graphic)	Mn(Extracted detail +Indexical sign)	1
	Filtering equipment (sandbag)	N(Shape+Arrow)	T(Cross section+Process graphic)	Mn(Extracted detail +Indexical sign)	1
Potential NPP accidents	Locations of potential NPP accidents (Japan)	N(Shape+Symbolic sign of radiation)	M(Japan)	Mn(Map+Symbolic sign)	7
	Locations of potential NPP accidents & population (Japan)	A(Circle, Hue, Position)+N(Shape)	M(Japan)+C(Color plot)	Mn(Map)+Mp(Heat)	1
	Locations of potential NPP accidents (Japan)	N(Shape+Iconic sign(NPP))	M(Japan)+C(Multiple arrangement chart)	Mn(Map+Iconic sign)	1
	Locations of potential NPP accidents (Japan)	N(Shape+Symbolic sign of radiation)	M(Japan)+C(Multiple arrangement chart)	Mn(Map+Symbolic sign)	1
	Locations of potential NPP accidents (Japan)	A(Circle)+N(Shape)	M(Japan)+C(Multiple arrangement chart)	Mn(Map)	1
	Locations of potential NPP accidents (Moscow)	N(Shape+Symbolic sign of radiation)	M(Moscow)	Mn(Map+Symbolic sign)	1
	Locations of potential NPP accidents (Belarus)	A(Circle, Position)+N(Shape)	M(Belarus)	Mn(Map)	1
	Locations of potential NPP accidents (World)	A(Circle, Position)+N(Shape)	M(World)	Mn(Map)	1
	Locations of potential NPP accidents (Europe)	N(Shape+Symbolic sign of radiation)	M(Europe)	Mn(Map+Symbolic sign)	2
	Locations of potential NPP accidents (Ontario, Canada)	N(Shape+Symbolic sign of radiation)	M(Ontario, Canada)	Mn(Map+Symbolic sign)	1
	Locations of potential NPP accidents (Korea, China)	N(Shape+Symbolic sign of radiation)	M(Korea, China)	Mn(Map+Symbolic sign)	1
General structure of reactors	General structure (reactor)	N(Shape)	T(Cross section)	Mn(Extracted detail)	15
	Reactors of the Fukushima and the Chernobyl	N(Shape)	T(Cross section)	Mn(Extracted detail)	1
	New technology in Ukraine (reactor)	N(Shape)	T(Cross section)	Mn(Extracted detail)	1
Meltdown process	Meltdown process (reactor)	N(Shape)	T(Cross section+Process graphic)	Mn(Extracted detail)	9
	Meltdown process (reactor)	N(Shape)	T(Cross section+Process graphic)+Motion	Mn(Extracted detail)	1
Reactor explosion process	Reactor explosion process (reactor)	N(Shape)	T(Cross section+Process graphic)	Mn(Extracted detail)	2
Fuel rods	Fuel rods structure & condition	N(Shape)	T(Cross section)	Mn(Extracted detail)	2
Safe structure of reactor against wave	Safe structure (reactor)	N(Shape)	T(Cross section)	Mn(Extracted detail)	1
Problems of ice wall	Problems of ice wall	N(Shape)	T(Cross section)	Mn(Extracted detail)	1

Table 9. The analysis of the cases representing technology issues

The largest number of the representational keys is again here shape, one of the non-arbitrary keys. This is found in 115 cases which display the physical forms of the reactors-related objects in 97 instances, and relating to the regional boundaries (i.e. maps) in 18 examples. Features specifically considered in relation to the reactors include the reactors themselves of the NPPs such as with Fukushima or the corresponding amount when considering Chernobyl (78 cases). We can also observe the ice wall which is a system to protect the spread of contamination from the NPP in 6 examples, fuel rods in the reactors in 4 instances, etc. In the cases of maps, the instances generally

describe the locations of potential NPP disasters, mainly displaying the amount and locations of the NPPs in operation or non-operation across diverse countries.

The major type of visualization utilized is of the technical drawing. This style is discovered in 57 cases of cross-section styles, 26 instances which employ the form of plan, 22 examples using process graphics, and 15 cases which utilize the type of photograph [Fig.18].

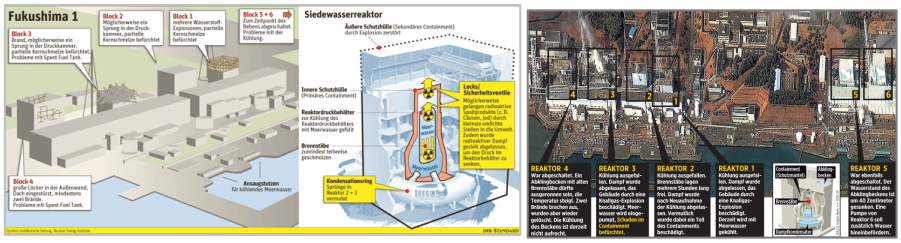


Figure 18. A case which represents the reactor by using the type of plan and cross section (left) and another case which employs the style of photography and technical drawing (cross section) (right). (Left: Die Presse(Austria). 2011. AKW Fukushima I: Zustand der sechs Reaktoren (Fukushima nuclear power plant I: state of the six reactors / Right: Der Standard(Austria). 2011. Fukushima 1 Siede wasser reaktor(Boiling Water Reactor))

The largest number of types found in this category is the form of cross section, which serves to narrate the internal structure or situations of the reactors in the Fukushima nuclear power plant. In addition, this type of plan is the second largest method by which to represent the positions of the 6 reactors and other facilities such as ice wall, barriers, ground-water tanks, etc. in the Fukushima power plant.

The form of process graphic is utilized in combination with cross section in 22 cases which involve the meltdown process in 10 instances, the operation principle of the ice wall in 4 examples, the explosion process of the reactors in 2 cases, and the principle of the filtering facilities in 2 instances.

There is one metaphorical expression in this category: the use of the hue of the thermography to display the population of Japan in an instance where there is a potential NPP disaster in Japan. On the contrary, there are much heavier uses of metonymical expression in most of the other cases due to the employment of extracted details of the reactors-related objects (97 cases) and maps (18 instances).

4.4. The analysis of cases which display social issues

There are 51 cases which deal with the topics related to social aspects, and the statistics relating to such materials can be presented as below [Fig.19].

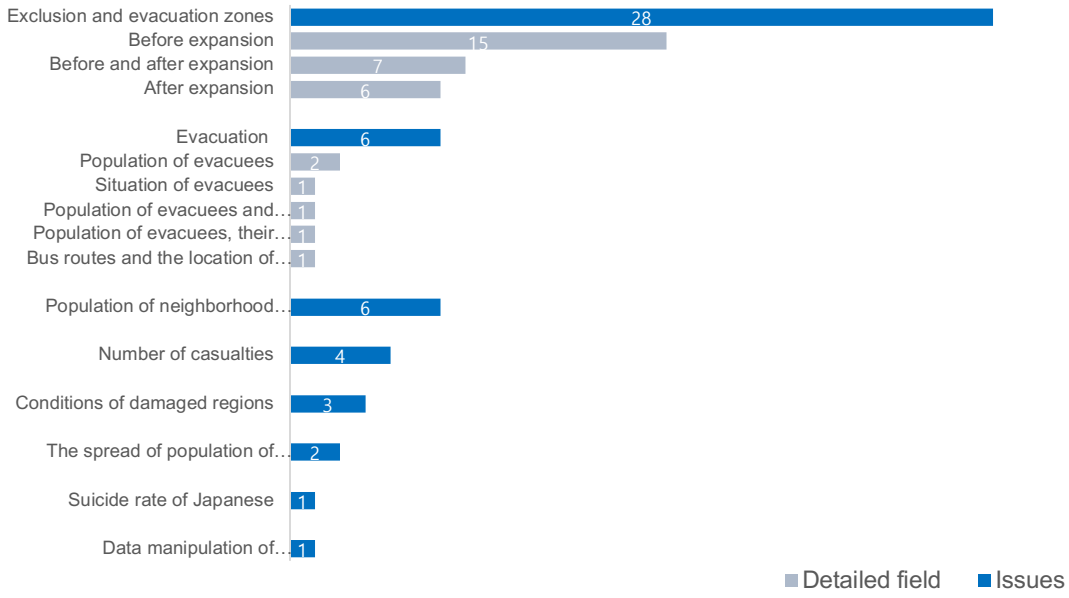


Figure 19. The statistics of the topics in the category of social issues

The largest number of detailed examinations of the issues in this category is that of the domains of the early exclusion and evacuation zones before the expansions. This is visible in 15 cases. These exhibit the exclusion zone within the 20 kilometers radius from the Fukushima nuclear power plant and the evacuation zone within 80 kilometers radius. In addition, these instances indicate the realms mainly by using colors, an arbitrary key and most of those are displayed on the map.

The analysis of the cases which represent social issues can be summarized as follow [Table 10].

Issues	Detailed field	Representational key (A: Arbitrary / N: Non-arbitrary)	Types of Vis. (M: Map / C: Chart / T: Technical drawing / P:Photograph)	Metaphor and Metonymy (Mp: Metaphor / Mn: Metonymy)	Number of the cases
Exclusion and evacuation zones	Before expansion (radius)	A(Color)+N(Shape)	M(Damaged areas)+Color	Mn(Map)	12
		A(Line+Color)+N(Shape)	M(Damaged areas) + Color +Line	Mn(Map)	2
		N(Shape)	M(Damaged areas) (Circle Shaped map)	Mn(Map)	1
	Both before and after the expansion	A(Color+Line)+N(Shape)	M(Damaged areas) + Color +Line	Mn(Map)+Mp(Heat)	7
	After expansion	A(Color)+N(Shape)	M(Damaged areas)+Color	Mn(Map)+Mp(Heat)	3
		A(Line)+N(Shape)	M(Damaged areas)+Line	Mn(Map)	2
		A(Color)+N(Shape)	M(Damaged areas)+Color	Mn(Map)+Mp(Heat)	1
Evacuation	Population of evacuees	N(Shape+Text)	M(Damaged areas)+Text	Mn(Map)	1
		A(Circle, Size)+N(Shape)	M(Damaged areas) by C(Bubble chart)	Mn(Map)	1
	Situation of evacuees	N(Shape+Text)	M(Central regions of Japan)+Text	Mn(Map)	1
	Population of evacuees and their route	N(Shape+Arrow+Text)	M(Central regions of Japan)+Arrow+Text	Mn(Map)	1
Evacuation	Population of evacuees, their route and interviews	A(Line+굵기)+N(Shape)	M(Japan)+Arrow+P+Text	Mn(Map+Indexical sign)	1
	Bus routes and the location of airpots	A(Line, Color)+N(Shape+Iconic sign)	M(Central regions of Japan)+Arrow+Text	Mn(Map+Iconic sign)	1

Population of neighborhood areas of Fukushima	Population of neighborhood areas of Fukushima	A(Circle, Position)+N(Shape)	M(Central regions of Japan)+C(Bubble chart)	Mn(Map)	2
		A(Hue)+N(Shape)	M(Nearby regions of the Fukushima)+C(Color plot)	Mn(Map)+Mp(Heat)	2
		N(Shape+Text)	M(Central regions of Japan)+Text	Mn(Map)	1
		A(Circle)	C(Pie chart)	-	1
Number of casualties	Number of the dead, missing and injured persons	N(Shape+Text)	M(Central regions of Japan)+Text	Mn(Map)	3
		A(Bar, Length)+N(Shape)	M(Central regions of Japan) C(Bar chart)	Mn(Map)	1
Conditions of damaged regions	Conditions of damaged regions	N(Shape+Text)	M(Central regions of Japan) byText	Mn(Map)	1
		N(Shape+Text)	M(Central regions of Japan)+Text	Mn(Map)	1
		N(Shape+Text)	M(Central regions of Japan)+Text+P	Mn(Map)	1
The spread of population of Japan	The spread of population of Japan	A(Circle, Size, Position)+N(Shape)	M(Japan)+C(Bubble chart)	Mn(Map)	1
		A(Hue)+N(Shape)	M(Japan)+C(Color plot)	Mn(Map)+Mp(Heat)	1
Suicide rate of Japanese	Suicide rate (1997-2011)	A(Bar, Length)	C(Bar chart)	-	1
Population of the nearby areas of major NPPs	Population of the nearby areas of major NPPs	A(Hue)+N(Shape)	M(Japan)+C(Color plot)	Mn(Map)+Mp(Heat)	1

Table 10. The analysis of the cases which represent social issues

In the representational keys, the most predominant key is shape, a non-arbitrary key. This style is discovered in 49 cases and most of those are displayed in the shape of boundary, namely the type of map. The arbitrary keys are found in 40 instances. Among them, 25 examples use colors to depict exclusion and evacuation zones and 4 cases depict the data of the spread of population by colors. [Fig.20].

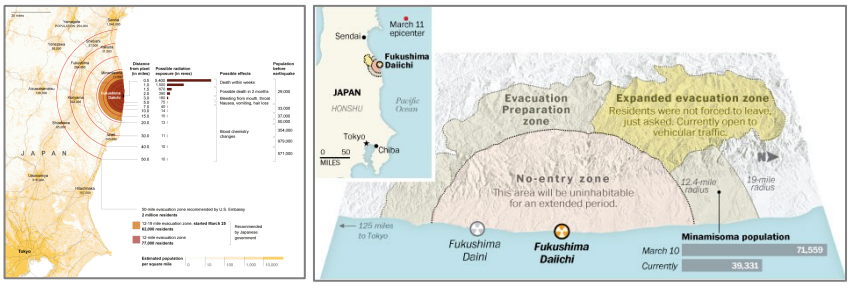


Figure 20. A case which indicates the exclusion and evacuation zones before the expansion and population of nearby areas of Fukushima (left) and an instance which displays the zones after the expansion (right). (Left: NY Times (US). 2011. Estimates of Possible Exposure Define U.S. Evacuation Zone / right: The Washington Post (US). 2011. Fukushima plant radiation)

The highest frequency of the types of visualization is the form of map, which can be found in 49 cases. This type is mainly used in combination with colors and this is found in 25 cases. In addition, a type of chart, color plot is also used in combination with the form of map in 4 instances, which depict the spread of population.

Due to the type of thematic map, there are 49 cases which employ the metonymical expression. On the other hand, the metaphorical representation of thermography is discovered in just 15 instances; composed of 11 examples to indicate the exclusion and evacuation zones by using colors of the hue of

thermography, and 4 cases to exhibit the data of the spread of population in the neighborhood regions of Fukushima or Japan generally.

4.5. The analysis of the cases which represent the natural disaster issues

The category of the cases which deal with natural disaster issues comprises 51 collected instances, and the related topics and their statistics can be presented as below [Fig.21].

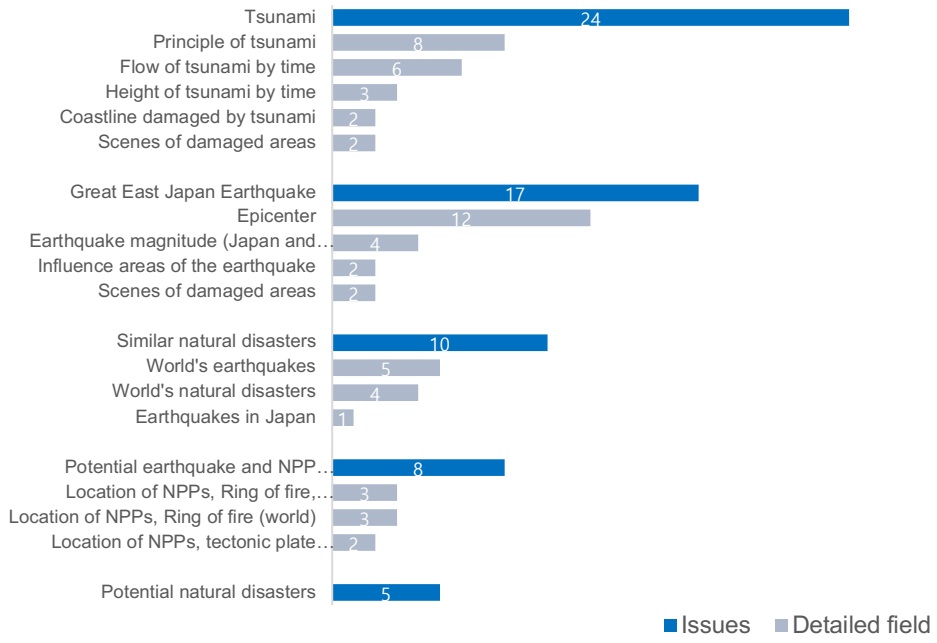


Figure 21. The statistics of the natural disaster issues

The analysis of the cases which display natural disaster issues can be summarized below [Table 11].

Issues	Detailed field	Representational key (A: Arbitrary / N: Non-arbitrary)	Types of Vis. (M: Map / C: Chart / T: Technical drawing / P:Photograph)	Metaphor and Metonymy (Mp: Metaphor / Mn: Metonymy)	Number of the cases
Tsunami	Tsunami principle	N(Shape)	T(Cross section+Process graphic)	Mn(Extracted detail)	8
	Flow of tsunami by time	A(Line)+N(Shape)	M(The Pacific)+Line	Mn(Map)+	5
		A(Hue)+N(Shape)	M(The Pacific)+C(Color plot)		1
	Coastline damaged by tsunami	A(Line)+N(Shape)	M(Damaged areas)+Line	Mn(Map)	4
	Height of tsunami by time	A(Hue)+N(Shape)	M(The Pacific)+C(Color plot)	Mn(Map)+Mp(Heat)	3
	Scenes of damaged areas	N(Shape)	P	Mn(Extracted detail)	2
	Coastline damaged by tsunami	N(Shape+Iconic sign of wave)	M(Damaged areas)+C(Scatter plot)	Mn(Map+Iconic sign)	1
Great East Japan Earthquake	Epicenter	N(Shape+Concentric circle)	M(Japan)+Concentric circle	Mn(Map+Indexical sign)	9
	Earthquake magnitude (nearby regions of Fukushima)	A(Circle, Position)+N(Shape)	M(Japan)+C(Scatter plot)	Mn(Map)	3
	Earthquake magnitude (Japan)	A(Circle, Size, Position)+N(Shape)	M(Japan)+C(Bubble chart)	Mn(Map)	1
	Scenes of damaged areas	N(Shape)	M(Damaged areas)+P	Mn(Extracted detail)	1

	Epicenter, Influence areas of the earthquake	A(Hue)+N(Shape+Concentric circle)	M(Japan)+Concentric circle	Mn(Map+Indexical sign)+Mp(Heat)	1
		A(Line, Hue)+N(Shape+Concentric circle)	M(Japan)+Concentric circle	Mn(Map+Indexical sign)+Mp(Heat)	1
	Epicenter, Scenes of damaged areas	N(Shape+Concentric circle)	M(Japan)+Concentric circle+P	Mn(Map+Indexical sign)	1
Similar natural disasters	World's earthquakes	A(Bar, Length)	C(Bar chart)	-	3
		N(Shape+Text)	M(World)+Text	Mn(Map)	2
	World's natural disasters	N(Shape+Text)	M(World)+Text	Mn(Map)	1
		A(Circle, Size, Position)+N(Shape)	M(World)+C(Bubble chart)	Mn(Map)	1
		A(Circle, Position)+N(Shape)	M(Japan)+C(Scatter plot)	Mn(Map)	1
		A(Bar, Length)+N(Shape+Iconic sign of human)	C(Bar chart)+P+Paintings	Mn(Map+Iconic sign)	1
	Historical earthquakes in Japan	A(Circle, Position)+N(Shape)	M(Japan)+C(Scatter plot)	Mn(Map)	1
Potential earthquake and NPP accidents	Location of NPPs, Ring of fire, tectonic plate (world)	A(Line(tectnoic plate), Hue(ring of fire))+N(Shape)	M(World)+Hue+Line	Mn(Map) + Mp(Heat)	2
	Location of NPPs, Ring of fire, tectonic plate (world)	A(Line(tectnoic plate), Texture(ring of fire))+N(Shape)	M(World)+Texture+Line	Mn(Map)	1
	Location of NPPs, Ring of fire (world)	A(Circle, Quadrangle(NPP)+Hue(ring of fire))+N(Shape)	M(World)+Hue	Mn(Map) + Mp(Heat)	2
		A(Circle, Quadrangle(NPP)+Hue(ring of fire))+N(Shape)	M(World)+C(Color plot)	Mn(Map)+Mp(Heat)	1
	Location of NPPs, tectonic plate (world)	A(Quadrangle(NPP)+Line(tectnoic plate))+N(Shape)	M(World)+Line	Mn(Map)	1
		A(Line(tectnoic plate))+ N(Shape+ Symbolic sign of radiation)	M(World)+Line	Mn(Map+Symbolic sign)	1
Potential natural disasters	Ring of fire (world)	A(Line, Position)+N(Shape)	M(World)	Mn(Map)	1
	Tectonic plate (world)	A(Line, Position)+N(Shape)	M(World)	Mn(Map)	1
	Potential earthquake location (France)	A(Circle, Position, Hue)+N(Shape)	M(프랑스)	Mn(Map) + Mp(Heat)	1
	Potential earthquake location (Canada)	A(Circle, Position)+N(Shape)	M(Canada 주요도시)	Mn(Map)	1
	Potential earthquake location (Ukraine)	A(Circle, Position)+N(Shape)	M(Ukraine)	Mn(Map)	1

Table 11. The analysis of the cases which represent natural disaster issues

Even though the largest number of the issues considered in this category is of course the tsunami itself, including the principle of the tsunami, its flow and height by time, the scenes of the damaged areas, etc., the most predominant information field is that of the epicenter of the Great East Japan Earthquake, which is observed in 12 cases. Most of those cases use concentric circles around the location of the epicenter in map [Fig.22]. Of course, these instances indicate not only the location of the epicenter, but also the magnitudes of the earthquakes in nearby regions, the realm of the coastline damaged by the tsunami and the domains of the influence areas of the earthquake.

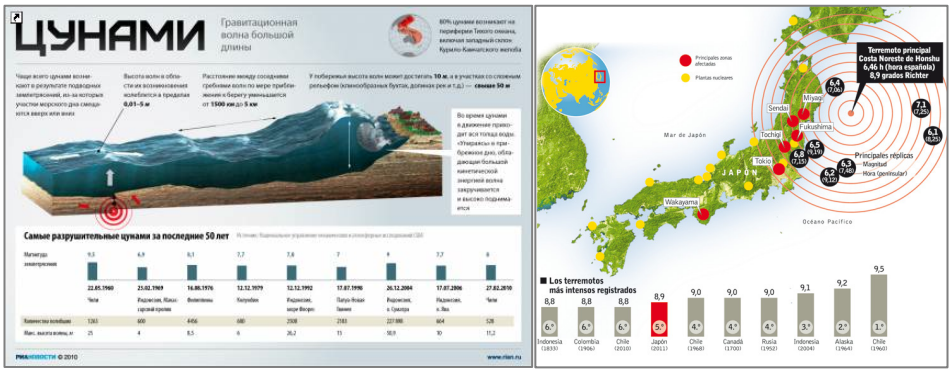


Figure 22. The cases which represent the issues of the tsunami (Left: Fraza (Ukraine). 2011. Tsunami / Right: Faro de Vigo (Spain). 2011. Gran tragedia en Japón (Great tragedy in Japan))

The predominant representational key is again shape, one of the non-arbitrary keys. This key is applied to 61 cases: the type of map seen in 50 instances, the description of the structure and principle of the tsunami in 8 examples and the scenes of the areas damaged by the tsunami in 3 cases. By way of contrast, there are 36 cases which employ arbitrary keys. Among those keys, one such dominant feature is that of line, and this is discovered in 17 instances. This key is used to depict tectonic plates in 6 instances, the data of flow of tsunami by time in 5 examples, the damaged coastline in 4 cases. They are mainly displayed in combination with the type of map.

In terms of the type of visualization, the type of map comprises the largest number of uses. The key which combines with this type most frequently is the aforementioned line. In addition, the second largest key which combines with the type of map is circle, which is found in 15 cases: to depict both the locations of the earthquakes and their magnitudes in 10 instances, etc.

In this category, the metonymy has the heaviest use, found in 50 cases. There are 11 instances which deal with extracted detail of the objects such as the structure of tsunami (8 examples) and the description of the damaged areas (3 cases). With regard to the metaphorical expression, there are 8 cases which employ this style and 7 instances use the metaphor of heat map: the hue of thermography is used to indicate the ring of fire in 4 cases and to depict wave height in 3 instances.

4.6. The analysis of the overall samples

In the overall samples which are not divided into the four categories, the largest number of the issues relate to the radioactivity-diffusion process. The statistics of the topics occurring in more than ten examples can be displayed as below [Fig.23].

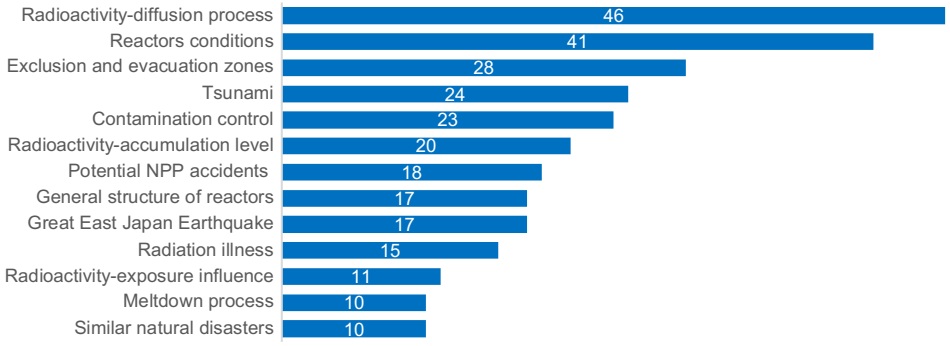


Figure 23. The major issues in the overall instances

In addition, the tendency of the use of representational keys can be displayed below [Fig.24].

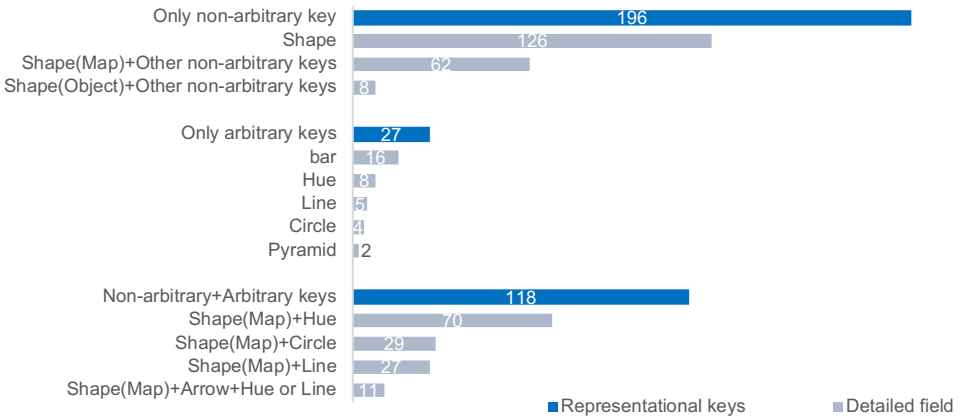


Figure 24. The representational keys in overall samples

The instances which use only non-arbitrary keys are the most abundant, giving rise to 196 in the overall examples. In addition, the largest number amongst those is the shape which is discovered in 126 examples. Again amongst those, there is only one sample which uses the shape of boundary, namely map, while the rest of them (126) display the shapes of objects such as the reactors, reactor-related things (i.e. barrier, ice wall, etc.), the structure of tsunami, human body and organs, etc. This tendency shows that the type of map is rarely used independently, but is generally most effective when in combination with other representational elements. With respect to the combinations between the non-arbitrary keys, the mixtures of maps and other keys (i.e. indexical or symbolic signs, etc.) comprise the largest number, sixty-two instances. Among them, the arrow, an indexical sign of wind, is the most dominant key which overlaps with the type of map in twenty-three samples. The second largest key used is a symbolic sign of radioactivity which indicates the location of the nuclear power plants on maps in thirteen instances [Fig.25].

Figure 25. A sample which uses symbolic sign of radioactivity which replaces NPPs and its enlarged part. (RIA (Russia). 2011. Землетрясения И аварии на ядерных объектах Японии в Марте—апреле 2011 года (Earthquakes and accidents at nuclear facilities in Japan In March and April 2011)

The instances which employ only arbitrary keys are far less frequent than the samples with only non-arbitrary keys. There are twenty-seven examples in such style and the keys include bar, hue, circle, etc. All the samples exhibit the type of statistical charts composed of such keys. The most heavily used key is bar, and this feature is discovered in sixteen instances including five samples which narrate the information of the radioactivity-exposure influences, five instances which describe the NPP-accident levels, etc. The second most frequent of the keys is hue. In all the eight samples, the hues are portrayed in the aforementioned bars [Fig.26].

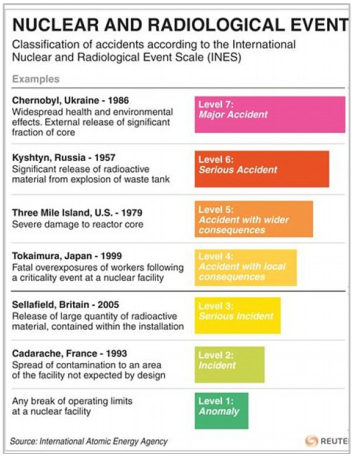


Figure 26. Reuters (UK). 2011. Nuclear and Radiological Event

There are 118 samples which contain the combinations of the non-arbitrary and arbitrary keys. Where there is such a combination, every one of those instances has the shapes of lands, namely map as a non-arbitrary key. The most abundant arbitrary key combined with the maps is hue, which is observed in 70 examples. Amongst those, there are 38 samples which indicate the domains of areas: the exclusion and evacuation zones in 27 samples, the realms of wind in 6 instances, etc. In addition, 32 examples employ the hue to represent quantitative data: the radioactivity-accumulation levels in 16, the population in 9, the height of tsunami, etc.

The tendency of the type of visualization across the overall instances can be presented as below [Fig.27].

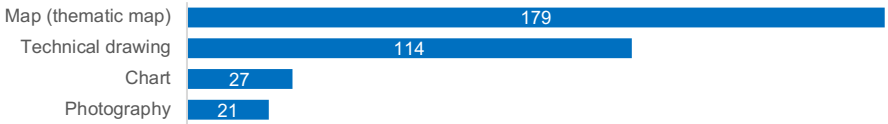


Figure 27. The types of visualization in the overall samples

The most plentiful style is the form of map. The main types which combine with the map are diverse statistical charts in 53 samples and the largest number of those is the type of color plot which employs the hue in 32 instances. In addition to the statistical charts, the type of map is generally partnered with various representational keys such as line, circle, signs (i.e. iconic, indexical and symbolic signs), etc. to narrate diverse data and information. The reason for the tendency of such abundant thematic maps seems that there are plentiful data and information of spatial dimension: the locations of NPPs in the world, the conditions of the damaged regions, the spread of radioactive contamination, the moving routes of evacuees, etc.

In terms of the regions represented by the maps, the whole Japan is shown in 60 samples, and this is the most plentiful such example of map [Fig.28]. These instances depict the data and information of the radioactivity-accumulation levels in 17 examples, the Great East Japan Earthquake in 16 samples, the wind passing through Japan in 9 instances, etc. In addition, examples depicting the regions near the Fukushima NPP (mainly the exclusion and evacuation zones and their neighborhood regions) comprise the second largest number, 56 samples [Fig.28]. They mainly display the domains of the exclusion and evacuation zones, the radioactivity accumulation levels, the population of the regions near to the power plant, etc.

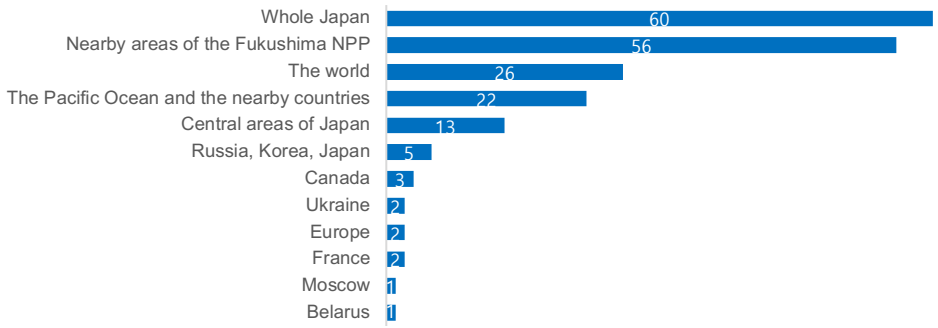


Figure 28. The regions represented by the maps

The second largest style is technical drawing, found in 114 samples [Fig.27]. The largest number within this type is the cross section discovered in 73 examples. The samples which contain the various types of technical drawing such as the cross section, process graphic, plan, etc. mainly describe the situations of the reactors in the Fukushima NPP or the diverse reactor-related objects such as the ice wall, ground-water tank, melt down, fuel rods, etc. (92 instances).

The statistics of metaphor and metonymy in overall samples can be summarized as below [Fig.29].

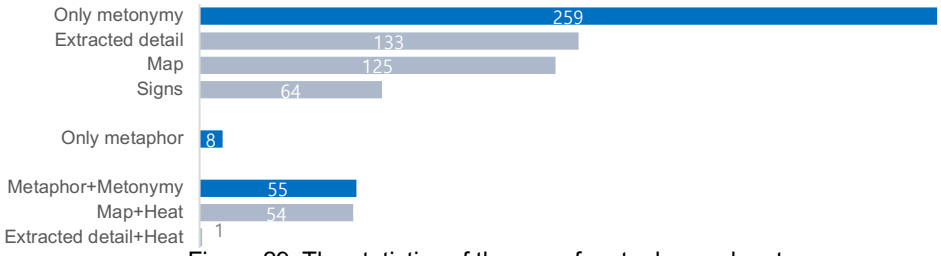


Figure 29. The statistics of the use of metaphor and metonymy

In the collected instances, the metonymical expressions are the most abundant. In terms of the examples which employ only metonymical representations, those which display extracted details are the most predominant, appearing in 133 samples. The majority of those deals with the information concerning the reactors or reactor-related objects, for a total of 113 instances.

On the other hand, the metaphorical expressions are discovered in 63 examples. They are mainly based on the similarity of the type of thermography due to the use of similar hues. The employment of only metaphor are discovered in those samples displaying statistical chart, particularly the type of bar chart which contains the hue of the heat map. The examples of such combinations represent the data and information of the NPP-accident levels (five samples), similar radioactive disasters (two instances) and radioactivity-exposure influences. However, the majority of the metaphorical expression samples are used in combination with the type of map which is a metonymical representation. The data and information of such samples include the radioactivity-accumulation level in nineteen instances, the realms of the exclusion and evacuation zones in eleven examples, the radioactivity-diffusion process in six samples, the spread of population across nearby areas of Fukushima or other NPPs of Japan in four instances, etc. Those are represented by using the similar hues of the heat map.

Based on the analysis above, the tendency of the samples of visualization which represent the Fukushima disaster can be summarized as below.

Firstly, with respect to the issues of the data and information, the characteristics of those represented in the majority of the instances are closely related to the radioactive contamination, even though the collected samples can be further divided into the four different categories. There are top-three issues, being the radioactivity-diffusion process, the reactors conditions and the exclusion and evacuation

zones. In those, the topic of the reactors conditions is included in the category of technology issues, but damage suffered by the reactors is the most crucial and direct factor in triggering and determining the extent of the radiation leak. In addition, the issue of the exclusion and evacuation zones is categorized into the section dealing with social issues, but the realms of those areas are actually defined and changeable depending on the original influence of the radioactive contamination.

Secondly, in terms of the representational keys, the majority of the cases employ the non-arbitrary key, shape. This tendency is due to the abundant cases which depict the shape of land (map), and the reactors and the diverse objects relative to those. In addition, there are other major non-arbitrary keys such as signs: for example the indexical sign of the wind flow such as arrow, the symbolic sign of radioactivity employed to display the locations and amount of NPPs, etc. With respect to the arbitrary keys, the largest number of those is hue which indicates the levels of radioactive material accumulated in soil, the domains of the exclusion and evacuation zones, the population data, etc.

Thirdly, with regard to the type of visualization, the most abundant cases represent diverse topics by using the type of map which display regional data and information. The aforementioned diverse signs and hues are the representational keys which are frequently used in combination with the maps. In addition, the second largest type observed is the technical drawing such as cross section, process graphic and plan, all of which describe the information related to the reactors: the damaged conditions and the control of those, etc.

Finally, with respect to the expressions of metonymy and metaphor, the metonymical representations are the most plentiful. This tendency is due to the frequent uses of the non-arbitrary key, shape, employed in the extracted details and maps. One notable point here is that the kinds of the topics of the samples using metonymy are limited compared to the large number of their uses. This is because the extracted details of the objects are mainly related narrowly to the reactors whereas the domains of the maps generally display Japan and the neighboring regions of Fukushima. On the other hand, even though the metaphorical expression is discovered in fewer samples compared to those found in metonymy, the metaphor of the type of heat map (thermography) is employed as a universal visual syntax which deals with a far more broad range of issues: the levels of radioactive contamination, the domains of the exclusion and evacuation zones, the height of tsunami, the population data, etc. From the perspective of the use of familiarity based on the similarity of another visualization system, it is

possible to obtain positive influences to aid understanding, but there is probably also a negative effect to challenge this view. This is because even though the various topics are represented by the metaphor of thermography, the domains of the maps used in combination with this type are mainly oriented toward Fukushima and Japan. To put it another way, such thematic maps using this metaphor are exhibited as similar visual products with similar methods even though they represent diverse themes of data and information. As the most plentiful samples of this metaphor mainly display the data of radioactivity-accumulation level, it is necessary to consider whether the different issues identified in this metaphorical expression might inadvertently be misunderstood as issues relating to the radioactive contamination.

5. Methodology

5.1. Structure of visual method: visual materials and questionnaire

This research employs a questionnaire as the preferred method for the interview. In addition, and as a part of the questionnaire, it uses visual samples as prompts for the interviewees. These samples serve as the tools to discover the understanding-related effects of some of the deconstructed elements of visualization and other various conditions around the understanding of visualization. In other words, they are there to assist in the investigation of which traits, devices, structures, etc. (based on the framework) make people understand the difficult and multidimensional issues of data sets and information; which elements of those lead to a more heightened emotional state by (after) effective understanding; and what are the other conditions which have influences on the understanding of viewers.

To achieve those targets, there are many important issues to be carefully explored: the dynamics of tripartite composed of the event, subject, and visualization. The event is the Fukushima disaster; the subject can be the diverse viewers with various backgrounds and contexts; the visualization involves a diversity of the forms and components of visual syntax: the representational keys, types of visualization and metonymy and metaphor.

In the process of understanding visualization, the components of the tripartite cannot work or exist discretely. The variety in the possible relationships are described below [Fig.30].

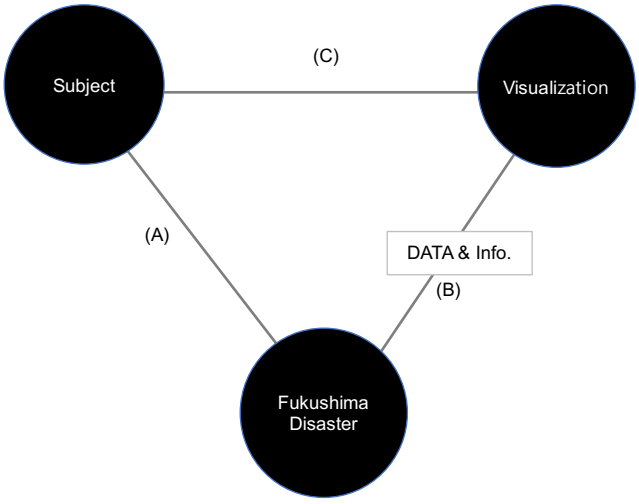


Figure 30. The relationship between the tripartite

With respect to relationship (A), it is impossible for all subjects to involve the same relationships with the Fukushima disaster. This is because the subjects have different backgrounds and circumstances: direct or indirect experiences related to the accident, nationality, personal interest, educational, occupational, and cultural conditions, etc. Depending on such backgrounds, it is highly probable that the respondents possess a range of different foreknowledge of and perspectives on the event before they are given the opportunity to interpret the visualization. In addition, this situation can have an influence on the interpretation of visualization. To put it in another way, it is probable that the subjects have receptive, selective, resisting, etc. attitudes toward visualization of the accident due to their personal backgrounds. This shows the possibility that relationship (A) can have an influence over relationship (C) and hence that relationship (A) is not an insignificant factor when considering the process of interpreting and understanding visualization. Bearing this in mind, the questionnaire should therefore be constructed allowing for the investigation of the backgrounds of the participants of the interview.

In terms of relationship (B), all the various and multidimensional aspects of the Fukushima event cannot be directly contained within the single visualization. Only secured data sets and information regarding specific agendas are represented in the forms of visualization. However, the data and information are not always transparent. As aforementioned in the background chapter, data and information are vetoed and sanctioned in the political hegemony. In this situation, it is highly possible that the subjects present specific attitudes toward the data sources depending on their political disposition. As a result, there can be a finding that they are receptive or defiant positions on visualization.

Among the collected samples, there is a coexistence between the diverse sources which can be considered in relation to such topics above. Seventy-one sources in total were considered, all of which had a variety of characteristics and inclinations including governmental agencies of not only Japan but other various countries, international organizations, independent institutes, news agencies, research labs, etc. The sources of the collected samples are presented as below [Table 12].

The category of data source		The name of data source
specialized agency	- International Org.	World Nuclear Association (UK)
		IAEA (International Atomic Energy Agency)
		WHO (World Health Organization)
		OCHA (United Nations Office for the Coordination of Humanitarian Affairs)

		UNSCEAR (United Nations Scientific Committee on the Effects of Atomic Radiation)
		Canadian Nuclear Association (Canada)
		International Nuclear Safety Center (Kazakhstan)
	- Independent agency of Gov.	U.S. Environmental Protection Agency (US)
		Nuclear Regulatory Commission (US)
		NASA (US)
		JAEA (Japan Atomic energy Agency) (Japan)
		Japan's Nuclear Safety Commission (Japan)
	- Agency of Gov.	NOAA (National Oceanic and Atmospheric Administration) (US)
		USGS (U.S. Geological Survey) (US)
		MEXT (Ministry of Education, Culture, Sports, Science and Technology) (Japan)
		National Police Agency of Japan (Japan)
		METI (Ministry of Economy, Trade and Industry) (Japan)
		Reconstruction Agency (Japan)
		Japan's Nuclear and Industrial Safety Agency (Japan)
		ZAMG (Central Institution for Meteorology and Geodynamics) (Austria)
		Roshydromet (Russian Federal Service for Hydrometeorology and Environmental Monitoring) (Russia)
		Bundesamt für Strahlenschutz (Federal Office For Radiation Protection) (Germany)
		National Institute of Fisheries Science of KOREA (Korea)
research institution	**- Univ.**	Geoscience at the Univ. of Texas at Dallas (US)
		Geophysicist at Columbia Univ (US)
		Universities Space Research Association in Columbia (US)
		Stanford University (US)
		fisico médico del HUV (Hospital University of Valley) (Spain)
	- national institution	Oak Ridge National Laboratory's Landscan data (US)
		National Institutes of Health (US)
		IRSN et Météo France (French public expert in nuclear and radiological risks) (France)
		Center For Disease Control (Canada)
	- Journal	PNAS (Proceedings of the National Academy of Sciences) (US)
		La Radioactivité (EDP Science) (France)
	- independent institution	Woods Hole Oceanographic Institution (US)
		HPS (Health Physics Society) (US)
		JCIV (Institute for Information design Japan) (Japan)
	- museum	Pacific Tsunami Museum (US)
	- book	Longman-Physical Geography in Diagrams (UK)
Journalism media and the related field	**- newspaper**	NY times (US)
		The Washington Post (US)
		Wall Street Journal (US)
		Le Figaro (France)
		Con información Le Monde (France)
		Die Welt (Germany)
		The Globe and Mail (Canada)
		Sole 24 Ore dati (Italy)
		ABC (Spain)
		DN (Sweden)
		Dagbladet (Norway)
		H ΚΑΘΗΜΕΡΙΝΗ (Kathimerini) (Greece)
	- news agency	AP (US)

		Kyodo News (Japan)
		Reuters (UK)
		AFP (France)
		APA (Austria)
		РИА (RIA.ru) (Russia)
	- Media company	ANSA-Centimetri (Italy)
		Sina Corp (Chinese online media company) (China)
		Ifeng (China)
		Ukraine Media Service (Ukraine)
	- Infographic news company	Graphic News (UK)
		Isotype (Germany)
	- Magazine	Limes (Italy)
	- Broadcasting station	BBC (UK)
Company	**- Reinsurance company**	Munich Re (Germany)
	- public enterprise	TEPCO (Tokyo Electronic Power Company) (Japan)
	- Marketing consulting company	Objective Analysis (US)
	- map service	GoogleEarthPro (US)
	- Lobbying company	JAIF (Japan Atomic Industrial Forum) (Japan)
	- Database company	Statista (Germany)

Table 12. Various data sources of the collected samples.

Therefore, the questionnaire used needs to be composed carefully in order to investigate effectively whether the participants have true credibility for the sources. This precedes the subject's personal disposition to interpret visualization and hence has a high chance of affecting the understanding of visualization.

There are two purposes behind investigating relationship (C): to discover 1) how visualization leads to effective understanding and ensuing emotional stimulation and 2) whether visualization can have an influence on changing the perspective on and recognition of the Fukushima disaster.

The first purpose is designed to investigate which and how traits and structures of visual syntax encourage the viewers to extract and understand information. The aforementioned traits and structures are based on the components of the framework including the representational key, type of visualization and metaphor and metonymy. To be more specific, there needs to be a deeper consideration of which elements of those factors above allow for more effective understanding, and whether the results differ. Those results will ultimately depend on the diverse backgrounds of the participants, or it may be that there could be one universal visual language that will determine the ultimate effectiveness. In addition, one of the main purposes of this exploration is to discover which visual syntax makes emotional reaction

more distinct. This is because emotion ensues from understanding and is “a contributor to the advancement of understanding” (Elgin, 2008: 34), and hence, it is closely related to the effectiveness of understanding.

In terms of the second purpose, it is probable that the effective understanding and resulting emotion brings about change in the cognition and perspective which the viewers have had before considering that particular visualization. Of course, such changes cannot only stem from the representational methods of visualization. A more likely factor for the result is the subjects’ own understanding of unknown or reflection of more intense information about the event. However, we have seen that not only the content itself, but also the communication presentation technique to deliver that information, has been an important method to persuade and enlighten people. The communication skills such as rhetoric, metaphor, metonymy, etc. are familiar techniques with which to highlight the importance of the presentational manner. As visualization is one of the techniques of communication and the data and information contained therein are closely related to our lives in the post-disaster period, visualization needs to function as not only a transparent window of, but also a lens which highlights, the significant data and information observed.

Therefore, it is necessary to explore whether visualization can bring about a change in the cognition and perspective on the Fukushima event and if so, which combination forms of data (and information) and representational methods cause such effect. The questionnaire and visual materials should be composed carefully to investigate those issues.

5.1.1. Visual materials

5.1.1.1. The criteria behind the selection of the visual materials

In respect of the various collected samples, it is necessary to select those visual materials that are deemed most suitable to assist in the exploration of the aforementioned dynamics of the tripartite. For the materials to properly investigate relationship (C), the samples based on the main tendencies of the collected samples discovered by the analysis are chosen. In other words, the materials were to be composed of the samples which demonstrate the main tendencies of a) data (information) field (issue),

b) representational key, c) type of visualization and d) metaphor and metonymy.

Using these criteria above, there are other further considerations to bear in mind when composing the visual materials.

Firstly, even though the visual materials include various samples composed of the combination between diverse issues and expressional elements, it should be possible to compare the effectiveness of understanding between the samples which contain the same data and information fields, but also include different representational methods. In other words, in terms of how some of the same issues of the event are addressed, different representational keys, types, metonymical and metaphorical expressions should be compared.

Secondly, there is also a need to discover the most effective combination form in the diversity of the entire set of samples of the materials. Ultimately, the comparison needs to be conducted between the visual instances with different topics and expressions. To be specific, if it is possible to rank in order the samples selected in the first comparison above, the instances at the top of the rank and their construction methods can be regarded as being effective in inducing meaningful understanding.

Finally, in the cases where there was a limited ability to compare the published (collected) instances, some samples produced by the researcher were employed. This production was applied to the samples which do not have the appropriate counterparts to be compared against, despite being a notable example in the tendencies observed in the analysis.

5.1.1.2. The selected visual materials

In the light of the criteria above, the selected visual materials to investigate the effectiveness of understanding of the visualizations are as below [Table 13].

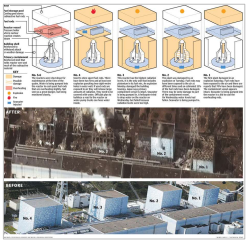
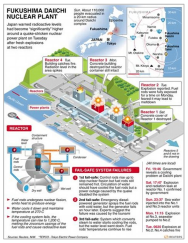
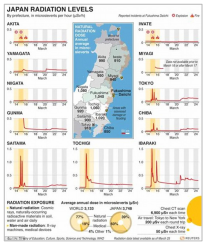
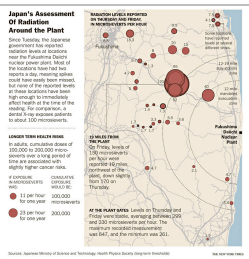
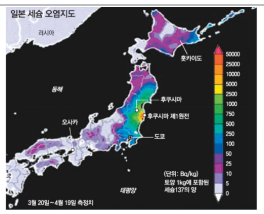
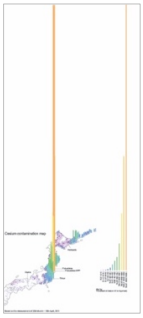
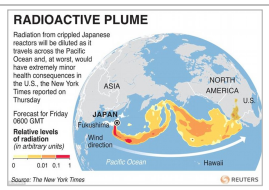
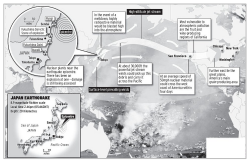
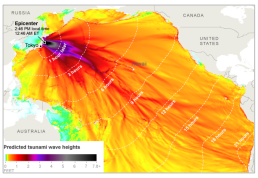
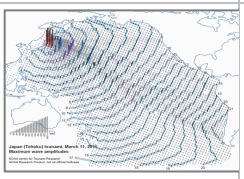
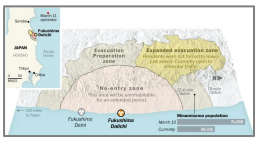
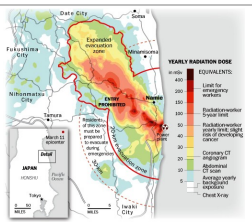
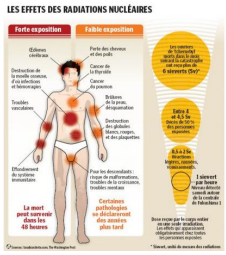
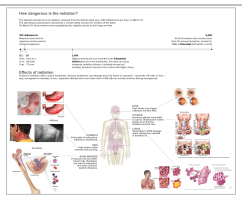
 V.1. Explaining Japan's Nuclear Reactor Disaster	 V.2. Fukushima Daiichi Nuclear Power Plant	 V.3. Japan Radiation Levels	 V.4. Japan's Assessment of Radiation Around the Plant
 V.5. Caesium Contamination Map	 V.6. Caesium Contamination Map	 V.7. Radioactive Plume	 V.8. America on Radiation Alert
 V.9. Predicted Tsunami Wave Height	 V.10. Predicted Tsunami Wave Height	 V.11. Fukushima plant radiation	 V.12. Yearly Radiation Dose
 V.13. LES EFFETS DES RADIATIONS NUCLÉAIRES (THE EFFECTS OF NUCLEAR)	 V.14. Effects of Radiation		

Table 13. Visual materials used as part of interview[16]

[16] V.1: Explaining Japan's Nuclear Reactor Disaster, 2011, National Post
V.2: Fukushima Daiichi Nuclear Power Plant, 2011, The Daily Telegraph
V.3: Japan Radiation Levels, 2011, Dailymail
V.4: Japan's Assessment of Radiation Around the Plant, 2011, NY Times
V.5: Caesium Contamination Map, 2011, The Dong-a Ilbo
V.6: Caesium Contamination Map (produced by the researcher)
V.7: Radioactive Plume, 2011, Dailymail
V.8: America on Radiation Alert, 2011, Dailymail
V.9: Predicted Tsunami Wave Height, 2011, NY Times
V.10: Predicted Tsunami Wave Height (produced by the researcher)
V.11: Fukushima Plant Radiation, 2011, The Washington Post
V.12: Yearly Radiation Dose, 2011, The Washington Post
V.13: LES EFFETS DES RADIATIONS NUCLÉAIRES, 2011, Le Parisien
V.14: Effects of Radiation (reconfigurated by the researcher). For accurate and minute representation of the

In addition, the taxonomies of the the samples can be presented again as below [Table 14].

No.	Issues	Detailed field	Purpose (Variables)	Representational key (A: Arbitrary / N: Non-arbitrary)	Types of Vis. (M: Map / C: Chart / T: Technical drawing / P:Photograph)	Metaphor and Metonymy (Mp: Metaphor / Mn: Metonymy)
V.1	Reactors conditions	After the explosion	Representing the shapes, structures, and conditions of the reactors	N (Shape)	T (Cross section)	Mn (Extracted detail)
		Before and after the explosion	Comparison of the reactors between before and after the explosion	N (Shape)	P (Top view)	Mn (Extracted detail)
V.2	Reactors conditions	After the explosion	Representing the conditions of the reactors	N (Shape)	T (Plan)	Mn (Extracted detail)
		General structure	Representing the shape and structure of a reactor	N (Shape)	T (Cross section)	Mn (Extracted detail)
	Exclusion and evacuation zone	Before expansion	Indicating the domains and locations of the exclusion and evacuation zone	N (Shape)	M (Japan+Fukushima)	Mn (Extracted detail)
V.3	Radiation level and distribution	By date and region	Representing the distribution and levels of radiation depending on time and space	A (Line)	C (Line chart)	Mn (Extracted detail)
		Locations (Central Japan)	Indicating the locations	N (Shape)	M (Central Japan)	Mn (Extracted detail)
V.4	Radiation level and distribution	By region	Representing the distribution and levels of radiation depending on space	A (Circle, Size, Position)	C (Bubble chart on map)	
		Locations (Near Fukushima)	Indicating the locations	N (Shape)	M (Near Fukushima)	Mn (Map)
V.5	Radiation level and distribution	Whole Japan	Representing the distribution and levels of radiation depending on space	A (Hue)	C (Color plot)	Mp (Heat)
			Indicating the locations	N (Shape)	M (Whole Japan)	Mn (Map)
V.6	Radiation level and distribution	Whole Japan	Representing the distribution and levels of radiation depending on space	A (Bar, Hue)	C (Bar chart)	Mp (Heat)
			Indicating the locations	N (Shape)	M (Whole Japan)	Mn (Map)
V.7	The movement of radiation diffusion	Air on the Pacific Ocean	Representing the route, realm and levels of radiation depending on space	A (Hue)	C (Color plot)	Mp (Heat)
			Indicating the direction	N (Arrow)	T (Process graphic)	Mn (Indexical sign)
			Indicating the locations	N (Shape)	M (The world (Pacific))	Mn (Map)
V.8	The movement of radiation diffusion	Air on the Pacific Ocean	Representing the route, direction, and strength of air flow depending on space	N (Arrow)	T (Process graphic)	Mn (Indexical sign)
			Indicating the locations	N (Shape)	M (The world (Pacific))	Mn (Map)

symptoms, V.14 utilizes the visualization cases already produced in the field of medical science. The sources are as below.
a) Body and information: Washington Post, “How dangerous is the radiation?”, http://www.washingtonpost.com/wp-srv/special/world/japan-nuclear-reactors-and-seismic-activity/
b) Eye: Florida Eye Institute, “What is a cataract?”, http://www.fleye.com/cataract-center/cataract-faqs/
c) Thyroid: Nucleus Medical Media, “Thyroid Cancer”, http://conditions.healthgrove.com/l/1013/Thyroid-Cancer
d) Lungs (Pneumonia): NY times, “Pneumonia - Adults (Community Acquired)”, http://www.nytimes.com/health/guides/disease/pneumonia/overview.html
e) Lungs (Pulmonary fibrosis): Mayo Foundation for Medical Education and Research (MFMER), “Pulmonary fibrosis”, http://www.mayoclinic.org/diseases-conditions/pulmonary-fibrosis/home/ovc-20211752
f) Stomach: A.D.A.M. (American Accreditation HealthCare Commission), “Peptic ulcer”, https://medlineplus.gov/ency/article/000206.htm
g) Skin: NNHSphysics, “Effects of Radiation on Health”, http://nnhsphysics.wikispaces.com/Effects+of+Radiation+on+Health
h) Bone marrow: NIH (National Cancer Institute), “Bone Anatomy”, https://www.cancer.gov/types/leukemia/patient/adult-aml-treatment-pdq

V.9	The spread and height of the tsunami	By time and space (the Pacific)	Indicating the height	A (Hue)	C (Color plot)	Mp (Heat)
			Indicating the time and range	A (Line)	T (Process graphic)	
			Indicating the locations	N (Shape)	M (The world (Pacific))	Mn (Map)
V.10	The spread and height of the tsunami	By time and space (the Pacific)	Indicating the height	A (Bar)	C (Bar chart)	
			Indicating the time and range	A (Line)	T (Process graphic)	
			Indicating the locations	N (Shape)	M (The world (Pacific))	Mn (Map)
V.11	The realm and location of the exclusion and evacuation zones	Near the Fukushima NPP	Indicating the realms	A (Hue)		Mp (Heat)
			Indicating the locations	N (Shape)	M (Near the Fukushima NPP)	Mn (Map)
V.12	The realm and location of the exclusion and evacuation zones and the distribution and level of radiation	By the regions (Fukushima and its neighboring regions)	Representing the distribution and levels of radiation depending on space	A (Hue)	C (Color plot)	Mp (Heat)
			Indicating the realms	A (Line)		Mp (Heat)
			Indicating the locations	N (Shape)	M (Fukushima and nearby regions)	Mn (Map)
V.13	Radiation illness and the influence of radiation exposure	Human body and general influences	Describing symptoms of the illness	N (Shape: external body) A (Red and orange Circles)	T (External description)	Mn (Extracted detail), Mp (Heat)
			Explaining the influence of the radiation depending on the amount	A (Circle, Size, Position)	C (Bubble chart)	
V.14	Radiation illness and the influence of radiation exposure	Human body and organs and general influences	Describing symptoms of the illness	N (Shape: internal and external body and organs) A (Red and orange Circles)	T (Cross section)+P (skin)	Mn (Extracted detail)
			Explaining the influence of the radiation depending on the amount	A (Bar)	C (mono bar chart)	

Table 14. The taxonomy of the deconstruction of the visual materials

The selected samples address five issues which are predominant across the overall collected samples: Radioactivity-diffusion process, Reactors conditions, Exclusion and evacuation zones, Tsunami, and Radioactivity-accumulation level. The topic of Contamination control is represented in 23 instances, but this issue is not included in the selected samples [Fig.31]. This is because this topic mainly presents the method of protecting the spread of contaminated water and cooling the reactors of the Fukushima NPP, but the representational key such as shape and type of technical drawing are very similar to those of the samples already viewed when representing the condition of the reactors.

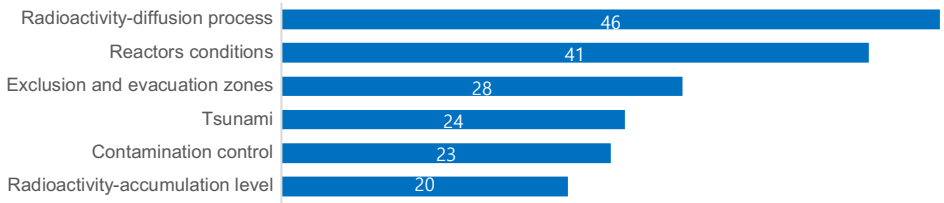


Figure 31. The major issues addressed in the overall instances

As aforementioned, the visual materials include the samples which contain the same data and information, but employ different representational techniques. In terms of V.5 and V.9, it is hard to find

appropriate counterparts to be compared, and hence the materials V.6 and V.10 were produced by the researcher to act as the closest possible counterparts.

The materials also reflect other tendencies revealed by the analysis. The major inclination of the representational key can be presented as below [Fig.32].

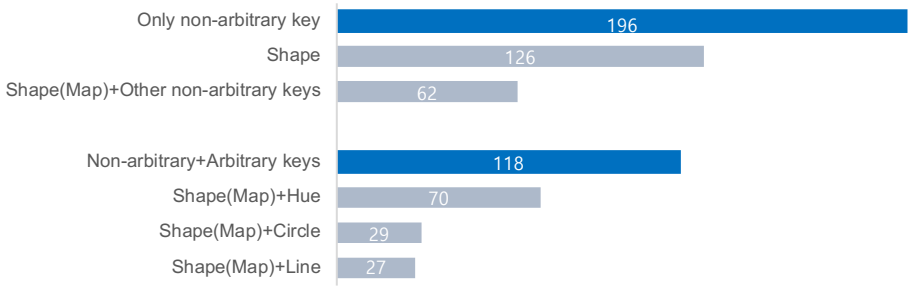


Figure 32. The representational keys across the set of samples

The most predominant key, Shape, is mainly employed to display the form of land (territory), namely map. Another frequent use of this key is found in the descriptions of the reactors and the reactor-related objects such as V.1 and V.2. Other visual samples which use Shape are V.13 and V.14 which describe the information surrounding radiation illness.

In addition, the major non-arbitrary key which combines with the type of map is, as aforementioned, an indexical sign, arrow (which indicates routes or direction of movement), with V.8 serving as a good example of use in this context.

The combination of non-arbitrary and arbitrary keys is the second most common observed. More specifically, this inclination can be mainly found in the combination between the type of map (Shape of territory) and that of color-plot chart (Hue for quantitative data): V.5 and V.7 display radiation levels on the type of map; V.11 represents the height and spread of the tsunami. V.11 is another example where Hue is used in the same combination type: the Hue in this case is merely used to divide the different realms of the exclusion and evacuation zones. In addition, V.4 shows another combination form of the different kinds of representational keys: Shape (non-arbitrary) and Circle (arbitrary). This sample uses a type of bubble-plot chart (circles with various scales on different positions) to represent the accumulated radiation level.

In terms of the type of visualization, the inclination can be presented as below [Fig.33].

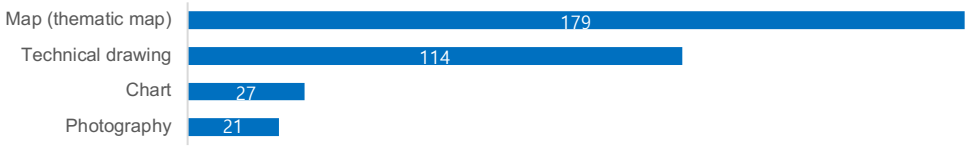


Figure 33. The types of visualization across the samples

The most common type seen is in the form of thematic map. All the selected samples excluding V.1 and V.2 employ the type of thematic map. V.1 and V.2 are the exceptions which utilize the form of technical drawing. In addition, those materials which involve the type of chart include V.3 (Line chart), V.4 (Bubble-plot chart), V.6 (Bar chart) and V.10 (Bar chart). The color-plot chart, one of the subset forms of chart, is found in V.5, V.7, V.9 and V.12. Finally, V.1 involves the type of photography.

The inclination of metonymy and metaphor can be presented as below [Fig.34].

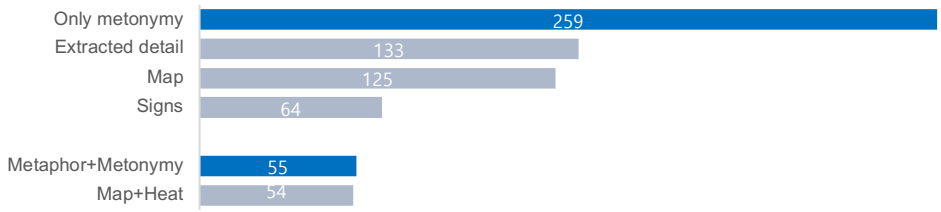


Figure 34. The statistics of the use of metaphor and metonymy

As to the extracted details, metonymical expressions are employed in V.1 and V.2 to display the shapes of the reactors' conditions (regarding the explosions) and their structures. In addition to those expressions, metonymy can be found in other samples due to the use of map. In addition, the indexical sign is one of the metonymical representations employed, and V.8 involves this expressional manner. With regard to metaphor, the most predominant form is the metaphorical expression of heat (thermography) and this can be found in V.5, V.7, V.9, V.11, and V.12.

The visual materials, therefore, reflect the inclinations revealed by the overall analysis. Those materials are composed to compare the effects of the different representational methods regarding each of the issues and topics.

5.2. Topic guide and questionnaire

In order to retain the integrity of the context of the investigation, and in order to achieve the purpose of the same, a questionnaire which also includes the visual materials mentioned above is employed in the interview.

The questionnaire is composed of a mixture of open-ended and closed questions. The reason for this is that this exploration requires the generation of objective data, which should be regarded as a measure to judge the effectiveness of the visual samples, as well as allowing for variety in the backgrounds of the participants and their subjectivity.

On the one hand and as aforementioned, this research allows for and pays attention to the diversity of the backgrounds of the subjects and the causality between the multiplicity and understanding of visualization. This is because it is highly probable that the diverse backgrounds of the respondents will call upon their previous education, perceptions, perspectives, interests in terms of the event, reliabilities of data sources, preferences of representational methods, etc. All of these factors represent the qualitative components of the dynamics of the event, subject, and visualization. Therefore, the open-ended question is a suitable way of exploring these elements in greater detail.

However and on the other hand, this research does also employ the form of the closed question to gather quantitative and objective data with respect to the respondents' understanding-related reactions. Particularly, these questions can be applied to the emotional reactions which follow after understanding the visual instances. Since it is highly probable that the occurrence of the emotional condition and its intensity differ depending on various personal dispositions and other backgrounds, it is too ambiguous, as well as ambitious, to definitively judge the degrees of emotional influences of the visual samples by relying only on such free responses. Instead, it is more appropriate to estimate the overall effect in this regard by using quantified data of emotional intensities depending on the individuals. For this process, therefore, the type of the closed question is employed, which allows for the conversion of the degree of emotion into a measurable score on a case by case basis.

In consideration of all the contexts above, the topic guide which can be a basis of the questionnaire can be presented as below [Table 15].

Topic number	The relationship of the tripartite	Topic
T. 1 (Topic 1)	(A): Event and Subject	The backgrounds of the participants and their opinions, perspectives, interests, relationship, etc. in terms of the Fukushima disaster (before reading the samples of visualization)
T. 2	(B): Data (information) and Visualization	Susceptibilities to and reliabilities of data (information) sources
T. 3	(C): Visualization and Subject	The effective expressional methods in terms of understanding (Based on the representational key / type of visualization / metaphor and metonymy / the forms of combination between those)
T. 4	(C): Visualization and Subject	The effective expressional methods in terms of ensuing emotions (Based on the representational key / type of visualization / metaphor and metonymy / the forms of combination between those)
T. 5	(A): Event and Subject	The changes of ideas, perspectives, interests in terms of the Fukushima disaster (after reading the samples of visualization)

Table 15. The summary of the purpose of the questionnaire

Based on this topic guide, the questionnaire can be organized as per [table 16] below.

Question number	Question
Q. 1 (Question 1)	Age: □ 20~29 □ 30~39 □ 40~49 □ 50~59 □ 60~ Nationality: _____ Place where you grew up: _____
Q. 2.1 ~ Q. 2.3	Q. 2.1: Were you immediately affected by the Fukushima disaster? Q. 2.2: Does the event matter to you now? Please explain the reason. Q. 2.3: As a result of the Fukushima accident, what is the most intense or important matter to you? □ Technical aspect: the explosion of the reactors in the Fukushima NPP and control of those reactors □ Environmental aspect: radiation contamination, its spread, and influences on food, health, etc. □ Social aspect: exclusion and evacuation zones, evacuees' situations and any other conditions in terms of the evacuations □ The aspect of natural disaster: the tsunami and earthquake

Q. 3

There are different data sources despite the same data field: the level of the accumulated radioactive material. Please rank them in order of believability.

No.	Name of the source (nationality)	Category of the source	Level of reliability
1	MEXT (Ministry of Education, Culture, Sports, Science and Technology) (Japan)	Agency of Government	0 1 2 3 4 5 6 7 8 Hardly reliable — Reliable — Very reliable
2	Bundesamt für Strahlenschutz (Federal Office For Radiation Protection) (Germany)	Agency of Government	0 1 2 3 4 5 6 7 8 Hardly reliable — Reliable — Very reliable
3	JCIV (Institute for Information design Japan) (Japan)	independent institution	0 1 2 3 4 5 6 7 8 Hardly reliable — Reliable — Very reliable
4	Universities Space Research Association in Columbia (US)	University	0 1 2 3 4 5 6 7 8 Hardly reliable — Reliable — Very reliable
5	Reuters (UK)	news agency	0 1 2 3 4 5 6 7 8 Hardly reliable — Reliable — Very reliable
6	DN (Sweden)	newspaper	0 1 2 3 4 5 6 7 8 Hardly reliable — Reliable — Very reliable
7	Safecast (International)	NGO	0 1 2 3 4 5 6 7 8 Hardly reliable — Reliable — Very reliable

Q. 4

There are 14 visual samples (V.1~V.14) which represent the information regarding the Fukushima event. Please give scores to the ease of understanding, the amount of information you perceived, and emotional stimulation after understanding.

[V.1] How easy was it to understand the situations of the reactors of the Fukushima Daiichi NPP?

0 1 2 3 4 5 6 7 8
Very difficult — Normal — Very easy

How much information did this visual sample give you?

0 1 2 3 4 5 6 7 8
Very small — Normal — Very large

How much does this stimulate your emotion? (i.e. fear, anxiety, uncomfortableness

0 1 2 3 4 5 6 7 8
Hardly emotional — Normal — Very emotional

[V.2] How easy was it to understand the situations of the reactors of the Fukushima Daiichi NPP?

0 1 2 3 4 5 6 7 8
Very difficult — Normal — Very easy

How much information did this visual sample give you?

0 1 2 3 4 5 6 7 8
Very small — Normal — Very large

How much does this stimulate your emotion? (i.e. fear, anxiety, uncomfortableness

0 1 2 3 4 5 6 7 8
Hardly emotional — Normal — Very emotional

[V.3] How easy was it to compare and understand the levels of radiation in the various regions and their changes by time?

0 1 2 3 4 5 6 7 8
Very difficult — Normal — Very easy

How much information did this visual sample give you?

0 1 2 3 4 5 6 7 8
Very small — Normal — Very large

How much does this stimulate your emotion? (i.e. fear, anxiety, uncomfortableness

0 1 2 3 4 5 6 7 8
Hardly emotional — Normal — Very emotional

[V.4] How easy was it to compare and understand the levels of radiation in the various regions?

0 1 2 3 4 5 6 7 8
Very difficult — Normal — Very easy

How much information did this visual sample give you?

0 1 2 3 4 5 6 7 8
Very small — Normal — Very large

How much does this stimulate your emotion? (i.e. fear, anxiety, uncomfortableness

0 1 2 3 4 5 6 7 8
Hardly emotional — Normal — Very emotional

[V.5] How easy was it to understand the dispersion of the radiation contamination in Japan?

0	1	2	3	4	5	6	7	8
Very difficult			Normal				Very easy	

How much information did this visual sample give you?

0	1	2	3	4	5	6	7	8
Very small			Normal				Very large	

How much does this stimulate your emotion? (i.e. fear, anxiety, uncomfortableness

0	1	2	3	4	5	6	7	8
Hardly emotional			Normal				Very emotional	

[V.6] How easy was it to understand the dispersion of the radiation contamination in Japan?

0	1	2	3	4	5	6	7	8
Very difficult			Normal				Very easy	

How much information did this visual sample give you?

0	1	2	3	4	5	6	7	8
Very small			Normal				Very large	

How much does this stimulate your emotion? (i.e. fear, anxiety, uncomfortableness

0	1	2	3	4	5	6	7	8
Hardly emotional			Normal				Very emotional	

[V.7] How easy was it to understand the movement and spread of contamination on the Pacific Ocean?

0	1	2	3	4	5	6	7	8
Very difficult			Normal				Very easy	

How much information did this visual sample give you?

0	1	2	3	4	5	6	7	8
Very small			Normal				Very large	

How much does this stimulate your emotion? (i.e. fear, anxiety, uncomfortableness

0	1	2	3	4	5	6	7	8
Hardly emotional			Normal				Very emotional	

[V.8] How easy was it to understand the movement and spread of contamination on the Pacific Ocean?

0	1	2	3	4	5	6	7	8
Very difficult			Normal				Very easy	

How much information did this visual sample give you?

0	1	2	3	4	5	6	7	8
Very small			Normal				Very large	

How much does this stimulate your emotion? (i.e. fear, anxiety, uncomfortableness

0	1	2	3	4	5	6	7	8
Hardly emotional			Normal				Very emotional	

[V.9] How easy was it to understand the height and spread of the tsunami wave by time and space?

0	1	2	3	4	5	6	7	8
Very difficult			Normal				Very easy	

How much information did this visual sample give you?

0	1	2	3	4	5	6	7	8
Very small			Normal				Very large	

How much does this stimulate your emotion? (i.e. fear, anxiety, uncomfortableness

0	1	2	3	4	5	6	7	8
Hardly emotional			Normal				Very emotional	

[V.10] How easy was it to understand the height and spread of the tsunami wave by time and space?

0	1	2	3	4	5	6	7	8
Very difficult			Normal				Very easy	

How much information did this visual sample give you?

0	1	2	3	4	5	6	7	8
Very small			Normal				Very large	

How much does this stimulate your emotion? (i.e. fear, anxiety, uncomfortableness

0	1	2	3	4	5	6	7	8
Hardly emotional			Normal				Very emotional	

[V.11] How easy was it to understand the realms of the divided controlled zones and their conditions?

0	1	2	3	4	5	6	7	8
Very difficult			Normal				Very easy	

How much information did this visual sample give you?

0	1	2	3	4	5	6	7	8
Very small			Normal				Very large	

How much does this stimulate your emotion? (i.e. fear, anxiety, uncomfortableness

0	1	2	3	4	5	6	7	8
Hardly emotional			Normal				Very emotional	

[V.12] How easy was it to understand the realms of the divided controlled zones and their conditions

0	1	2	3	4	5	6	7	8
Very difficult			Normal				Very easy	

How much information did this visual sample give you?

0	1	2	3	4	5	6	7	8
Very small			Normal				Very large	

How much does this stimulate your emotion? (i.e. fear, anxiety, uncomfortableness

0	1	2	3	4	5	6	7	8
Hardly emotional			Normal				Very emotional	

[V.13] How easy was it to understand the influences of radiation on the human body?

0	1	2	3	4	5	6	7	8
Very difficult			Normal				Very easy	

How much information did this visual sample give you?

0	1	2	3	4	5	6	7	8
Very small			Normal				Very large	

How much does this stimulate your emotion? (i.e. fear, anxiety, uncomfortableness

0	1	2	3	4	5	6	7	8
Hardly emotional			Normal				Very emotional	

[V.14] How easy was it to understand the influences of radiation on the human body?

0	1	2	3	4	5	6	7	8
Very difficult			Normal				Very easy	

How much information did this visual sample give you?

0	1	2	3	4	5	6	7	8
Very small			Normal				Very large	

How much does this stimulate your emotion? (i.e. fear, anxiety, uncomfortableness

0	1	2	3	4	5	6	7	8
Hardly emotional			Normal				Very emotional	

Q. 5	After looking at the visual instances, are there any changes in your perspective on and interest in the Fukushima disaster? If yes, What is your amended opinion? How much did the material affect you? Please score the degree of its influence. 0 1 2 3 4 5 6 7 8 Very difficult Normal Very easy

Table 16. The questionnaire

[Q. 1] and [Q. 2.1] to [Q. 2.3] in [Table 16] above represent questions based on the topic of [T. 1] in [Table 15].

In addition, [Q. 3] is related to [T. 2]. The reason behind using the sources whose data deal with the level of accumulated radioactive material is due to the political sensitivity of the data source. With respect to the data of the radiation level, the fabrications by the Japanese government has subsequently been revealed, and has provoked considerable outrage from the international community (Der Spiegel, 2011). However, many samples employ the data provided by the organizations supported by the Japanese government [Table 17]. On the other hand, none of the collected visualizations used the data and information from sources that were NGOs. To address this imbalance one such organization was added, Safecast, to the list of sources in Q.3. It is crucial to inspect the credibility of the data and information of NGOs since they are the most active bodies that collect and generate data and information which the government of Japan has tried to conceal and downplay. In this situation, it is probable that there are more marked differences in the preferences for and attitudes towards these potentially biased sources, in comparison to other data and information fields.

Issue	The category of the data sources		Name of the source	Number of the samples using the source
Radioactivity-accumulation level	National or international agency	Agency of Gov.	MEXT (Ministry of Education, Culture, Sports, Science and Technology) (Japan)	6
			Reconstruction Agency (Japan)	1
			Bundesamt für Strahlenschutz(Federal Office For Radiation Protection) (Germany)	1
		Independent agency of Gov.	Nuclear Regulatory Commission (US)	1
	research institution	independent institution	HPS (Health Physics Society) (US)	1
			JCIV (Institute for Information design Japan) (Japan)	1
		Univ.	Universities Space Research Association in Columbia (US)	1
	Journalism media and its related company	news agency	Reuters (UK)	1
		news agency	AFP (France)	1
		newspaper	DN (Sweden)	1

Table 17. The data sources of radioactivity-accumulation level and the number of samples which employ those.

[Q. 4] is designed to investigate [T. 3] and [T. 4], with [Q. 5] being a question to study [T. 5].

In particular, [Q. 4] asked the three categories together: level of understanding achieved, the amount

of information delivered, and the degree of emotional stimulation brought about by the visualization samples. This is because they are closely related.

In particular, the amount of information issue relates to the number of variables, or that of visual objects (visual artifacts). It is highly probable that the simpler the number of variables is, so the easier it is for the viewer to understand what is being observed. In addition, the amount of information people receive from visualization is likely to vary depending on their background knowledge regarding the topics or types of visualization. Therefore, this study explored the amount of information actually received by the participants versus the amount of information actually contained in the visualization.

In addition, the formation of emotional state is followed by understanding, and thus effective understanding is likely to be the precondition of effective emotional stimulation.

It follows that one possible question which can be raised from those assumptions is whether those two conditions are always causally connected to produce a single result. Put another way, the question is whether visualization which deals with small amounts of information always yields an effective understanding, and whether it then leads to highly effective (or high) emotional stimulation.

However, one point which should be considered regarding the interpretation of visualization is that there are other conditions at play, all working together in the process of interpretation. These conditions include the viewer's background, visual syntax of visualization, the characteristics of data or information represented in visualization, etc. The complex actions incited by those variables may affect changes to the aforementioned causal link. For instance, visualization which deals with more kinds of, or larger, amounts of information (or data) can possess a higher effectiveness in bringing about understanding compared to those containing a lesser volume of information; visualization which represents small amounts of information may not necessarily produce a high effectiveness of emotional stimulation. Subsequently, the level of understanding and emotional stimulation can differ depending on various expressional types of visualization despite the presentation of identical information or data.

In consideration of the context above, the effects of various visual syntax of the visual materials were explored in several contexts: the level of effective (easy) understanding those materials yielded; the amount of information people perceived; how intense was the emotional stimulation produced; and finally, depending on the participants' backgrounds such as region, age, whether the Fukushima event matters or not and the reason for it, and the overall perspectives on the disaster.

Therefore, the questionnaire possesses multiple functions, to examine not only the effectiveness of deconstructed elements of visualization, but also the diverse conditions in relation to the subject's personal reading of the visualization at hand, and the ultimate influences of those on overall understanding of the visualization.

5.3. Semi-structured interview

This research employs semi-structured interview based on a questionnaire composed of, as aforementioned, a combination of open-ended and closed questions. The reason for employing this mixture of techniques is that this research allows for the variance in the backgrounds of the participants of the interview to truly come to the fore. The process of understanding visualization and arousing emotions are likely to be various as well and hence, in some situations, it is necessary to extend questions and gather further responses depending on the differences between the participants. The questionnaire is also the means by which there can be a preliminary gathering of participants' opinions and ideas. This in turn enables the expansion of such further investigation. In this regard, the semi-structured interview based on the questionnaire allows for further elaboration of the issues discussed, and this is an essential part of this investigation.

There are several possible cases that need to be expanded and elaborated upon.

Firstly, the interview should gather free opinions and perspectives on the Fukushima disaster. As aforementioned in the previous chapter, the relationship between the subject and the event (relationship A) is likely to be a decisive factor in determining the potential influences on the relationship between the visualization and the subject (relationship C). Individual opinions and ideas (of subjects) regarding the accident can differ depending on the participants' diverse backgrounds. In common with those, the participants' psychological or physical distances from the accident and direct or indirect experiences related to the event are also likely to be varied in terms of both nature and extent. In addition, possible changes to the existing ideas and perspectives on the event following a fuller understanding of the visualization samples are likely to be diverse and unpredictable. With that in mind it is not suitable merely to employ closed questions to gather such a diverse range of results and responses. Hence,

the questions need to be extended to collect such unfettered opinions, as well as to understand the reasons behind those responses.

Further, the factors which cause effective understanding can also be various. Such factors could include the representational manners of, the background knowledge of, the curiosities of, and the interests in, the disaster, or combinations of such matters. Questioning the variety of the causes is also unlocked when using the form of the semi-structured interview.

One should remember, however, that the questionnaire does contain some closed questions too. This is because, as aforementioned, it is necessary to quantify the degree of qualitative conditions of the responses. For instance, in terms of trying to assess the personal intensities of emotional states and the extent of the personal importance of the disaster, it is likely to be more suitable to gather restricted responses through a consistent scoring method (such as a selection attracting numerical values) in order to objectify the measurements and avoid ambiguity that may be present within individual differences.

Therefore, this research employs semi-structured interview based on the questionnaire which is composed of the open-ended questions to generate the in-depth qualitative data on the one hand, and closed questions to enable objectification via quantitative data on the other.

.

5.4. Sampling

There are several conditions for the sampling of the interview.

Firstly, the interviewees are selected by random sampling. Due to the context of this research, the interview requires a sufficient number of participants possessing various conditions (age, nationality, etc.). In addition, the usual targets of journalism media such as daily newspapers (from which the visual samples were collected and explored) tend to be the general public. The subject matter which composes the three components to be investigated (the event, subject, and visualization) is not confined in a specific group or circumstance but the general public. It is this generic set who encounter information visualization and use it to understand information or datasets in their daily lives. Therefore, in a region where it is possible to observe true diversity, the participants are collected by using random sampling, and not in some artificial groups based on a control category or break characteristics (Seal,

2012: 203) but selected from a large number of the general public.

Secondly, the sampling is based on an area in which the interest in the Fukushima event is at a decent level. This is a factor in investigating the participants' fore- and background knowledge, perspectives, etc. and their influences on interpreting visualization. The subjectivity and diversity in responses are likely to be more obvious in those regions where some element of the event has been communicated(exposed) between the general public compared to those domains which are too distant from the disaster or have only remote interests. In addition, it is highly probable that the aforementioned further and extended investigations are more stark in those regions (i.e. those with some real connection to the event).

Finally, sampling from a region which has historically been weighted toward a specific political disposition is rejected. The reason for this concern (consideration) is that this research deals with the integrity of the data sources and their influences on understanding the visualization samples. There are a number of sources and some of those have political sensitivity as aforementioned. In this situation, if political disposition becomes a factor in affecting the individual reliability of and preference for the specific data sources, it is highly probable there will be biased and spoiled responses and reactions in terms of the event and visual materials in such a cultural region. This would be deemed a natural consequence of their political (and even economical) interests. Therefore, it is necessary to consider whether the region for sampling is weighted towards a specific political propensity.

In the context above, this research selected participants by random sampling in Seoul, South Korea: in particular, from several locations in and around Seoul National University. The reason for this geographical selection is because these places have the conditions which meet the diversity criteria: international students, researchers, and workers as well as people from miscellaneous regions in South Korea. According to a statistical yearbook of Seoul National University in 2016, there are 2116 foreigners hailing from over a hundred nations (Na, 2018[17]). Moreover, when hoping for future opportunities to meet the subjects' families, it is advantageous to secure the various participants from

[17] http://www.snua.or.kr/magazine/view.asp?gotopage=1&startpage=1&mgno=&searchWord=&mssq=02005000&seq=13674

those particular areas.

It is also well worth bearing in mind that South Korea is one of the countries in which that particular disaster still has been a concern of the people. According to Google Trends[18], this nation has had significant interests in the theme of “the accident in the Fukushima Daiichi Nuclear Power Plant” [19] since 11th of March, 2011 to 31st of December, 2017 [Fig.35].

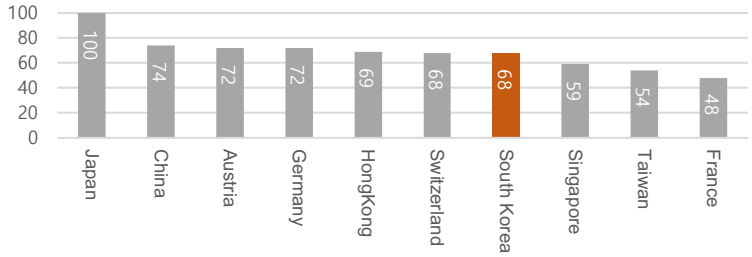


Figure 35. The ranking of interest in the theme of “the accident in the Fukushima Daiichi Nuclear Power Plant” by country (from 11th March 2011 to 2017. Data source: Google Trends).

Over the same period of time, South Korea has shown high interest in the same theme by year [Fig.36].

[18] Google Trends is a data service system produced by Google. It is a tool to analyze a percentage of web searches by using Google and Youtube to discover the amount of searches over a certain period of time and by region (country and city). It shows the popularity of the searched terms and their themes. The numerical values of the popularity are not the actual number of searches but the percentage, scale from 0-100. (https://newsinitiative.withgoogle.com/training/lesson/6507480104304640?image=trends&tool=Google%20Trends)
(Of course, popular search engines vary depending on each of the countries and web search is not the only indicator of interests across the world. Hence, it is not appropriate to regard the data set taken from Google Trends to be the absolute data to present the trends. However, Google is not a popular search engine in South Korea, and “Naver” and “Daum” are the most preferable search engines. In this regard, the statistics from Google Trends provides one clue which proves that this event has been a great interest among many people in South Korea.)

[19] The main search terms corresponding to this theme are as follows: Fukushima, 原発(Nuclear power plant), 福島(Fukushima), 原発 福島(Fukushima NPP), Fukushima nuclear, Japan, Fukushima japan, Fukushima radiation, 原発 事故(NPP accident), Fukushima news, Fukushima plant, Fukushima disaster, фукусима(Fukushima), Fukushima nuclear plant, 福島 原発 事故(Fukushima NPP accident), Chernobyl, tsunami, tsunami Fukushima, nuclear power, Fukushima power plant, Fukushima 2011, Fukushima map, japon, 福岛(Fukushima), Fukushima reactor, etc.
(https://trends.google.com/trends/explore?date=2011-03-11%202017-12-31&q=%2Fm%2F0gh8rq9)

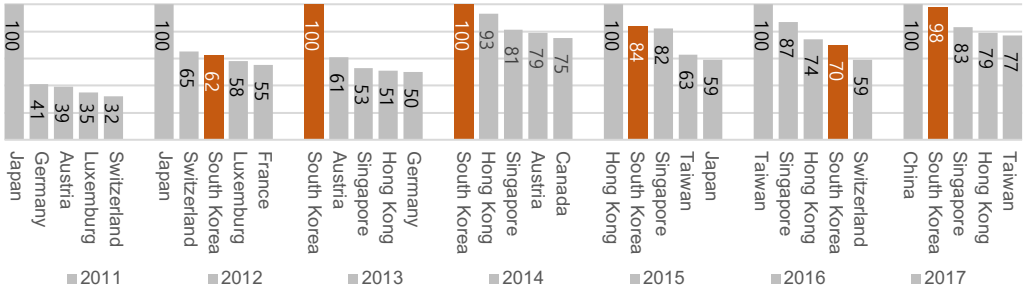


Figure 36. The ranking of interest in the theme of “the accident in the Fukushima Daiichi Nuclear Power Plant” by year and country (from 11th March 2011 to 2017. Data source: Google Trends).

In addition, Seoul, the capital of South Korea is one of the cities which has held a high ranking regarding interest in this event. Under the same conditions, the interest shown in Seoul is as below [Fig.37 and Fig.38].

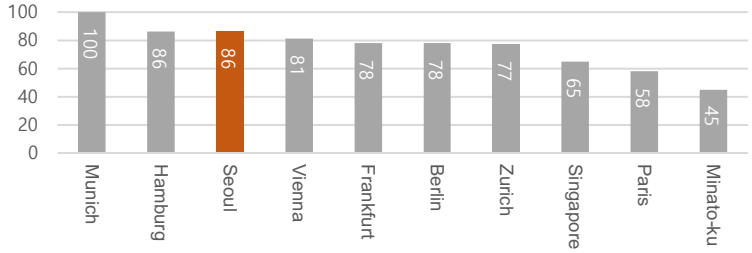


Figure 37. The ranking of interest with the theme of “the accident in the Fukushima Daiichi Nuclear Power Plant” by city (from 11th March 2011 to 2017. Data source: Google Trends).

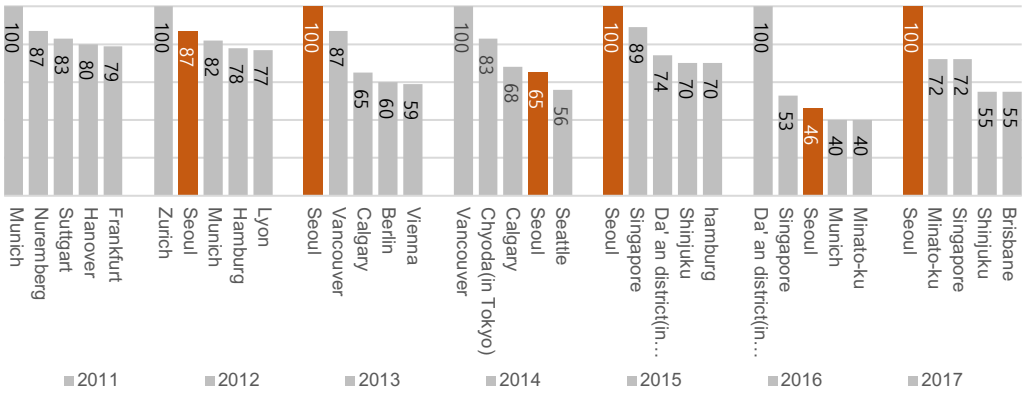


Figure 38. The ranking of interest with the theme of “the accident in the Fukushima Daiichi Nuclear Power Plant” by year and city (from 11th March 2011 to 2017. Data source: Google Trends).

Over the same period of time, the most popular topic of discussion in relation to the Fukushima disaster in South Korea has been Radiation (Radioactivity). In addition there have been other popular

issues such as Fukushima Prefecture, Nuclear Power Plant, Chernobyl Nuclear Power Plant, etc.[20]

The political atmosphere in Korea, as one of Japan's neighboring countries directly affected by this event, is not in general amicable to Japan. Having said that, it is neither totally neutral nor unconditionally critical of Japan. Rather, concerns and criticisms on the domestic issues encountered in Korea are prevalent due to the incapacity of the Korean government and perceived immoral commercial activities by Korean retailers. For instance, there are ambiguous applications of the quarantine standards by the Korean government regarding imported fishery products[21], and conflicts in front of the WTO in terms of an import prohibition of Fishery products from Fukushima, involving cases that the Korean government lost[22]. These include illegal acts such as disguising Japanese fishery products as being domestic products of Korea[23], etc.

Therefore, the conditions above should demonstrate that Seoul, Korea is a good candidate from which to take the sampling of the interview.

---

[20] https://trends.google.com/trends/explore?date=2011-03-11%202017-12-31&geo=KR&q=%2Fm%2F0gh8rq9

[21] In 2013, some aquatic products captured by Taiwanese fishing boats in the northeastern sea of Fukushima were classified as Taiwan aquatic products and imported into Korea. This is because the quarantine standards are based on the subject (country) of fishery work. Hence, many experts point out that the standard should be centered on the place of the work (Lee, 2013).
https://news.sbs.co.kr/news/endPage.do?news_id=N1002081212&plink=COPYPASTE&cooper=SBSNEWSEND

[22] Since 2011, the Korean government has banned the import of fishery products produced in Fukushima and seven other neighboring provinces and also banned agricultural products produced in thirteen neighboring provinces of Fukushima. In terms of this policy of Korea, the Japanese government filed a lawsuit against South Korea in front of the WTO and the Korean government lost this case in February 2018 (Jeon, 2018).
http://biz.chosun.com/site/data/html_dir/2018/04/09/2018040902283.html)

[23] In South Korea in 2015, there were 218 cases of deception of the origin of imported fishery products and of these, 41 cases (19%) concerned Japanese products. This is a big increase after 14% in 2013 and 13% in 2014 (Lee, 2016).
https://www.youtube.com/watch?v=2DaHWwk7mpA,
This deception has been a continuous problem since the event (Kwon, 2013; Lee, 2015; Lee, 2017).
https://www.youtube.com/watch?v=h1fzt52yrxI
http://www.mediatoday.co.kr/?mod=news&act=articleView&idxno=123869#csidx10eb43710aa6ec98e84674c6cf2a905
http://m.hankookilbo.com/News/Read/201710190412888309

6. Interview

This chapter presents the analyzed data from all participants' responses. The answers were analyzed according to various categories depending on region, age, whether or not the Fukushima event matters to them and the reasons given for this response, and perspective on the disaster. The main issues found in section 6.2 is closer to the aspect of the background of the respondents, i.e. their nationalities, ages, matters of concern, existing viewpoints on the event. These discoveries are concerned with questions [Q.1]~[Q.2] from the questionnaire. Section 6.3 describes the credibility of the sources of the data and information. This result is concerned with question [Q.3]. Section 6.4 explains the data of responses in terms of the understanding-related effects of visual materials in an aspect of visual syntax (representational method). This includes the results of comparisons of the materials divided into 7 pairs and across the entire set of visual instances without any division. These findings are related to [Q. 4]. The main topic of section 6.5 concerns the influence of visualization. This describes the impact of visualization which the participants received and to what extent their perspectives changed through interpreting visualization and understanding its information. These are the results of [Q. 5] in the questionnaire.

6.1. The sample of the interview

The number of the participants, assembled by random sampling, totaled 113 people. Since this research takes account of the respective backgrounds of the individual interviewees, it is necessary to investigate the personal circumstances and perspectives of the interviewees. Firstly, some statistics of those people by region and age group are as the table below [Table 18].

Region		20s	30s	40s	50s	Over 60	Total
Asia	Japan	3	2	2			7
	South Korea	3	2	2	1	4	12
	China	4	3	1	2		10
	Russia	2	1	2			5
	Taiwan	1	2	2	1		6
	Thailand	2		1			3
	India		2	2	2		6
	Australia	3	1				4
	Ukraine	1	2				3
Americas	USA	3	3	1	2		9
	Canada	4	2	1			7
	Paraguay		2	1			3

	Argentina	1	1	2			4
Europe	France	1	2	3	1	1	8
	Germany	2	2	4			8
	UK	1	2	1	1		5
	Netherlands	2					2
	Finland	3	1				4
Africa	Egypt	3		1			4
	Ghana		2	1			3
Total		39	32	27	10	5	113

Table 18. Some statistics of the sample

In terms of the age group analyzed, the single largest group of respondents were from their 20s and 30s: 39 and 32 people respectively, while there were limited number of participants from other age groups, 15 in total from the group of 50s and over 60s (ten and five persons from these groups respectively). In terms of the region (country), the majority of the participants are from South Korea (12 interviewees), China (10) and Japan (7) complete this set. On the other hand, smaller numbers heralded from countries such as Thailand (3), Ukraine (3), Paraguay (3), Netherlands (2), and Ghana (3). It would not be reasonable to suggest that such small groups are fully representative of the general tendency of their countries. Nevertheless, the answers provided from these groups are valuable to observe the general patterns of responses.

6.2. The backgrounds of the participants

This chapter presents the results according to the sequence of the questions of the questionnaire, although sometimes the responses to several questions will be presented together. For example, it is more desirable to present the results data with regard to the level of understanding, amount of information, and emotional aspects of the visualization samples together rather than separately. This allows for consideration of the overall relevance of the three categories. Therefore, the results data will be presented based on the following categories:

a) The direct or indirect influence of the disaster,

b) Whether the event matters now or not and the reasons thereof,

c) The perspectives on the event (before showing the visual materials),

d) Integrated presentation of the results as to the level of understanding, amount of information,

and emotional stimulation of the visualization samples,

e) The level of influence on perspective toward the event by understanding information through the visualization samples, and

f) The movement patterns of the perspectives on the disaster.

In addition, the results above will be combined to reflect the diverse backgrounds and contexts of the participants. This can be briefly explained in the table below [Table 19].

The category of the results data	Consideration (variables)
a) The direct or indirect influence of the disaster	depending on regions and age group
b) Whether the event matters now or not and the reasons,	depending on regions, age group, and category a)
c) The perspectives on the event (before showing the visual materials),	depending on regions, age group, as well as category a) and b)
d) Integrated presentation of the results of the level of understanding, amount of information, and emotional stimulation of the visualization samples,	depending on regions, age group, and category a), b) and c)
e) The level of influence on the perspective toward the event by understanding information through the visualization samples	depending on regions, age group, and category a), b), c) and d)
f) The movement patterns of the perspectives on the disaster	depending on regions, age group, and category a), b), c) and d)

Table 19. The results to be presented and the variables contained therein

6.2.1. Direct or indirect influence of the Fukushima disaster

Q.2.1 of the questionnaire asks whether the participants were directly or indirectly affected by the Fukushima disaster. Five respondents answered yes to this question. None of them were directly affected by the disaster and the majority of them answered that they were influenced through indirect experiences via the situations faced by their family or acquaintances. The nationalities of the respondents in this category are presented as below [Fig.39] and [Table 20].

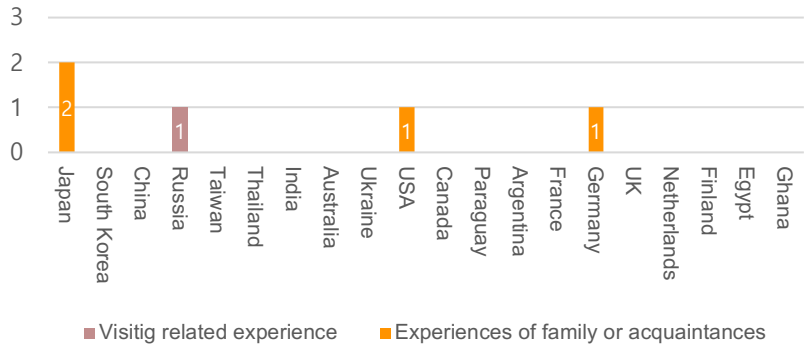


Figure 39. The statistics of the respondents of Q.2.1 by nationality

Region		20s	30s	40s	50s	Over 60	Total
Asia	Japan	1	1				2
	Russia	1					1
Americas	USA		1				1
Europe	Germany			1			1
Total		2	2	1	0	0	5

Table 20. The age group and nationality of the respondents

One Japanese respondent in her 20s said that her relative lived in a place very close to Fukushima Prefecture at the time of the tsunami and the family had to evacuate their home due to this incident. Another Japanese participant in his late 30s answered that he feels he has been affected by this event because of a friend who has been engaged in the distribution industry. His friend had often told that the distribution of agricultural products from Fukushima rapidly decreased in the immediate aftermath of the disaster, and the lives of the farmers near Fukushima suddenly became difficult due to this event. He recalled that the friend's frequent explanation made him feel quite agitated and worried, and that this disaster was still causing great difficulties for those in the Fukushima Prefecture.

A Russian respondent in her 20s said that the Great East Japan Earthquake happened just three days after she returned from Tokyo. She said that while this event did not directly affect her, she was still afraid of what would have happened had her own visit to Japan was just a week earlier.

One US respondent in his 30s replied that his younger brother, who was deployed in the US Navy, was staying on a ship anchored in the East Sea of Japan to support the disaster relief at that time. He responded that there was no specific operation directly involving his brother, and no other serious disaster during his deployment, but he still vividly remembered that he and his family were very worried about his brother during that period.

Similarly, a German respondent told that his relative had been staying in Japan and still remembered the anxiety of that time.

6.2.2. Whether the Fukushima event still matters or not and the reasons why this is the case

Question 2.2 asks if the case is still a matter of concern and the reasons for these views. Fifty-five participants answered yes to this question, while 58 respondents replied no. There are various reasons

for these two opposite responses and those can be categorized based on their similarities. The [Fig.40] below briefly summarizes the categories of the reasons provided.

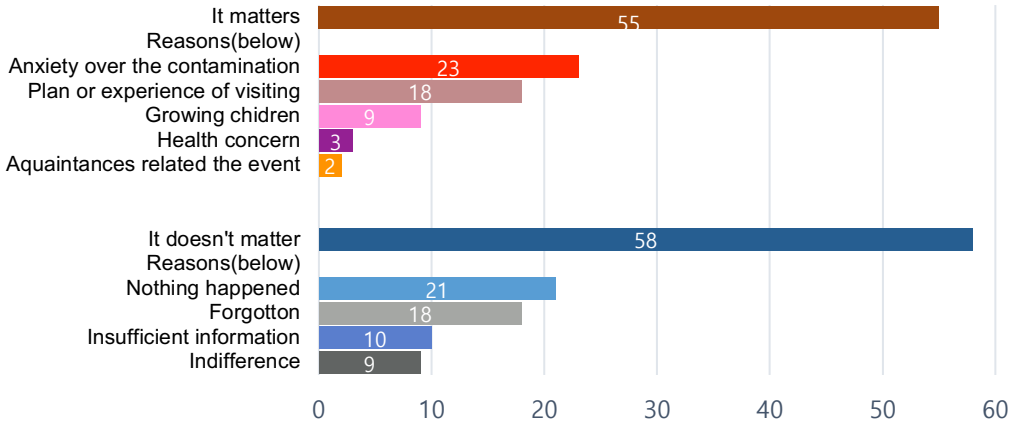


Figure 40. The statistics of the matter of concerns and the reasons behind the responses

In those responses where the interviewee suggested that the event is still a matter of concern, the single most common reason given was in relation to the radiation contamination. Many respondents in this category were concerned about the spread of radioactive materials and that there was already contamination of the neighboring land and sea. In addition, others answered that it still mattered because of general uncertainty surrounding contamination. One interviewee also replied that he never saw specific or formal information or data as to whether the environment was still contaminated or not.

The second most frequent reason given was related to past experiences or plans to visit Japan. In particular, in recalling the upcoming travel to Japan, one of the participants answered that she agonized over whether to eat the local seafood or not due to the conflicting opinions she faced. On one hand where the Japanese citizens who regarded many foods produced in Japan to be contaminated, against those who asserted that Japanese foods were safe. In addition, there were other respondents who regarded this event as a matter of concern because of their future plans to visit Japan. They recalled that they had various reasons for visiting Japan, i.e. on holiday, business trip, study, volunteer work for Tokyo Olympics in 2020, etc., and hence they wanted to have information as to the current state of the radioactive pollution, and which if any regions were safe from the contamination.

One further matter of concern was for children. One Japanese respondent in her 30s told that she saw the news reporting that even after a long time following the Chernobyl disaster, radioactive material had been detected in milk and meat produced as far away as the Swiss Alps, leaving her reluctant to give seafood to her children.

Fourthly, some participants' reasons surrounded their own health concerns. Many of them were keen to maintain their healthy lives and lifestyles. To expand on this, one participant commented that her current health condition was not good and guessed that it was a direct symptom stemming from this event.

Finally, there were responses suggesting that this event still mattered because of the ongoing struggles faced by their acquaintances who were involved in the Fukushima disaster. These particular respondents were the two Japanese interviewees who explained their acquaintances' experiences regarding the influence of this event.

With respect to the detailed reasons for the opinion that the Fukushima disaster no longer matters, the most response was that nothing happened. Some of Korean interviewees told that whlie it was true that they were sometimes exposed to news of this event, nobody in their immediate vicinity was directly influenced by the disaster, and they themselves could not feel any symptoms caused by this event either. In addition, there were some participants who answered that they had encountered no health problems even though they had taken part in marine sports on, or eaten sea foods from, the Pacific Ocean since the explosion of the Fukushima nuclear power plant.

The second largest set of responses in this category that the disaster no longer mattered pointed to the reasoning that this event has been largely forgotten. One participant commented that she did not care about Fukushima as much as during the immediate aftermath of the event even though she was still curious about the situation when taking in the intermittent news articles reporting on it. Another interviewee explained that he felt that the impact of other large events after the Fukushima disaster had blunted its edge.

The third largest reason given spoke to insufficient information given of the event. The majority of those replied that they did not have enough opportunities to comprehend the detailed status of the event and hence they did not take it seriously. In addition, one participant who had stayed in Ghana until 2016 responded that the information available through the news had been repetitive and limited, especially as to the radiation leak into the Pacific Ocean. Similarly, this repetition seemed to take the edge off the true gravity of the event.

The least common category observed was participant indifference. One interviewee told that she

knew this accident was one of the largest catastrophes in the world, but nevertheless she had been indifferent to this event. Another interviewee from Ukraine answered that he had felt the Chernobyl event was more serious than the Fukushima one, and that as a result he was more likely to be interested in other disasters that were deemed to be more serious than the Chernobyl one. Finally, two participants were indifferent to the event without giving any further detail.

6.2.2.1. The distribution of the reasons by country

[Fig.41] below shows the statistics of the responses to question 2.2 according to nationality of the respondent. The reddish bars at the top present the distribution of the various reasons for the answer that the event still matters, and the bluish bars at the bottom represent the statistics of the reasons for the reply that it does not matter.

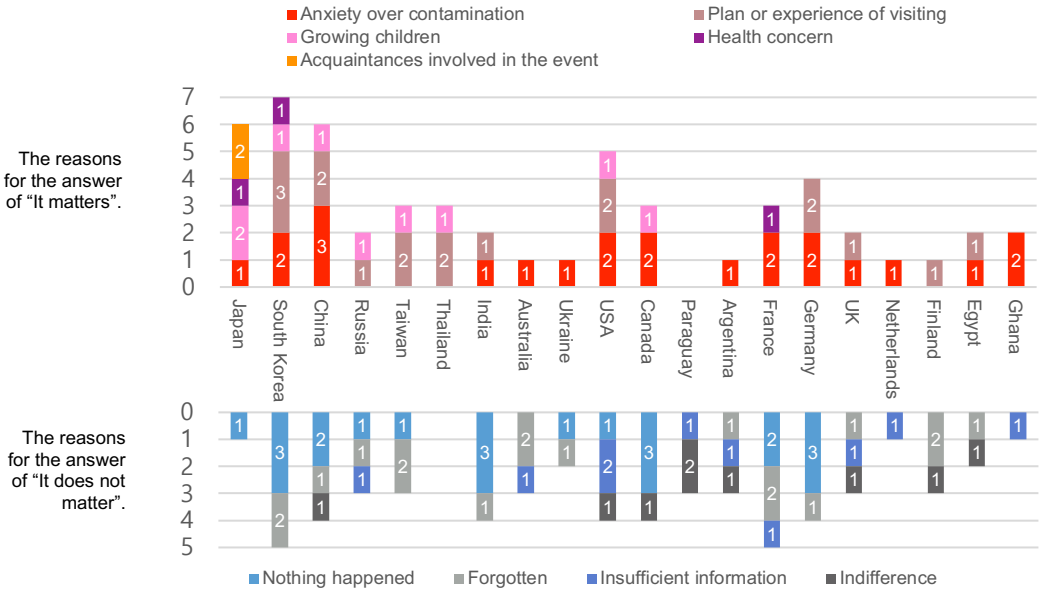


Figure 41. The distribution of the reasons by country

The proportion of the answer of "It matters" is overwhelmingly greater than that for the reply of "It doesn't matter" in Japan. This trend is also true for those respondents from South Korea and China, although the gap here is not as extreme as that found for those respondents from Japan. In addition, in terms of the reasons for giving the answer, "It matters", the countries closest to Japan provided a greater range of reasons including "Heath concerns", "Anxiety over contamination", "Plan or experience

of visiting", "Raising children" and "Acquaintances involved in the event". On the contrary, the number of the reasons for "It matters" decreases according to how far away the country of the respondent was in relation to Japan. The main reason given where one was provided was oriented toward "Anxiety over contamination".

In contrast to the findings for the answer, "It matters", the proportion of those who said "It doesn't matter" increases in more distant nations. In terms of the reasons given for this response, "Nothing happened" and "Forgotten" are the most common ones observed. On the other hand, certain reasons such as "Insufficient information" and "Indifferent" appear from nations more geographically distant from Japan.

6.2.2.2. The statistics by age group

The statistics of the reasons by age can be presented as per [Fig.42] below. The bluish bars on the left indicate the reasons for the opinion, "It does not matter" and the reddish bars on the right shows the reasons for the answer behind "It matters".

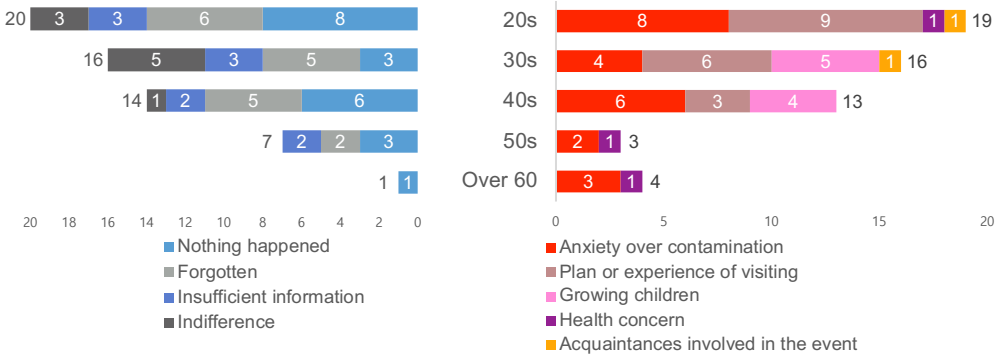


Figure 42. The distribution of the reasons by age

In the group saying "It matters", the participants whose reason given is "Plan or experience of visiting" are mainly distributed across their 20s and 30s. It seems that younger age groups have been planning more trips to Japan during their stay in Korea. In addition, the ages of the respondents citing "Raising children" are mainly found in the group of 30s and 40s. Where the reason given was "Health concern", the respondents were chiefly in their 50s and 60s.

Amongst the participants who answered "It does not matter", the most common reasons given across all age groups were "Nothing happened" and "Forgotten". These respondents are evenly spread across not only the age groups, but also evenly across nationalities as aforementioned. By contrast, the reason

“Indifference” can be mainly found in younger age groups such as 20s, 30s, and 40s.

The reasons generally distributed according to age and regional groups are “Anxiety over contamination” where the initial response was “It matters”, and “Nothing happened” in the case of “It does not matter” being given. It is safe to assume then that these two reasons seem to be the most common reactions with regard to the Fukushima disaster.

6.2.3. Perspectives on the Fukushima event

Q.2.3 asks as to the participants’ perspectives on the Fukushima disaster. In particular, even the interviewees who answered that the event does not matter were asked to select which point of view they had. [Fig.43] below displays the overall numbers of the perspectives selected by the participants.

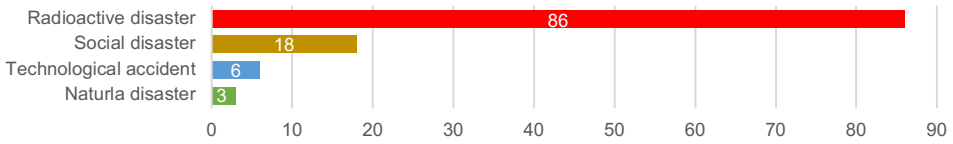


Figure 43. the overall statistics of perspectives on the Fukushima disaster

The majority of the respondents (86), chose radioactive disaster to be their perspective. This number is four times more than the number of people in the next largest perspective category of social disaster, totaling 18 respondents.

6.2.3.1. The perspectives by country

With respect to the tendency by region, the perspective of radioactive disaster is the most predominant found in most countries [Fig.44].

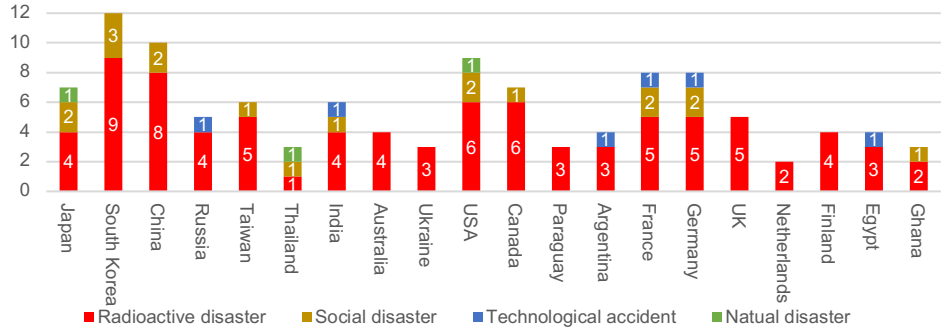


Figure 44. The statistics of the perspectives by country

The perspective of social disaster can be found in various countries in Asia, the Americas, Europe and Africa. In particular, this perspective is selected mainly from those countries closest to the area of the accident. We can observe this response for 18 respondents from 11 nations, made up of 10 people in 6 Asian countries and 8 participants in 5 non-Asian nations who answered this point of view. In addition, the number of the respondents giving this response just from Japan, South Korea, and China totals 7, which is almost the same as the total figure for all non-Asian countries.

On the other hand, the more distant from Japan the respondent is from, so the more answers relating to the technological accident appeared. In particular, the respondents from Russia, Egypt and Germany considered that it was technologically wrong to build a nuclear power plant on the coast in the first place.

The perspective of natural disaster can found be in responses from 3 nations. One Japanese participant said the destruction caused by the tsunami that preceded the explosion of the nuclear power plant was more intense and frightening. One respondent in Thailand said that the Fukushima incident reminded him of the 2005 Phuket Tsunami in Thailand, which caused many casualties and devastated the region. Although the number of such responses is very small, it shows that personal direct or indirect experience has a significant impact on the perspective on the event.

6.2.3.2. The perspectives by age

The perspective of radioactive disaster is the most dominant one which penetrates not only all the regions but also every age group [Fig.45].

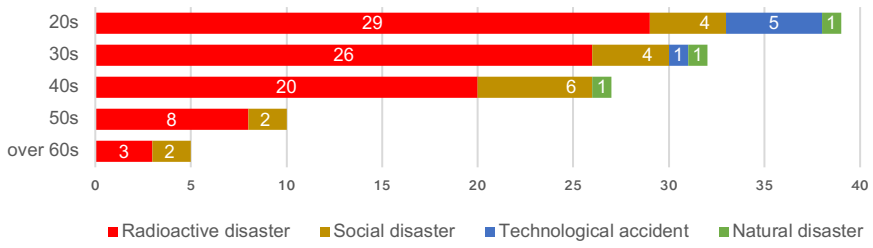


Figure 45. The statistics of the perspectives by age

The proportion of the social disaster is relatively small when compared to the radioactive disaster, but it also can be found in every age group. In addition, the perspective of the social disaster is quite

notable since the respondents from various regions which are close to and remote from Japan coexist in each of the age groups [Table. 21].

Age group	The countries of the respondents whose perspective is social disaster (the number of the answerer)					
20s	Japan(1)	South Korea(1)	Thailand(1)	Canada(1)		
30s	Japan(1)	China(1)	USA(1)	Germany(1)		
40s	South Korea(1)	China(1)	Taiwan(1)	France(1)	Germany(1)	Ghana(1)
50s	India(1)	USA(1)				
Over 60	South Korea(1)	France(1)				

Table 21. The age groups and nationalities of the participants who selected the perspective of social disaster

On the other hand, the answers of technological accident and natural disaster can be found predominantly in young people in their 20s, 30s, and 40s.

6.2.3.3. The perspectives depending on whether or not the Fukushima event matters

In the case of participants whose perspective is radioactive disaster, 44 people answered that the event still matters and 42 replied it does not matter [Fig.46].

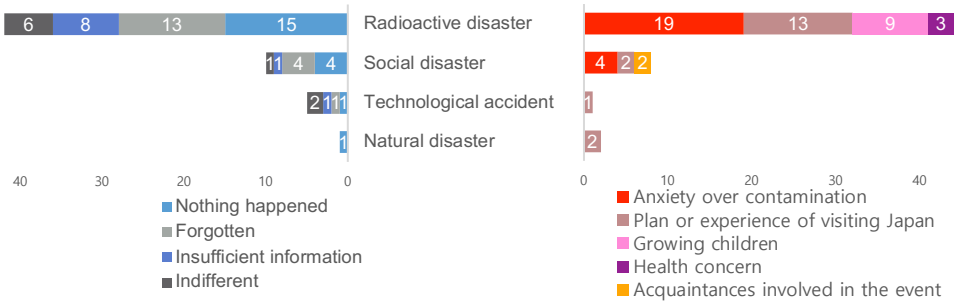


Figure 46. The statistics of the perspectives of whether or not the disaster matters

In particular, the former group (It matters) includes all the participants whose reasons were “Raising children” and “Health concern”. In terms of the latter group (It does not matter), a notable point is that the majority of the “Nothing happened” group which includes those who think there is no influence of radiation, do nevertheless recognize this incident to be a radioactive catastrophe.

Not all the respondents who demonstrate anxiety in relation to contamination were regarding this disaster as a radioactive disaster. There are four participants who feel the contamination anxiety but express the perspective of the social disaster. In addition, this point of view (social disaster) includes the two Japanese interviewees who have acquaintances involved in this disaster.

In case of the perspective of technological accident, there are 5 participants who answered “It does not matter”. As aforementioned, there were 3 respondents who focused on the technological aspect of the accident due the power plant’s perceived inappropriate location. In particular, 2 such respondents were from each of Germany and Egypt among the 5 in total who gave these responses.

6.3. The reliability of the sources of data and information

Q.3 is a question which goes to the credibility of the sources of data and information of the visualization cases. The overall statistics of the reliability can be represented in [Fig.47]. The numbers on the bars are the average scores marked by the respondents, which were rounded off to the nearest hundredths.

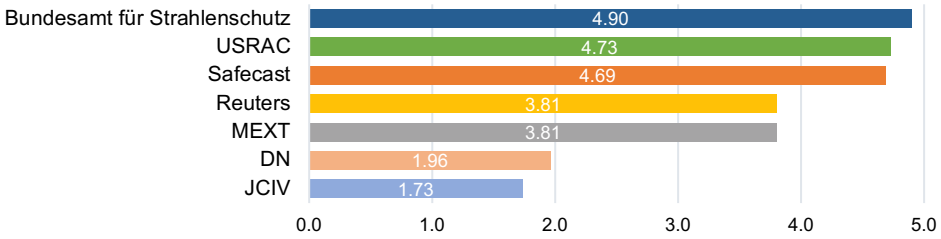


Figure 47. The overall statistics of the reliability of the data (information) source

Bundesamt für Strahlenschutz, the Federal Office for Radiation Protection of Germany elicits the highest reliability rating. The second largest reliability score is from USRAC, the Universities Space Research Association in Columbia, USA. Safecast, a NGO for monitoring the radiation contamination is in third place with a score slightly lower than USRAC. MEXT, the Ministry of Education, Culture, Sports, Science and Technology of Japan is in fourth place with a score equal to that given to Reuters.

6.3.1.1. The credibility rating by country

The tendencies of the reliabilities of the sources by country are shown below [Fig.48]. The chart is also based on the scores given by the participants.

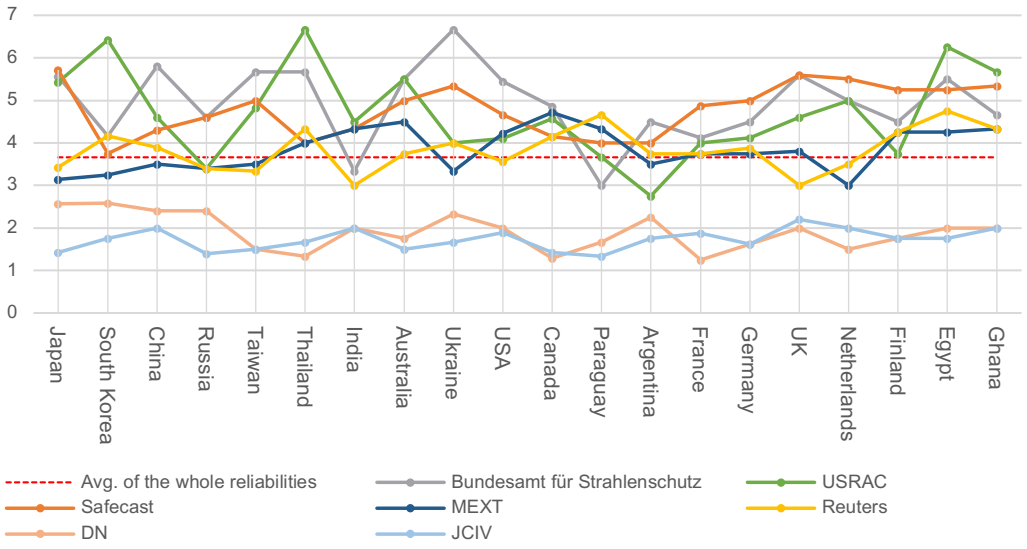


Figure 48. The tendencies of the reliability by country

The highest ranking group with a data reliability over 3.66 (the average score of the whole reliabilities) is afforded to the German government organization and US institutions.

24 people who gave high scores to the government institution of Germany explained that they gave more credence to sources from countries which did not have political interests with Japan today. Those 24 respondents were spread cross a broad range of countries: Japan (3), South Korea (5), China (5), Taiwan (3), Ukraine (2), USA (4), Britain (2), Egypt (1) and Ghana (1)[24].

Nine others gave high scores to the USRAC, explaining that this source is more reliable due to it being a research institution. The respondents in this group are also from diverse nations: South Korea (2), Thailand (2), India (1), Netherlands (1) and Egypt (1).

The scores given to Bundesamt für Strahlenschutz and USRAC are high in their averages but also have high deviations according to country source. With regard to the Bundesamt für Strahlenschutz, the gap between the highest score, 6.67 from Ukraine, and the lowest score, 3.00 from Paraguay is stark at over 3 points difference. The divergence in scores given to USRAC is similar: there is about a four-point gap between the highest score, 6.67 from Thailand and the lowest score, 2.75 from Argentina.

On the other hand, the deviation of the reliability of the Safecast data is lower than those of the two institutions which have obviously stated the nationality of origin. Given that the highest score here is

[24] Some of the respondents commented on the specific political interests: 11 participants from Japan (2) South Korea (3), China (2), USA (3) and Ghana (1) said that Japanese and American governments had maintained a politically friendly relationship to counter the expansion of China's power in Asia.

5.71 from Japan and the lowest score is 3.75 from South Korea, only 1.96 is the gap between those outlying ratings. In addition, the 17 participants who gave high scores to Safecast explained that they did not have much information surrounding that sources but thought that it is more credible compared to others since it is an international NGO. The 17 respondents' nationalities in this group are also diverse: Japan (1), Taiwan (1), USA (2), Canada (3), Argentina (1), France (2), Germany (4), Britain (1), Finland (1) and Ghana (1).

In terms of MEXT, a Japanese governmental organization, its scored reliability is lower than that of Safecast. [Fig.49] below shows the credibility of the two organizations, with the context that the MEXT and Safecast attributes are quite different.

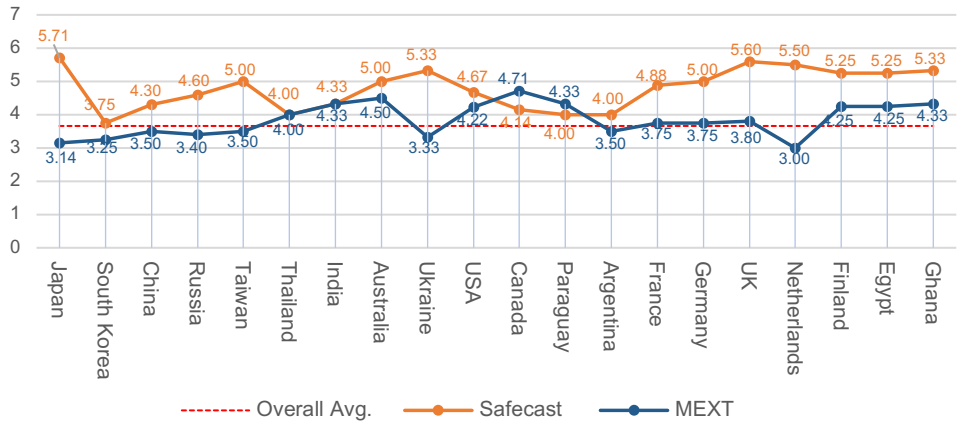


Figure 49. The tendency of the reliability rating of Safecast and MEXT by country

A notable point here is in the credibility difference between the two organizations among Japanese participants. The gap amongst this group is the largest among all countries: the reliability of MEXT, their own national organization belongs to the lowest-ranking group, while that of an international NGO is the highest compared to other nations.

In two countries, Canada and Paraguay, the reliability of MEXT is higher than that of Safecast. However, the rest of the countries give a higher credibility to Safest and in particular, the reliability of Safecast is over one point higher than that of MEXT in 11 diverse nations including Japan, Russia, Taiwan, Ukraine, France, Germany, UK, Netherlands, Finland, Egypt, and Ghana.

Another notable point is that there were 14 participants who regarded the data released by MEXT as less reliable than others due to the political tendency of the Japanese government, even though they are not expressly familiar with Japan's state secrecy law. However, there are also 67 participants from

various nations who gave a high reliability score of over four points to MEXT. Many of them believed that MEXT could collect and release more sufficient and accurate data and information since it is an organization of a country where the disaster itself occurred.

6.3.1.2. The credibility ratings by age

The tendency of the reliability ratings by age can be demonstrated below [Fig.50].

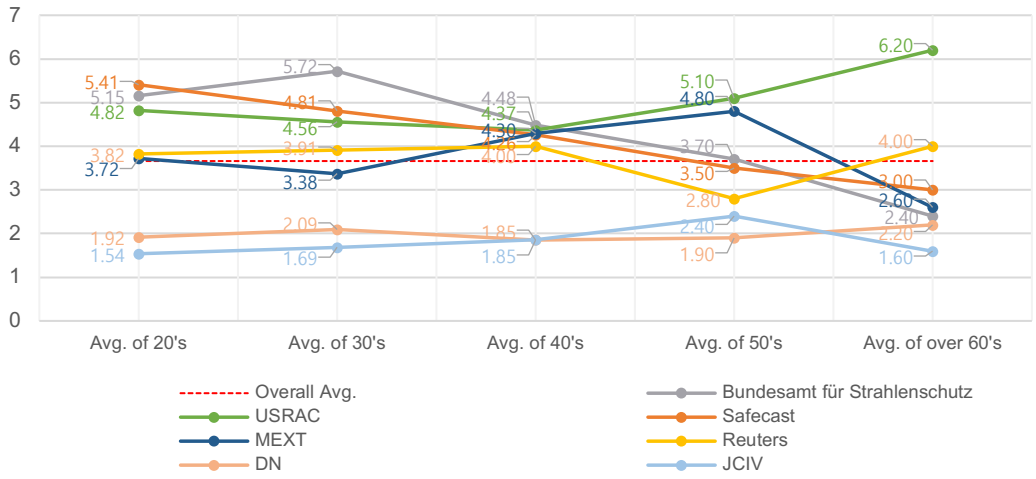


Figure 50. The reliability ratings of the data (information) sources by age

In the cases of Bundesamt für Strahlenschutz and Safecast, the lower age groups have given the higher credibility ratings. On the other hand, USRAC demonstrates a higher reliability rating among the higher age groups. The reliability rating of MEXT grows as the age increases until the 50s group, but then drops to the lowest rating amongst those in their 60s.

6.3.1.3. The credibility rating depending on whether or not the Fukushima event matters and their reasons

[Fig.51] shows the different credibility rating between the group of “It matters” and the opposite group stating “It does not matter”.

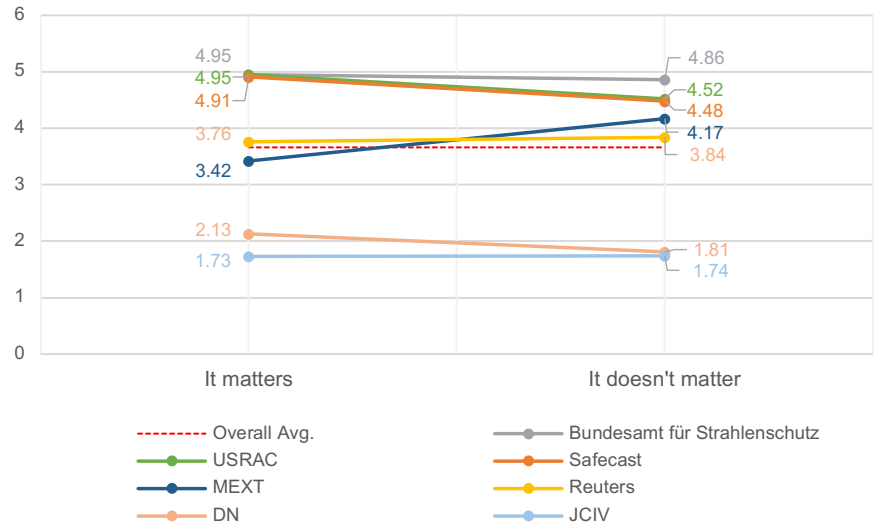


Figure 51. The reliability rating depending on whether or not the event matters to the respondent.

In the “It matters” group, the sources including Bundesamt für Strahlenschutz, USRAC, and Safecast are thought to be more credible than others. In particular, the reliability rating of MEXT is about 1.50 points lower than the three top-ranking sources.

On the other hand, the credibility rating of MEXT increases in the group of “It does not matter”: it is higher than the reliability rating given to Reuters and the gap between MEXT and the high rank group including Bundesamt für Strahlenschutz, USRAC, and Safecast also decreases.

In addition, the statistics of the credibility rating depending on the reasons for “It matters” or “It does not matter” can be represented in [Fig.52] below.

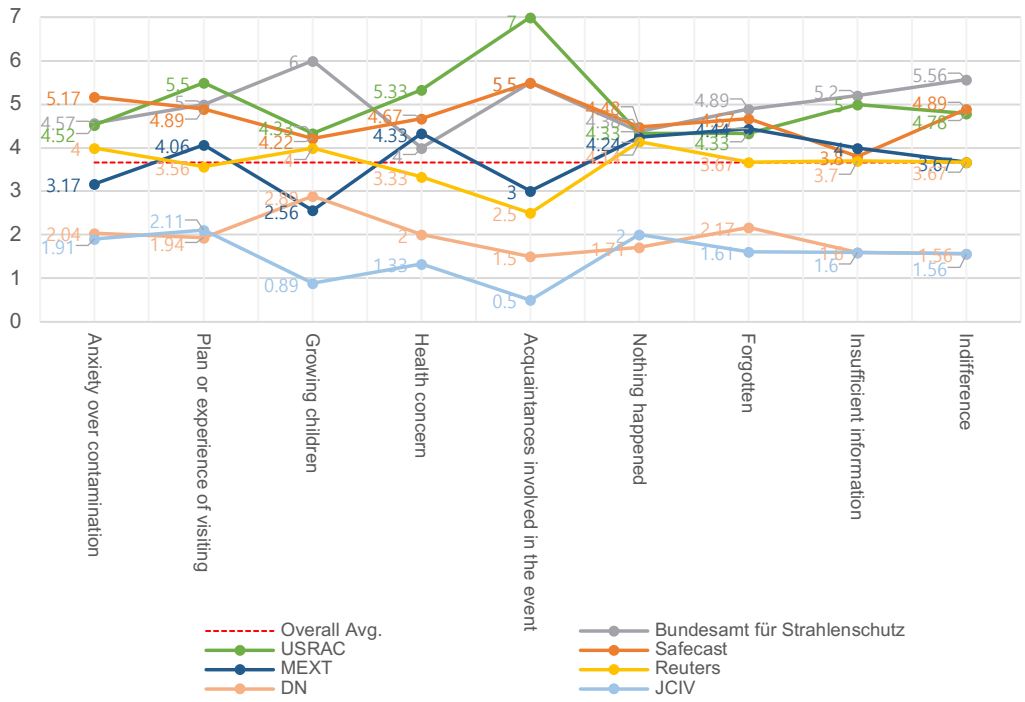


Figure 52. The reliability rating according to the reasons for whether or not the disaster matters to the respondents

For those who gave their reasons as “Anxiety of contamination”, “Raising children”, and “Acquaintances involved in the event”, there are evidently large gaps between the scores given to MEXT and others in higher ranks such as Bundesamt für Strahlenschutz, USRAC, and Safecast.

On the other hand, despite being included in the group of “It matters”, the gaps between the reliability ratings of those sources above decreases where the reasons for those responses include “Health concern” and “Plan or experience of visiting to Japan” groups whose participants are from diverse nations. Additionally, MEXT's reliability rating surpasses that of Safecast in the "Insufficient Information" group.

6.3.1.4. The credibility rating by the perspective on the Fukushima disaster

[Fig.53] displays the scores of the reliability ratings depending on the perspectives on the event.

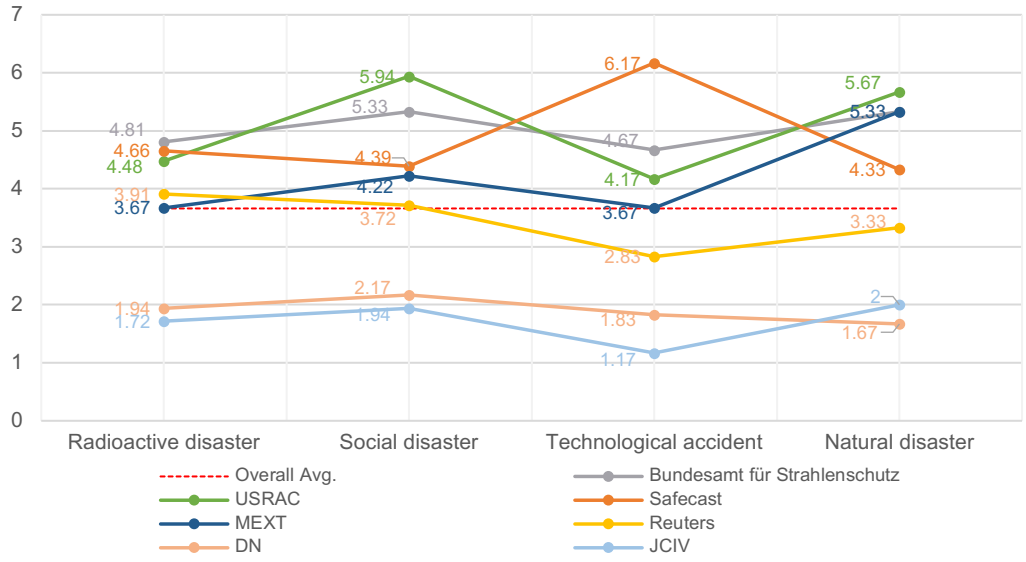


Figure 53. The credibility ratings depending on the perspective on the Fukushima event

For three perspectives including “Radioactive disaster”, “Social disaster” and “Technological accident”, the reliability ratings of Bundesamt für Strahlenschutz, USRAC, and Safecast are higher than others. On the other hand, the credibility rating of MEXT is higher than Safecast and equal to that given to Bundesamt für Strahlenschutz for those in the group of the natural disaster perspective.

To sum up, the credibility of the data or information source differs depending on the various backgrounds of the participants including nationality, age, political interest, background knowledge of the event, etc. In addition, in light of such diversity within the respondents, there are several patterns observed: people generally have a higher reliability on the data (information) sources that are distant from the political interests of the Japanese government; there is a high credibility given to those sources whose characteristics are of a research institution; and finally that formal and large-scale organizations such as governmental organizations or research institutions of universities or international NGOs generally are afforded a high reliability rating.

However, MEXT, a Japanese governmental organization, also has a high reliability rating among a) the majority of participants (67), b) the countries distant from Japan such as from most nations in the Americas and Europe, c) the age groups including 40s and 50s, d) the respondents who answered that the Fukushima event does not matter to them, and e) the participants who regard this disaster as a natural disaster.

Nevertheless, the low reliability rating given to MEXT among the respondents who are critical of the

political tendencies of the Japanese government, or amongst those who are more familiar with Japan's state secrecy laws, suggests that credibility of the source of data or information can have influence on the process and attitude behind information acceptance.

In addition, there are 143 visual samples on which the sources are indicated from 235 collected instances. This large number also shows the necessity of considering the credibility of the sources of data and information.

6.4. The effectiveness of understanding of the visual materials

In this section, the results of the comparisons of understanding-related effects[25] are presented: i.e. (1) the degrees of understanding; (2) the amount of information received; and (3) the emotional impact of the visual materials which were divided into 7 pairs.

Prior to the presentation of the data of the responses, one point to explain in advance is with regard to the categories of regional conditions of the participants. In particular, this research explored not only the tendencies by country but also considered more macroscopic regional patterns.

The first categorization of groups of countries distinguished from where the visual instances were gathered and the contrasting group of countries was made up those nations that were excluded from this list. The reasoning for making the categorizations in this was is that the disaster relevance within the countries of collected samples, as aforementioned, has been more formally proven by IAEA and CTBTO. Another reason is that it is uncertain how the disaster has been represented by visualization in the nations from which no samples were gathered. If these conditions cause differences in the interpretation of the visualization samples between the two groups, it is probable that they lead to different effects of understanding of the collected visualization samples. The countries are divided as follows [Table 22].

[25] When it is necessary to refer to the three items which include: (1) the level of understanding, (2) the amount of information people received, and (3) the degree of emotional stimulation at the same time, they will be replaced by the words, "understanding-related effects".

The countries of origin of the collected samples	The countries from which there were no collected samples
Japan South Korea China Russia Australia Ukraine USA Canada France Germany UK Finland	Taiwan Thailand India Paraguay Argentine Netherland Egypt Ghana

Table 22. Division of the countries depending on whether the visual samples were collected from those countries or not

The second category distinguishes countries by continent. The reason for this division is to discover patterns which appear among geographically and culturally adjacent nations. The countries can be categorized below [Table 23].

Asia	Americas	Europe	Africa
Japan South Korea China Russia Taiwan Thailand India Australia Ukraine	USA Canada Paraguay Argentina	France Germany UK Netherlands Finland	Egypt Ghana

Table 23. Categories of the countries by continent

Finally, the countries are categorized by their geographical circumstances according to the following criteria: which ocean is adjoining that country; whether a nation belongs to an inland area, etc. The reason for selecting these categories is that the sea is closely aligned with this event: the Fukushima nuclear power plant is adjacent to the Pacific Ocean in and from which the radioactive contamination spreads. This geographical situation can have different influences on the countries which have diverse geographical surroundings. The nations can be divided as [Table 24] below.

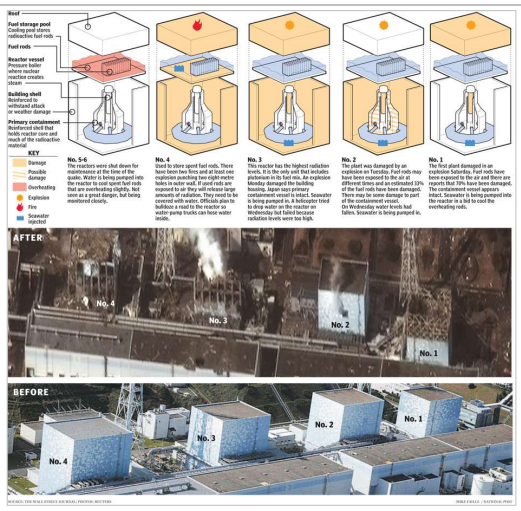
The Pacific Ocean	The Indian Ocean	The Atlantic Ocean	Other Oceans (the Mediterranean, Red, and Black Seas)	Inland (No Oceans around)
Japan South Korea China Russia Taiwan Australia USA Canada	Thailand India	France Germany UK Netherland Finland Ghana Argentine	Egypt Ukraine	Paraguay

Table 24. The division of the countries according to their geographical surroundings

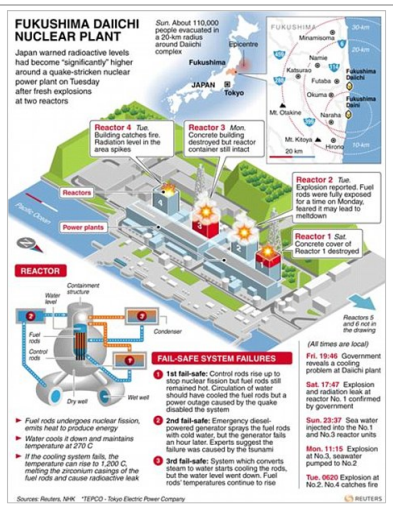
From the next section, the analyzed data of the understanding-related effects by the regional category above are described in relation to the country of origin.

6.4.1. The understanding-related effects of V.1 and V.2

The figures of V.1 and V.2 are shown again in [Table 25] below.



V.1. Explaining Japan's Nuclear Reactor Disaster



V.2. Fukushima Daiichi Nuclear Plant

Table 25. V.1 (Explaining Japan's Nuclear Reactor Disaster) and V.2 (Fukushima Daiichi Nuclear Plant)

The examples above represent some of the visual samples whose major issue is the conditions of the reactors in the Fukushima nuclear power plant. The analysis of those visualizations can be presented below [Table 26].

No.	Issues	Detailed field	Purpose (Variables)	Representational key (A: Arbitrary / N: Non-arbitrary)	Types of Vis. (M: Map / C: Chart / T: Technical drawing / P:Photograph)	Metaphor and Metonymy (Mp: Metaphor / Mn: Metonymy)
V.1	Reactor conditions	After the explosion	Representing the shapes, structures, and conditions of the reactors	N(Shape)	T(Cross section)	Mn(Extracted detail)
		Before and after the explosion	Comparison of the reactors before and after the explosion	N(Shape)	P(Top view)	Mn(Extracted detail)
V.2	Reactor conditions	After the explosion	Representing the conditions of the reactors	N(Shape)	T(Plan)	Mn(Extracted detail)
		General structure	Representing the shape and structure of the reactors	N(Shape)	T(Cross section)	Mn(Extracted detail)
	Exclusion and evacuation zone	Before expansion	Indicating the domains and locations of the exclusion and evacuation zones	N(Shape)	M(Japan+Fukushima)	Mn(Extracted detail)

Table 26. The analysis of V.1 and V.2

Despite their being several shared themes across both of the visual materials, there are nevertheless differences in the amount of information and data shown, and in the representational methods between the two samples. For example, V.2 deals with greater detail of information including not only the reactors' conditions but also the location of the event and exclusion zone, shown on the maps. Another difference in expressional means is in their types: V.1 employees photograph and V.2 uses plan, the latter being a kind of technical drawing to exhibit the scene of the exploded reactors.

6.4.1.1. The understanding-related effects of V.1 and V.2 by region

Prior to presenting statistics of the data by country, the average of the data of the entire set of participants are shown as follows [Fig.54].

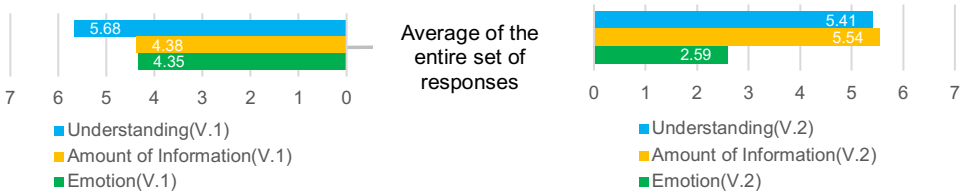


Figure 54. The average values of the whole set of responses regarding understanding-related effects of V.1 and V.2

Of note in the overall statistics above, the amount of the accepted information from V.1 is less than that of V.2, while both the level of understanding and the degree of emotional stimulation of V.1 is higher than those of V.2.

The average of the numeric data of the effects by country can be represented as below [Fig.55]. The bars on the left indicate the data of V.1 and the figures on the right depict those of V.2.

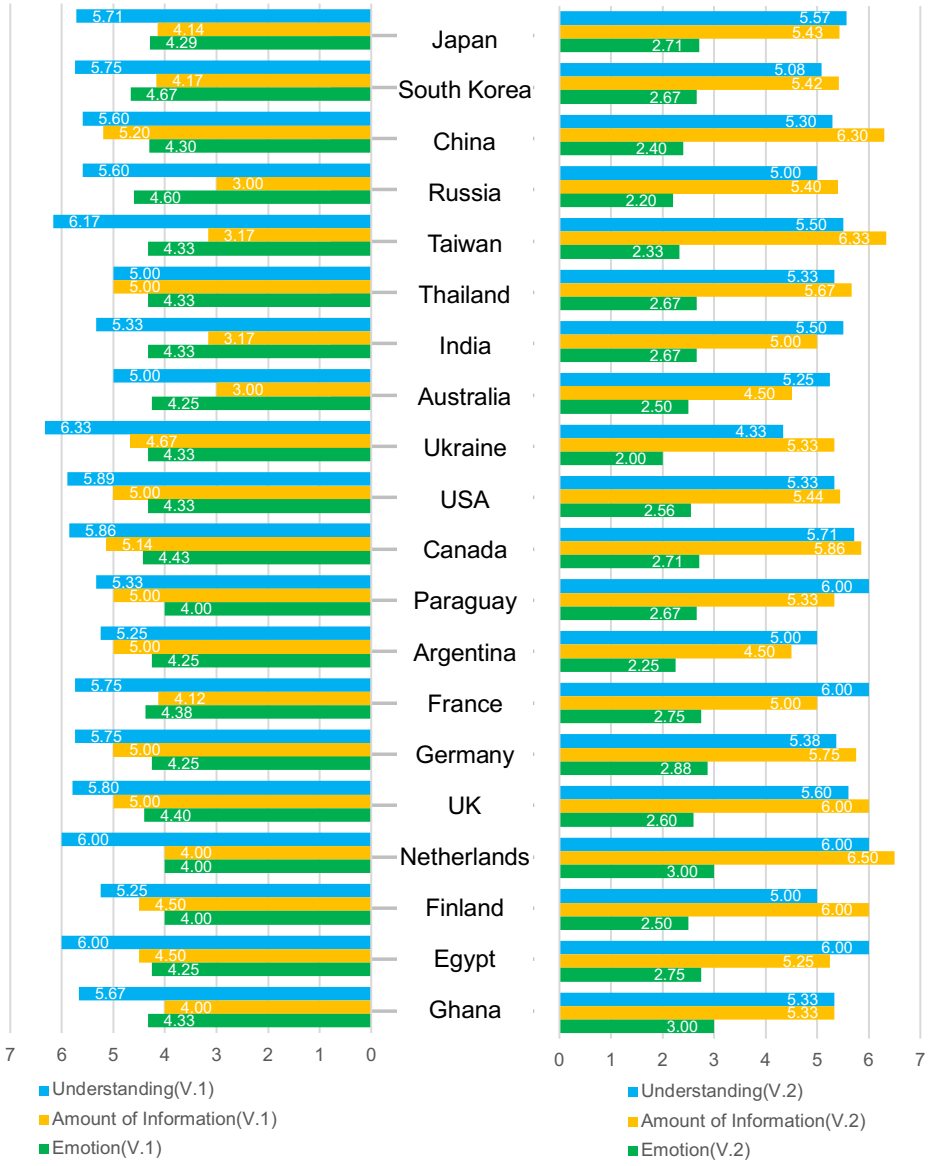


Figure 55. The average values of understanding-related effects of V.1 and V.2 by country

The tendency of the responses of most of the nations, which are observed from [Fig.55], is that: a) the levels of understanding of the two visual instances are similar to each other, but V.1 which contains less information causes slightly higher effectiveness of understanding; b) most of the respondents recognized that V.2 contains more information even though they regarded the volume of information actually presented as being different in nature; and c) there are clear gaps of emotional-stimulation levels between V.1 and V.2. In this respect the affecting degree of V.1 is evidently higher than that of V.2.

In particular with regard to the emotional stimulation, 52 respondents gave scores which are higher

than the overall average of 4.35.[26] In addition, 37 participants from various countries answered that the reason for feeling a greater emotional response toward V.1 was because of the realistic depictions of the damaged reactors captured in the photograph.

In case of V.1, the producers of the collected instances have a higher level of understanding and emotional stimulation, while those of V.2 are higher from the countries producing no **collected** visual instances [Fig.56].

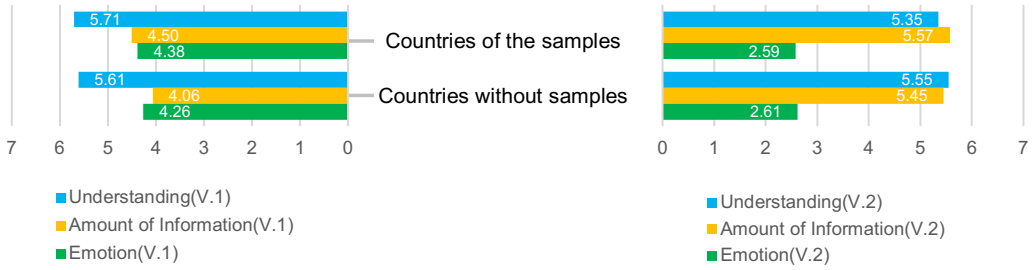


Figure 56. The average values of understanding-related effects of V.1 and V.2 depending on whether or not the countries are producers of the collected visual samples.

In addition, the effectiveness resulting from the amount of information of the two visual instances were felt higher among the producers of collected samples. Nevertheless, the gaps between the two groups are negligible and their tendencies are very similar to the overall average values.

V.1 (photography) and V.2 (technical drawing) seem to produce very similar understanding-related effects among the countries on different continents as well. There are inevitably slight differences between the two, but in most of the continents, the level of understanding of V.1 is higher than that of V.2. The amount of information available in V.1 is recognized as being less than that of V.2, and V.1's emotional intensity is higher than that of V.2. As a result, places that are geographically remote from Asia demonstrated levels of understanding and emotional stimulation which are similar to or even higher than those witnessed in Asia [Fig.57].

[26] When including the respondents who gave 4 points, the number of people in this group increases to 94.

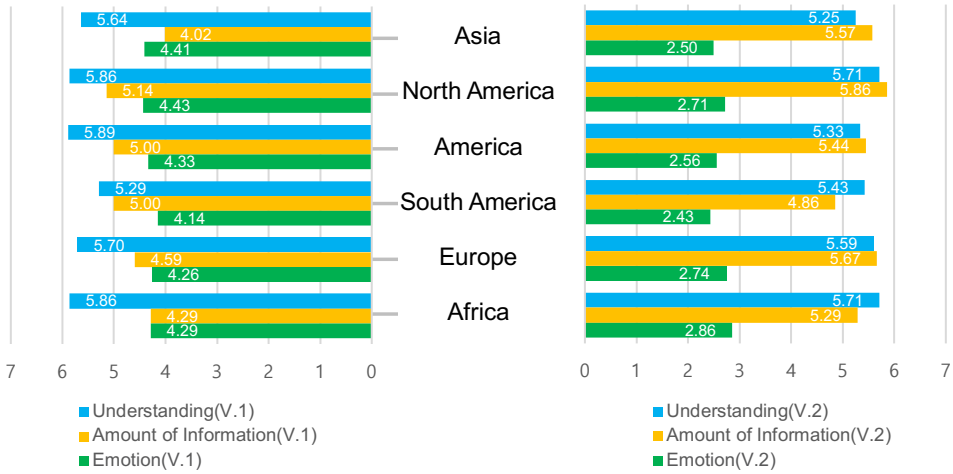


Figure 57. The average values of understanding-related effects of V.1 and V.2 by continent

This classification according to the geographical environment also leads to a similar pattern: whilst the amount of information recognized from V.2 is more than that of V.1, the levels of understanding and emotional stimulation of V.1 are actually more sharply felt than V.2 [Fig.58].

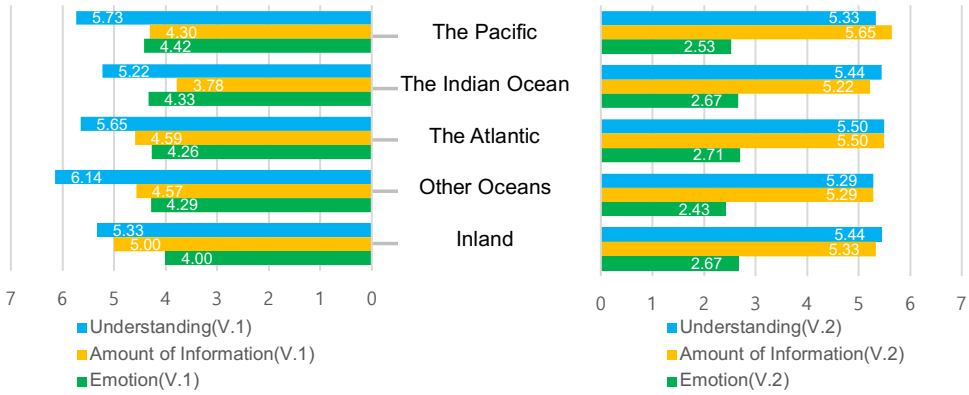


Figure 58. The average values of understanding-related effect of V.1 and V.2 by geographical surroundings

However, one point to note from [Fig.57] and [Fig.58] above is that V.1's degree of emotional stimulation was higher than those of others countries which are included in Asia or adjacent to the Pacific Ocean. These such countries are from the regions which are close to or can be influenced most keenly by the area of the disaster.

6.4.1.2. The understanding-related effects of V.1 and V.2 by age

[Fig.59] below shows the average values of the understanding-related effects by age group.

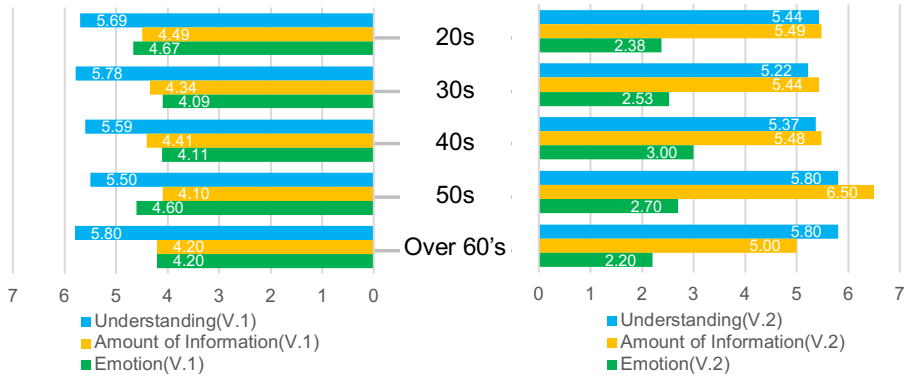


Figure 59. The average values of understanding-effects of V.1 and V.2 by age group

In the case of V.1, the highest understanding level belongs to the group of over 60's, while the group in their 20's produces the highest value of emotional stimulation. In terms of V.2, there is a correlative tendency showing towards a higher level of understanding as the age group interviewed also increases. In addition, the degree of emotional stimulation of V.2 is the highest among the group in their 40's.

Nevertheless, the tendencies of the effects between V.1 and V.2 by age group are not significantly different from those by region: the understanding and emotional stimulation levels of V.1 are still higher than those of V.2. And when considering the amount of information that was felt transferred by the participants, the value of V.2 is higher when compared to that of V.1.

6.4.1.3. The understanding-related effects of V.1 and V.2 by whether or not the Fukushima disaster matters, and the reasons for that response

The degrees of understanding and emotional stimulation are higher among the group of "It does not matter" [Fig.60].

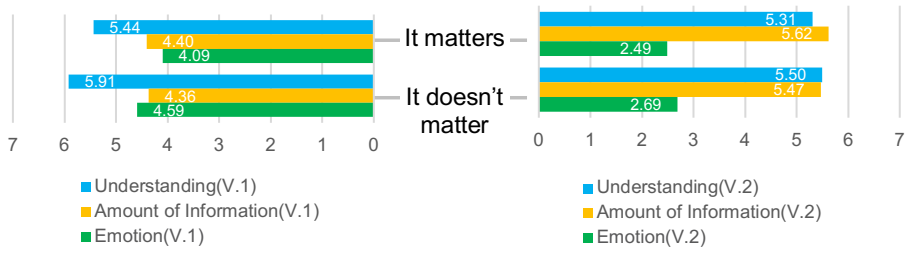


Figure 60. The average values of understanding-effects of V.1 and V.2 by whether the Fukushima event matters or not

In addition, the average values of the effects according to the specific reasons behind each of those responses above can be shown as follows [Fig.61].

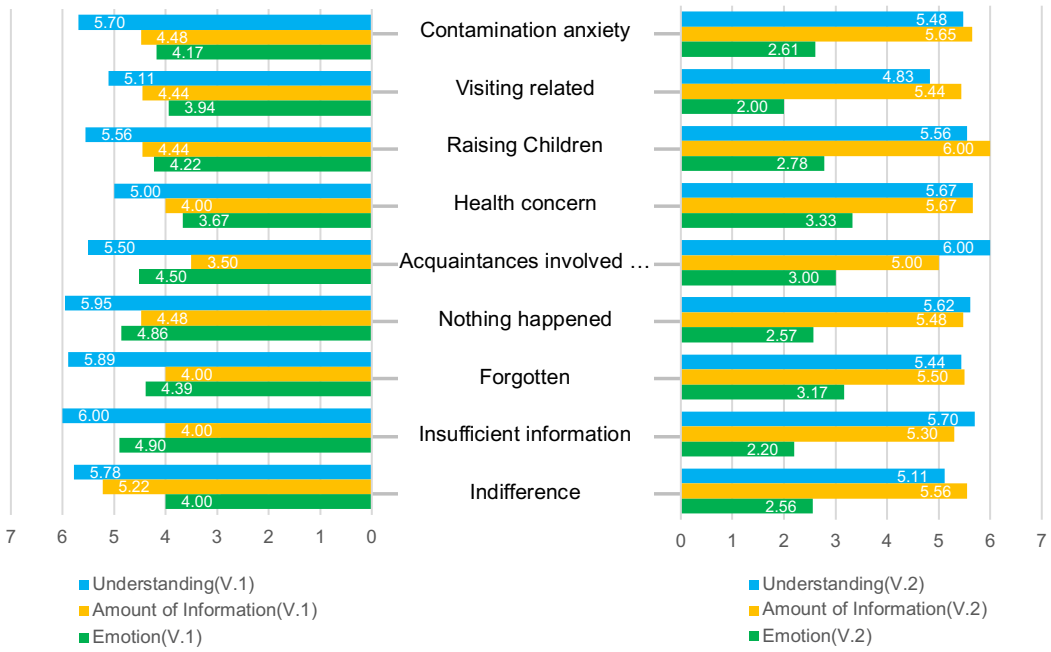


Figure 61. The average values of understanding-effects of V.1 and V.2 according to the supporting reasons

In terms of where we witness the highest levels of understanding of V.1, the supporting reasons include: “Nothing happened”, “Forgotten”, and “Insufficient information” as the responses from participants who ultimately responded that the event did not matter (to them). In terms of the emotional stimulation of V.2, the degrees of those groups also are higher than others.

On the other hand, with regard to V.2, among the most common reasons given where there were strong understanding-related effects, a variety were given from both the “It matters” as well as the “It does not matter” groups. In relation to the level of understanding achieved, the highest and the second highest values belong to the “Acquaintances involved in the event” and “Insufficient information” groups, respectively. In addition, with respect to emotional stimulation, the “Health concern” group demonstrates the highest degree of stimulation and the “Forgotten” group is in second place.

6.4.1.4. The understanding-related effects of V.1 and V.2 by perspective on the Fukushima disaster

The levels of understanding and emotional stimulation of V.1 is the highest among the participants who have the “Technological disaster” perspective on the event. The highest degrees of understanding and emotional stimulation of V.2 belong to the group of approaching the event from a social disaster perspective [Fig.62].

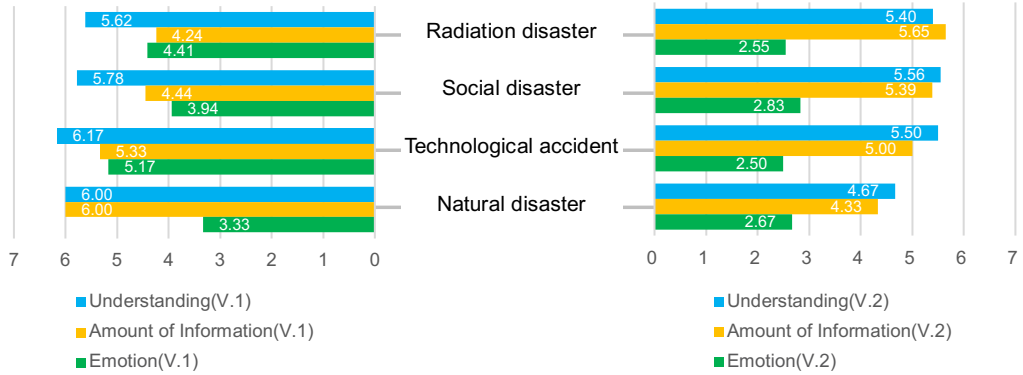


Figure 62. The average values of understanding-effects of V.1 and V.2 by perspective

Taking all the above into consideration, the comparison between V.1 and V.2 can be summarized as per the table below [Table 27].

	V.1	V.2
Main issue	The conditions of the reactors	
Main purpose	Representing the shapes, structures, and conditions	
Main representational key	Non-arbitrary (Shape)	Non-arbitrary (Shape)
Main type	Technical drawing: Cross section Photograph	Technical drawing: Plan + Cross section
Metonymy or Metaphor	Metonymy: Extracted detail	Metonymy: Extracted detail
The number of information objects (information field)	2	3
Effectiveness of understanding	Effective **(More effective than V.2)**	Effective
Region	In most of the countries	In most of the countries
Age	Among most age groups	Among high age groups (50s and 60s)
Whether or not the event matters and the reasons	In “Insufficient information” and “Nothing happened” groups Within the “It does not matter” group	In “Insufficient information” group Within the “It does not matter” group In “Acquaintances involved in the event” group within the “It matters” group
Perspective	In “Technological disaster” group	In “Social disaster” group
Effectiveness of transition from understanding to emotional stimulation	Effective **(More effective than V.2)**	-
Region	In most of the countries, slightly higher occurrence in the Asian nations, and slightly higher in the countries in the Pacific region	-

Age	Among most of the age groups, and particularly higher in 20s group	-
Whether or not the event matters and the reasons	In “Insufficient information” and “Nothing happened” groups within the “It does not matter” group	-
Perspective	In “Technological accident” group	-

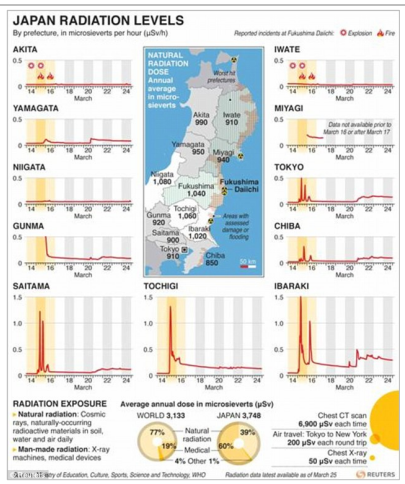
Table 27. The summary of the understanding-related effects of V.1 and V.2

Where the conditions of the reactors of the damaged power plant were described, technical drawing and the combination of technical drawing with photograph (which are based on non-arbitrary representational key and metonymical expression) are highly effective in bringing about understanding in general. In particular, using a photograph of the damaged scene is highly likely to cause the transition from understanding to emotional stimulation.

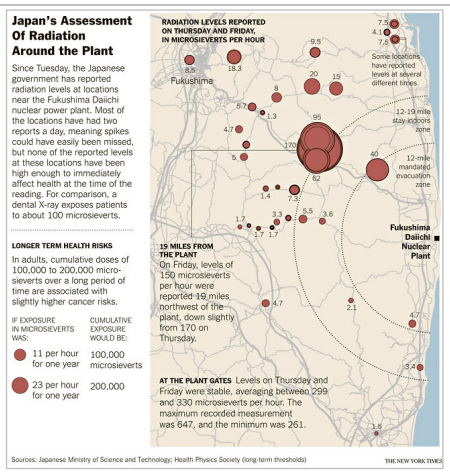
6.4.2. The understanding-related effects of V.3 and V.4

Prior to describing the analysis of the data with regard to understanding-related effects of V.3 and V.4, it is necessary to study the visual materials and their characteristics once more.

Figures V.3 and V.4 are displayed again in [Table 28] below.



V.3. Japan Radiation Levels



V.4. Japan's Assessment of Radiation Around the Plant

Table 28. V.3 (Japan Radiation Levels) and V.4 (Japan's Assessment of Radiation Around the Plant)

The main issue concerning these samples relates to the level of radiation of the regions around the Fukushima Daiichi Nuclear Power Plant. The analysis of both visual instances can be organized below [Table 29].

No.	Issues	Detailed field	Purpose (Variables)	Representational key (A: Arbitrary / N: Non-arbitrary)	Types of Vis. (M: Map / C: Chart / T: Technical drawing / P:Photograph)	Metaphor and Metonymy (Mp: Metaphor / Mn: Metonymy)
V.3	Radiation level and distribution	By date and region	Representing the distribution and levels of radiation depending on time and space	A (Line)	C (Line chart)	
		Locations (Central Japan)	Indicating the locations	N (Shape)	M (Central Japan)	Mn (Map)
V.4	Radiation level and distribution	By region	Representing the distribution and levels of radiation depending on space	A (Circle, Size)	C (Bubble chart on map)	
		Locations (Near Fukushima)	Indicating the locations	N (Shape)	M (Near Fukushima)	Mn (Map)

Table 29. The analysis of V.3 and V.4

Even though the two examples share one main issue and theme, there are of course notable differences between those in terms of the amount of information and data contained within, as well as

the fundamental manner in which that information is represented. V.4 indicates the data relevant to the radiation level of the regions in Fukushima prefecture, while V.3 deals with the wider regions (other prefectures around Fukushima) to which the time variable (by date) is added. One further difference in expressional methods is found in their types: in order to indicate the level of radiation, V.3 uses multiple line charts which are separated from a map, whereas V.4 employs a type of bubble chart plot overlapped on a map.

6.4.2.1. The overall average values of understanding-related effects of V.3 and V.4

The average values of the data from the whole set of respondents are presented below [Fig.63].

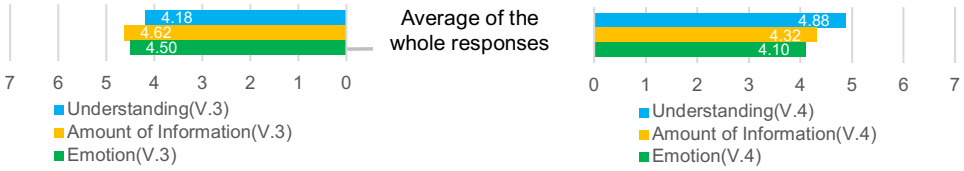


Figure 63. The average values across the whole set of responses regarding understanding-related effects of V.3 and V.4

In terms of the amount of information (or data) observed, the respondents appreciated that V.3 dealt with and presented more information than V.4.

In addition, more than half of the participants (61) answered that the understanding level as a result of V.4 is higher than that of V.3. In particular about 70% (43 respondents) cited the separation of the individual elements of the information as being a determining factor in increasing their overall appreciation. The participants cited the radiation level and regional information as being possible reasons behind misinterpretation of what was being observed.

In terms of the degree of emotional stimulation, 46 people gave higher scores to V.3. This represents less than half of all the participants, but the degree of emotional stimulation within this particular group was clearly higher than others. Approximately 63% (27 respondents) answered that the gap between the maximum and the minimum levels of radiation caused them to react in this way: due to the large gap, the contaminated situation encountered in the area with the highest level seemed to be much more serious than compared to the situation encountered elsewhere. In addition, in case of V.4, 9 people answered that they felt the emotional tension decreased due to the empty spaces (the places without

any marks of the circles of data) on the map.

6.4.2.2. The understanding-related effects of V.3 and V.4 by region

The average ratings of these effects by country can be demonstrated as below [Fig.64].

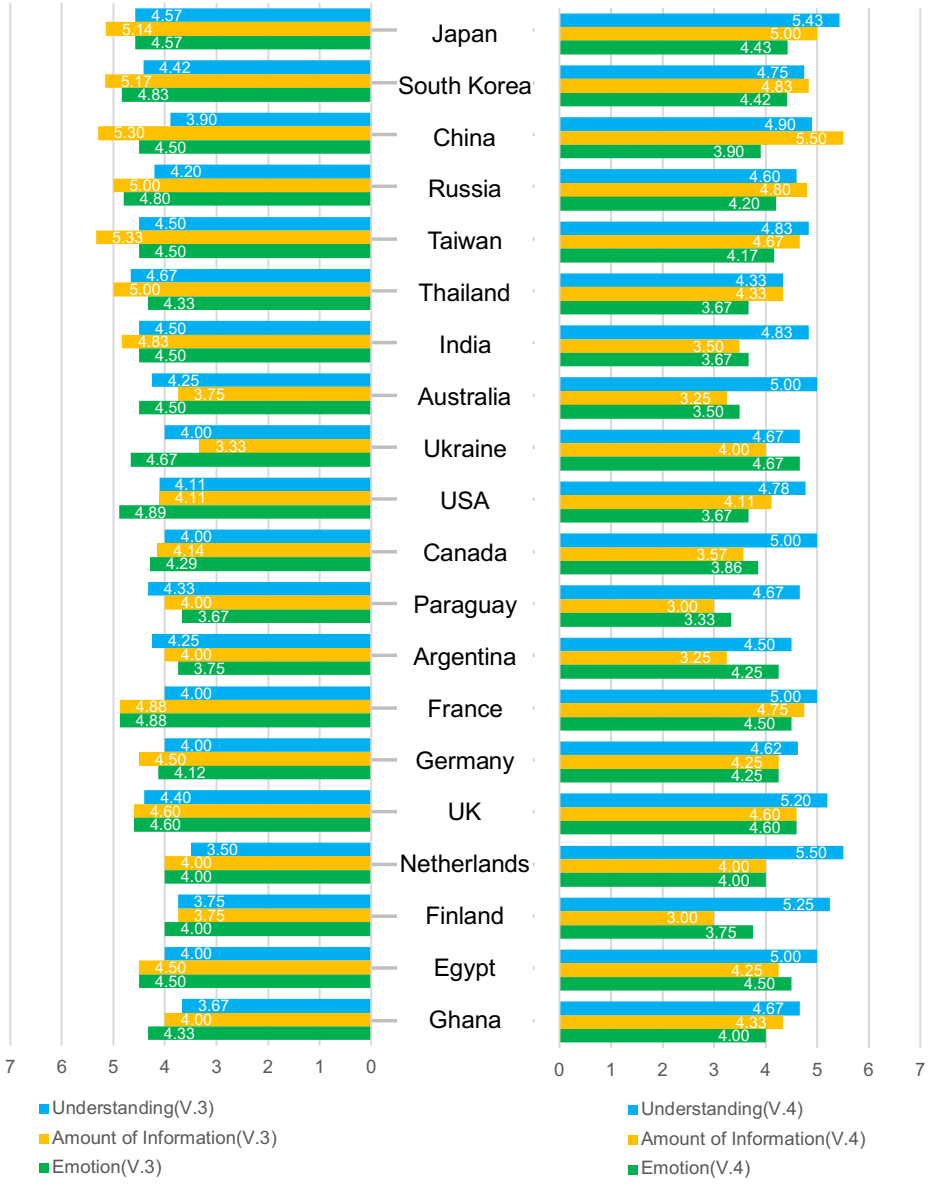


Figure 64. The average values of understanding-related effects of V.3 and V.4 by country

The tendency of most of the nations as per [Fig.64] is that: a) the level of understanding of V.4 is generally higher than that of V.3; b) most of the respondents recognized that V.4 contains less

information; and c) the emotional stimulation levels of V.3 are higher than those felt with of V.4.

When dividing the nations into two groups, being those which are the producers of the collected visual samples, and alternatively those countries from which no visual instances were gathered, the average values of the both groups can be represented below [Fig.65].

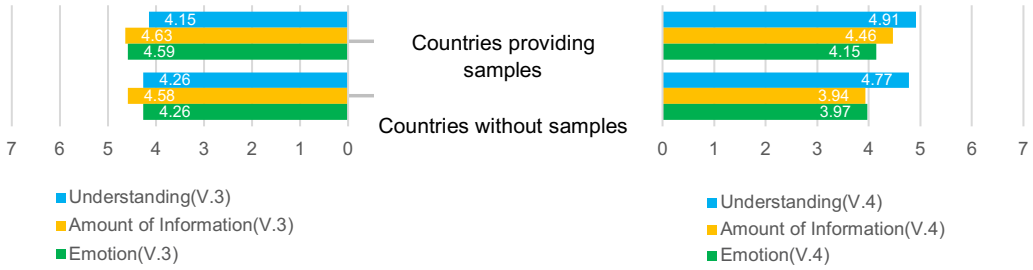


Figure 65. The average values of the understanding-related effects of V.3 and V.4 depending on whether or not the countries are producers of the collected visual samples.

In case of V.3, the gap between the two groups is very small, but the understanding level is higher in the countries where there were no collected samples. Further, the amount of information and the degree of emotional stimulation are higher from nations where there were collected samples. In terms of V.4, the nations from which there were collected samples show a higher level of understanding, amount of information, and degree of emotional stimulation.

However, and similar to the previous patterns of V.1 and V.2, the gaps observed in the understanding-related effects are very small between the groups and the patterns of those are not significantly different from the overall average values amongst the entirety of the participants.

In case of V.3, the understanding level is the highest in the countries of Asia. In addition, this region shows a high value in terms of emotional stimulation: overall, Asia has the second highest value with regard to emotional stimulation after America [Fig.66].

With regard to V.4, the understanding level is the highest in North America and Europe; the degree of emotional stimulation is higher in Europe and Africa. In addition, the participants in Asia regarded the amount of information presented in both visual samples as the largest.

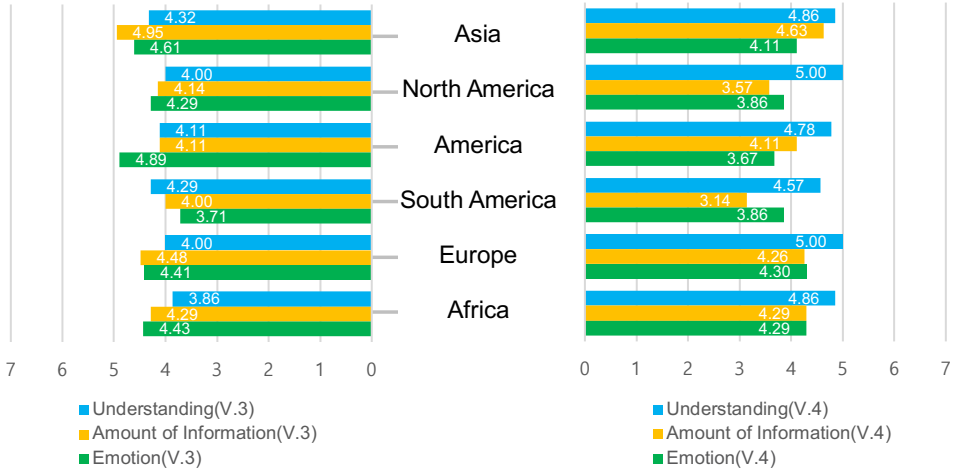


Figure 66. The average values of understanding-related effects of V.3 and V.4 by continent

In particular, the average understanding level of V.3 among Japanese respondents is 4.57 which is the highest among all countries. This value is higher than the average amongst Asian countries (4.32), and of course higher than the average of all countries in this category (4.18). In addition, as shown in the values by country [Fig.64], the closer the countries physically are to Japan, the higher understanding levels of V.3 are shown. These statistics indicate that it is highly probable that regional information (or data) separate from the map is more easily understood by people who already have background knowledge of the region such as the location of the disaster.

[Fig.67] below exhibits the average values of the nations by geographical surroundings.

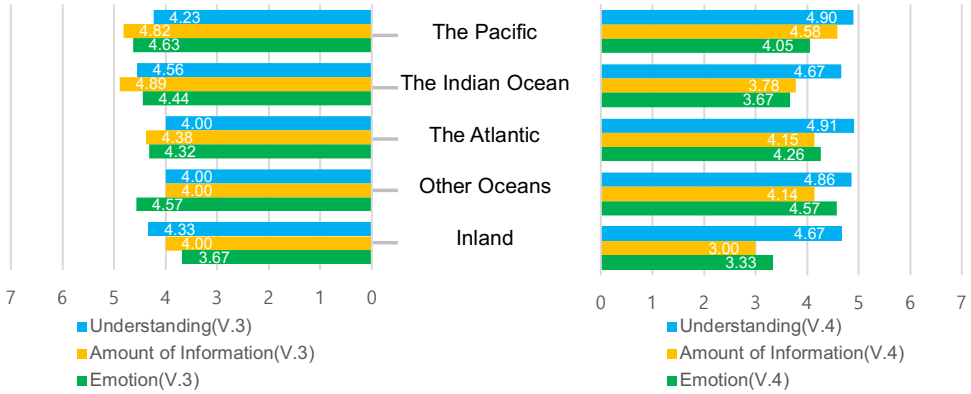


Figure 67. The average values of understanding-related effect of V.3 and V.4 by geographical surroundings

In terms of V.3, the nations adjacent to the Indian Ocean demonstrate the highest level of

understanding and the largest amount of information. In addition, the neighboring countries of the Pacific Ocean elicit the highest degree of emotional stimulation.

In case of V.4, the understanding levels of the Pacific and the Atlantic related countries are higher than others; the degree of emotional stimulation is highest among the nations immediately adjacent to that shown from other nations from other parts of the world. In addition, the nations from the Pacific region regard the amount of information included in V.4 to be the largest witnessed.

To summarize all the regional tendencies, the understanding-related effects of V.3 are higher in the nations in Asia, to those closest to the Pacific Ocean, and to those near the Indian Ocean. On the other hand, even though V.4 specifically deals with the radiation levels in a very narrow region, i.e. the Fukushima prefecture, it is notable that the level of understanding remains high in various nations which are actually very distant from Japan such as those of Europe, Africa, North America, the Atlantic Ocean and other oceans. This tendency shows that it is highly probable that this type of chart combined with map is more effective than using a technique containing separate forms of expression of the information to be communicated.

6.4.2.3. The understanding-related effects of V.3 and V.4 by age

In case of V.3, the level of understanding achieved is higher among the groups in their 30s and 40s, while the degree of emotional engagement is higher in older age groups in their 40s, 50s, and over 60s. In terms of V.4, the highest level of understanding belongs to the group in their 50s. In addition, the group in their 40s gave the highest scores to V.4 in the level of emotional stimulation [Fig.68].

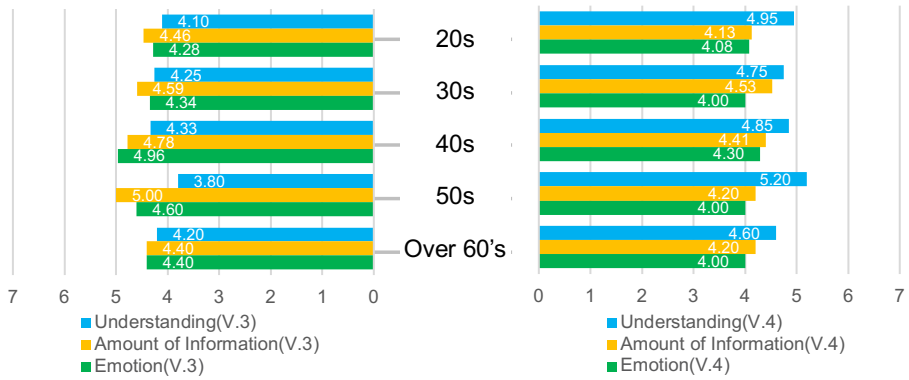


Figure 68. The average values of understanding-effects of V.3 and V.4 by age group

6.4.2.4. The understanding-related effects of V.3 and V.4 by whether or not the Fukushima disaster matters to the respondents and the reasons given for that response

The levels of understanding and amount of information contained in both visual samples are higher among the participants who answered that the event still matters to them. On the other hand, the degree of emotional stimulation of the two samples are higher in the group who replied that the disaster does not matter [Fig.69].

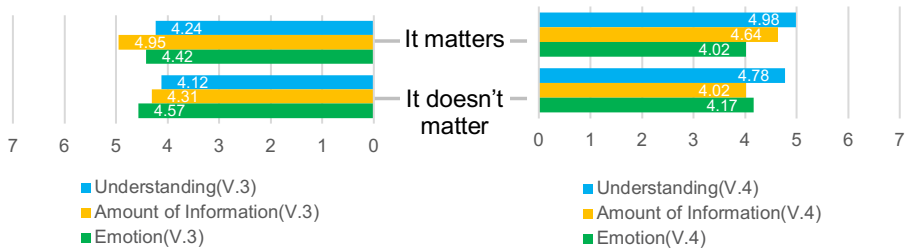


Figure 69. The average values of understanding-effects of V.3 and V.4 by whether the Fukushima event matters or not to them

In addition, the average values of the effects corresponding to the reasons given for answering whether or not the disaster matters are indicated as per [Fig.70].

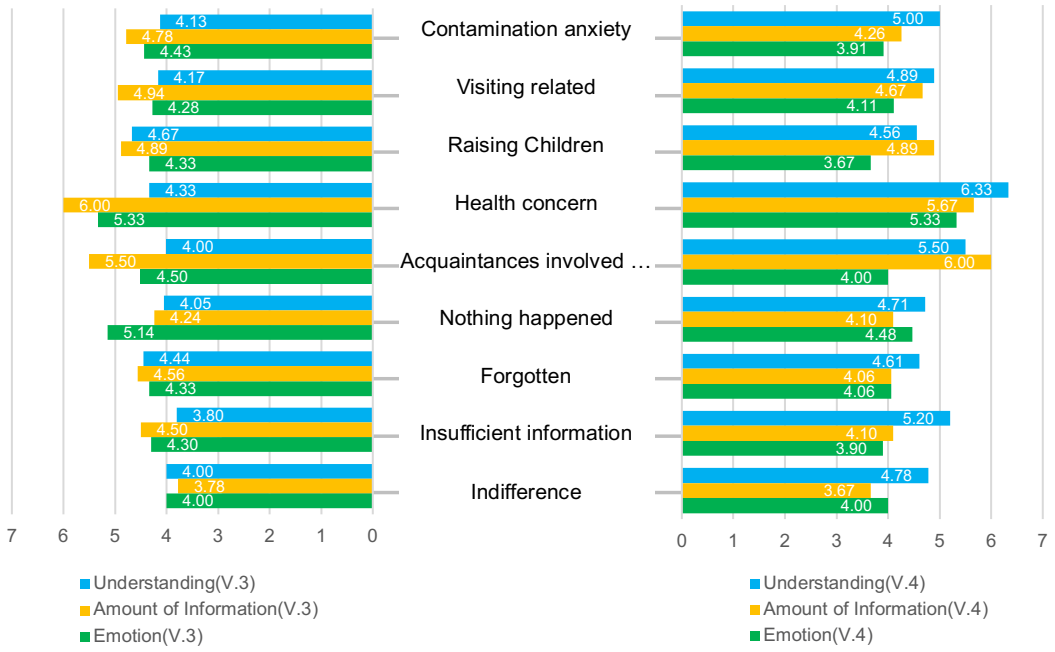


Figure 70. The average values of understanding-effects of V.3 and V.4 according to the reasons for the responses

It seems that the more interest in the disaster, the higher understanding-related effects of V.3 and V.4. In terms of V.3, the overall level of understanding is the highest among the group of “Raising Children”; the amount of information available here is regarded as being the largest by the “Health concern” group; the degree of emotional stimulation is the highest among those giving the “Health concern” group as well. In particular, the understanding level given by the “Raising Children” group is 4.67 which is higher than the average value across all interviewees of 4.18. In addition, the emotional stimulation level shown from the “Health concern” group comes to 5.33 which is about one point higher than the overall average value reflecting the emotional stimulation.

As seen previously when considering the effects of V.3, the understanding-related effects seen with V.4 are higher among the participants in the group of “Health concern”. The highest levels of understanding and emotional stimulation are observed in the “Health concern” group. The value given to the understanding level here is 6.33 which is 1.45 points more than the overall average for this question (4.18). By contrast, the emotional stimulation level score is 5.33 which is 1.23 points higher than the average across all respondents (4.10).

Another notable point here is that the understanding-related effects and reasons behind the groups giving the response of “it does not matter” are not significantly less than as found in the groups aforementioned above. In the case of V.3, the second highest understanding level belongs to the group of “Forgotten” whose value is 4.33 which is also higher than the overall average. In terms of the emotional stimulation level of V.3, the second highest score belongs to the group of “Nothing happened” whose figure is 5.14, and which is 0.19 points less than the highest value.

6.4.2.5. The understanding-related effects of V.3 and V.4 according to the perspective on the Fukushima disaster

In case of V.3, the group of “Radiation disaster” has the highest understanding level and the “Natural disaster” group shows the highest degree of emotional stimulation. With regard to V.4, the highest understanding level is from the group whose perspective is “Radiation disaster”. The extent of emotional stimulation is the highest among the “Natural disaster” group [Fig.71].

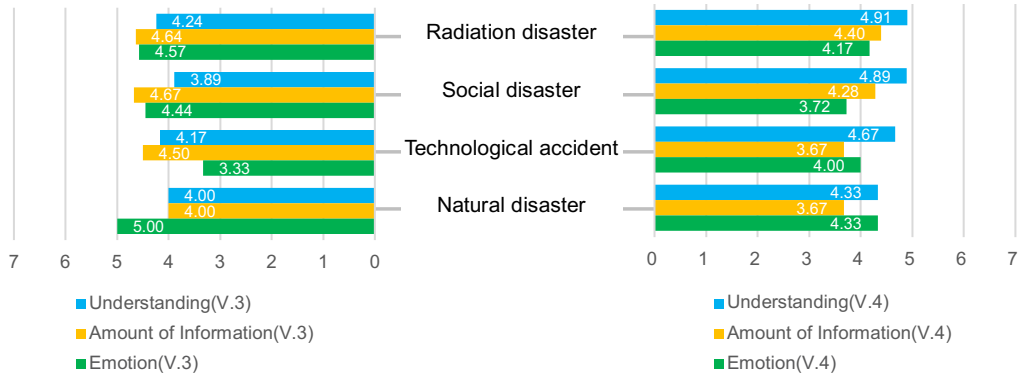


Figure 71. The average values of understanding-effects of V.3 and V.4 by perspective

Taking all of the above into consideration, the comparison between V.3 and V.4 can be summarized as per the table below [Table 30].

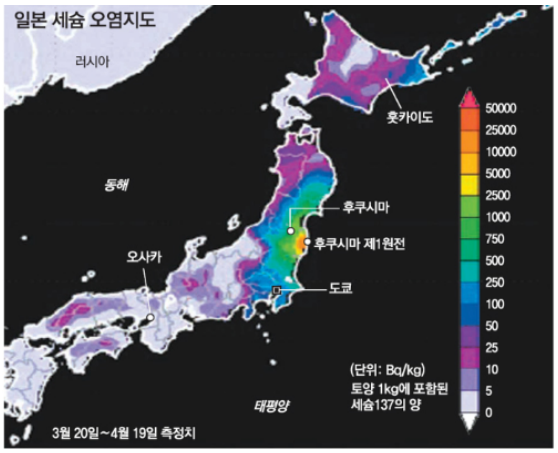
	V.3	V.4
Main issue	The conditions of the reactors	
Main purpose	Representing the distribution of radiation by region	
Main representational key	Arbitrary(Line), Non-arbitrary(Shape)	Arbitrary(Circle, Size), Non-arbitrary(Shape)
Main type	Separated Line chart and Map	Bubble chart on Map
Metonymy or Metaphor	Metonymy: Map	Metonymy: Map
The number of information objects (information field)	3	2
Effectiveness of understanding	Effective	Effective **(More effective than V.3)**
Region	The most effective in Japan, More effective in the regions of Asia, the Pacific Ocean, and Indian Ocean	In most of the countries
Age	30s and 40s	20s and 50s
Whether or not the event matters and the reasons	In “Raising Children” group of “It matters” group	In “Health concern” group of “It matters” group
Perspective	In “Radiation disaster” group	In “Radiation disaster” group
Effectiveness of transition from understanding to emotional stimulation	Effective **(More effective than V.4)**	Effective
Region	The regions of America, Asia, and the Pacific Ocean	The regions of Europe, Africa, other oceans
Age	40s and 50s	40s
Whether or not the event matters and the reasons	In “Health concern” group of “It matters” group	In “Health concern” group of “It matters” group
Perspective	In “Natural disaster” group	In “Natural disaster” group

Table 30. Summary of the understanding-related effects of V.3 and V.4

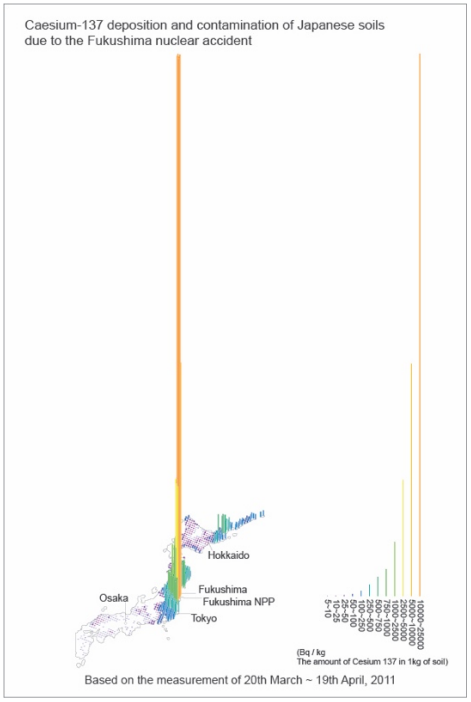
In attempting to represent the distribution of the radiation contamination, the type of chart combined with map is more effective to bring about understanding than when the two forms are separated. In case of emotional stimulation, it is highly possible that the type of line chart which indicates quantitative data based on height and length is more effective than employing the type of bubble chart plot which depicts the same set of data based on the size of area highlighted.

6.4.3. The understanding-related effects of V.5 and V.6

The figures of V.5 and V.6 are shown again in [Table 31] below.



V.5. Caesium Contamination Map



V.6. Caesium Contamination Map (02)

Table 31. V.5 (Caesium Contamination Map) and V.6 (Caesium Contamination Map (02))

The main topic addressed in these visual instances is the level of radiation (Caesium-137) witnessed in Japan. The analysis of the two visual samples can be summarized below [Table 32].

No.	Issues	Detailed field	Purpose (Variables)	Representational key (A: Arbitrary / N: Non-arbitrary)	Types of Vis. (M: Map / C: Chart / T: Technical drawing / P:Photograph)	Metaphor and Metonymy (Mp: Metaphor / Mn: Metonymy)
V.5	Radiation level and distribution	Whole Japan	Representing the distribution and levels of radiation by space	A (Hue)	C (Color plot)	Mp (Heat)
			Indicating the locations	N (Shape)	M (Whole Japan)	Mn (Map)
V.6	Radiation level and distribution	Whole Japan	Representing the distribution and levels of radiation by space	A (Bar, Hue)	C (Bar chart)	Mp (Heat)
			Indicating the locations	N (Shape)	M (Whole Japan)	Mn (Map)

Table 32. The analysis of V.5 and V.6

Despite the common themes running through both examples, there is a difference between V.5 and

V.6 in terms of the representational methods used. V.5 uses hue to represent the quantitative data of the radioactive material based on metaphor found in thermography (heat map). On the other hand, the main representational key of V.6 is bar to depict the same quantitative data.

6.4.3.1. The overall average values of understanding-related effects of V.5 and V.6

In terms of the level of understanding achieved the average value resulting from V.6, which employs bar, is higher than that of V.5. The gap between the two visual samples is 1.26 points, which is more of a noticeable gap than that seen between previous instances of understanding levels. With regard to the comparison of the amount of information presented between V.5 and V.6, even though the visual samples contain the same amount of information, some of the participants perceived it as different: for example, the amount of information (or data) in V.5 is slightly larger than that seen in V.6. When considering the degree of emotional stimulation, the average values seen here indicate a minor difference: the score for V.5 is 0.03 points higher than V.6 [Fig.72].

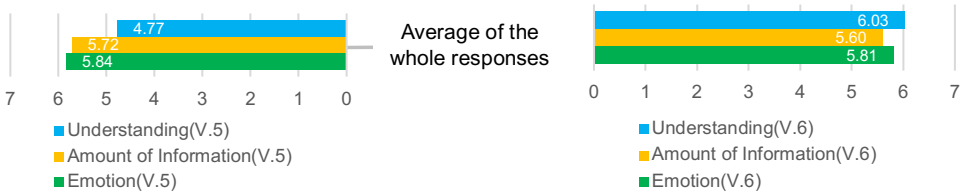


Figure 72. The average values of the entire set of responses regarding understanding-related effects of V.5 and V.6

In terms of the understanding level, 82 people answered that V.6 is easier to understand than V.5. In addition, 63 participants (78%) cited the obvious contrast of the lengths of the bars as the primary reason behind effective understanding. With regard to the degree of emotional stimulation, 37 participants gave the same marks to both instances; 37 respondents provided higher scores for V.5; the remaining 39 people gave higher marks to V.6.

6.4.3.2. The understanding-related effects of V.5 and V.6 by region

The average value of the effects by country can be presented as [Fig.73] below.

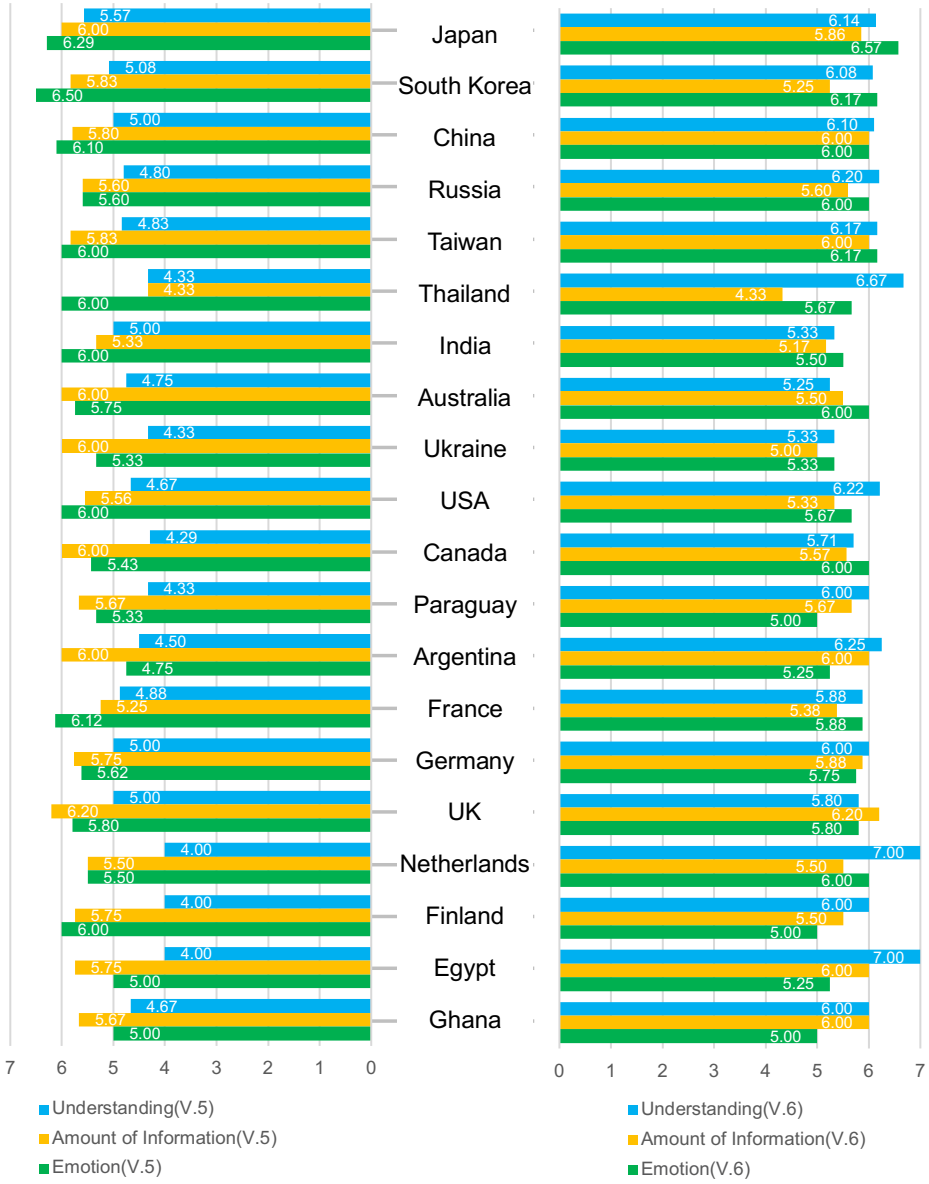


Figure 73. The average values of understanding-related effects of V.5 and V.6 by country

The pattern seen in most of the countries according to the analysis of [Fig.73] is that: a) the level of understanding of V.6 is higher than that of V.5 in all nations above; b) in 6 countries including Russia, Thailand, Paraguay, Argentina, UK, and the Netherlands, the quantity of information contained in both samples are recognized as being equal; and c) in all countries, the gaps in scores of the emotional

stimulation levels between the two visual materials are not noticeably significant: for the Netherlands, V.5's mark in this respect is 1 point higher; in Canada, V.6 scores 0.5 points higher; and in all other 18 countries, the gap is 0.5 points or less.

The level of understanding, the amount of information presented, and the degree of emotional stimulation of V.5 all score higher from the countries of the collected samples. In respect of V.6, the understanding level and information volume are given higher scores from the nations of no collected visual instances, although the degree of emotional stimulation is lower in these countries [Fig.74].

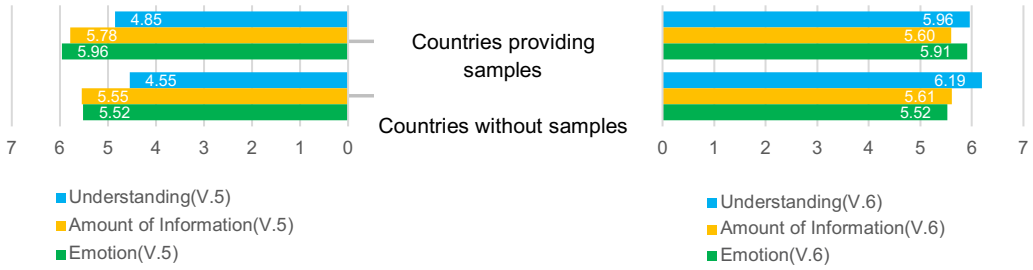


Figure 74. The average values of understanding-related effects of V.5 and V.6 depending on whether or not the countries are producers of the collected visual samples.

In addition, the degree of understanding of V.6 is higher in both groups. In case of the emotional stimulation level, V.5 scores higher in the countries providing samples and the two materials produce the same marks from the countries of no collected samples.

With respect to the level of understanding achieved, V.6 scores higher than V.5 in all continents. This is similar to the tendency witnessed in terms of the overall average across all respondents. However, when assessing the degree of emotional stimulation, there are some continents whose preferences are different from that of the overall average: V.6 scores higher in North America, South America, and Africa [Fig.75].

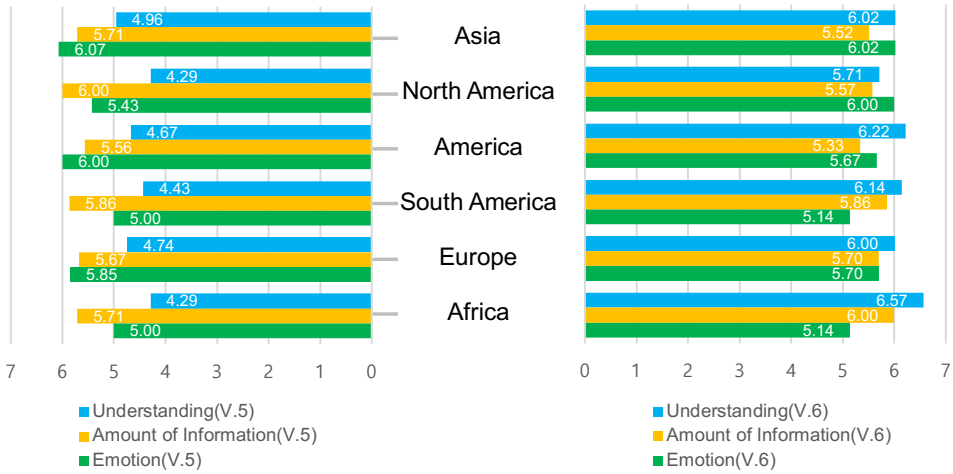


Figure 75. The average values of understanding-related effects of V.5 and V.6 by continent

In addition, the levels of understanding and emotional stimulation of V.5 are the highest in Asia, whose countries are physically closest to the area of the disaster. On the other hand, the degree of emotional stimulation of V.6 is the highest in Asia, but the understanding level of this case is higher in the continents remote from Asia such as Africa, America, South America, etc.

In terms of the levels of understanding and emotional stimulation of V.5, the highest and second-highest marks are given from the Pacific Ocean group and the Indian Ocean group respectively [Fig.76]. In case of V.6, the Pacific Ocean group shows the highest level of emotional stimulation.

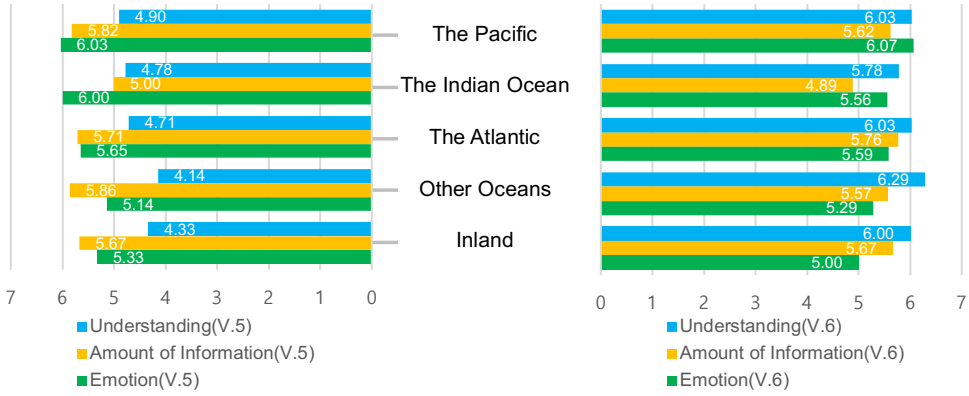


Figure 76. The average values of understanding-related effect of V.5 and V.6 by geographical surroundings

The Pacific Ocean group is included in the top rank groups with respect to the degree of understanding of V.6. However, the level of understanding is the highest in the Other Oceans group and there are various other groups which have high values of the understanding level.

To summarize the regional patterns above, in case of V.5, there is an inclination that the understanding-related effects are higher among the regions which are closest to the area of the disaster such as the groups of Asia, the Pacific Ocean, and the Indian Ocean. Even though the emotional stimulation degree of V.6 also scores high in Asia and the Pacific Ocean groups, its understanding level and amount of information are high in most of the regions.

6.4.3.3. The understanding-related effects of V.5 and V.6 by age

When considering categorization by age group, in general the higher the age, the higher the levels of understanding and emotional stimulation achieved from both V.5 and V.6. On the other hand, the higher the age of the group, the lower the amount of information of the two visual materials was perceived by the participants [Fig.77].

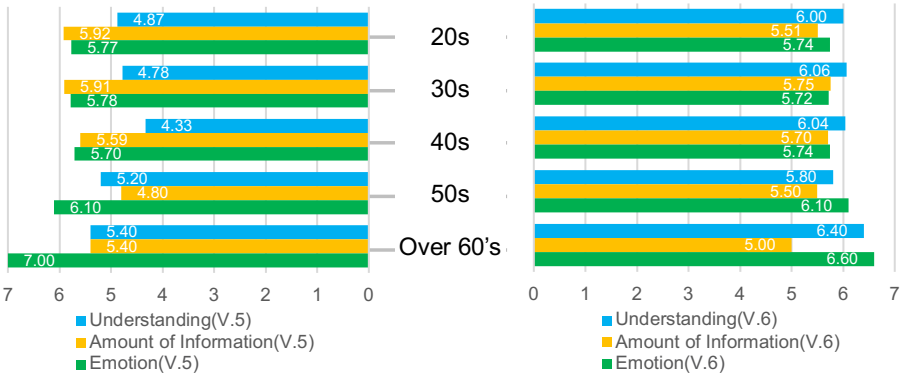


Figure 77. The average values of understanding-effects of V.5 and V.6 by age group

6.4.3.4. The understanding-related effects of V.5 and V.6 by whether or not the Fukushima , and the reasons for that response

The levels of understanding and emotional stimulation of the two visual materials are higher among the interviewees of the “It matters” group [Fig.78].

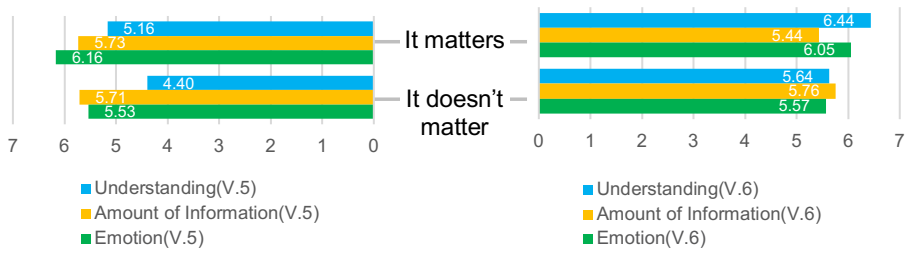


Figure 78. The average values of understanding-effects of V.5 and V.6 by whether the Fukushima event matters or not to the respondent

Across all nations, V.6 has the greater effectiveness in understanding. In addition, in terms of the emotional stimulation, the effectiveness of V.5 is deemed higher among the "It matters" group while that of V.6 is slightly higher among the group stating "It does not matter". Nevertheless, the values of emotional stimulation degree in the "It does not matter" group are almost identical.

The average values with the reasons for whether or not the disaster matters are shown below [Fig.79].

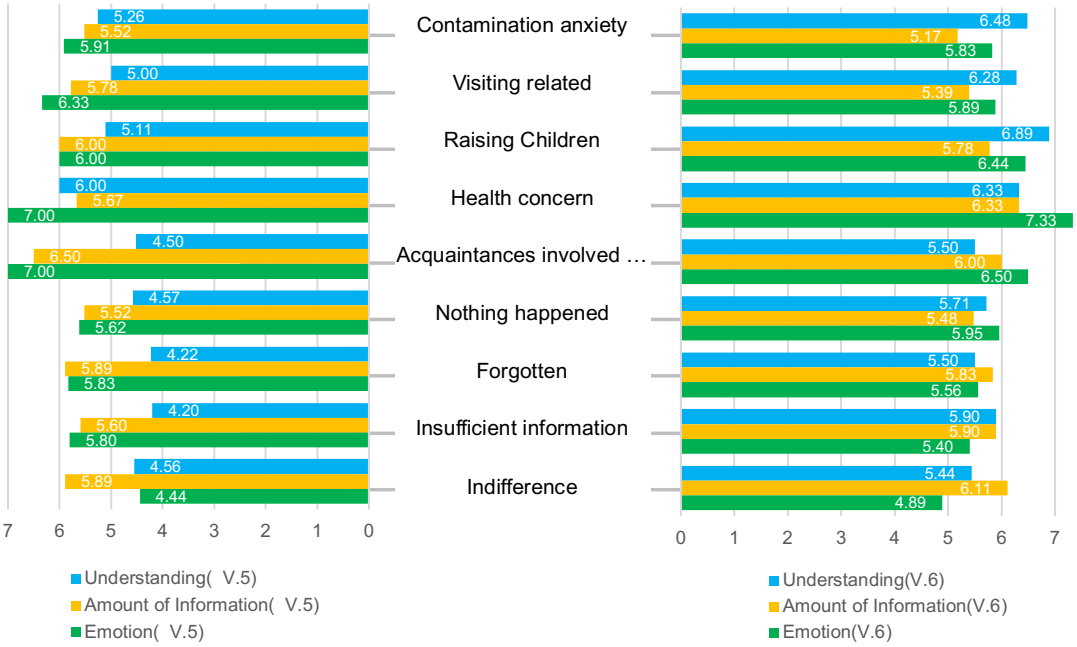


Figure 79. The average values of understanding-effects of V.5 and V.6 with supporting reasons

In terms of the understanding level of V.5, the group of "Health concern" and that of "Contamination anxiety" provided the highest and the second highest marks for this sample respectively. In addition, the amount of information available in this visual instance was regarded as the largest among the "Acquaintances involved in the event" group. In case of V.6, its understanding level scored the highest

among the “Raising Children” group; the group of “Health concern” provided the highest scores for the degree of emotional stimulation and recognized the extent of the amount of information contained within this visual material.

In addition, similar to the overall average across all participants, the understanding levels of V.6 of are higher than those of V.5 in all the groups where supporting reasons were given. However, in terms of the extent of emotional stimulation, not all groups follow the tendency of the overall average, which is that the degree shown in V.5 is slightly more predominant than that of V.6: in the “Raising Children”, “Health concern”, “Nothing happened”, and “Indifference” groups, the scores for the emotional effect of V.6 are higher than those of V.5.

6.4.3.5. The understanding-related effects of V.5 and V.6 by perspective on the Fukushima disaster

[Fig.80] shows the average values of data by perspective. In terms of both visual samples, the group “Radiation disaster” has the highest levels with regard to understanding and emotional stimulation.

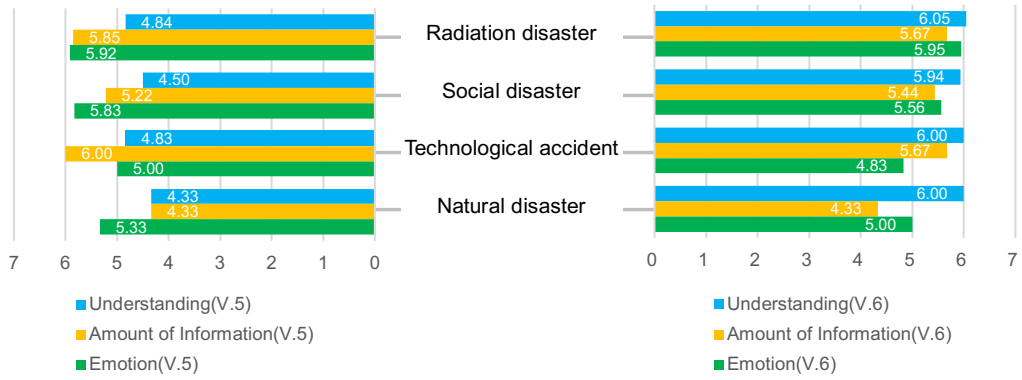


Figure 80. The average values of understanding-effects of V.5 and V.6 by perspective

In addition, the understanding levels of V.6 amongst all the perspective groups are higher than those of V.5, and the degrees of emotional stimulation of V.5 are higher than those of V.6 in the three groups, with the exception of the “Radiation disaster” group.

Taking all the above into consideration, the comparison between V.5 and V.6 can be summarized as

per the table below [Table 33].

	V.5	V.6
Main issue	The distribution and the level of radiation	
Main purpose	Representing the distribution and level of radiation on Japan	
Main representational key	Arbitrary (Hue), Non-arbitrary (Shape)	Arbitrary (Bar, Length) Non-arbitrary (Shape)
Main type	Color plot on Map	Bar chart on Map
Metonymy or Metaphor	Metaphor: Heat Metonymy: Map	Metonymy: Map
The number of information objects (information field)	2	2
Effectiveness of understanding	Effective	Effective **(More effective than V.5)**
Region	In the regions of Asia, the Pacific Ocean, the Indian Ocean	In most of the regions
Age	the higher the age, the higher the effectiveness	the higher the age, the higher the effectiveness
Whether or not the event matters and the reasons	In the “Contamination anxiety” group of the “It matters” group	In the “Raising Children” group of the “It matters” group
Perspective	In the “Radiation disaster” group	In the “Radiation disaster” group
Effectiveness of transition from understanding to emotional stimulation	Effective **(more effective than V.6)**	Effective
Region	The highest in the regions of Asia, the Pacific Ocean, the Indian Ocean More effective in most of regions	The highest in the regions of Asia, and the Pacific Ocean In particular, in “South America”, “Africa”, and “the Pacific Ocean” groups, the emotional effect is higher than V.5
Age	the higher the age, the higher the effectiveness More effective in most of age groups	the higher the age, the higher the effectiveness In particular, in 40s group, the emotional effect is higher than V.5
Whether or not the event matters and the reasons	In the “Health concern” group, the “Acquaintances involved in the event” group of the “It matters” group	In the “Health concern” group of the “It matters” group In particular, in the “Raising Children”, “Health concern”, “Nothing happened”, and “Indifference” groups, the emotional effect is higher than V.5
Perspective	In the “Radiation disaster” group More effective in most of the perspective groups	In the “Radiation disaster” group In particular, in the “Radiation disaster” group, the emotional effect is higher than V.5

Table 33. The summary of the understanding-related effects of V.5 and V.6

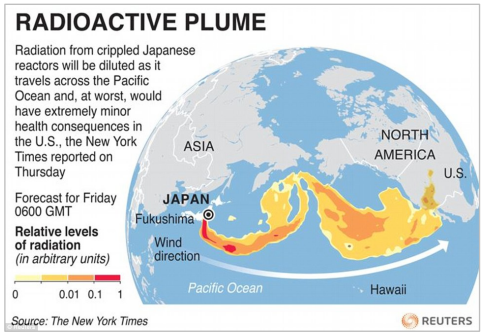
In terms of the representation of the distribution and level of radiation across the whole of Japan, the bar chart on map is more effective in producing understanding than the type of color-plot chart on map based on the metaphorical expression of thermography (heat map) in most of the regions. This also means that one of the representational keys, Bar (based on length) is a more effective representation with which to deliver the information of data regarding the degree and spread of radiation contamination on map, in comparison to another representational key (Hue). Nevertheless, the representation by using Hue based on heat map caused a higher degree of emotional stimulation than the expression which employs Bar, whose understanding level is higher.

These results above show that the level of emotional stimulation is not necessarily in direct proportion to that of understanding. Despite the same content and amount of data and information involved, the effectiveness of understanding and emotional stimulation can differ depending on the representational methods in play. In addition, even though the expressional manner is less effective to understanding, it is possible to cause higher stimulation and emotion.

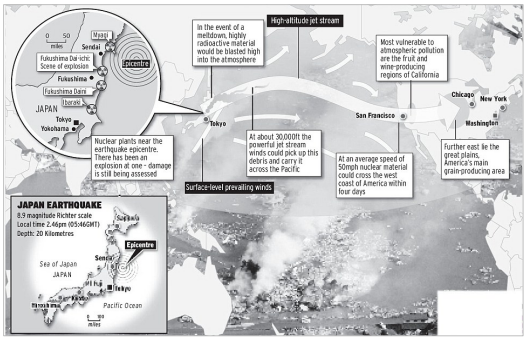
The possibilities above will be more evident throughout the following section in which there is a comparison between other visual samples whose representational methods are similar, but where the data and information are different from V.5 and V.6.

6.4.4. The understanding-related effects of V.7 and V.8

[Table 34] below shows V.7 and V.8 again.



V.7. Radioactive Plume



V.8. America on Radiation Alert

Table 34. V.7 (Radioactive Plume) and V.8 (America on Radiation Alert)

These visual materials aim to present information and data relating to radiation spread, mainly representing the route, direction, realm, etc. of air currents, which are the vehicle of radiation. [Table 35] below briefly describes the analysis of the two visual instances.

No.	Issues	Detailed field	Purpose (Variables)	Representational key (A: Arbitrary / N: Non-arbitrary)	Types of Vis. (M: Map / C: Chart / T: Technical drawing / P:Photograph)	Metaphor and Metonymy (Mp: Metaphor / Mn: Metonymy)
V.7	The movement of radiation diffusion	Air on the Pacific Ocean	Representing the route, realm and levels of radiation depending on space	A (Hue)	C (Color plot)	Mp (Heat)
			Indication the direction	N (Arrow)	T (Process graphic)	Mn (Indexical sign)
			Indicating the locations	N (Shape)	M (The world (Pacific))	Mn (Map)
V.8	The movement of radiation diffusion	Air on the Pacific Ocean	Representing the route, direction, and strength of air flow depending on space	N (Arrow)	T (Process graphic)	Mn (Indexical sign)
			Indicating the locations	N (Shape)	M (The world (Pacific))	Mn (Map)

Table 35. The analysis of V.7 and V.8

Even though they share some common themes including the movement and spread of radiation, there is a difference in the respective expressional manners. V.7 employs Hue as its representational key to describe the route, domain, and degree of radiation in the air. In addition, an arrow in this sample is used to indicate the main direction of the movement, but it does not contain any further information which could also have been depicted by an arrow such as route, strength of wind, scale of wind path, etc.

On the other hand, in case of V.8, the arrow is one of the main representational keys with which to depict the route of radiation spread and approximate strength of the wind by using the different widths of the arrows. For detailed information such as the power, speed and influences on America of the wind, however, it uses texts linked to the arrows in conjunction with the thin leader lines.

6.4.4.1. The overall average values of understanding-related effects of V.7 and V.8

With regard to the overall understanding-related effects, V.8 is shown in a more dominant fashion than V.7 [Fig.81].

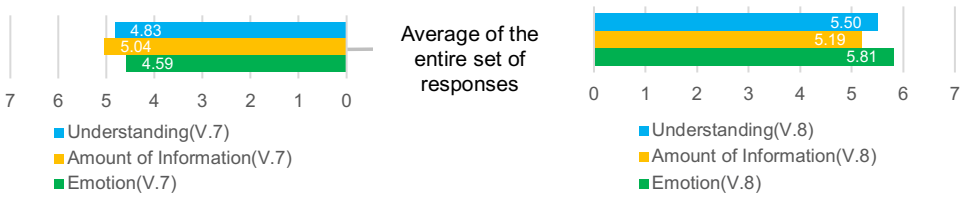


Figure 81. The average values of the entire set of responses regarding understanding-related effects of V.7 and V.8

In respect of the understanding level achieved, 61 participants regarded V.8 as easier to understand compared to V.7. Among those, 39 respondents cited the reason for this view as partly being base on the use of multiple arrows which have different thicknesses and scales. In addition, there were other 27 respondents who struggled to fully appreciate another sample. They considered that V.7 is confusing as regards being an accurate representation of contamination of the Pacific Ocean because of the type of heat map used, even though the original intent of the visualization was to represent air pollution in the Pacific region.

In addition, with regard to the degree of emotional stimulation, 56 interviewees evaluated that V.8 was more effective than V.7. Among this group, 21 participants said the pace perceived from the length and thickness of the larger arrow in the center made the wind feel more threatening. In addition, some interviewees thought that the multiple arrows pointing in various directions made the radiation contamination appear to spread to more diverse and wider locations across the entire area within view.

6.4.4.2. The understanding-related effects given to V.7 and V.8 by region

[Fig.82] below indicates the average values of the effects by country.

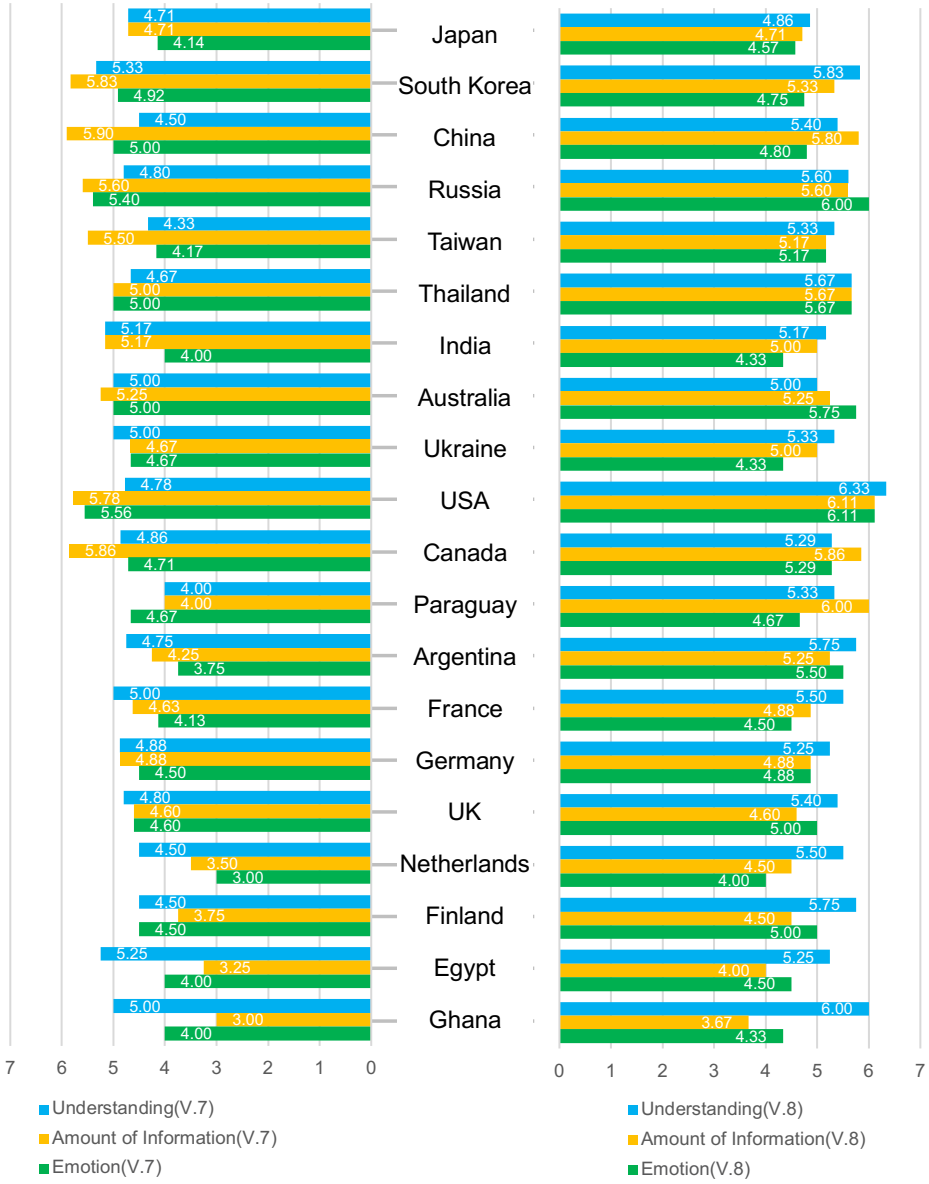


Figure 82. The average values given to understanding-related effects of V.7 and V.8 by country

The tendencies which can be discovered from [Fig.82] above is that a) the understanding level achieved from V.8 is higher than that of V.7 in almost every country (the values are equal only in two countries, Australia and Egypt); b) in Asian nations such as South Korea, China, etc., the amount of information obtained from V.7 was recognized as larger, while the countries in the Americas such as USA, Canada, Paraguay, etc. regarded the amount of information of V.8 to be larger; and c) the

emotional stimulation levels of both samples were more intense in the countries to which there was radiation spread (for example USA, Australia, Russia, etc.) once the visual materials were viewed.

The understanding-related effects of both visual instances were higher in the countries of collected visual samples. In addition, the two groups of nations evaluated that the understanding-related effects of V.8 were higher than those of V.7 [Fig.83].

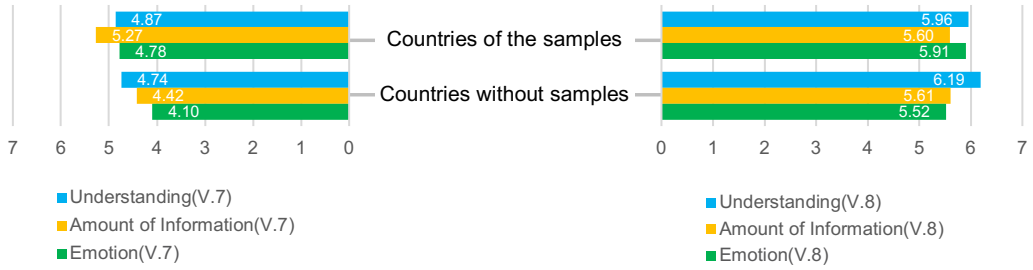


Figure 83. The average values of understanding-related effects of V.7 and V.8 depending on whether or not the countries are producers of the collected visual samples.

In addition, the understanding-related effects of both visual samples were higher in the nations of the Americas to which the radioactive wind spreads [Fig.84]. Considering the groups generally by continent, V.8 was shown to be more dominant than V.7 in producing understanding-related effects.

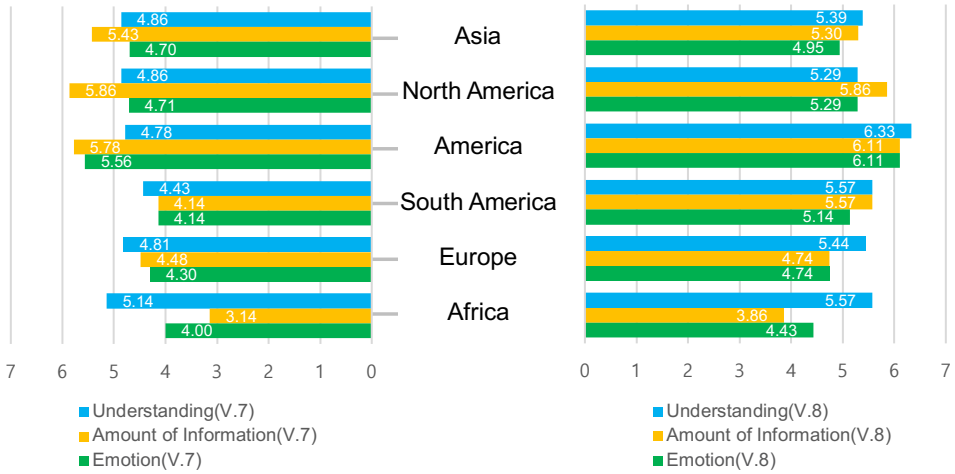


Figure 84. The average values of understanding-related effects of V.7 and V.8 by continent

The tendency in the classifications according to the surrounding environments was also similar to the

trend seen when distinguishing by continent above. Even though the understanding levels produced by V.7 was the highest among the Other Oceans party, the Pacific Ocean group demonstrated higher levels of understanding-related effects when taking the degrees of the information amount and the emotional effect into consideration [Fig.85]. In case of V.8, nations adjacent to the Pacific and Atlantic Oceans had the highest values in understanding and emotional stimulation levels.

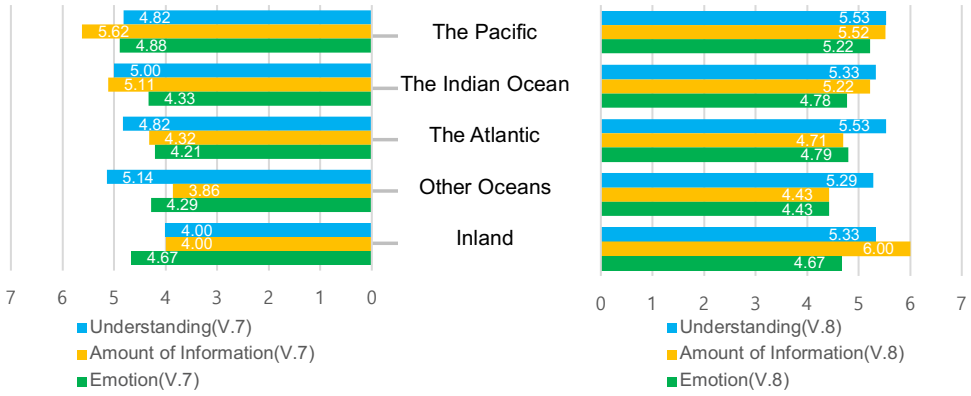


Figure 85. The average values of understanding-related effect of V.7 and V.8 according to geographical surroundings

Taking a broader view and in an effort to summarize the tendencies of the diverse regional categories above, V.8 was shown as being more dominant in producing understanding-related effects compared to V.7 in most of the regions. In addition, both visual samples were more effective in generating understanding and emotional stimulation particularly in the regional groups such as Asia, the Americas, the Pacific Ocean, Inland, etc. These groups include the countries such as Australia, Russia, Canada, USA, Argentina, Paraguay, etc. which are the regions to which the radiation spread moves or on which the vehicle of radiation passes, in the two visual materials.

6.4.4.3. The understanding-related effects of V.7 and V.8 by age

The most notable findings were observed when considering some of the results from the group of the Over 60s. This is because the levels of the understanding-related effects were generally similar in the groups from 20s to 50s, but the corresponding levels of understanding from both visualizations suddenly increased in the group of the Over 60s [Fig.86].

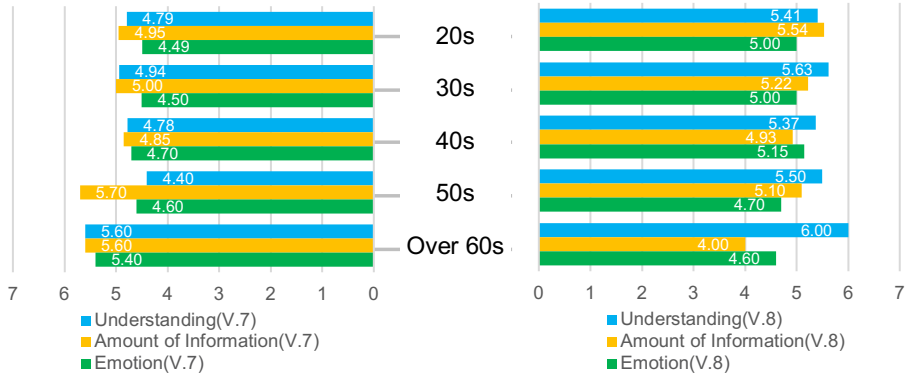


Figure 86. The average values of understanding-effects of V.7 and V.8 by age group

This group also provided higher scores to the understanding level of V.5, which employed a similar representational method based on Hue. In terms of emotional stimulation n of V.7, the trend appears to be the higher the age, the higher the degree of the effect caused.

In addition, with respect to V.8, the higher the age, the higher the understanding level, but also interestingly, the lower the degree of emotional effect and perceived amount of information.

In all groups other than the over 60s group, the levels of understanding and emotional stimulation of V.8 were higher than those of V.7.

6.4.4.4. The understanding-related effects of V.7 and V.8 by whether or not the Fukushima disaster matters, and the reasons for that response

The levels of understanding and information volume taken in from V.7 were higher among the group of “It does not matter”. Nevertheless, the degree of emotional stimulation of V.7 and the understanding-related effects of V.8 were higher among the “It matters” group [Fig.87]. In addition, both groups provided higher scores to the understanding-related effects of V.8.

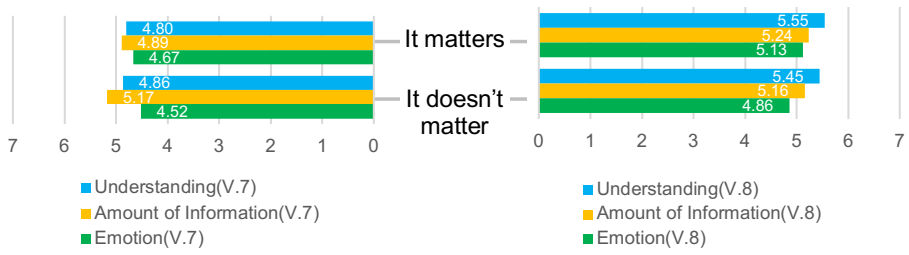


Figure 87. The average values of understanding-effects of V.7 and V.8 by whether the Fukushima event matters or not

Even though various groups, who had given reasons, demonstrated high understanding-related

effects from both visual samples, high levels of the effects produced were actually found in the groups whose reasons given were mainly related to their concerns in relation to the effects of radiation such as Raising children, Health concern, Contamination anxiety, etc. [Fig.88].

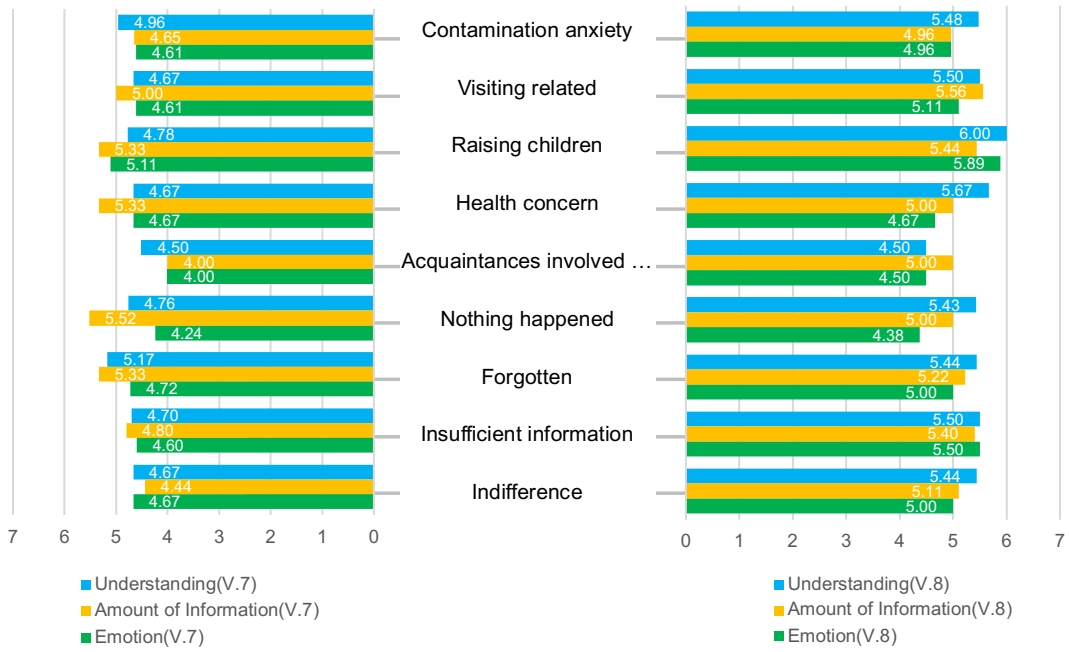


Figure 88. The average values of understanding-effects of V.7 and V.8 according to the supporting reason

In terms of V.7, the group saying “Forgotten” rated its own understanding level as being the most effective. The group giving the second highest score as to understanding level achieved was from the group of “Contamination anxiety”. In addition, the degree of emotional stimulation was the highest among the “Raising children” group.

This group also gave the highest scores to the levels of understanding and emotional stimulation of V.8. The second highest degree of understanding level of V.8 was in the “Health concern” group.

6.4.4.5. The understanding-related effects of V.7 and V.8 by perspective on the Fukushima disaster

The average values of data by perspective are depicted in [Fig.89].

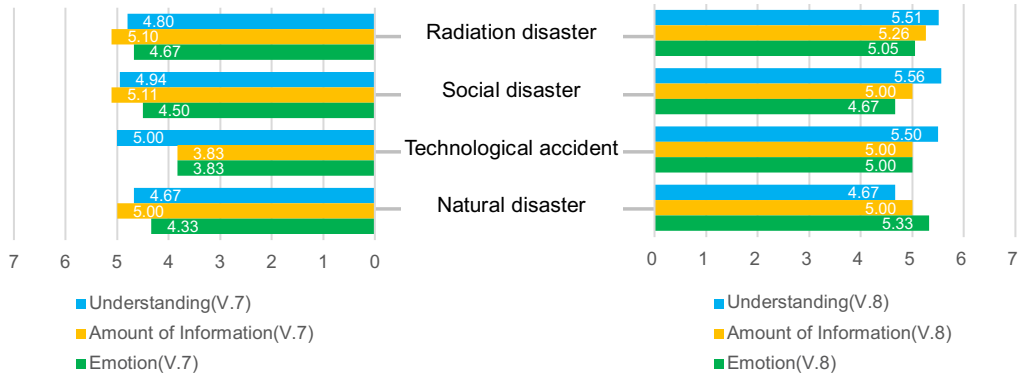


Figure 89. The average values of understanding-effects of V.7 and V.8 by perspective

When taking the effects relating to understanding together into consideration, the groups of Radiation disaster and Social disaster resulted in higher understanding-related effects of both visual samples than others. In this tendency, the effects of V.8 was higher than those of V.7.

Taking all the analysis of understanding-related effects of V.7 and V.8 into account, the overall comparison between the results can be briefly explained as per the table below [Table 36].

	V.7	V.8
Main issue	The movement of radiation diffusion	
Main purpose	Representing the vehicle of radiation spread and its direction, route, etc.	
Main representational key	Arbitrary (Hue), Non-arbitrary (Shape)	Non-arbitrary (Arrow) Non-arbitrary (Shape)
Main type	Color plot on Map	Thematic Map combined with arrows
Metonymy or Metaphor	Metaphor: Heat Metonymy: Map	Metonymy: indexical sign (arrow) Metonymy: Map
The number of information objects (information field)	5 (The route, direction, realm, and radiation level of air by location)	4 (The route, direction, strength of air by location)
Effectiveness of understanding	Effective	Effective **(More effective than V.7)**
Region	In most of the regions	In most of the regions (Particularly more effective in the regions in the influence of radiation in visual sample: groups of Asia, Americas, the Pacific, Indian and Atlantic Oceans, etc.)
Age	Over 60s and 30s	the higher the age, the higher the effectiveness
Whether or not the event matters and the reasons	In “Forgotten” group within the “It does not matter” group	In “Raising children” group within the “It matters” group
Perspective	In “Social disaster” group	In “Social disaster” group and “Radiation disaster” group
Effectiveness of transition from understanding to emotional stimulation	Effective	Effective **(More effective than V.7)**

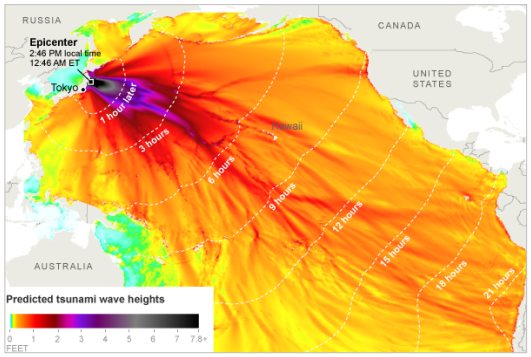
Region	In the groups of Asia, Americas, and the Pacific and Indian Oceans, etc.	In most of the regions (Particularly more effective in the regions in the influence of radiation in visual sample: groups of Asia, Americas, the Pacific, Indian and Atlantic Oceans, etc.)
Age	the higher the age, the higher the effectiveness	the higher the age, the lower the effectiveness
Whether or not the event matters and the reasons	In “Raising children” group within the “It matters” group	In “Raising children” group within the “It matters” group
Perspective	In “Radiation disaster” group	In “Natural disaster” group

Table 36. The summary of the understanding-related effects of V.7 and V.8

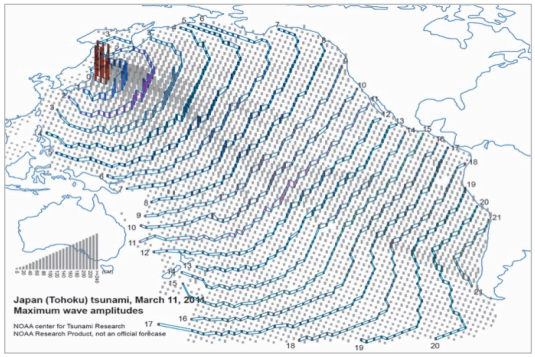
Therefore, with regard to the representation of the movement and spread of radiation, the use of multiple arrows is likely to be a more effective representational method in leading to understanding for various participants from diverse regions when compared to use of another key, hue. From the aspect of metaphor and metonymy, this means that the metaphorical expression of the thermography could be less effective than the metonymical representation of indexical sign, which is where the arrow describes the movement and spread of radiation contamination. In particular, this tendency is highly probable to be more evident in the countries included in the regions that were directly influenced by radiation spread in the visualization.

6.4.5. The understanding-related effects of V.9 and V.10

[Table 37] below presents V.9 and V.10 again.



V.9. Predicted Tsunami Wave Height



V.10. Predicted Tsunami Wave Height (02)

Table 37. V.9 (Predicted Tsunami Wave Height) and V.10 (Predicted Tsunami Wave Height (02))

The visual materials above aim to represent information and data as to the height and spread of tsunami depending on time and space. [Table 38] briefly explains the analysis of both visual materials again.

No.	Issues	Detailed field	Purpose (Variables)	Representational key (A: Arbitrary / N: Non-arbitrary)	Types of Vis. (M: Map / C: Chart / T: Technical drawing / P:Photograph)	Metaphor and Metonymy (Mp: Metaphor / Mn: Metonymy)
V.9	The spread and height of the tsunami	By time and space (the Pacific)	Indicating the height	A (Hue)	C (Color plot)	Mp (Heat)
			Indicating the time and range	A (Line)	T (Process graphic)	
			Indicating the locations	N (Shape)	M (The world(Pacific))	Mn (Map)
V.10	The spread and height of the tsunami	By time and space (the Pacific)	Indicating the height	A (Bar)	C (Bar chart)	
			Indicating the time and range	A (Line)	T (Process graphic)	
			Indicating the locations	N (Shape)	M (The world(Pacific))	Mn (Map)

Table 38. The analysis of V.9 and V.10

These two visualizations share a common topic which is the height and spread of the tsunami which occurred on 11th of March, 2011. The two samples contain not only the same main issues but also include the same data, since V.10 was produced by the researcher based on the data released by NOAA who created V.9.

Having said that, they do have differences in their expressional methods, in particular, the kind of

representational key and the type of visualization employed. V.9 employs Hue as its representational key and the type of visualization is a combination of color plot on map. In addition, due to the Hue based on thermography, the metaphorical expression of heat map is applied to this sample. On the other hand, V.10's representational key is Bar and its type is a mixture form combining bar chart and map.

There has already been a brief comparative analysis between V.5 and V.6. The difference between that discussion and this comparison lies in the issues surrounding the visual materials, namely the level of radiation and the height and distribution of the tsunami. Despite this difference, this subsequent comparison between V.9 and V.10 would be helpful to reveal with greater clarity the difference of understanding-related effects between the disparate types of visualization based on the two representational keys, Hue and Bar in relation to the presentation of quantitative data.

6.4.5.1. The overall average values of understanding-related effects of V.9 and V.10

In terms of the overall understanding-related effects, V.10 scores higher as to the level of understanding achieved, while V.9 leads to higher degrees of emotional stimulation and amount of information taken in. This is shown in [Fig.90].

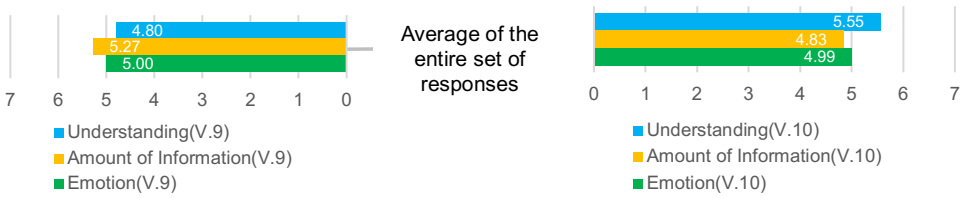


Figure 90. The average values of the entire set of responses regarding understanding-related effects of V.9 and V.10

69 people preferred V.10 to assist their overall understanding. About 60% of this group (38) gave their reasons on the same basis that the comparison of different lengths makes it easier to understand the status of the height, compared to the different hues. In addition, 11 respondents replied that they misunderstood V.9 to be a map which represented radiation contamination on the Pacific Ocean. This is similar to the reactions of people who saw the NOAA's wave amplitude map aforementioned in the introduction chapter.

By contrast, there were also 44 participants who stated that V.9 was easier to understand. Among those, 9 respondents replied that the interpretation of V.9 was more familiar to them because such type

of data representations (V.9) had already been generally used to visualize wave heights. Even though this in itself is not a large number, such replies nevertheless show that there is a noticeable difference in effective methods, depending on the viewer of visualization.

In terms of the degree of emotional stimulation, and in keeping with the previous comparison between V.5 and V.6, V.9, which employs Hue, scores higher than an alternative sample. In both comparisons, the samples which used Hue were less effective in understanding but more intense in emotional effects. This is highly likely to originate from not only understanding information itself but also from other elements of visualization: possibly, Hue. 45 people gave higher scores as to V.9's emotional stimulation degree, and most of those cited the reason that the reddish colors on the Pacific Ocean seemed to make the situation more serious. This is the same reason given by the participants who referred to V.5's apparently greater emotional effect as well.

With regard to the amount of information observed, even though both visual samples represent the same data, 52 respondents suggested that V.9 dealt with a greater amount of information than V.10. One respondent supported their response by replying that the hues fully covered the Pacific Ocean in V.9, while there was the perception of an omission of data due to the empty spaces between the bars in V.10.

6.4.5.2. The understanding-related effects of V.9 and V.10 by region

In the case of map-based visualizations, the understanding-related effects seemed to be higher in the regions which themselves appeared in the visualizations [Fig.91].

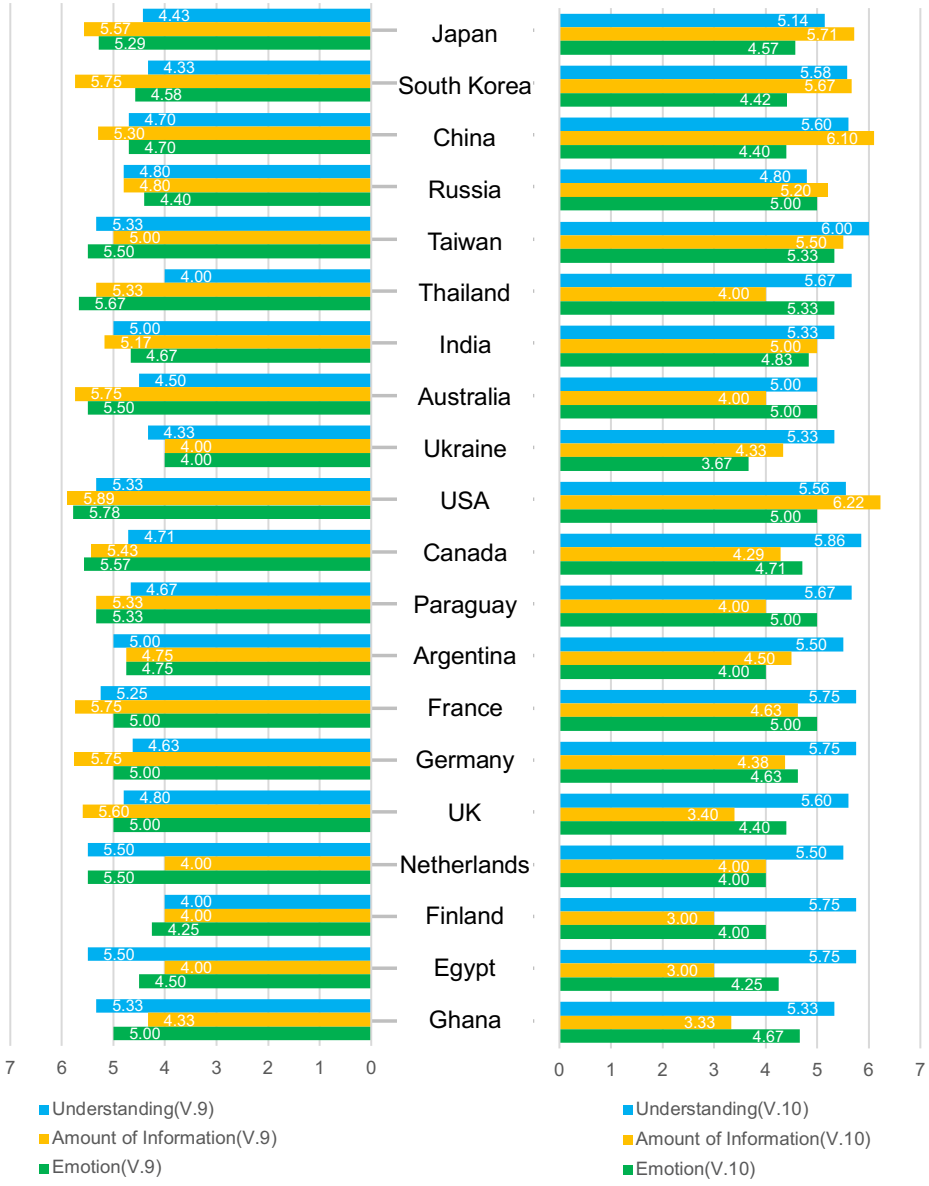


Figure 91. The average values of understanding-related effects of V.9 and V.10 by country

The patterns observed from the category by country [Fig.91] are that a) in most countries except for Russia, Netherlands, and Ghana, the understanding level of V.10 was higher than that of V.9; b) the amount of information in V.9 was regarded as larger than that of V.10 in 13 nations relatively more distant from Japan; and c) the degree of emotional stimulation of V.9 scores higher than that of V.10 in 16 countries except for Russia, India, Australia, and France.

When categorizing the nations into two groups depending on whether or not the countries are the producers of the collected cases, the average values of the understanding-related effects can be

presented below [Fig.92].

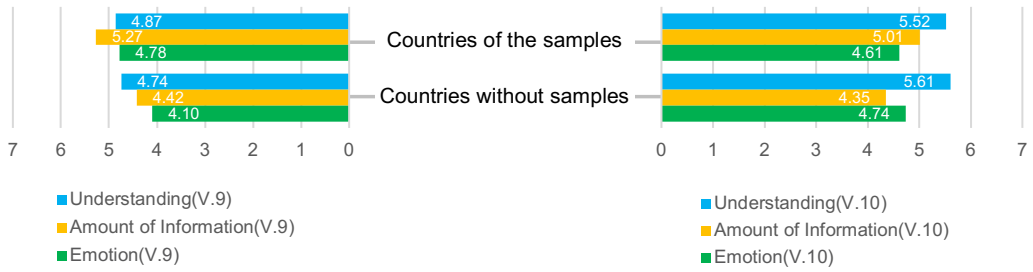


Figure 92. The average values of understanding-related effects of V.9 and V.10 depending on whether or not the countries are producers of the collected visual samples.

In terms of both visual instances, the amount of information visible was perceived to be higher in the producers of the collected samples, while the levels of both the understanding and emotional stimulation were higher in the nations which are not the producers of the samples.

In addition, the understanding-related effects of V.9 was higher in the producers and those of V.10 was more evident in others.

Finally, both groups of countries have higher levels of understanding from V.10 than V.9 and higher degrees of emotional effect in response to V.9 than V.10.

[Fig.93] depicts the average values of understanding-related effects by continent.

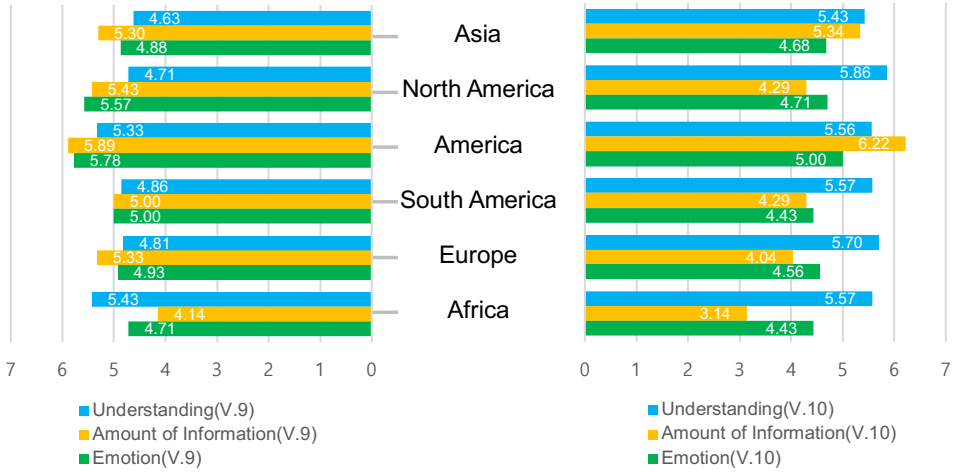


Figure 93. The average values of understanding-related effects of V.9 and V.10 by continent

When considering V.9, the highest level of understanding was found in Africa and the second highest level was in America. When including the degree of the emotional effect, the understanding-related

effects of this visual sample are higher in the groups of America and North America than other groups. On the other hand, the degrees of understanding and emotional stimulation of Asia were lower than others.

This result is quite different from the tendency of V.5 of the previous comparison which employs similar representational methods: the closer the distance from the area of the accident, the higher the values of understanding-related effects. It seems that this difference stemmed from the main topic (information) of the visualization. V.5 represents the distribution and level of radiation accumulated across the entirety of Japan, while the groups showing high effectiveness in understanding and emotional stimulation are close to this highly contaminated area. On the other hand, V.9 depicts the height and spread of the tsunami from Japan to other countries across the Pacific. In case of V.9, those who had higher understanding-related effects tended to hail from the nations to which the tsunami spreads. On the contrary, the group from Asia (including Japan from where the tsunami originated) elicited lower levels of the effects.

Another notable point is that, among the Asian countries, the understanding-related effects of V.9 scored higher in Japan, which was clearly affected most directly by the tsunami, as well as Australia by which the tsunami passed. Meanwhile the understanding-related effects were relatively lower in the nations less impacted by the tsunami spread such as South Korea, China, Russia, India, Ukraine, etc. Such tendency has also been discovered through another previous comparison between V.7 and V.8: the understanding-related effects of the visual materials were higher in the regions under the heaviest influence of the main objects dealt with in the visualizations.

The understanding-related effects of V.10 are similar to the tendencies above as well. The groups of America and North America to which the tsunami spread showed higher levels of understanding and emotional stimulation, compared to the group of Asia. In addition, V.6, with its similar expressional methods, which were explored in the previous comparison, also earned higher understanding-related effects among the countries closest to the influence of the main topics in the visualization sample.

After all, the tendencies above suggest that the regional conditions are deeply involved and indicative of the effects of understanding and emotional stimulation.

The inclination among the groups depending on their geographical environments also follows the

same trend as above. In terms of the effect of understanding of V.9, the highest score belonged to the Other Ocean group. However, when considering understanding level, volume of information, and the degree of emotional effects all together, the overall effects were higher in the groups of the Pacific and Indian Oceans, whose nations were under the direct influence of the tsunami spread in the visual material [Fig.94].

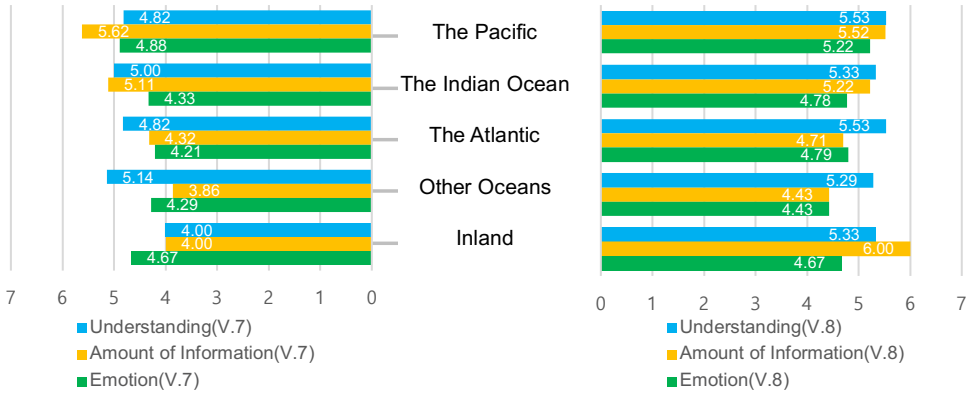


Figure 94. The average values of understanding-related effect of V.9 and V.10 by geographical surroundings

V.10 also produced a similar pattern. Even though the gaps among the groups in respect of their understanding level are not significant, the degree of understanding-related effects of the Pacific Ocean group is nevertheless higher than others.

To summarize the patterns of the diverse regional categories above, in most of the regions, V.9 whose representational key was Hue, was deemed more effective than V.10 in emotional stimulation. On the other hand, V.10, which used Bar as a representational key, was more effective than V.9 in resulting in overall understanding. Even though there is a difference in degree, this inclination is similar to the result of the previous comparison between V.5 and V.6.

The actual effectiveness of those techniques, however, differs depending on locational and environmental conditions. To be more specific, understanding-related effects of both visual samples were higher in the groups of Asia, America, North America, the Pacific Ocean, the Indian Oceans, etc. whose countries were under the direct influence of the tsunami, and which is the central topic of the two visual materials. This tendency is similar to the findings from the previous comparison between V.7 and V.8.

Therefore, these present the inclinations that a) when representing the height and spread of tsunami,

the combination of map and color plot chart based on Hue is highly likely to be more effective in emotional stimulation compared to the combination of map and bar chart; and b) When dealing with the same data and information, the combination of map and bar chart composed of Bar is more effective in understanding compared to the form based on Hue. In particular, these tendencies are highly likely to be more evident among people from the nations under the influence of the tsunami represented in visualization.

6.4.5.3. The understanding-related effects of V.9 and V.10 by age

Similar to the overall tendency, in every age group, the understanding levels of V.9 were more dominant than those of V.10 while the degrees of emotional stimulation of V.10 scored higher than those of V.9 [Fig.95].

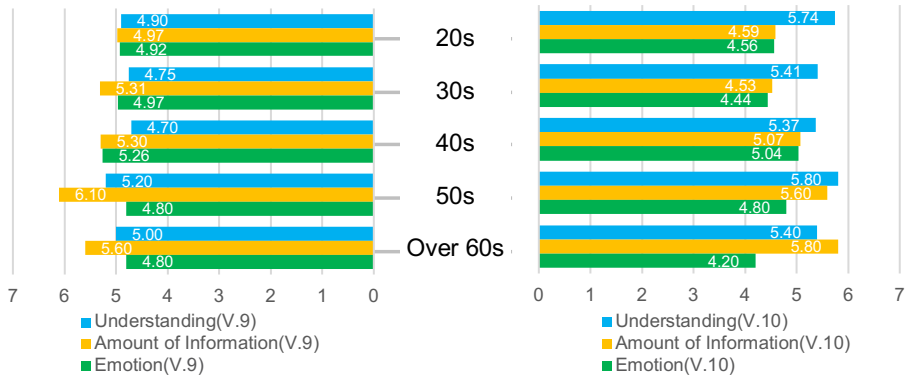


Figure 95. The average values of understanding-effects of V.9 and V.10 by age group

In case of V.9, the level of understanding scored the highest for those in their 50s and the second highest scores were observed for the Over 60s group. In addition, the degree of emotional stimulation was higher among the groups in their 30s and 40s. On the other hand, in terms of V.10, the understanding level was the highest among the 50s group, and the second highest was seen in the group in their 20s. The degree of emotional effects scored the highest among the 40s group; the second highest was among the 50s group.

The tendency of all the groups between their 20s and 50s regarding V.9 and V.10 is similar to the patterns witnessed in the same age groups who considered V.5 and V.6. Nevertheless, the group of the Over 60s had slightly lower understanding-related levels of V.9 and V.10 compared to those of V.5 and V.6. One potential explanation for this pattern could be due to the nationalities of the participants of the

Over 60s group. Among the 5 respondents in this group, 4 are from South Korea and 1 is from France. It is undeniable that South Korea is behind the tsunami spread in the visual samples. This suggests that the regional conditions were involved more evidently in understanding-related effects, in comparison to the age-related conditions.

6.4.5.4. The understanding-related effects of V.9 and V.10 by whether or not the Fukushima disaster matters, and the reasons for that response

It seems that the visual syntax of V.10, which is composed of Bar chat and map is easier for even those who have been distant from this event psychophysically. Meanwhile, V.9 is based on Hue and map, and is generally easier for people who already have had background knowledge of or interest in this event to understand what is being communicated to them [Fig.96].

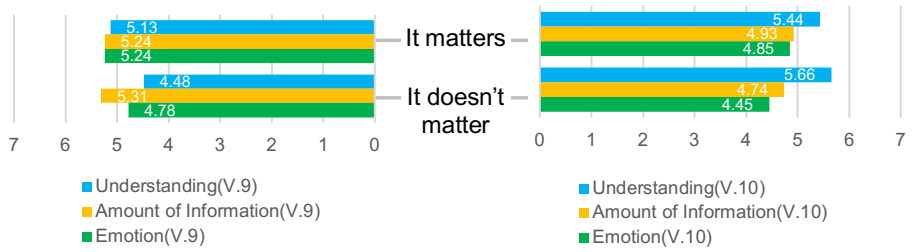


Figure 96. The average values of understanding-effects of V.9 and V.10 by whether the Fukushima event matters or not

In case of V.9, the levels of understanding and emotional stimulation were higher among the group of “It matters”. In addition, the degree of emotional effect brought about by V.10 also scored higher in this group. On the other hand, the understanding level of V.10 was higher in the other group, “It does not matter”.

The tendencies observed when organizing the groups into categories by reasons given also reflects the trend above. The understanding level resulting from V.9 was mainly higher in the reason groups within the group of “It matters”. The group which gave the highest score to V.9 in terms of understanding achieved was the Raising children group, closely followed by the Visiting related group, with a slight

gap of 0.05 points. In terms of the volume of information of this sample, the groups of “Health concern” and “Acquaintances involved in the event” provided the highest score. The degree of emotional stimulation was the highest in the Raising children group; the second highest in this category was from the group of Contamination anxiety [Fig.97].

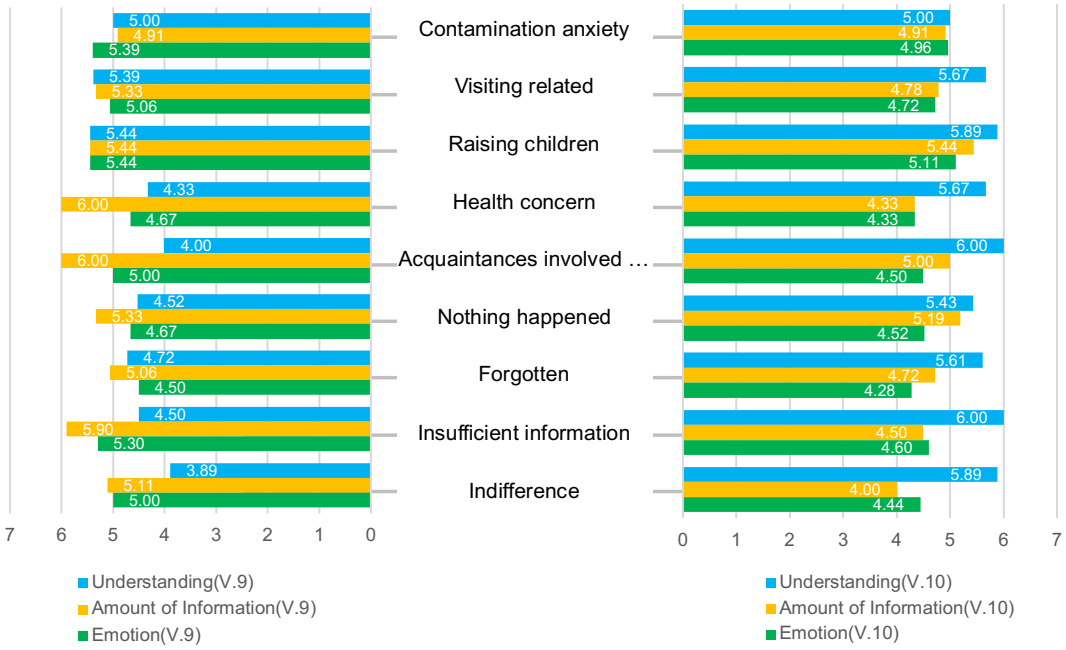


Figure 97. The average values of understanding-effects of V.9 and V.10 according to the reason given for the response

By contrast, in case of V.10, the groups with high understanding-related effects were supported by a more diverse set of reasons for the answers given. The highest level of understanding belonged to the “Acquaintance involved in the event” and “Insufficient information” groups. In addition, the second highest level found was in the “Raising children” and “Indifferent” groups. In terms of the amount of information observed, the “Raising children” and “Nothing happened” groups provided the highest and second highest scores respectively. In terms of the emotional effect of V.10, the highest degree found was in the “Raising children” group and the second highest level was in the “Contamination anxiety” group.

6.4.5.5. The understanding-related effects of V.9 and V.10 by perspective on the Fukushima disaster

The emotional stimulation of both visual materials seemed to occur more evidently in the participants

whose perspective is linked to the main issue of the visual samples: the group of Natural disaster provided the highest scores as to the degree of the emotional effect of V.9 and V.10. The amount of information contained in both materials was perceived to be the largest among this group as well [Fig.98].

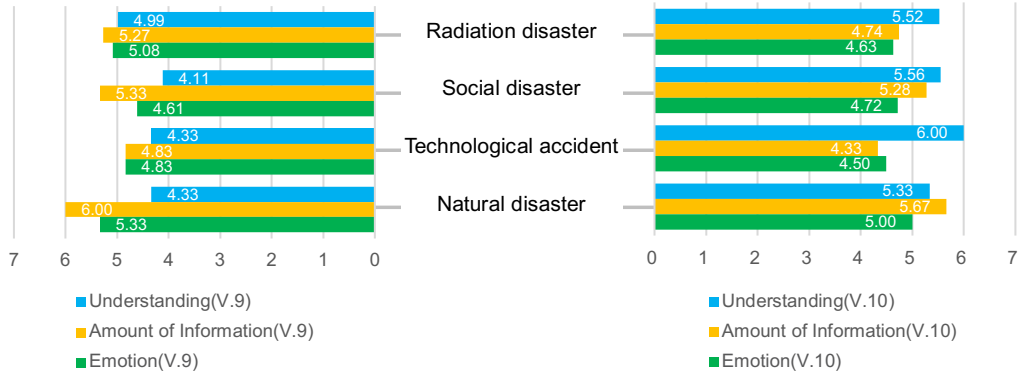


Figure 98. The average values of understanding-effects of V.9 and V.10 by perspective

On the contrary, in case of other effects seen, with the exception of emotional stimulation, it is difficult to find a connection between the perspective groups with high scores and the main subject (tsunami). In terms of V.9, the group which regarded the understanding level as the highest was the Radiation disaster group. In particular, this group also provided the highest score to the understanding level of V.5 whose representational methods were similar to V.9. The second highest score for understanding level was from the Natural disaster and Technological accident groups. In addition, in case of V.10, its understanding level was deemed highest from the Technological group.

Taking all the analysis above into consideration, the comparison between V.9 and V.10 can be summarized as per the [Table 39] below.

	V.9	V.10
Main issue	The height and spread of the tsunami	
Main purpose	Representing the height and spread of the tsunami by time and space	
Main representational key	Arbitrary (Hue), Non-arbitrary (Shape)	Arbitrary (Bar), Non-arbitrary (Shape)
Main type	Color plot on Map	Bar chart on Map
Metonymy or Metaphor	Metaphor: Heat Metonymy: Map	Metonymy: Map
The number of information objects (information field)	3 (The height, spread (location), time)	3 (The height, spread (location), time)
Effectiveness of understanding	Effective	Effective **(More effective than V.9)**

Region	Particularly more effective in the regions under the influence of the tsunami in visual sample: Japan, the groups of North America, America, the Pacific Ocean, Indian Ocean, Other Oceans, etc.	In most of the regions (Particularly more effective in the regions under the influence of the tsunami in visual sample: the groups of North America, America, the Pacific Ocean, Atlantic, etc.)
Age	50s and 20s	50s and 20s
Whether or not the event matters and the reasons	In “Raising children” group within the “It matters” group	In “Acquaintances involved” group within the “It matters” group and “Insufficient information” group within the “It does not matter” group
Perspective	In “Radiational disaster” group	In “Technological accident” group
Effectiveness of transition from understanding to emotional stimulation	Effective **(More effective than V.10)**	Effective
Region	In most of the regions (Particularly more effective in the regions under the influence of the tsunami in visual sample: the groups of North America, America, the Pacific Ocean, Inland, etc.)	Particularly more effective in the regions under the influence of the tsunami in visual sample: the groups of North America, America, Asia, the Pacific Ocean, etc.)
Age	30s and 40s	40s and 50s
Whether or not the event matters and the reasons	In “Raising children” group within the “It matters” group	In “Raising children” group within the “It matters” group
Perspective	In “Natural disaster” group	In “Natural disaster” group

Table 39. The summary of the understanding-related effects of V.9 and V.10

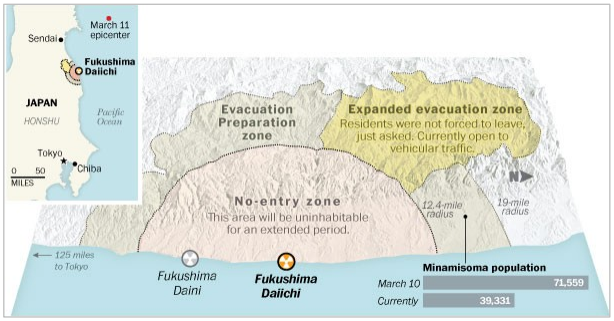
With regard to the representation of the height and spread of the tsunami on the Pacific Ocean, the combination of map and a representational key (Bar) was seen as being more effective in understanding among most of the participants, compared to the combined use of map and another key, Hue. On the other hand, in case of emotional stimulation, the type of color plot based on Hue on map was more effective than the form of bar chart on map.

In particular, the understanding-related effects of both visual samples were higher among the respondents from the nations where certain regions were under the influence of the tsunami which was a main topic of the visual samples. This regional condition was more evidently involved in the understanding-related effects compared to the condition of age.

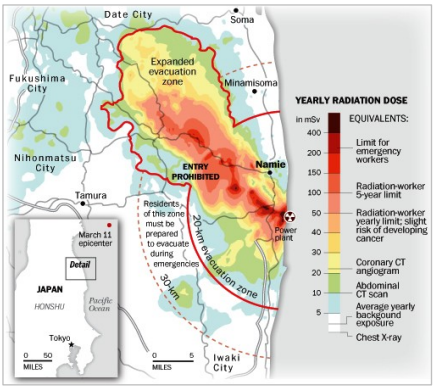
In addition, the degrees of emotional effect of both visual instances were the highest among the people whose perspectives on this event was that of the natural disaster, that being the closest to the main topic of both visual samples.

6.4.6. The understanding-related effects of V.11 and V.12

[Table 40] below presents V.11 and V.12 again.



V.11. Fukushima plant radiation



V.12. Yearly Radiation Dose

Table 40. V.11 (Fukushima plant radiation) and V.12 (Yearly Radiation Dose)

A common purpose behind the visual samples above is to represent the domain of exclusion and evacuation zones. [Table 41] below briefly presents the analysis of both visual instances again.

No.	Issues	Detailed field	Purpose (Variables)	Representational key (A: Arbitrary / N: Non-arbitrary)	Types of Vis. (M: Map / C: Chart / T: Technical drawing / P:Photograph)	Metaphor and Metonymy (Mp: Metaphor / Mn: Metonymy)
V.11	The realm and location of the exclusion and evacuation zones	Near the Fukushima NPP	Indicating the realms	A (Hue)		Mp (Heat)
			Indicating the locations	N (Shape)	M (Near the Fukushima NPP)	Mn (Map)
V.12	The realm and location of the exclusion and evacuation zones and the distribution and level of radiation	By the regions (Fukushima and its neighboring regions)	Representing the distribution and levels of radiation depending on space	A (Hue)	C (Color plot)	Mp (Heat)
			Indicating the realms	A (Line)		Mp (Heat)
			Indicating the locations	N (Shape)	M (Fukushima and nearby regions)	Mn (Map)

Table 41. The analysis of V.11 and V.12

Despite some shared issues being discussed and purpose, however, the two diagrams incorporate different expressional manners and different kinds of additional information. V.11 employs Hue as a representational key so as to divide the realms of exclusion and evacuation zones. The additional information includes the population of a region within the evacuation zone before and after the accident, whose data are displayed by the type of bar chart. On the other hand, V.12 uses lines to indicate the

domains of exclusion and evacuation zones: thick red lines used to mark out the exclusion zone and a thin dotted line to represent the evacuation zone. The additional information referred to above relates to the level of radiation contamination in the restricted areas; the data indicating the radiation level is depicted by the type of color-plot chart based on Hue. One particular point to note here is that the realm of this color plot presents the cause of the exclusion and evacuation zones: the shapes of these restricted zones are revealed along the border of the domain of the heavily contaminated areas.

6.4.6.1. The overall average values of understanding-related effects of V.11 and V.12

In the overall average values given, the understanding level given to V.11 was higher than those of any other visual materials [Fig.99]. In addition, almost all respondents (96 people) preferred V.11 in terms of their understanding level when comparing V.11 and V.12. The standard deviation of the total population for the understanding levels of V.11 is 0.69 (the lowest point was 6 and the highest point was 8). However, this sample produced lower scores in the amount of information recognized by participants, as well as the degree of emotional stimulation compared to those felt as a result of V.12.

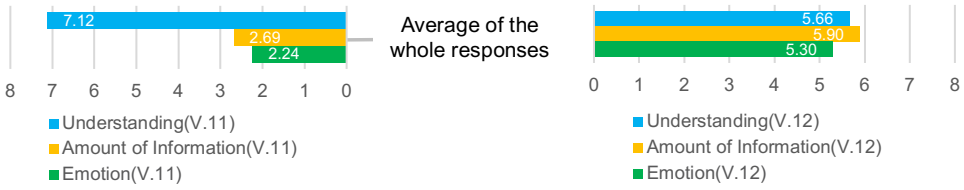


Figure 99. The average values of the entire set of responses regarding understanding-related effects of V.11 and V.12

Another notable point is the relatively small gap between the understanding levels behind the two samples, when compared to the large gaps witnessed between other effects of those two. By way of further explanation, the gaps between the overall averages of information amounts and emotional effect of the two samples are 3.21 and 3.14 respectively, and these are found to be the highest gaps among all visual materials. Nevertheless, the gap between the understanding levels of the two materials is 1.46, which is smaller than the gaps observed in other effects. This shows, after all, V.12's high effectiveness in producing understanding in the participants.

There were 12 participants whose tendencies were different from that described in the overall averages: 5 respondents stated that V.12's understanding level was higher than that of V.11, and 7 participants said the two instances resulted in the same understanding level.

One respondent who gave a higher score to V.12's understanding level mentioned the causality between radiation contamination and the realms of restricted zones as being a reason for that opinion. He said that the realm of the contaminated area presented by the type of color-plot chart helped understanding since it was an obvious indication of the restricted zones.

In addition, it was possible to find responses that supported the position that metaphorical expression of thermography based on Hue is effective in leading to emotional stimulation following the understanding process. Almost all respondents (110 people) regarded V.12 as more effective in emotional stimulation compared to V.11 and most of those described how they felt the situation of the exclusion zone was more serious due to the visual effect of the reddish color-plot chart of the contaminated area which overlapped the domain of the restricted zones.

6.4.6.2. The understanding-related effects of V.11 and V.12 by region

The tendency of the overall averages above is not significantly different from the inclinations observed by country. The tendencies which can be discovered in [Fig.100] below are a) the understanding level of V.11 is higher than that of V.12 in all countries; b) the amount of information observed in V.12 was perceived as being more than that available in V.11 in all nations; c) the degree of emotional stimulation of V.12 was higher than that of V.11 in all countries. In particular, with regard to the information amount, the maximum gap between the two samples is 3.2 times in the UK. The degree of emotional stimulation produces similar results: the maximum gap between the materials is 3.4 times in Russia.

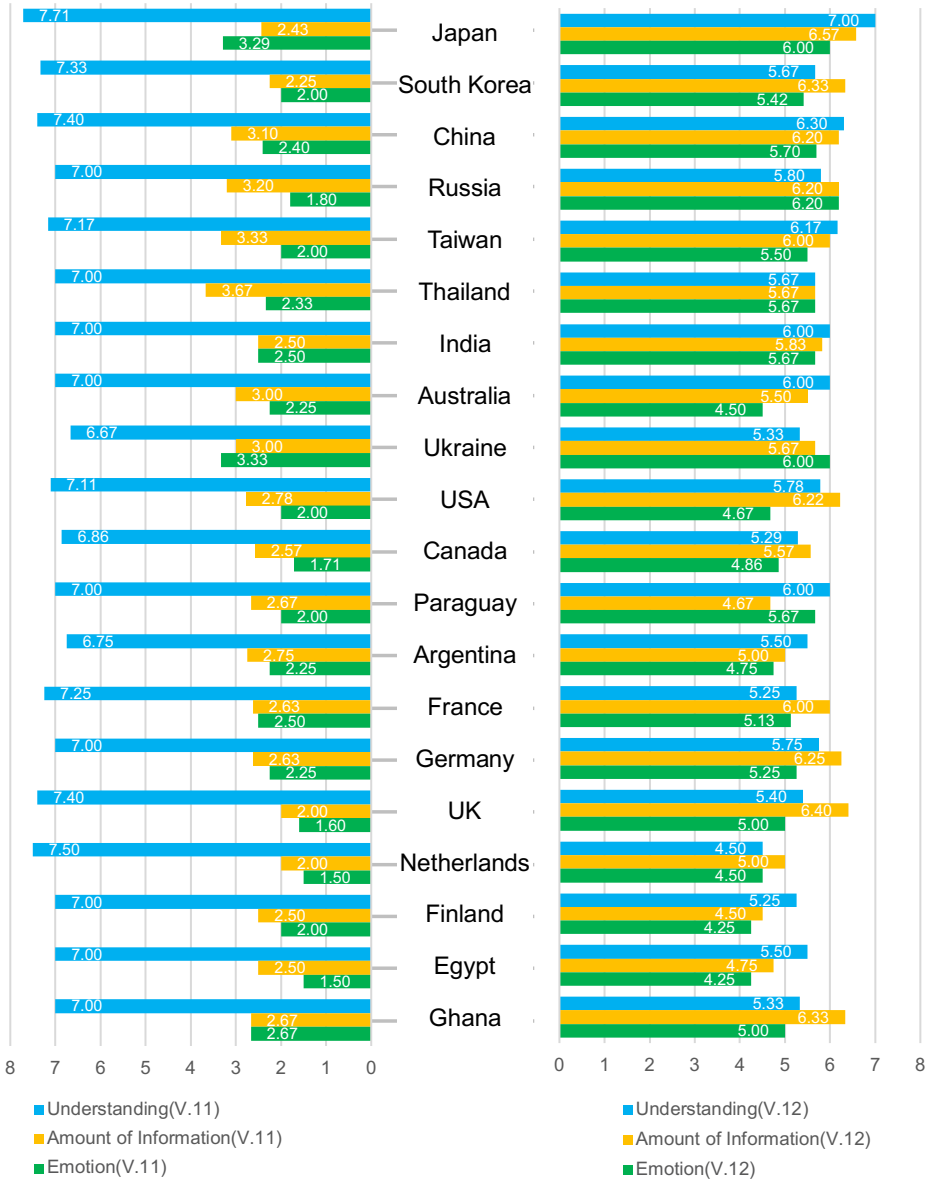


Figure 100. The average values of understanding-related effects of V.11 and V.12 by country

These general tendencies show that: a) a simple and small volume of information in visualization is likely to lead to a high level of understanding, and b) high understanding level does not necessarily result in high emotional stimulation.

In the categories depending on whether or not the nations are the producers of collected samples or not, the levels of understanding and emotional stimulation of both visual samples were higher among the producers of the collected samples [Fig.101].

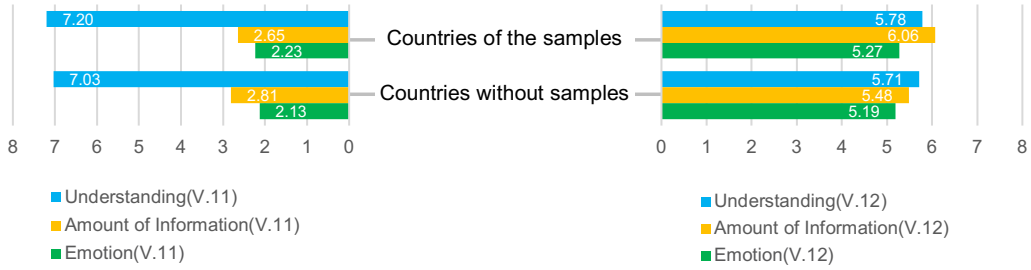


Figure 101. The average values of understanding-related effects of V.11 and V.12 depending on whether or not the countries are producers of the collected visual samples.

In addition, and similar to the tendencies observed across the overall average, V.11 was more seen to be effective in understanding while V.12 was more effective in emotional stimulation across both groups.

When it comes to the patterns observed according to continent, it seems that the visualization which deals with the local area such as with the two samples is more easily understood, mainly by those who are familiar with that region[27]. In case of V.11, the understanding-related effects were the highest amongst the Asias groups. In addition, V.12 was also the most effective in understanding and emotional stimulation in the same group [Fig.102].

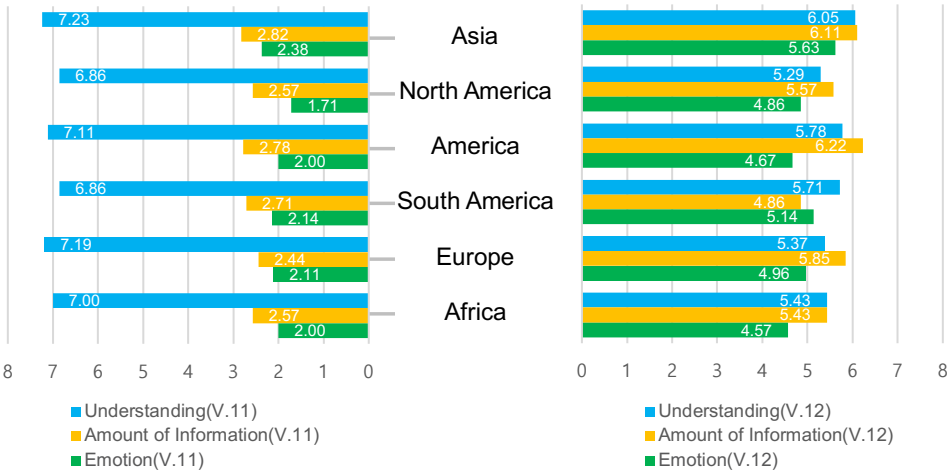


Figure 102. The average values of understanding-related effects of V.11 and V.12 by continent

The patterns of the groups by their own geographical environments are similar to the results

[27] In particular, the understanding-related effects of the two materials were the highest in Japan [Fig.100].

described immediately above. The understanding level of V.11 was the highest in the group of the Pacific Ocean (which includes Japan) and the information amount and emotional stimulation levels were the highest in the Indian Ocean group, one which is composed of nations which are also relatively close to Japan [Fig.103].

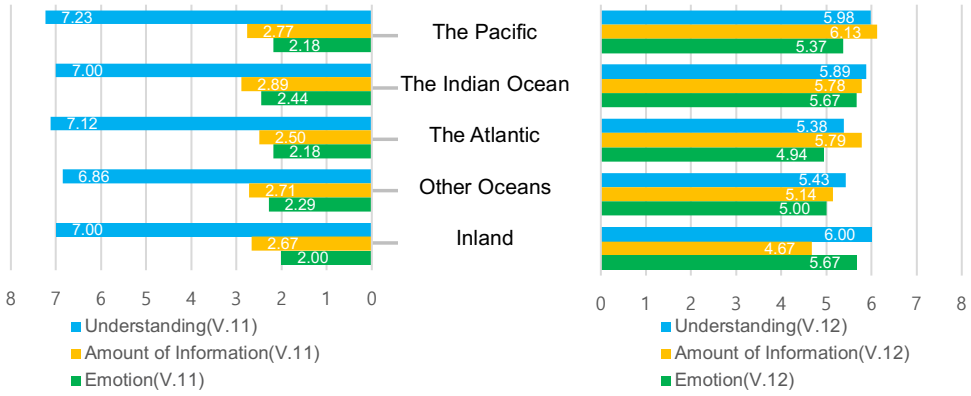


Figure 103. The average values of understanding-related effect of V.11 and V.12 by geographical surroundings

In the case of V.12, the level of understanding was the highest in the Inland group. However, the ultimate values given were higher in the Pacific Ocean group compared to the Inland group since there was only a small gap (only 0.02 points) between the understanding levels of the two groups, while the perceived information amount was evidently larger in the Pacific Ocean group.

The Indian Ocean group also showed high understanding-related effects with respect to V.12 as well. The information amount perceived was second highest and the level of emotional stimulation recorded was the highest in this group.

To summarize the tendencies of the various regional categories above, V.11, with its comparatively small volume of information resulted in a remarkably high understanding level, but noticeably low degree of emotional stimulation for all responding regions.

In the case of V.12, which contains more volume of information, the levels of understanding and emotional stimulation were higher mainly among the regions close to the local area that was the very subject of the visual sample: this group includes Japan and other groups including Asia, the Pacific Ocean, the Indian Ocean, etc.

6.4.6.3. The understanding-related effects of V.11 and V.12 by age

In the category depending on age, almost all groups demonstrated a similar tendency except for the sudden reduction in the levels of emotional effects of both visual samples in the group of the Over 60s [Fig.104]. Nevertheless, the levels of understanding-related effects were the highest in the group of 20s with only small variations in the averages here.

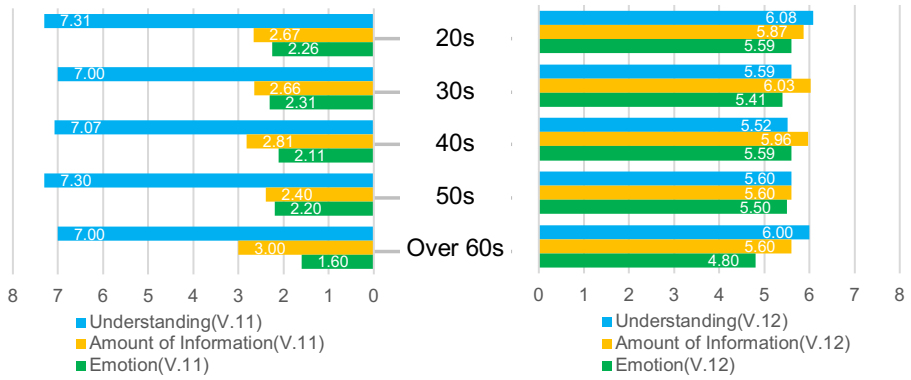


Figure 104. The average values of understanding-effects of V.11 and V.12 by age group

6.4.6.4. The understanding-related effects of V.11 and V.12 by whether or not the Fukushima disaster matters, and the reasons for that response

It is difficult to find significant differences between the groups of “It matters” and “It does not matter”: the understanding levels of both groups were still high in respect of V.11, exceeding 7 points, and the understanding levels of V.12 were similar across the two groups [Fig.105]. However, the degrees of emotional effect of both visual materials were higher in the “It matters” group despite a narrow differential in the averages.

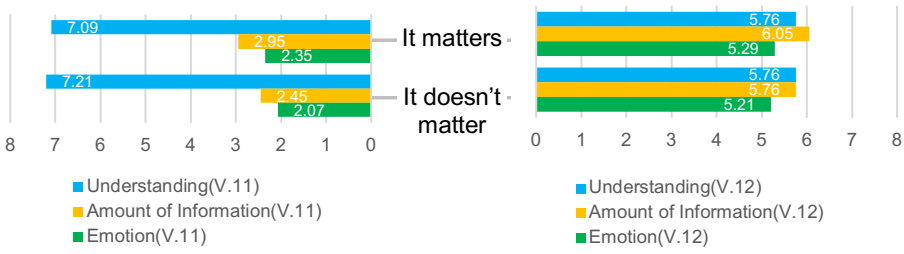


Figure 105. The average values of understanding-effects of V.11 and V.12 by whether the Fukushima event matters or not

With regard to groupings according to the reasons given for their respective responses, the understanding-related effects of both visual instances scored the highest in the group of “Acquaintance involved in the event” [Fig.106]. In particular, the noticeably high values in this group are in part due to the small number of people in this group (2 Japanese participants). Furthermore, when taking their concerns into account, it seems that their understanding levels were affected by similarities between their concerns and the main issues tackled by the visualization. This is because one of the two in this group had an acquaintance who was evacuated from the Fukushima accident and another participant who had a friend who frequently entered Fukushima prefecture.

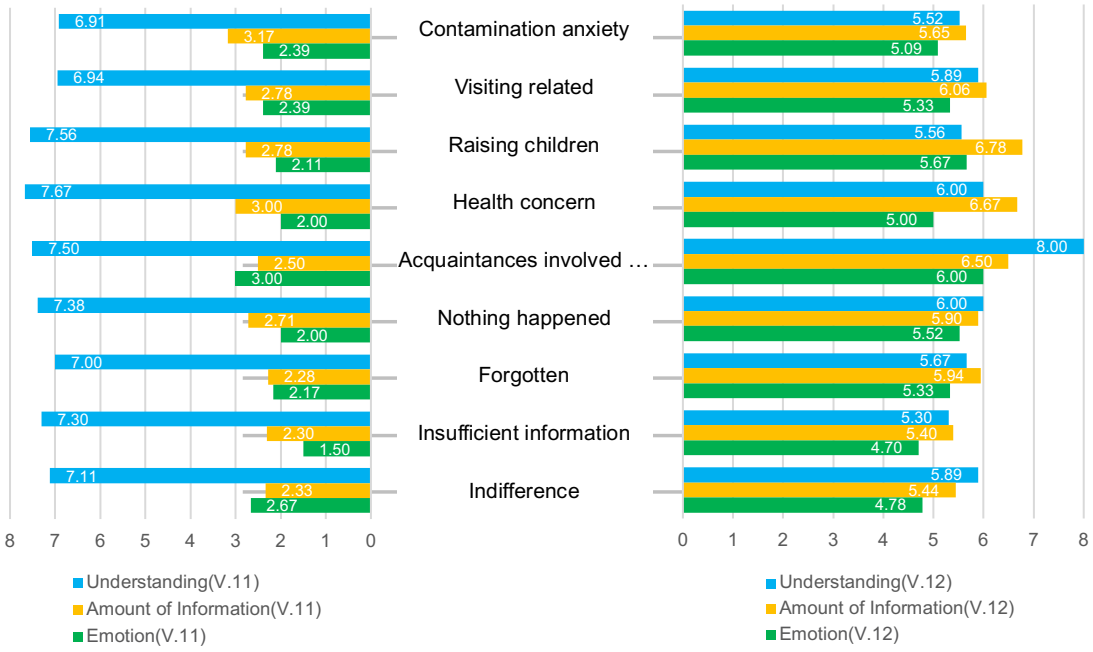


Figure 106. The average values of understanding-effects of V.11 and V.12 by the reasons given for the responses

Except for the group of “Acquaintance involved in the event”, the understanding levels of both visual samples were the highest in the group of “Health concern”. In addition, with respect to emotional stimulation, the rating attaching to V.11 was the highest in the “Indifference” group while the emotional stimulation rating of V.12 was the most dominant in the “Raising children” group.

6.4.6.5. The understanding-related effects of V.11 and V.12 by perspective on the Fukushima disaster

In the categories organized into perspective groups, it is difficult to identify the correlation between the main issues at hand in the visual samples and the perspectives of the groups who gave high marks to the effectiveness of the materials [Fig.107]. The understanding level of V.11, which does not address the radiation issue, was the highest in the group of Radiation disaster, whereas that of V.12, which does consider the radiation-contamination topic, was regarded as the highest among the group of Natural disaster. In addition, the degrees of emotional stimulations caused by the two visual instances were the most dominant in the group of Natural disaster.

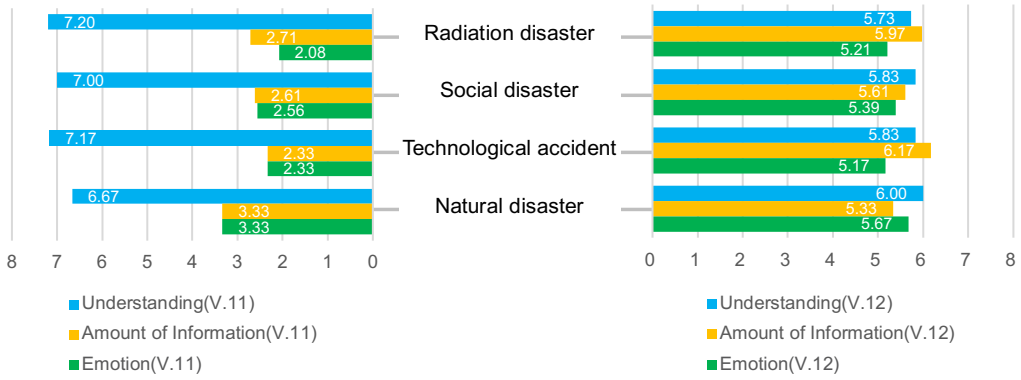


Figure 107. The average values of understanding-effects of V.11 and V.12 by perspective

Taking all the analysis above into consideration, the comparison between V.11 and V.12 can be summarized as per the [Table 42] below.

	V.11	V.12
Main issue	The realms and locations of the exclusion and evacuation zones	The realms and locations of the exclusion and evacuation zones and the distribution of radiation
Main purpose	Indicating domain and location	Indicating domain and location and level of radiation by space
Main representational key	Arbitrary (Hue: to indicate the domains), Non-arbitrary (Shape)	Arbitrary (Hue: to indicate radiation level), Arbitrary (Line: to indicate the domain), Non-arbitrary (Shape)
Main type	Map	Color plot on Map
Metonymy or Metaphor	Metonymy: Map	Metaphor: Heat Metonymy: Map

The number of information objects (information field)	3 (The domains, location, and population)	4 (The domains, location, and radiation level)
Effectiveness of understanding	Effective **(More effective than V.12)**	Effective
Region	In most of the regions (Particularly more effective in the regions close to the restricted zones: Japan, the groups of Asia, the Pacific Ocean, Indian Ocean, etc.)	In most of the regions (Particularly more effective in the regions close to the restricted zones: Japan, the groups of Asia, the Pacific Ocean, Inland, etc.)
Age	In most of the age groups (Slightly more effective in 20s group)	In most of the age groups (Slightly more effective in 20s group)
Whether or not the event matters and the reasons	In “Acquaintances involved…” and “Health concern” groups within “It matters” group	In “Acquaintances involved” and “Health concern” groups within the “It matters” group and “Nothing happened” group within the “It does not matter” group
Perspective	In “Radiational disaster” group	In “Natural disaster” group
Effectiveness of transition from understanding to emotional stimulation	-	Effective
Region	-	In most of the regions (Particularly more effective in the regions close to the restricted zones: Japan, the groups of Asia, the Pacific Ocean, the Indian Ocean, Inland, etc.)
Age	-	20s and 40s
Whether or not the event matters and the reasons	-	In “Acquaintances involved..” and “Raising children” groups within “It matters” group and
Perspective	-	In “Natural disaster” group

Table 42. The summary of the understanding-related effects of V.11 and V.12

The findings from the comparison between V.11 and V.12 suggests several possibilities.

Firstly, in case of the map-based type of visualization, it is highly probable that easy understanding results when there is a combination of a small volume of information viewed, such as the boundaries of certain areas, together with a simple expression of indicating the realms by using Hue.

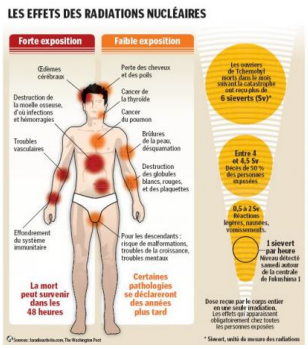
In addition, even though the map-based visualization deals with multiple pieces of separate information and data, and therefore employs different expressional methods, it is also highly possible to lead to effective understanding under the following conditions: a) causality between the various pieces of information (data) available and b) their representations which can be overlapped on similar

positions on the map and interpreted together.

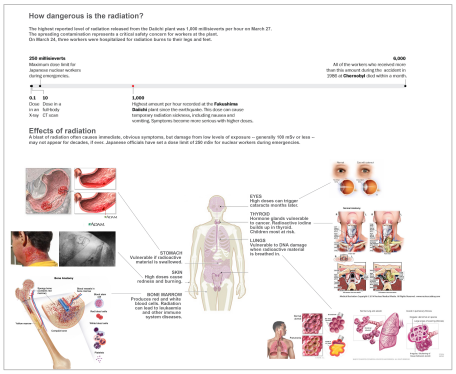
Finally, in case of the visualization which deals with the local area whose scale is smaller than a country, there is a greater chance that the visualization is more easily understood by people from regions close to the area portrayed (This seems to be due to the background knowledge of the area).

6.4.7. The understanding-related effects of V.13 and V.14

V.13 and V.14 represent visual samples whose common purpose is to present information relating to radiation illness and the influences of radiation according to the severity of the level of exposure. The samples and their analysis are shown again in [Table 43] and [Table 44] respectively.



V.13. LES EFFETS DES RADIATIONS NUCLÉAIRES (The Effects of Nuclear)



V.14. The Effects of Radiation

Table 43. V.13 (The Effects of Nuclear) and V.14 (The Effects of Radiation)

No.	Issues	Detailed field	Purpose (Variables)	Representational key (A: Arbitrary / N: Non-arbitrary)	Types of Vis. (M: Map / C: Chart / T: Technical drawing / P:Photograph)	Metaphor and Metonymy (Mp: Metaphor / Mn: Metonymy)
V.13	Radiation illness and the influence of radiation exposure	Human body and general influences	Describing symptoms of the illness	N (Shape: external body) A(Red and orange Circles)	T (External description)	Mn (Extracted detail), Mp (Heat)
			Explaining the influence of the radiation depending on the amount of exposure	A (Circle, Size, Position)	C (Bubble chart)	
V.14	Radiation illness and the influence of radiation exposure	Human body and organs and general influences	Describing symptoms of the illness	N (Shape: external body and internal organs)	T (Cross section)+P (skin)	Mn (Extracted detail)
			Explaining the influence of the radiation depending on the amount	A (Bar)	C (mono bar chart)	

Table 44. The analysis of V.13 and V.14

The two visual materials contain differences in relation to the amount of information on display, and the respective representational method employed.

With regard to the information amount, V.13 describes 10 kinds of symptoms and V.14 represents 6 kinds of side-effects regarding radiation illness. In addition, there is another difference in the amount of information included, in terms of the level of detail given as to the symptom in question: the representation of the affected organs in V.14 are more in-depth compared to V.13.

When it comes to the representational manner employed, it is possible to observe the differences

largely in two parts: a) the main visual artifact to illustrate the symptoms and b) the type of chart to depict the amount of radiation exposure and its influences. With regard to the first category, a), V.13 employs one main visual artifact which represents the external human body, and the information regarding the symptoms are presented by using texts which are located around the positions of the symptoms. On the other hand, V.14 details the information of the symptoms by using not only text but also adding detailed representations of internal organs which have been affected by illness. In both cases, the main representational key is Shape (a non-arbitrary key) and the main type is Technical drawing based on metonymical expression which uses extracted detail. However, V.13 employs a simple drawing to portray the external body, while V.14 mainly uses cross section for the internal organs. In terms of the category, b), different arbitrary keys are employed: V.13 uses bubble chart based on circle and V.14 employs the type of bar chart composed of a single bar, which is reminiscent of the form of timeline.

6.4.7.1. The overall average values of understanding-related effects of V.13 and V.14

One particularly notable point as part of this discussion relates to the larger amount of information of V.14 perceived by participants. It would appear that qualitative depth took precedence over quantitative size in this comparison. In this situation, the understanding level achieved by V.14 was rather higher when compared to that of V.13. These results show that the degree of understanding is not necessarily inversely proportional to the amount of information on display. In addition, the emotional effect of V.14 was also higher than that of V.13 [Fig.108].

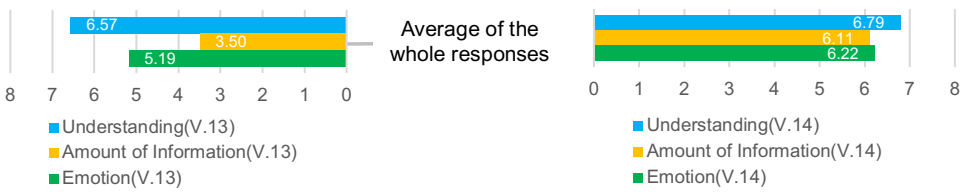


Figure 108. The average values of the entire set of responses regarding the understanding-related effects of V.13 and V.14

Even though there is difference in degree, almost all participants (103 people) replied that V.14 delivered a greater volume of information regarding the main issues at hand. Among those, 47 participants mentioned the detailed visual descriptions of the symptoms as a reason for their opinions.

In particular, there were 18 respondents who shared the view that the in-depth information depicted in V.14 in terms of the organs portrayed was more effective, when compared to text-only approach taken in V.13 which merely presented the name or simple explanation of the illness.

In addition, despite the higher understanding level of V.14, only 35 people regarded this visual instance as more effective to overall understanding. On the other hand, the majority of participants (65 people) considered the understanding levels of the two visual instances to be the same. One major reason for the preference of V.14 in understanding seems to be the lack of background knowledge regarding the symptoms of the illness: most of the 35 people explained that they only came to know how the symptoms appear in the human body through the visual explanation of V.14.

The detailed visual description seems to be more effective in inducing emotional stimulation as well. 69 people provided higher marks to the emotional effect of V.14, the reasons given by 31 of these respondents were based on the same context in that it was uncomfortable to see the physicality of the affected internal organs as a result of the illness. One respondent mentioned that although it was common to witness various anatomical charts of the human body, the representation of the symptoms of illness was unfamiliar. Moreover, the grouping of the multiple visual descriptions regarding the symptoms made her feel more uncomfortable. In addition, one participant displayed anxiety about her own health condition regarding thyroid when she saw the visual description of the symptom of thyroid cancer.

6.4.7.2. The understanding-related effects of V.13 and V.14 by region

Understanding-related effects of V.14 were generally higher than those of V.13 across all countries. The degrees of emotional stimulation and perceived information amount taken from V.14 were higher among almost all nations except for Taiwan in which the degrees of emotional effect of the two instances were regarded as equal. In addition, the levels of understanding of V.14 were evaluated as being higher than V.13 in several countries except for China, Thailand, Australia, Ukraine, USA, and Canada [Fig.109].

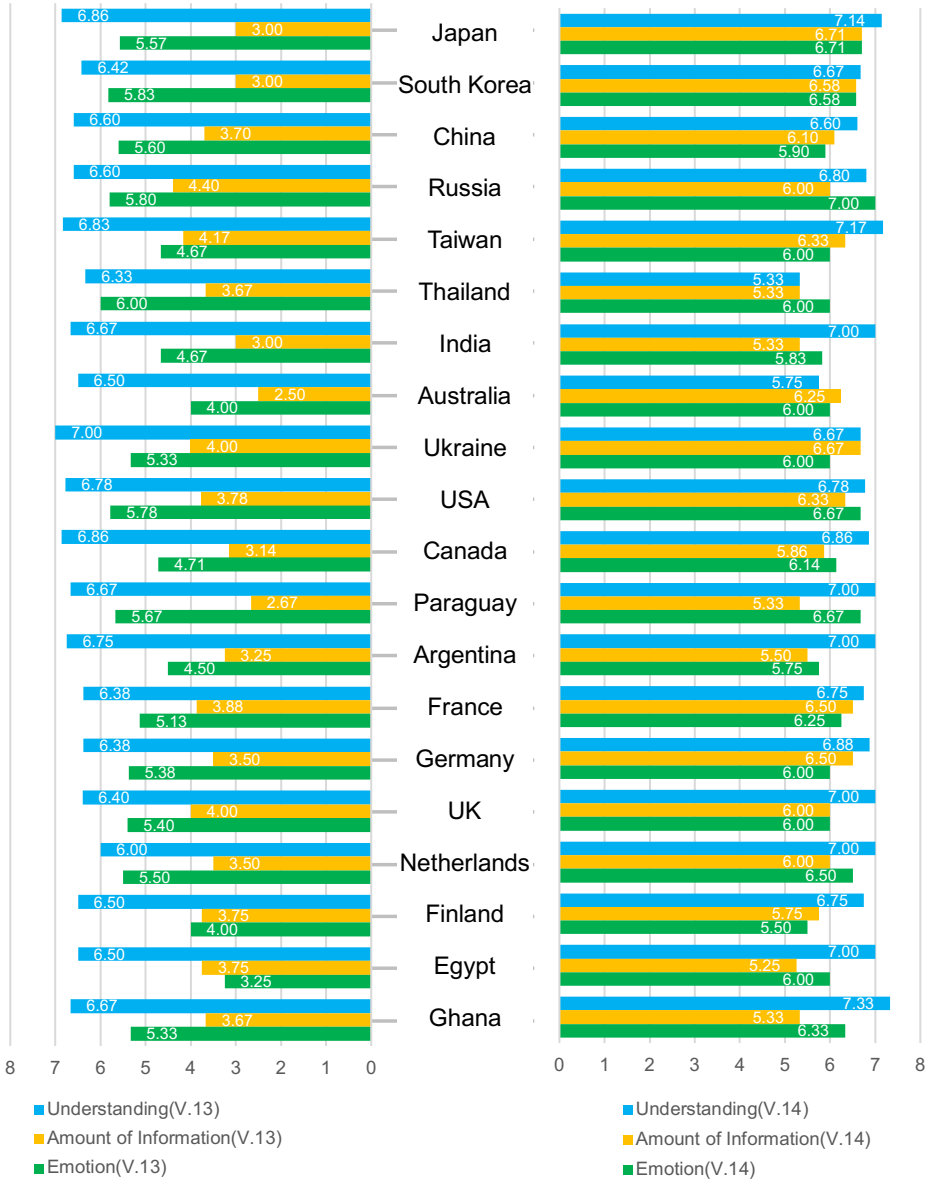


Figure 109. The average values of understanding-related effects of V.13 and V.14 by country

A notable point here is that, in the comparison by country, the degrees of emotional stimulation of V.13 demonstrate larger gaps in the ratings than those of V.14. In terms of the emotional effect, the standard deviation of V.13 is 0.72 while that of V.14 is 0.37. This shows that the high degree of this emotional effect in relation to V.14 is a general tendency that is reflected in the responses of most countries.

In the case of dividing the collected data according to whether or not the countries are the producers of collected visual samples, the understanding levels of both visual instances were slightly higher in the

group of non-producers of collected instances while the degrees of emotional stimulation were more clearly lower in this group [Fig.110].

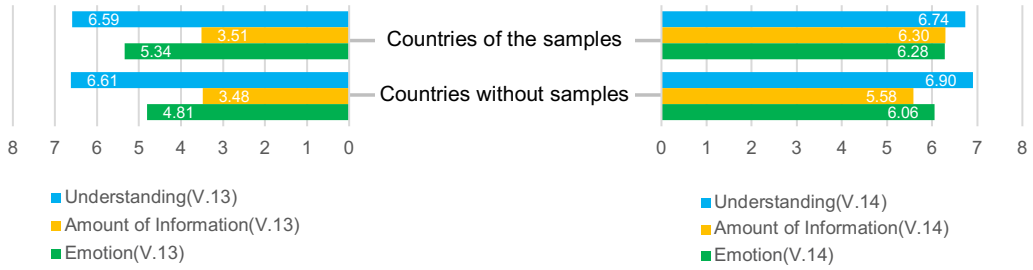


Figure 110. The average values of the understanding-related effects of V.13 and V.14 depending on whether or not the countries are producers of the collected visual samples.

The type of visualization which employs Shape seems to be effective regardless of the boundaries of the continents. The understanding levels of both visual samples were also high even amongst those countries that are remote from the disaster area, such as the nations included in South America, Europe, and Africa [Fig.111].

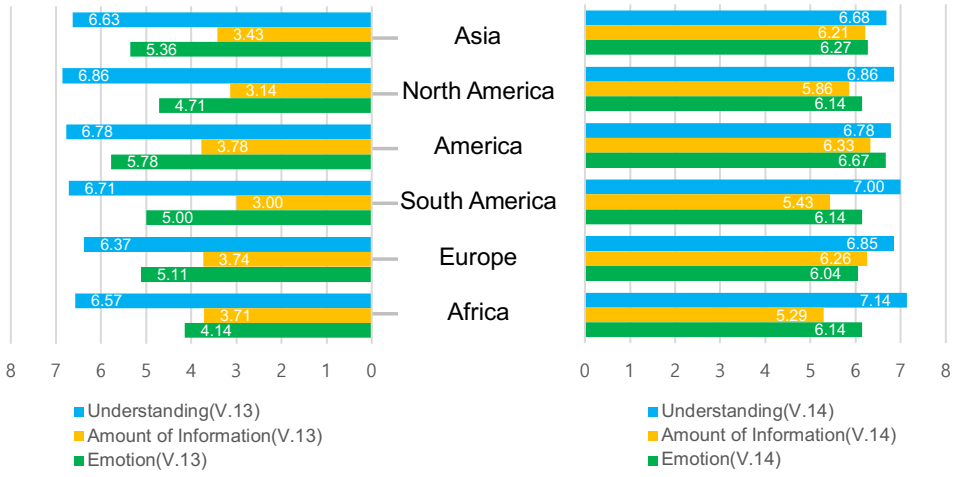


Figure 111. The average values of understanding-related effects of V.13 and V.14 by continent

Nevertheless, when taking the statistics by continent and geographical circumstances together, it is possible to discover a pattern which appears in certain regions. That is to say, the nations in the continents around the Pacific Ocean such as Asia, North America, and America possess several common features including a) a small gap between the understanding levels of the two instances, b) a large gap between the perceived information amount of the two samples, and c) higher emotional effect of V.14 compared to other regions [Fig.112].

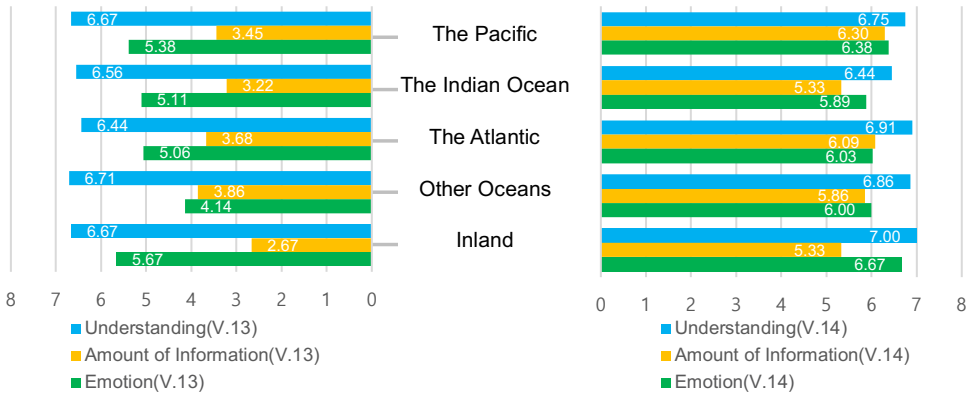


Figure 112. The average values of the understanding-related effect of V.13 and V.14 by geographical surroundings

With regard to a) and b), the similar understanding levels achieved, despite V.14's larger information volume, means that there is a high understanding level of V.14, and moreover, when taking c) into account, the understanding-related effects in those regions can be regarded as higher than those observed in other regions.

Taking an overall view of the data, and in order to summarize the inclinations depending on the regional conditions above, one can see that even though the understanding levels of the two visual materials were generally high in almost all regions, the understanding-related effects of V.14 were ultimately higher than those of V.13. Additionally and in particular, those effects of V.14 were more dominant in the regions around the Pacific Ocean: the groups of Asia, America, North America, the Pacific Oceans, etc.

6.4.7.3. The understanding-related effects of V.13 and V.14 by age

The tendency found in the categories by age is that, in both cases of visual samples, the higher the age, the higher the understanding-related effects [Fig.113]. In addition, V.14 was more effective than V.13 in the overall age groups.

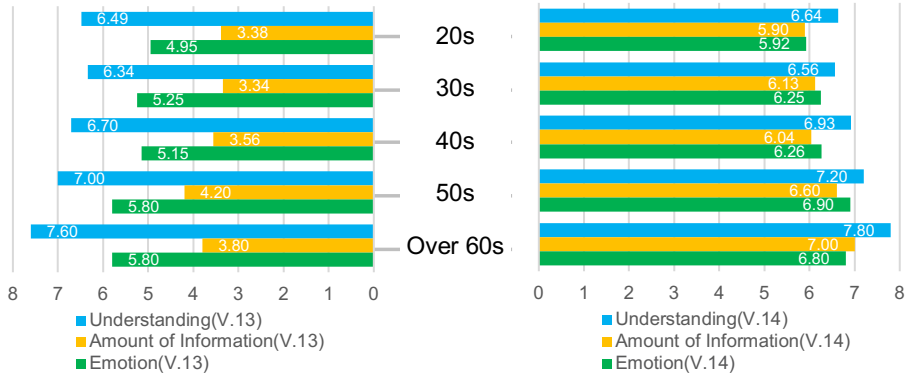


Figure 113. The average values of the understanding-effects of V.13 and V.14 by age group

6.4.7.4. The understanding-related effects of V.13 and V.14 by whether or not the Fukushima disaster matters, and the reasons for that response

Both the “It matters” and “It does not matter” groups gave higher scores to V.14 in terms of the understanding-related effects. In addition, the effects of the two visual instances were slightly higher in the group of “It matters” than the group that gave the opposite response [Fig.114].

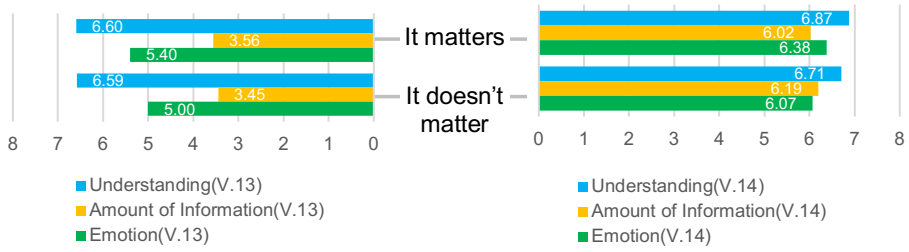


Figure 114. The average values of the understanding-effects of V.13 and V.14 by whether the Fukushima event matters or not

The effects of both materials were particularly high in the group giving supporting reasons related to the main issue of the visual materials. The levels of understanding and emotional stimulation of both materials were highest in the group of Health concern [Fig.115].

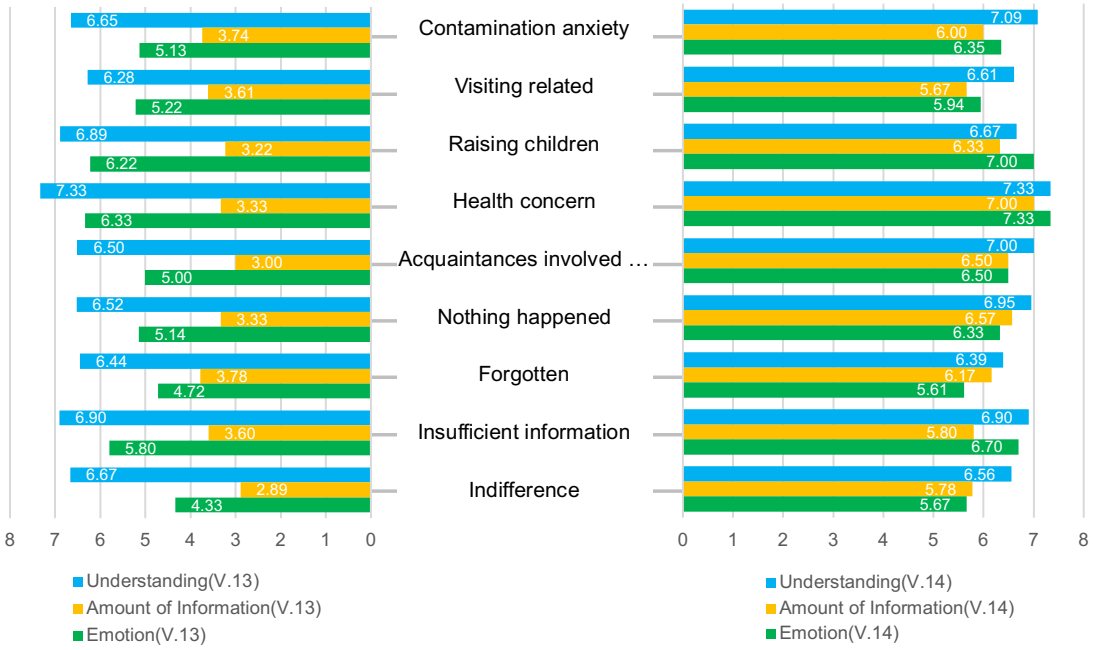


Figure 115. The average values of the understanding-effects of V.13 and V.14 by the reason

Nevertheless, the groups giving the reasons in the “It does not matter” camp, such as “Insufficient information” and “Nothing happened”, also demonstrated high levels of understanding-related effects.

6.4.7.5. The understanding-related effects of V.13 and V.14 by perspective on the Fukushima disaster

In the category by perspective on the event, the group of Technological accident had the highest level of understanding [Fig.116]. However, when taking other effects into consideration such as the degrees of perceived information amount and emotional stimulation, the understanding-related effects of Radiation disaster group was the highest in nature. This is because of the relatively smaller gaps between the understanding levels of the two groups compared to differences between the two groups’ evaluated information amount and emotional effect.

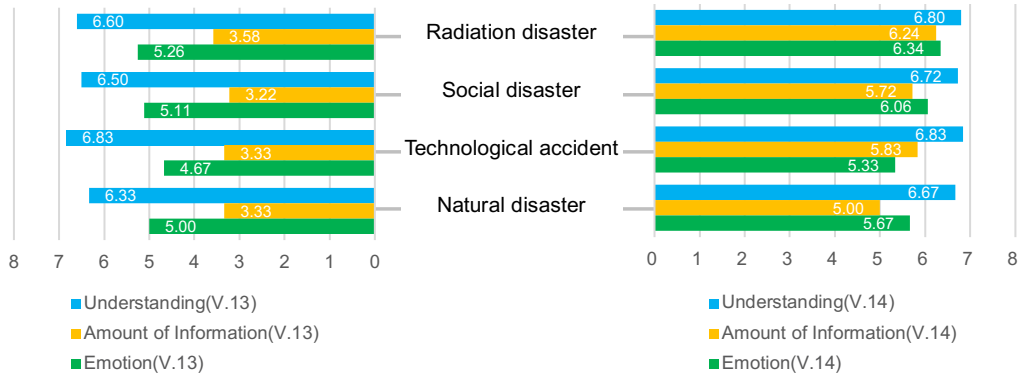


Figure 116. The average values of the understanding-effects of V.13 and V.14 by perspective

Taking all the analysis above into account, the comparison between V.13 and V.14 can be briefly presented below [Table 45].

	V.13	V.14
Main issue	Radiation illness and the influence of radiation exposure	
Main purpose	Presenting symptoms of the illness	
Main representational key	Non-Arbitrary key (Shape: human body) Arbitrary key (Red and orange Circles)	Non-Arbitrary key (Shape: internal organs and external body)
Main type	Technical drawing	
Metonymy or Metaphor	Metonymy: Extracted detail	
The number of information objects (information field)	14 (The 10 kinds of symptoms and 4 kinds of influences of Radiation exposure)	10 (The 6 kinds of symptoms and 4 kinds of influences of Radiation exposure)
Effectiveness of understanding	Effective	Effective **(More effective than V.13)**
Region	In most of the regions	In most of the regions (Particularly more effective in the regions around the Pacific Ocean: the groups of Asia, America, North America, the Pacific Ocean, etc.)
Age	The higher the age, the higher the effectiveness	
Whether or not the event matters and the reasons	In “Health concern” group within the “It matters” group and in “Insufficient information” group within the “It does not matter” group	In “Health concern” group within the “It matters” group and in “Nothing happened” group within the “It does not matter” group
Perspective	In “Radiational disaster” group	

Effectiveness of transition from understanding to emotional stimulation	Effective	Effective **(More effective than V.13)**
Region	In most of the regions (Particularly more effective in the regions around the Pacific Ocean: the groups of Asia, America, North America, the Pacific Ocean, inland, etc.) In most of the regions	
Age	The higher the age, the higher the effectiveness	
Whether or not the event matters and the reasons	In “Health condition” and “Raising children” groups within the “It matters” group and in “Insufficient information” group within the “It does not matter” group	
Perspective	In “Radiational disaster” group	

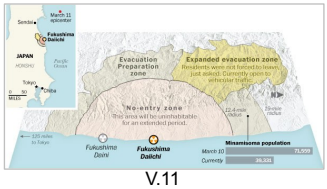
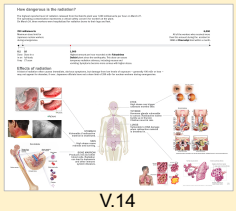
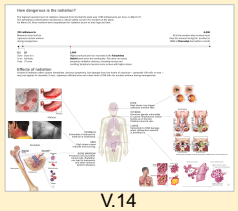
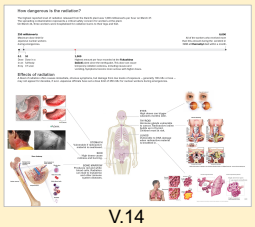
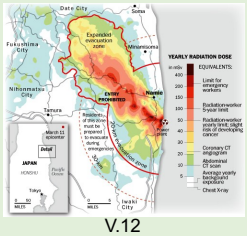
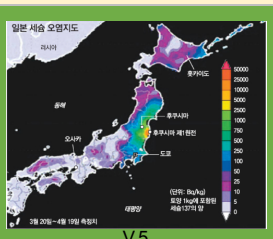
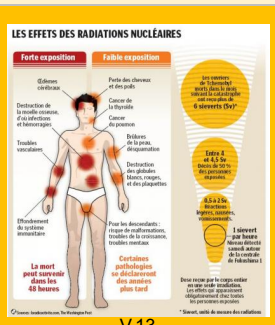
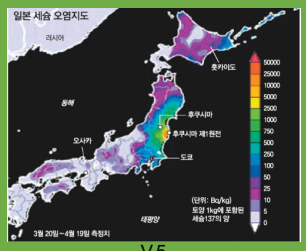
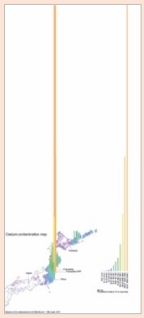
Table 45. The summary of the understanding-related effects of V.13 and V.14

In the case of using metonymical expression to represent the symptoms of radiation illness, multiple detailed visual descriptions based on exquisitely extracted detail is most likely to lead to not only effective understanding but also evident emotional effect regarding the material viewed. In addition, the levels of these understanding-related effects are likely to be high among various regions, higher age groups, and people who have concerns for the main issues that are the subject matter of the visualizations.

6.5. The tendency of understanding-related effects of overall visual materials.

Unlike the previous sections of this study in which the pairs of visual materials were compared, this section compared all the cases in order to investigate more macroscopic trends. Across all the visual materials, the top five samples which had high understanding-related effects were selected to investigate: whether these instances were generally evaluated to be highly effective despite the various backgrounds of the participants; and then what was the extent of the gaps between the levels of effectiveness; and finally, whether there were particularly more effective visual languages for certain backgrounds; etc.

Firstly, the top five materials which received high scores from the entire set of respondents were as follows [Table 46].

	Top five visual instances in understanding level and the Avg. scores from all respondents	Top five visual instances in perceived information amount and the Avg. scores from all respondents	Top five visual instances in emotional stimulation degree and the Avg. scores from all respondents
1	 V.11	 V.14	 V.14
Avg.	7.15	6.11	6.22
2	 V.14	 V.12	 V.5
Avg.	6.79	5.90	5.84
3	 V.13	 V.5	 V.6
Avg.	6.59	5.72	5.81

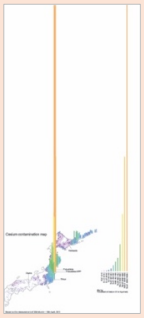
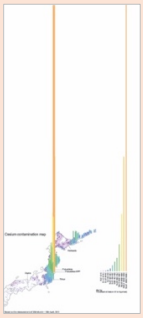
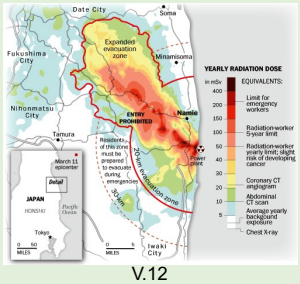
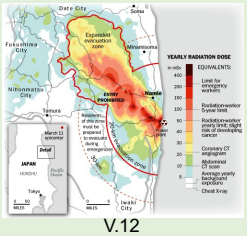
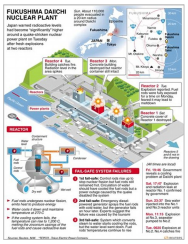
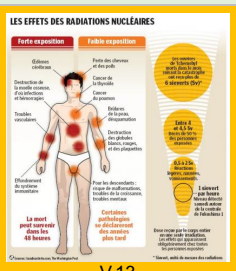
4	 V.6	 V.6	 V.12
Avg.	6.03	5.60	5.25
5	 V.12	 V.2	 V.13
Avg.	5.76	5.54	5.19

Table 46. The visual samples which received high overall average scores in understanding-related effects

In the group of the samples with high understanding levels, the materials employing a non-arbitrary key, Shape ranked in the top three. Among the two visual samples which use arbitrary keys, the one with Bar was more effective than the other employing Hue.

On the other hand, the top five instances highly regarded in terms of emotional stimulation were similar to those from the high understanding level group, but this party mentioned V.5 instead of V.11. In other words, the number of samples using Hue had increased, and their rankings had also been elevated compared to when they were in the group of the samples with high understanding levels. This change shows that, even in the case of a comparison of the overall instances, Shape (a non-arbitrary key) was more effective in understanding, whereas Hue (an arbitrary key) was more effective in emotional stimulation.

Another tendency discovered from the table above is that the majority of the instances appeared more than twice. V.14, V.6, and V.12 can be found in all three categories; V.5 appears in both the groups mentioning the large amount of information and high emotional stimulation; and V.13 is shown in both the high understanding level and emotional stimulation groups. These results show that ultimately, the visualizations which possess high effectiveness in understanding are also effective in emotional stimulation.

However, a high degree of understanding is a pre-requisite to high emotional effect. In other words, not all visual instances that resulted in high understanding level necessarily also lead to high emotional stimulation. This is shown by the evidence of V.5 and V.11 being excluded from the high emotional stimulation group despite encouraging high effectiveness of understanding.

6.5.1. The visual instances with high understanding-related effects by region

The visualizations above were generally retained in the classifications by region as well, but their ranking and the degree of effectiveness varied depending on the regional conditions. Nevertheless, there were some noticeable features regarding the visual samples with high understanding-related effects in the regional divisions.

Firstly, in relation to both understanding level and emotional stimulation, the scores for the visual materials in the top five were generally higher in the regional groups which were closer to the areas directly influenced by the event. [Table 47] below shows which of the visual samples resulted in high effectiveness in both understanding and emotional effect by continent. In particular, the cells of the given scores were covered by reddish colors based on the metaphorical expression of thermography. In that table, the darker red spectrums of the groups of Asia, America, and North America show that their given scores were higher than that given by other regional groups. The three regional categories include various nations closer to the influence of the disaster in the vicinity of the Pacific Ocean.

	Top five visual instances in understanding level and the Avg. scores from the category of groups					Top five visual instances in emotional stimulation degree and the Avg. scores from the category of groups				
Asia	V.11	V.14	V.13	V.12	V.6	V.14	V.5	V.6	V.12	V.13
	7.23	6.68	6.63	6.05	5.96	6.27	6.07	6.02	5.63	5.36
North America	V.11	V.13	V.14	V.1	V.10	V.14	V.6	V.9	V.5	V.8
	6.86	6.86	6.86	5.86	5.86	6.14	6	5.57	5.43	5.29
America	V.11	V.13	V.14	V.8	V.6	V.14	V.8	V.5	V.9	V.13
	7.11	6.78	6.78	6.33	6.22	6.67	6.11	6	5.78	5.78
South America	V.14	V.11	V.13	V.6	V.12	V.14	V.6	V.8	V.12	V.5
	7	6.86	6.71	6.14	5.71	6.14	5.14	5.14	5.14	5
Europe	V.11	V.14	V.13	V.6	V.1	V.14	V.5	V.6	V.13	V.12
	7.19	6.85	6.37	6	5.7	6.04	5.85	5.7	5.11	4.96
Africa	V.14	V.11	V.6	V.13	V.1	V.14	V.6	V.5	V.9	V.12
	7.14	7	6.57	6.57	5.86	6.14	5.14	5	4.71	4.57

Table 47. The visual samples most effective in leading to understanding and emotional effects of the regional categories by continent

In addition, the groups of the visual samples showing high understanding levels from America and North America contain V.10, representing the spread of tsunami, and V.8, describing the diffusion of

radiation. A common feature of both instances is that they deal with the Pacific as the main region under scrutiny. Moreover, these visual materials were not included in other regional groups.

The groups of the materials with high emotional stimulation degrees also demonstrate similar inclinations. The group of Asia in this regard contained V.5, V.6, and V.12, which all dealt with the territories of Japan and Fukushima prefecture while V.8 and V.9, which represent topics more relevant to the Pacific Ocean, mainly belonged to America and North America.

In terms of the expressional manner, the regional groups closer to the disaster area more easily understood various samples based on more diverse representational keys. For instance, all groups' visual materials that showed high understanding levels were composed of the samples based on Shape (V.11 (restricted zones), V.13 (radiation illness), and V.14 (radiation illness)) and Bar (V.6 (radiation levels on Japan), but the Asia group (and South America) additionally contained material based on Hue (V.12 (radiation levels and restricted zones in Fukushima)).

The inclination in the categories by geographical environments follow a similar pattern. V.12 was highly evaluated in understanding, but only in the groups of the Pacific Ocean and the Indian Ocean, which were closer to the area of the disaster. On the other hand, V.1 or V.2 (representing reactors' condition) employing Metonymical expressions based on Technical drawing and Photograph were more highly evaluated in understanding than V.12 in those regional groups remote from Japan such as the Atlantic, Other Oceans, and Inland [Table 48].

In addition, and as witnessed with the tendency in the categories by continent, the scores given by the group of the Pacific Ocean were also generally higher than that seen from other groups.

	Top five visual instances in understanding level and their Avg. scores					Top five visual instances in emotional stimulation degree and their Avg. scores				
The Pacific Ocean	V.11	V.14	V.13	V.6	V.12	V.14	V.6	V.5	V.13	V.12
	7.23	6.75	6.67	6.03	5.98	6.38	6.07	6.03	5.38	5.37
The Indian Ocean	V.11	V.13	V.14	V.12	V.6	V.5	V.14	V.12	V.6	V.13
	7	6.56	6.44	5.89	5.78	6	5.89	5.67	5.56	5.11
Atlantic	V.11	V.14	V.13	V.6	V.1	V.14	V.5	V.6	V.13	V.12
	7.12	6.91	6.44	6.03	5.65	6.03	5.65	5.59	5.06	4.94
Other Oceans	V.11	V.14	V.13	V.6	V.1	V.14	V.6	V.5	V.12	V.3
	6.86	6.86	6.71	6.29	6.14	6	5.29	5.14	5	4.57
Inland	V.11	V.14	V.13	V.2	V.6	V.14	V.12	V.13	V.5	V.9
	7	7	6.67	6	6	6.67	5.67	5.67	5.33	4.29

Table 48. The visual samples most effective in understanding and emotional effects of the regional categories by geographical surroundings

6.5.2. The visual instances with high understanding-related effects depending on whether or not the Fukushima event matters and the reasons for the cases.

The scores given to the visual materials were generally higher in the reason groups within the “It matters” group. In particular, there were similarities or causalities between the supporting reasons given, and the main issues found in their visual instances. This is shown by the darker red spectrums of the reason groups including Health concern, Raising children, Acquaintances involved in the event, etc. in both sides of the understanding and emotional stimulation categories [Table 49].

	Top five visual instances in understanding level and their Avg. scores					Top five visual instances in emotional stimulation degree and their Avg. scores				
Anxiety Over contamination	V.14	V.11	V.13	V.6	V.1	V.14	V.5	V.6	V.9	V.13
	7.09	6.91	6.65	6.48	5.7	6.35	5.91	5.83	5.39	5.13
Plan or experience of visiting	V.11	V.14	V.6	V.13	V.12	V.5	V.14	V.6	V.12	V.13
	6.94	6.61	6.28	6.28	5.89	6.33	5.94	5.89	5.33	5.22
Raising children	V.11	V.6	V.13	V.14	V.8	V.14	V.6	V.13	V.5	V.8
	7.56	6.89	6.89	6.67	6	7	6.44	6.22	6	5.89
Health concern	V.11	V.13	V.14	V.4	V.6	V.6	V.14	V.5	V.13	V.3
	7.67	7.33	7.33	6.33	6.33	7.33	7.33	7	6.33	5.33
Acquaintances involved in the event	V.12	V.11	V.14	V.13	V.2	V.5	V.6	V.14	V.12	V.9
	8	7.5	7	6.5	6	7	6.5	6.5	6	5
Nothing happened	V.11	V.14	V.13	V.12	V.1	V.14	V.6	V.5	V.12	V.3
	7.38	6.95	6.52	6	5.95	6.33	5.95	5.62	5.52	5.14
Forgotten	V.11	V.13	V.14	V.1	V.12	V.5	V.14	V.6	V.12	V.8
	7	6.44	6.39	5.89	5.67	5.83	5.61	5.56	5.33	5
Insufficient information	V.11	V.13	V.14	V.1	V.10	V.14	V.5	V.13	V.8	V.6
	7.3	6.9	6.9	6	6	6.7	5.8	5.8	5.5	5.4
Indifference	V.11	V.13	V.14	V.10	V.12	V.14	V.8	V.9	V.6	V.12
	7.11	6.67	6.56	5.89	5.89	5.67	5	5	4.89	4.78

Table 49. The visual samples most effective in understanding and emotional effects of the categories depending on the reasons for whether or not the Fukushima event matters.

With regard to the expressional method employed, the groups within the “It matters” group more easily understood the samples based on the use of more various arbitrary representational keys. Those parties highly evaluated V.4 (based on Circle), V.12 (based on Hue), and V.6 (based on Bar) in understanding, whereas others gave high scores to V.12 and V.6.

In addition, the estimated understanding levels of those instances were higher in the group of “It matters”. In case of V.12, the scores provided by the groups including “Acquaintances involved in the event”, and “Plan or experience of visiting” were equal to or higher than those given by the groups of “Forgotten”, “Indifference”, etc. within the “It does not matter” group.

However, not all reason groups within the “It does not matter” party resulted in lower levels of understanding-related effects than those within the “It matters” group. For instance, in the case of the

Insufficient information group, the understanding and emotional stimulation degrees of V.13 (radiation illness) and V.1 (reactors) were higher than the group of Anxiety over issues relating to contamination.

6.5.3. The visual instances with high understanding-related effects by age

In terms of identifying insights in the categories by age, one tendency is that the higher the age, so the higher the levels of understanding and emotional stimulation achieved. In [Table 50] below, the red spectrums which indicate the scores turn darker in accordance with the rising corresponding age.

	Top five visual instances in understanding level and their Avg. scores					Top five visual instances in emotional stimulation degree and their Avg. scores				
20's	V.11	V.14	V.13	V.12	V.6	V.14	V.5	V.6	V.8	V.13
	7.31	6.64	6.49	6.08	6	5.92	5.77	5.74	5	4.95
30's	V.11	V.14	V.13	V.6	V.1	V.14	V.5	V.6	V.12	V.13
	7	6.56	6.34	6.06	5.78	6.25	5.78	5.72	5.41	5.25
40's	V.11	V.14	V.13	V.6	V.1	V.14	V.6	V.5	V.12	V.9
	7.07	6.93	6.7	6.04	5.59	6.26	5.74	5.7	5.59	5.26
50's	V.11	V.14	V.13	V.2	V.6	V.14	V.5	V.6	V.13	V.12
	7.3	7.2	7	5.8	5.8	6.9	6.1	6.1	5.8	5.5
Over 60s	V.14	V.13	V.11	V.6	V.8	V.5	V.14	V.6	V.13	V.7
	7.8	7.6	7	6.4	6	7	6.8	6.6	5.8	5.4

Table 50. The visual instances highly evaluated in understanding and emotional effects by age

In both understanding and emotional effect, the older age groups predominantly highly estimated the materials which represent radiation illness by using the type of technological drawing. In the case of understanding level, V.11 (restricted zones) ranked first among all groups except for the Over 60s group, for which V.14 (radiation illness) ranked first. In addition, with regard to the emotional stimulation degree of V.14, the score given by the 50s and Over 60s groups were higher than those provided by other age groups even though this case did not rank first in the Over 60s group.

In addition, the youngest age group (20s) seemed to feel more comfortable when interpreting the visualization based on Hue. The sample based on Hue (such as V.12 (radiation levels and restricted zones) was highly evaluated in understanding only by this group (20s)).

6.5.4. The visual instances with high understanding-related effects according to perspectives on the Fukushima event

[Table 51] shows an inclination that the scores given by the group of Radiation disaster were

generally higher than those provided by others.

	Top five visual instances in understanding level and their Avg. scores					Top five visual instances in emotional stimulation degree and their Avg. scores				
Radiation disaster	V.11	V.14	V.13	V.6	V.12	V.14	V.6	V.5	V.13	V.12
	7.2	6.8	6.6	6.05	5.73	6.34	5.95	5.92	5.26	5.21
Social disaster	V.11	V.14	V.13	V.6	V.12	V.14	V.5	V.6	V.12	V.13
	7	6.72	6.5	5.94	5.83	6.06	5.83	5.56	5.39	5.11
Technological accident	V.11	V.13	V.14	V.1	V.6	V.14	V.1	V.12	V.5	V.8
	7.17	6.83	6.83	6.17	6	5.33	5.17	5.17	5	5
Natural disaster	V.11	V.14	V.13	V.1	V.6	V.12	V.14	V.5	V.8	V.9
	6.67	6.67	6.33	6	6	5.67	5.67	5.33	5.33	5.33

Table 51. The visual instances highly estimated in understanding and emotional effects of the division according to perspectives on the Fukushima event

Additionally, in terms of the materials which received higher scores in each of the groups, there were similarities or causalities between the main issues of those samples and the subject (topic) of the perspectives. This tendency is shown by the top 5 materials of understanding and emotional effects in various groups. The Radiation disaster group selected the visual samples describing the information of radiation contamination or radiation illness; the group of Technological accident contained V.1 whose main issue was the reactors' conditions; the Natural disaster chose V.9 in the category of emotional stimulation whose main topic was spread of tsunami; and both Radiation disaster and Social disaster groups contained V.12, which represented both radiation and social topics at the same time.

To sum up all the discussions above, the tendencies can be described as follows.

1. Information amount (or data variation) and understanding:

Simple representation containing a small volume of information (small number of data variable) is most likely to lead to easy understanding for diverse viewers from various backgrounds. However, the amount of information or data represented is not necessarily in inverse proportion to the effectiveness of understanding ultimately achieved. Despite the large amounts of information and data observed, effective understanding can result from a) multiple and delicate delineations based on fine extracted detail (Shape) for qualitative information and b) a combination of multiple kinds of information and data in a same phase space (such as overlapping layers) based on effective applications of arbitrary and non-arbitrary keys.

2. Understanding and emotional stimulation:

Effective understanding is a necessary pre-condition to a high degree of emotional stimulation. However, not all visualizations with high effectiveness of understanding necessarily induce high levels of emotional stimulation. There are other requisites such as the main subjects (issues) of information and data, various personal situations (backgrounds) of viewers, representational methods, etc. (these requirements are described in [Table 52] below).

3. The backgrounds of the viewers and their understanding:

Viewers' backgrounds are closely concerned with understanding of visualization. At the very least, in the case of information visualization for Journalism media, the level of understanding was elevated when there were relationships (such as similarity and causality) between the concerns, perspectives, background knowledge, regional conditions, etc. of the viewers and the main subject represented in the visualization. Age was also one of the background conditions related to understanding level, but the regional condition was a more dominant factor than the age condition in understanding-related effects (the tendencies by age summarized in [Table 52] below).

However, the visual samples highly evaluated in understanding-related effects depending on various backgrounds were not significantly different in the aspects of the main topics, visual syntax, amount of information, etc. It is rather easier to find differences between the estimated levels of understanding and emotional stimulation and their rankings. After all, this suggests that the manner in which the information (or data) is represented, together with the way the visualizations are interpreted and understood, are similar in global inclination. This is noticeable even though various nations have produced diverse visualizations of the Fukushima event for the journalism media. In this situation, the backgrounds of the individual participants seemed to be a motivating factor that allowed them to actively and constructively interpret, focus on, and understand the visual samples, especially when there are relationships between the viewers' backgrounds and the components of the visualization in question (including information content, visual syntax, etc.).

4. Visual syntax and understanding:

[Table 52] summarizes the findings with regard to the relationship between understanding and the

major representational methods of the visualizations of the Fukushima event.

	Purpose	Main terms for comparison	Effectiveness and conditions			
			Understanding		Emotion	
			Effective or not	Condition of effectiveness	Effective or not	Condition of effectiveness
1	Distribution and Density	Type: Color-plot chart on map Representational key: Hue_(Arbitrary)+Shape(map)_(Non-arbitrary) Metaphor and Metonymy: Metaphor_(Heat map) + Metonymy_(Map)	Effective (Less effective than Bar chart on map)	- In the regions presented in Vis., - Among the viewers in their 20s, but generally the higher the age, the higher the effectiveness	Effective (More evident than understanding, and more effective than Bar chart on map)	- In most regions, but more intense in the regions presented in Vis., - In most ages, but the higher the age, the higher the effectiveness
		Type: Bar chart on map Representational key: Bar_(Arbitrary)+Shape(map)_(Non-arbitrary) Metaphor and Metonymy: Metaphor_(Heat map) + Metonymy_(Map)	Effective (More evident than emotion, and more effective than Color-plot chart on map)	- In most regions - The higher the age, the higher the effectiveness	Effective (Less effective than Color-plot chart on map)	- When the gap between Max. and Min. values are large - in the regions presented in Vis., - The higher the age, the higher the effectiveness
2	Route, direction, speed, strength, etc. of movement	Type: Arrows(Technical drawing) on map Representational key: Arrow_(Non-arbitrary)+Shape(map)_(Non-arbitrary) Metaphor and Metonymy: Metonymy_(Indexical Sign) + Metonymy_(Map)	Effective (More effective than Color-plot chart on map)	- In most regions - The higher the age, the higher the effectiveness	Effective (More effective than Color-plot chart on map)	- In most regions, but more intense in the regions to which the arrow points - The higher the age, the lower the effectiveness
		Type: Color-plot chart on map Representational key: Hue_(Arbitrary)+Shape(map)_(Non-arbitrary) Metaphor and Metonymy: Metaphor_(Heat map) + Metonymy_(Map)	Effective (Less effective than arrows(technical drawing) on map)	- in the regions presented in Vis., - Among the viewers in their 30s, and over 60s	Effective (Less effective than arrows(technical drawing) on map)	- in the regions presented in Vis. - In most ages, but the higher the age, the higher the effectiveness
3	Description of scene	Type: Technical drawing(Cross section) with Photograph Representational key: Shape_(Non-arbitrary) Metaphor and Metonymy: Metonymy_(Extracted detail)	Effective (More effective than Technical drawing without Photograph)	- In most regions - Among most ages	Effective (More effective than Technical drawing without Photograph)	- In most regions - Among most ages

		Type: Technical drawing(Plan+Cross section) without Photograph Representational key: Shape_(Non-arbitrary) Metaphor and Metonymy: Metonymy_(Extracted detail)	Effective (Less effective than Technical drawing with Photograph)	- in the regions presented in Vis., - Among most ages, but particularly high among 20s	Less effective	- Less effective when the description is not realistic
4	Description of symptom (Description of Shape, structure, principle, influence, etc.)	Type: Technical drawing with multiple and detailed visual artifacts Representational key: Shape_(Non-arbitrary) Metaphor and Metonymy: Metonymy_(Extracted detail)	Effective (More effective than Single (or a few) and simple visual artifacts)	- In most regions - Among most ages, but the higher the age, the higher the effectiveness	Effective (More effective than Single (or a few) and simple visual artifacts)	- In most regions - Among most ages, but the higher the age, the higher the effectiveness
		Type: Technical drawing with single(or a few) and simple visual artifacts Representational key: Shape_(Non-arbitrary) Metaphor and Metonymy: Metonymy_(Extracted detail)	Effective (Less effective than Multiple and detailed visual artifacts)	- In most regions - Among most ages, but the higher the age, the higher the effectiveness	Effective (Less effective than Multiple and detailed visual artifacts)	- In most regions - Among most ages, but the higher the age, the higher the effectiveness
5	Distribution and Density	Type: Separated form of Statistical chart(Line chart) and Map Representational key: Line_(Arbitrary)+Shape(map)_(Non-arbitrary) Metaphor and Metonymy: Metonymy_(Map)	Less Effective	- Effective among viewers familiar with the location of the regions presented in map - The lower the age, the higher the effectiveness	Effective (Less effective than Combination form)	- Effective among viewers familiar with the location of the regions presented in map - The higher the age, the higher the effectiveness
		Type: Combination form of Statistical chart (Bubble-plot chart) and Map Representational key: Circle_(Arbitrary)+Shape(map)_(Non-arbitrary) Metaphor and Metonymy: Metonymy_(Map)	Effective (More effective than Separated form)	- In most regions, but more intense in the regions presented in Vis. - Among the viewers particularly in their 20s, and 50s	Effective (More effective than Separated form)	- In most regions, but more intense in the regions presented in Vis. - Among the viewers particularly in their 40s

Table 52. The major visual syntax and their effectiveness and the conditions for those results

6.6. The impact of the visualizations

[Q.5] of the questionnaire asked how much the visual materials had influenced the participants' ideas or concerns regarding the Fukushima event. In particular, the level of influence was evaluated after viewing the visual materials. The relationship between the influence levels assessed by the respondents and understanding-related effects according to their backgrounds was analyzed. In

addition, the question asked whether or not the respondents' perspectives on the event changed after seeing the materials. Any such alteration is notable since it means that the understanding-related effects, after all, can lead to the function of persuasion. Therefore, I investigated the types and causes of changes, to the extent they were observed at all.

6.6.1. The relationship between the level of influence and understanding-related effects

The overall average score of the influence level given by all respondents was 4.09 and hence the tendency of the score of 4 (which is the closest to the average) and over was investigated. [Fig.117] shows the pattern of the levels of the understanding-related effects depending on the evaluated leveraged scores.

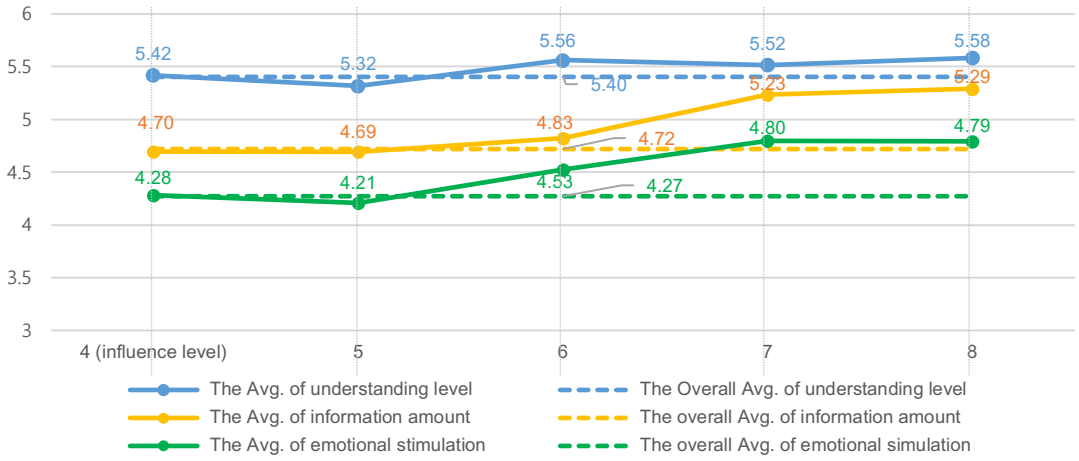


Figure 117. The levels of understanding-related effects by influence degree

One general tendency observed in the data above is that the higher the level of influence, the higher the degrees of understanding, perceived information amount, and emotional stimulation. To put it in another way, among the participants who gave higher scores to the influence perceived, the degree of the leverage was proportional to the level of understanding-related effects.

6.6.2. The level of influence by region

There were 9 nations whose influence levels showed higher ratings than the overall average (4.09). These constituted Asian countries such as Japan, South Korea, China, Russia, Thailand, and Ukraine;

the nations also included some from the Americas such as USA and Canada; and finally the UK from Europe [Fig.118]. The influence levels of those were similar to the pattern of their understanding-related effects: the values of both categories were higher than seen in other regions. However, in particular, the pattern of the emotional stimulation degree was more similar to that of the influence levels compared to others such as the degrees of understanding level and information amount.

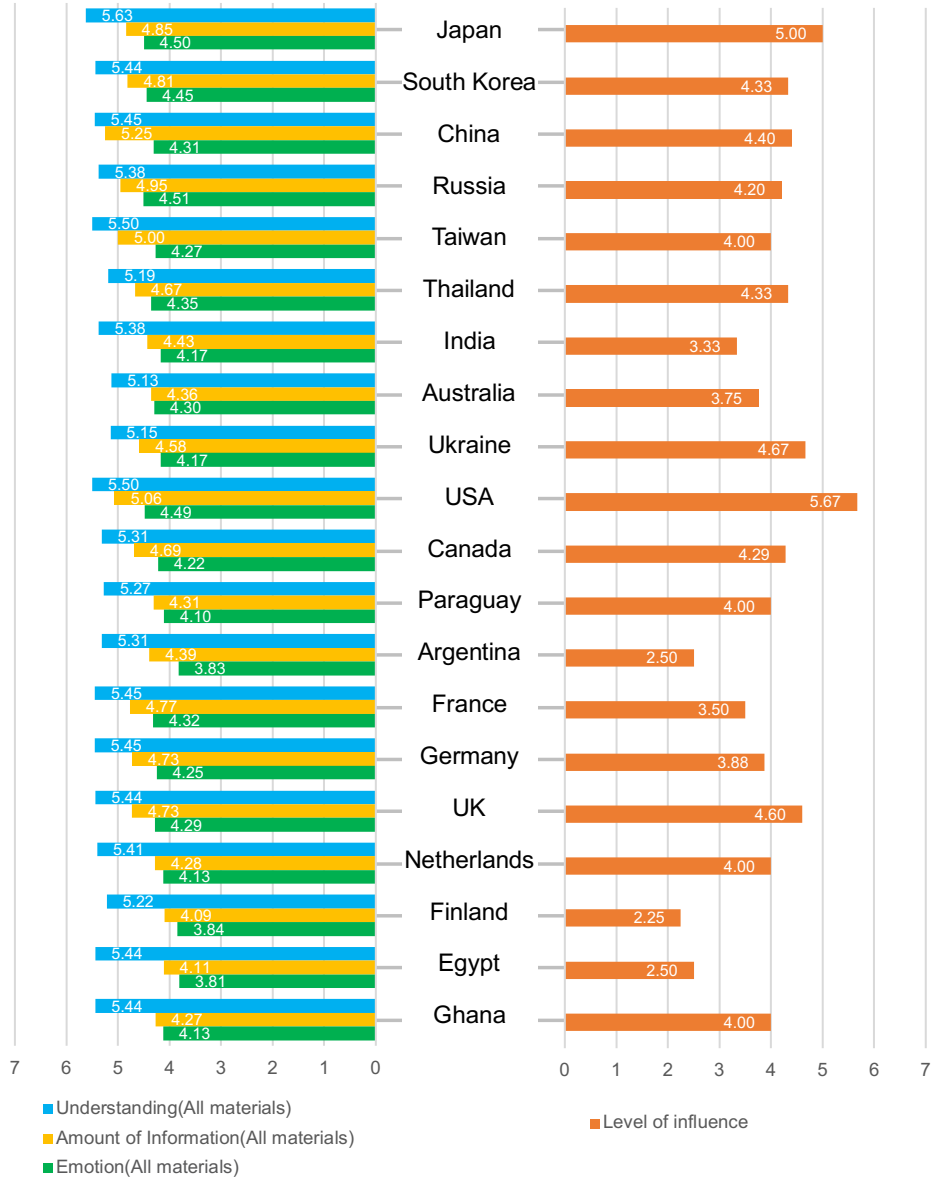


Figure 118. The average values of understanding-related effects and influence level by country

In the categories by nation, it is possible to observe that the influence levels are generally higher among the regions physically close to the influence of the Fukushima disaster. As briefly aforementioned above, the values were mainly higher in the regions of Asia, the Americas and around

the Pacific Ocean. [Fig.119] below indicates this tendency more clearly.

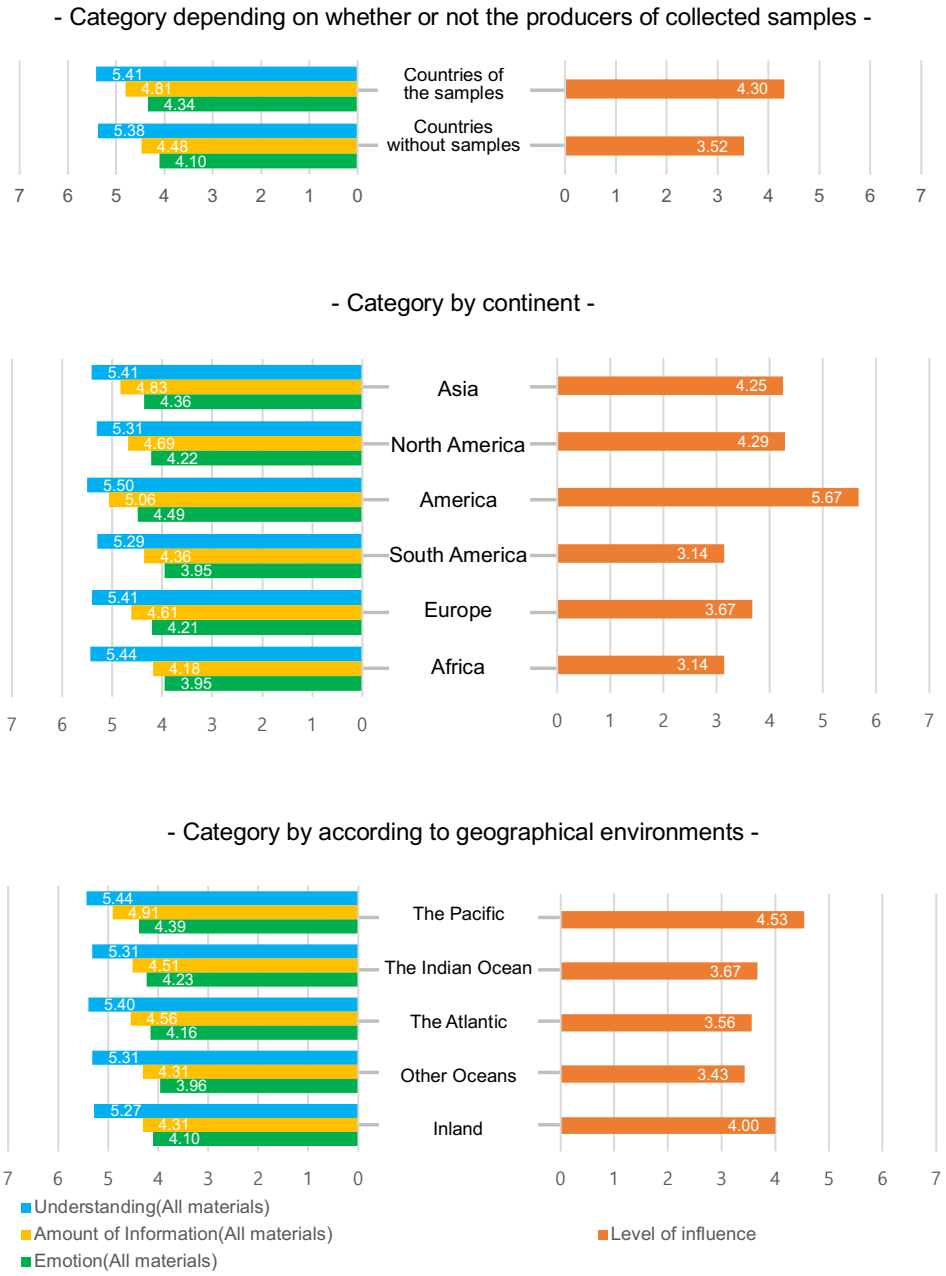


Figure 119. The average values of understanding-related effects and influence level depending on other regional conditions including whether or not the country was a producer of collected samples, continent, geographical surroundings

In particular, the influence level of America was noticeably higher than of other regions. This stemmed from the high scores given by the 3 respondents from USA. One of them was in her 30s and in the group of “Raising children” within the “It matters” group. She provided a relatively high score (7 points) to the emotional stimulation levels of various cases including V.7 and V.8, which were depicting the diffusion of radiation, as well as to V.12, which represented the level of radiation in restricted zones in

Fukushima, and finally V.13 and V.14 which described the information of radiation illness. She also gave the highest score (8 points) to the influence level of these samples. Another interviewee in his 30s and in the group of “Contamination anxiety” within the “It matters” group gave 8 points to the emotional stimulation levels of V.5 which represented the data of the radiation level across the whole of Japan, and 7 points to V.6 which indicated the same data. He provided another high score (7 points) to the degree of influence that was felt. The final interviewee who was in her 20s, and who belonged to the group of “Nothing happened” within the “It does not matter” group, evaluated V.14 as an instance leading to the most intense emotional effect, resulting in a score of 8 points. She also gave the same score to the level of influence perceived. This shows, therefore, that a high influence level resulted especially from the high understanding-related effects (particularly, the emotional stimulation) in the region to which the influence of the Fukushima event spreads across the Pacific.

6.6.3. The level of influence by age

In case of the category by age group, a general tendency is that the higher the age, the higher the influence degree. However, despite the gradual increase of the level of emotional stimulation as we move from the 20s group to the Over 60s group, the influence degree reduced at the group of 40s. In addition, in case of the comparison between the group of 40s and the Over 60s, despite the higher level of the emotional stimulation of the 40s group, the degree of the influence was remarkably lower than that of the Over 60s party [Fig.120].

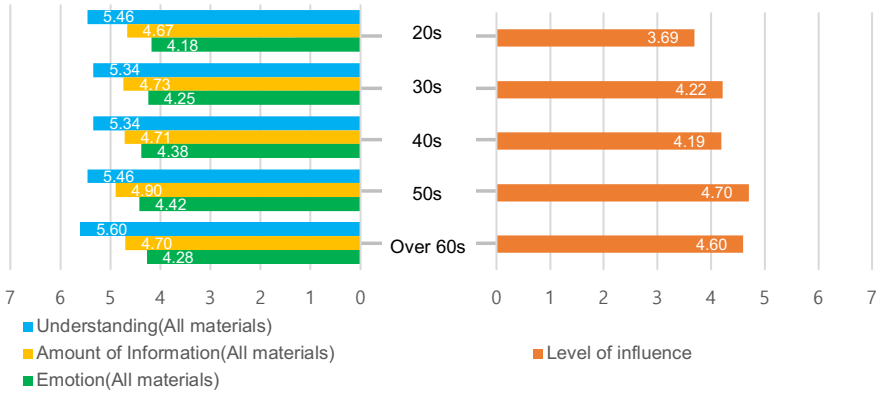


Figure 120. The average values of understanding-related effects and influence levels by age

The reason for this seems to be found in the dominance of the regional condition criteria compared to the age condition. The participants in their 50s and 60s with higher influence levels were mainly from the regions of Asia or the Americas (particularly America and North America) which are close to the impact site of the event, while the group of the 40s contained a larger proportion of the respondents from other regions which were relatively remote from the incident such as South America, Africa, and Europe. The groups of the 50s and 60s contained 12 people from the regions of Asia and the Pacific Ocean and 3 participants from Europe: the gap between the highest and lowest scores in this group is three-fold. On the other hand, the group of the 40s comprised 14 respondents from the groups of Asia and the Pacific Ocean (such as America and North America) and 13 people from the regions of South America, Africa, and Europe.

6.6.4. The level of influence depending on whether or not the Fukushima disaster matters and the reasons for the response given

In the category depending on whether or not the Fukushima event matters to the respondents and the reasons given for those responses, it was possible to find the causality between the levels of understanding-related effects and the evaluated influence among the reasons given within the group of “It matters”. On the contrary, it is not easy to identify such a relationship within the group that stated “It does not matter”. In particular, despite almost identical levels of understanding-related effects between the groups of “Nothing happened” and “Insufficient information” observed, the degree of influence estimated by the “Insufficient information” party is clearly higher than that of the other group [Fig.121].

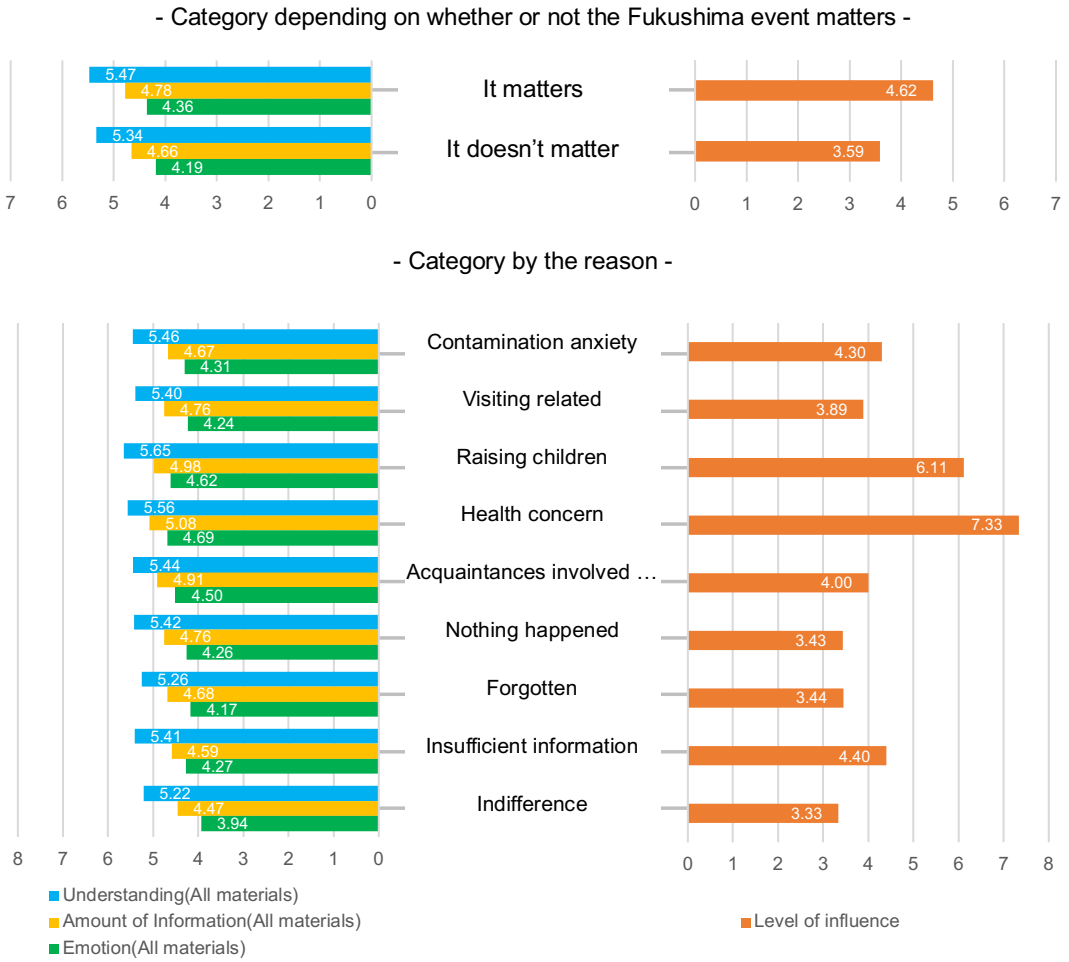


Figure 121. The average values of understanding-related effects and influence levels depending on whether or not the event matters to the respondent and the reasons given

The higher value attributed to the influence level of the "Insufficient information" group cannot simply be explained by the regional or age backgrounds of the participants. The members of this group were distant from the regional conditions which had led to high levels of understanding-related effects and influence (including the areas of Asia, America, North America, the Pacific Oceans, etc.). This party comprised 10 people amongst which 4 members were from the regions of Asia and the Pacific Ocean while the remaining 6 were from Europe and South America. In addition, this group had few participants from older age groups: 6 persons were in the group of either the 20s (3) or 30s (3), and 4 respondents were either in their 40s (2) or 50s (2). Rather than considering age as the man factor behind the results observed in this issue, it is highly probable that the high influence level given stemmed from the changes in their own personal, unique situations, that being a general lack of background knowledge regarding the Fukushima event. With this in mind, it seems to be more reasonable to regard this as an extended

effect of understanding.

6.6.5. The level of influence according to perspective on the Fukushima disaster

In the category of the perspectives on the event, the patterns of the levels of emotional stimulation and influence were generally similar. However, the influence evaluated by the Natural disaster group was higher than that of the Radiation disaster group even though the emotional stimulation degree of the Natural disaster party was lower than the other group [Fig.122].

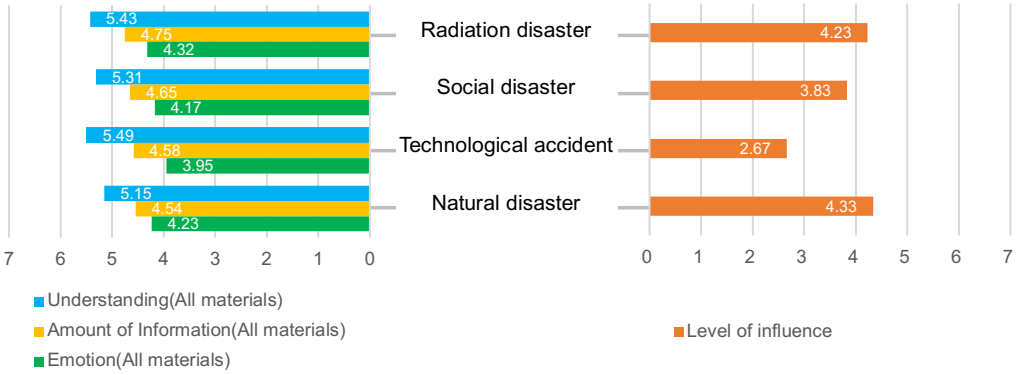


Figure 122. The average values of understanding-related effects and influence levels by perspective on the event

A notable point to mention here is that the visualizations to which this group gave high scores relating to emotional stimulation deals with issues that were not actually specifically focused on the aspect of natural disaster. In the case of the aforementioned members of the US who contributed to the high average score of the influence rating in their regional group, they generally provided high values of emotional effect to the visual materials which contain information relating to their main concerns. However, among the members who regarded the influence of the visual materials as high in the Natural disaster group, the visual materials which gathered high scores of emotional stimulation included V.12, which represented the restricted zones with their contaminated status, V.5 indicating the distribution of radiation in Japan, and V.14 which described the symptoms of radiation illness, etc.

This shows that the acceptance of information through visualization is highly likely to lead viewers into becoming more interested in other subjects that may have previously been ignored from their existing concerns, and may even have served to change their perspective on the subjects. There was in fact one participant who demonstrated this exact shift in attitude. An American participant in his 30s

gave the highest score (8 points) to the emotional effect of V.14; provided the same score to the level of influence; but then changed his existing viewpoint on the event after viewing all the visual materials: shifting his focus from natural disaster to social disaster.

Of course, not all the members of the Natural disaster group changed their perspectives and therefore there is a limitation on how one can generalize such influence of visualization in this group. Nevertheless, there were various respondents in other parties who changed their standpoints and the majority of them provided high scores of emotional effect to the instances whose main topic related to their changed perspectives. In addition, they also highly evaluated the influence of the information acceptance through the visualizations. This change is discussed in more detail in the following section.

6.6.6. The changes of the perspectives following the influences of the visual instances

24 participants responded that their existing viewpoints on the disaster had changed through proper understanding the visualizations, whereas other 89 respondents did not. In particular, the aspect of radiation catastrophe seems to be the most intense feature of the disaster. For both groups where there was a change of perspective or not, 78 participants selected the Radiation disaster as their final standpoint [Fig.123].

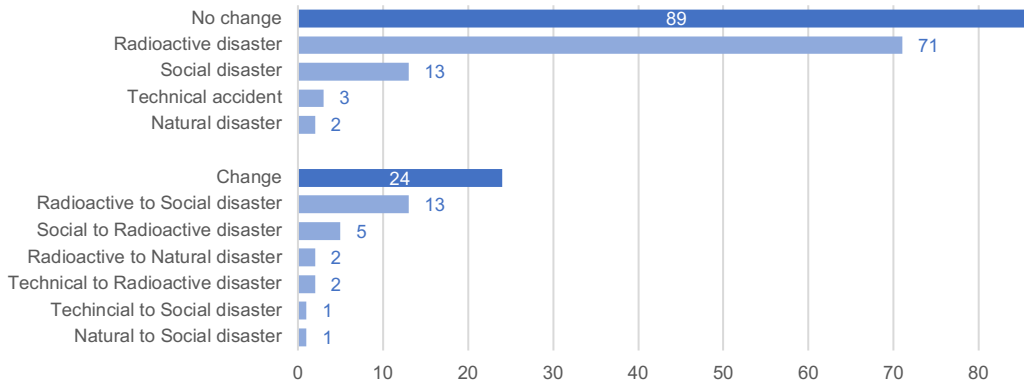


Figure 123. The number of participants who did or did not change their existing perspectives

The maintenance of the existing perspective itself can be regarded as a kind of reaction influenced by the visual samples as well. This is because not all the respondents who maintained their viewpoints provided markedly lower scores to the influence level when compared to the overall average value. The average value of the influence levels of those who did not change their existing perspectives was 4.07,

with this score being only 0.02 points lower than 4.09 (the overall mean score of the influence degree). Moreover, in case of those who maintain the perspective of Radiation disaster, the average value of the influence was 4.25 points which was higher than the overall mean score [Fig.124].

On the other hand, the influence degree of people who selected that they had experienced a change of perspectives was 4.17 points, this value being higher than that of the group who selected that their perspective had not been affected.

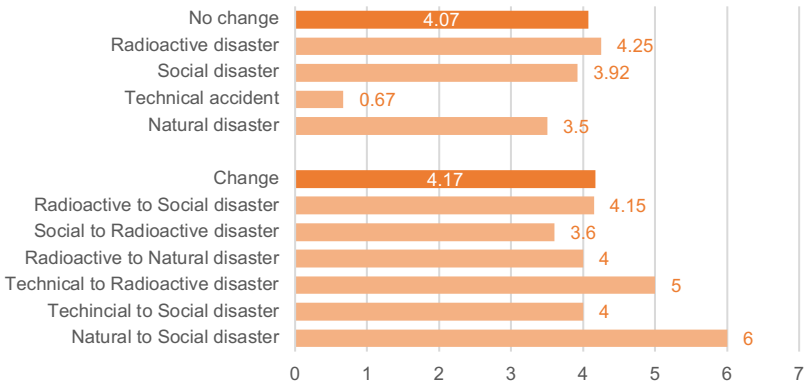


Figure 124. The scores of the influence levels given by participants who did and did not change their existing perspectives

As discovered in [Fig.123] and [Fig.124] above, there are 6 instances of changing standpoints. They can be organized as per [Table 53] below again.

Type	Type of the change	The number of People
A	Radioactive disaster → Social disaster	13
B	Social disaster → Radioactive disaster	5
C	Radioactive disaster → Natural disaster	2
D	Technological accident → Radioactive disaster	2
E	Natural disaster → Social disaster	1
F	Technological accident → Social disaster	1

Table 53. The types of change in perspectives on the event and the number of members in each of the types.

Type A which possesses the largest number of participants, represents the perspective movement from Radiation disaster to Social disaster. Type B contains the second largest members, and shows the reverse trend, i.e. the change from Social disaster to Radiation disaster. In terms of the number of people who selected this change, type A is the most predominant. However, when taking the population of each of the early perspective groups into account, the number of participants in type B nevertheless

constitutes a significant amount as well. The analysis of the statistics should be considered here: the numbers found in type A means that 15% of 86 participants in the Radiation disaster group changed their positions while type B shows an even greater percentage, leading to 28% (or 18 members) in the Social disaster group who ended up changing their viewpoints.

In addition, the nationalities of the participants who made such changes were generally found to be from the regional groups in which the influence levels of the visualizations were on the higher side. Types A, B, C, and D, all of which included at least one member, demonstrated that the respondents with changes in perspective were usually found in the groups of Asia and the Pacific Ocean. In addition, all groups of the change types except for the form of C, contained South Korea, China, and Russia which are the immediate neighbouring countries of Japan [Table 54].

Type	Countries of respondents and the number of those	Region by continent and the number of participants	Region by geographical surroundings and the number of respondents
A	Japan(2), South Korea(1), China(2), Russia(1), Ukraine(2), USA(1), Canada(2), Paraguay(1), Argentina(1)	Asia (8) The Americas (5)	The Pacific Ocean (9) Other oceans (2) The Atlantic Ocean (1) Inland (1)
B	South Korea(1), Thailand(1), India(1), Germany(2)	Asia (3) Europe (1)	The Pacific Ocean (2) The Atlantic Ocean (2)
C	Australia(1), France(1)	Asia (1) Europe (1)	The Pacific Ocean (1) The Atlantic Ocean (1)
D	Russia(1), India(1)	Asia (2)	The Pacific Ocean (1) The Indian Ocean (1)

Table 54. The regional backgrounds of the participants by type of change.

In each of the groups, the respondents have one changed perspective, but other factors such as whether or not they consider the event still matters, and their reasons for giving such response, are varied. [Table 55] shows this diversity.

Type	The group of "It matters"	The group of "It does not matter"
	Reasons and the number of people	Reasons and the number of people
A	Contamination anxiety (4) Raising children (2) Visiting related (1)	Indifference (3) Nothing happened (1) Forgotten (1) Insufficient information (1)
B	Contamination anxiety (1)	Nothing happened (2) Forgotten (2)
C	Contamination anxiety (1)	Insufficient information (1)
D	Visiting related (1)	Forgotten (1)

Table 55. The respondents' backgrounds regrading whether or not the event matters and its reasons by type of change.

In order to understand some of the reasons which have led such variety in reasons, this study has investigated the visual instances which were effective in instigating understanding and encouraging emotional stimulation among the participants in each of the types. As a result, it was possible to discover similarities between the main topics of those visual instances and the altered viewpoints of the participants. [Table 56] below shows the visualizations which received the highest scores in understanding and emotional effect.

Type	Visual instances with the highest understanding level		Visual instances with the highest degree of emotional stimulation	
	Visual instance	The Avg. of the type group / Overall Avg.	Visual instance	The Avg. of the type group / Overall Avg.
A	V.11	7.00 / 7.15	V.12	5.92 / 5.25
B	V.14	7.40 / 6.59	V.12	6.00 / 5.25
C	V.6	7.50 / 6.03	V.5 V.9	6.50 / 5.84 6.50 / 5.00
D	V.1 V. 11 V. 14	6.50 / 5.68 6.50 / 7.15 6.50 / 6.79	V.5 V.12	6.50 / 5.84 6.50 / 5.25

Table 56. the visual instances evaluated as the most effective in understanding and emotional stimulation among the participants in each of the types.

Among the members in the group of type A, the visual instance leading to the highest understanding level was V.11, which indicated the realms of restricted zones in Fukushima by using a representational key, Hue. In addition, the visual sample of the highest emotional stimulation degree was V.12 which represented the level of radiation contamination and the boundaries of the restricted zones all in one place. Both visual materials share a common issue, in that when considering the exclusion and evacuation zones in Fukushima, they both refer to the topic of the social aspect of this disaster. In particular, when taking the fact that V.12 also deals with the data of radiation level into consideration, such combination of the different issues seemed to be familiar among the participants with the perspective of radiation disaster, and this also allowed them to pay attention to another issue as part of the overall social aspects under consideration.

The B type is very similar to that seen with type A. The visual sample considered as the most effective in leading to effective understanding in this type (B) was V.14 which represented the symptoms of radiation illness. Further, and with regards to the emotional stimulation effects noticed, V.12 (which is

same to that of type A) scored the highest. It was highly probable that the two different sides of V.12 aroused interest with the people who approached the matter with the social disaster perspective and, after all, made them give added weight to the representation of radiation contamination, which is a cause of the social problem.

The types of C and D show similar tendencies as well. In case of type C in which the perspective of radiation disaster changed to natural disaster, the visual instance regarded as the most effective in emotional stimulation was V.9, which described a natural disaster, i.e. the spread of tsunami. In addition, among the respondents in type D who showed the change from technological accident to the radiation disaster perspective, V.12 and V.5, which had in common features representing the data of radiation level, were regarded as the most effective to elicit emotional stimulation.

With regard to the age groups of those who changed their perspectives, the groups of 30s and 40s were those who were shown to be the most likely to change their views. In particular, these groups were not weighted towards certain types of changes but distributed evenly across each of the types [Table 57].

Type	20s	30s	40s	50s	Over 60s
A	1	6	4	1	1
B		1	2	1	1
C		1	1		
D	1	1			

Table 57. The distribution of the ages of the participants depending on the types of changes

To summarize the discussions above, the influence of the visual materials can be regarded as a kind of subsequent and extended effect, stemming from high understanding-related effects, and particularly from the emotional point of view. There are several reasons why this is found to be the case: a) the intensity of the influences seen was proportional to the levels of understanding-related effects; b[28]) the level of the influence was higher mainly among the regions specifically represented in the visual

28

instances as being those areas which felt a direct influence of the Fukushima event, similar to the levels of understanding-related effects; c) the degree of the influence felt was more dominant when considering the regional conditions rather than the age condition, analogous to the case of the effects regarding understanding; and finally, d) the intense emotional stimulation and influence even led to persuasion: changing or reinforcing the early perspectives on the event.

In addition, another notable point is that the visual materials regarded as effective in emotional stimulation among the respondents who changed their perspectives were included in the visualizations with high overall average scores. This situation is shown in the groups of types B, C, and D, which contain a small number of members (5, 2, and 2, respectively). After all, this indicates the close relationship between the influence and understanding-related effects of visualization: the visual materials which are effective in understanding are, after all, also effective in the formation of the influence.

7. Conclusion

7.1. Visualization and understanding

In order to summarize the findings concerned with understanding visualization of the Fukushima event, the three aforementioned components to complete this process are recalled again, which are essential to the process where the event is represented in visualization and where viewers employ it to accept information. These components are subject, visualization, and the Fukushima disaster, as aforementioned [Fig.125].

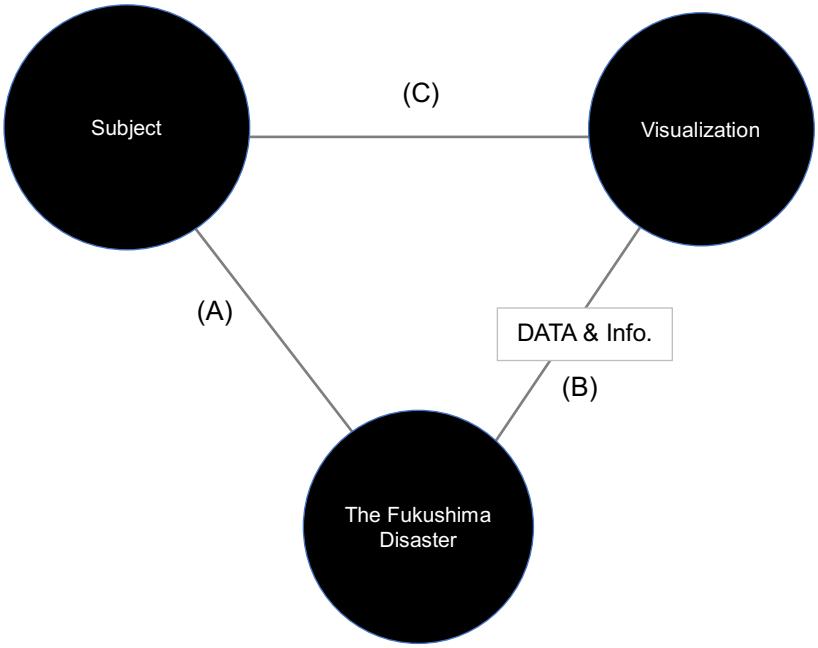


Figure 125. The relationship between the tripartite

Among the tripartite above, the findings concerned with understanding can be summarized as follows.

Firstly, in terms of (A), the relationship between Subject and the Fukushima disaster, the subjects (viewers) came into the process with different backgrounds surrounding this event and this resulted in different degrees of understanding and its subsequent effects. To be more specific, the visualization was more easily understood by those who had distinct interests, reasons for concerns, more background knowledge, or nationalities which were represented as one of those affected by the influence of the event in visualization, etc. However, this was not always the case. There were some

people who also demonstrated a high degree of understanding of the visualization despite a lack of background knowledge or indifference. In this case, they gave a high score to the influence of visualization after understanding, and more evidently changed their perspectives as well. This seems to suggest that the acceptance of new information motivated them to think about their concerns and encouraged them to interpret visualization actively.

Secondly, (B) refers to the relationship between the Fukushima event and visualization. In the collected visualization instances, most of them tended to deal with data and information regarding the radiation-related issues such as radiation level, radiation illness, spread of radiation, etc. The second most frequent topic in the visual samples represented the data and information of social aspects of the event including exclusion and evacuation zones, conditions regarding evacuation (population, route, etc.). The third most common theme concerned data and information relating to technological topics such as the conditions or structures of the reactors. Finally, the fourth most frequent issue was the data and information related to the issues of natural disaster such as tsunami, earthquake, etc.

As data and information is the essential resource to produce visualization, the origins of its source affects understanding visualization as well. In general, people answered that the reliability of data sources would have had an influence on their understanding of the visualization. In particular, most of the viewers relied on data sources which were not tied to the Japanese government, and depended more on the organizations with large scale, such as government agencies, international organizations, and university institutes. Nevertheless, among the collected cases, most of the visualizations related to radioactive contamination were based on data from MEXT, a Japanese governmental organization.

In this regard, it would be preferable to broaden the scope of the sources of data collected and used in journalism media (especially online newspapers). In particular, if journalism media employs data collected and opened in real time by diverse NGOs, the resulting visualizations are likely to be more reliable; provide more bountiful information; evolve in the aspect of presentational method. This is because, as discussed in the Background chapter, their data tend to be more elaborate, accurate and broader in scope.

Finally, (C) is the relationship between subject and visualization. This research discovered that

understanding effects differed depending on the various components of visual syntax such as representational key, type of visualization, metaphorical and metonymical expressions.

In the case of the representational key, non-arbitrary key is more effective and easy to understand compared to arbitrary key even though the features of data and information which they deal with are different to each other. In particular, Hue, one of the arbitrary keys, was more effective for those participants who had more experiences of its use (i.e. elder age groups), and more background knowledge of this key. On the other hand, Shape, one of the non-arbitrary keys was effective among the majority of viewers.

The tendency above is also true for the types of visualization. Despite the same data being employed, the combination of map and bar chart (based on Bar) was more effective than that of map and color plot chart (based on Hue) among the majority of people. In case of the type of technical drawing, the forms with more detailed and exquisite descriptions were more effective in leading to understanding and its related effects.

In case of metaphorical expression, viewers were more likely to misunderstand the information when the legends and explanations about what it represented were not effectively expressed. In addition, in terms of metonymical representation, the higher the degree of its extracted detail, the higher the level of understanding ensuing, and its subsequent effects.

Another point to note is that, in relationship (C), emotional effect was clear to see, and further, that this state of emotion changed the conditions of the subjects (viewers) in some cases. Particularly, participants with a higher understanding level received more emotional stimulation; it was evident that they had felt a greater influence from the visualization, which led them to eventually change their viewpoints.

In addition, relationship (C) was closely concerned with (A). The closer to the event psycho-physically, the higher the level of understanding in the relationship of (C).

7.2. Visualization and emotional impact

The condition required to result in a high emotional impact of visualization was firstly a high degree of understanding. Of course, visualization with high understanding did not necessarily have great

emotional impact. This is because, as aforementioned, emotional effects required not only high levels of understanding but also a variety of other background conditions of viewers.

One of those conditions is the relevance between the viewer's background and the subject (main topic) of data and information in the visualization. When viewers had personal concerns about the event; regarding their conditions (e.g. health condition, etc.) as stark signs of the influence of the event, it was discovered that the influence of the event was dependent on their own regional circumstances, and thereafter the emotional impact after understanding visualization became more intense.

One further issue related to the impact felt in the process of acquiring new knowledge. Unlike the conditions mentioned immediately above, this can be found with the participants who were indifferent to the disaster or who had required the fundamental information of this event regardless of their own concerns, before interpreting the visualization. However, even in this case, the topic of data and information is still very important. This is because the visual samples which scored highly dealt with the data and information of radiation illness or spread of contamination which can be personal concerns. None of them highly ranked the visualizations whose main information was the reactor's condition or the domains of the restricted zones, etc.

The final topic is of representation manner. Despite the visualizations largely representing the same data and information, the emotional impacts were more intense in the cases of a) realistic and detailed descriptions by using photos or multiple and elaborate depictions for qualitative information (compared to minimal and simple expression), and b) metaphorical expressions using the principle (Hue) of heat map (thermography) for quantitative data (compared to other representational keys using Bar, Circle, and Line). Of course, one possible criticism of this is that these findings could produce defective results since the visual samples with such expressional manner were those that deal with personally anxious topics such as radioactivity or radioactive contamination. However, this research addressed this by comparing diverse pairs of visual instances which used different methods but represented the same data and information.

7.3. Visualization and political impact

One of the meaningful discoveries of this research is that visualization can change people's

perspectives. Of course, this cannot be regarded as a meaningful or revolutionary political action to solve all disasters, or even this one disaster. However, it can at least mark the beginning of that process.

In addition, what has changed is not just a viewpoint. Interestingly, even though the question was not specifically asked, some of the participants who had originally planned to visit Japan soon confessed that they would cancel it. There were some respondents who said they should refrain from consuming Japanese products (such as sake, curry, snacks, even cosmetics, etc.) for the time being. It is uncertain whether these are positive changes or not, but what these reactions clearly show is an increase in interest and a change of opinion in people who understood the information through visualization.

Therefore, it is necessary to consistently and broadly deliver more various information and data which people have demanded and have been interested in, through visualization which is effective in understanding.

In this respect, it would be determinative if information visualization works within the context of a movement aimed at solving sociopolitical problems. This is because it is highly likely that visualization makes people participate in problem solving by showing that this event continues to affect diverse regions which are very distant from the disaster, and making people empathize with the difficulties of this event.

7.4. Guidelines for the field of practice

Taking all the discussions above, I suggest guidelines for the field of visualization production and visual journalism. This can be described in 3 stages including pre-production, production and post-production as follows:

a) The stage of Pre-production

a-1) Inspect the quality of data and information,

(It is necessary to check whether they contain misinformation and confirmation that the sources are reliable.)

a-2) Clarify the purpose of visualization,

(It is necessary to consider what it aims to represent: distribution, shape and structure,

movement and direction, comparison of quantity, etc.)

a-3) Make it clear whether the purpose of visualization is the formation of emotional impacts, or just the delivery of information,

(This is closely related to the levels (a-4) and (a-5).)

a-4) Clarify and understand the target (viewer) of visualization,

(It is necessary to consider the different backgrounds of those who use visualizations: their specific situations, relevance between the subject (main topic) of data and information and their backgrounds, etc.)

a-5) Try to gather additional data and information which is relevant to the viewers' background, besides given data and information,

b) The stage of Production

b-1) Indicate the source of data,

b-2) Carefully decide the representation key of visualization,

(Since the representational key is the encoded form of data and information, it is necessary to use it carefully based on the consideration in step a-2 above.)

b-3) Find causality between different types of visualization and when it is necessary to use multiple types,

(If complex and multiple data and information are to be presented, it is necessary to identify the causal relationships between those and present them as a combination of forms rather than a dispersal type. (Do not reduce the amount of information and data to improve understanding))

b-4) In the case of using metaphorical expression, be careful of the possibility of misunderstanding and actively use legends or explanations about the data and information to avoid any such risks,

b-5) In the case of using metonymical representation, elaborately describe the extracted detail

(It is necessary to extend to detailed visual presentations rather than relying on text if possible)

*** For more details on the representational methods, see [Table 52] on p.196.**

c) The stage of Post-production

c-1) Inspect whether the quality of visualization is publishable

c-2) Make sure that the visualizations created through the above process are used as a tool to easily understand information and data for various people, and to play a role in changing their viewpoints and thoughts.

7.5. Value of this research and contribution

This study confirmed that multidimensional issues have been represented even by the basic media type of visualization (2D and still image based media). In addition, digital algorithms and interactive media technologies have already largely overcome the technological limitations of traditional visualization media and have widened the kinds of information and data which visualization can represent. Thus, it seems that it is not easy to find the limitation of the topics (data and information) that the contemporary visualizations can represent. In addition, Artificial Intelligence (A.I.) and visualization are becoming more and more a hot topic as well. According to Nicolas Kruchten (2018[29]), a visualization designer and programmer, the technologies and principles of visualization have been very useful for A.I. learning, and that A.I will be a very useful tool to produce visualization. In this situation, the progress of visualization will continue as long as the growth of data and information does not stop and the subjects do not diversify to an uncontrollable amount.

On the one hand, the evolution of such advanced technologies are clearly necessary and inevitable, but on the other hand, there is a need to continue research on the fundamental function that visualization should not lose, which is the fundamental ease in its usability. This is based on the same line of the necessity of education and research on the basic function of visualization which was highlighted by Stephen Few and Arnold Norman (Few, 2008): Moreover, no matter how advanced the technology of visualization is or becomes, it necessarily possesses the components of the visual syntax which belongs to the framework of this research. In addition, most of all, both the advanced and basic media type of visualization share the ultimate goal of visualization to make people understand data and

[29] https://medium.com/@plotlygraphs/data-visualization-for-artificial-intelligence-and-vice-versa-a38869065d88

information as easily as possible. Therefore, I believe the function of visualization will be more powerful when my research findings and the principles of the advanced technology-based visualization are combined to work in harmony with each other.

It is probable that a disaster similar to the Fukushima event will occur again in the future. This is because of increasingly old nuclear power plants remaining in operation, and the unpredictability of climate and natural disaster. If a similar event occurs, then it is likely that the future disaster will result in more data and information being produced than the Fukushima incident. This is because the Fukushima incident led to the recognition of the importance of collecting and sharing data, and the activities of international NGOs struggling over trying to obtain that data are also continuing. In addition, as individuals become more involved in these events, the amount of information and data will become larger, and it is likely to result in more complex forms of visualization compared to the current visualizations of the Fukushima event. Nevertheless, the ultimate function and role of visualization of the disaster will not change. It should be used as a medium that serves to change the world by resolving the difficulties of disaster. To do so, visualization should allow for easy and accurate understanding for various people from diverse backgrounds; show that the disaster affects the viewers themselves; and strengthen their interest and involve them in solving problems.

This study is valuable in that it has studied how the elements of visualization can work towards this goal.

7.6. The limitation of this research

There are several limitations of this research. Firstly, there was a large gap in the number of samples provided by each of the age groups. In particular, the group of the Over 60s was only made up of a small number of people and their nationalities were not diverse either. Therefore, there is a limitation on generalizing the tendency specifically in relation to the Over 60s group as being the universal tendency of all older people. Secondly, the interview was conducted mainly around Seoul National University and hence, most of the participants with non-Korean nationality had a similar purpose (academic purpose) to be in that area. Therefore, they were assumed to have similar levels of education. In order to solve this problem, I interviewed other participants at other places (not around Seoul National

University), but the number of people in this sample was relatively insufficient. Therefore, there was a limitation in representing the full diversity of education level across the country, and across other countries. This study confirmed that the participants' perspectives had indeed changed in some way, but it could not observe what kind of action this change led to in terms of being actually helpful in the post-disaster society. More time is therefore required to fully appreciate how people can change the situation through visualization. These limitations will need to be addressed in my subsequent studies.

Bibliography

A.D.A.M. (American Accreditation HealthCare Commission), “Peptic ulcer”, [Illustration]. [Internet]. Available at <https://medlineplus.gov/ency/article/000206.htm>

Adjei, C. “Germany’s Top 20” [diagram] In: Klanten, R., et al. (2010). DATA FLOW 2. Berlin: Gestalten, p. 89

Aftonbladet, (2011), “Så skadas kroppen av strålning (Damaged body by radiation)”, [infographic]. [Internet]. Available at <http://www.aftonbladet.se/nyheter/jordskalvetijapan/article12742914.ab>

Ahmed, S. 2004a. “Affective economies”. Social Text, 22 (2), pp.117-139. Durham NC: Duke University Press.

Ahmed, S. 2004b, The Cultural Politics of Emotion. Edinburgh: Edinburgh University Press.

Asahi newspaper. (2011). “福島第一原発と福島第二原発の比較 (The comparison of No. 1 nuclear power plant and No. 2 nuclear power plant in Fukushima)”. [diagram]. [Internet]. Available at <http://www.asahi.com/special/10005/TKY201104050625.html>

Asahi Shimbun, (2011), “福島の 3 河川、汚染調査へ 海への広がり解析 金沢大 (Analysis of the spreading pollution from the three rivers in Fukushima to the sea, Kanazawa Univ.)” [infographic]. [Internet]. Available at <http://www.asahi.com/special/10005/TKY201106100688.html>

Asahi Shimbun, (2011),
“〈事故の最新情報〉福島第一原発 3 号機の構造と放水作戦 = 2011年3月18日朝刊 (The structure and strategy to cool down the Unit 3 of Fukushima Daiichi Nuclear Power Plant = March 18, 2011)”, [infographic]. [Internet]. Available at <http://www.asahi.com/photonews/gallery/infographics/npp318a.html>

Asahi Shimbun, (2011), “〈事故の最新情報〉福島第一原発の損傷 = 2011年3月21日朝刊 (The damaged situation of the Fukushima Daiichi nuclear power plant, 21st of March, 2011)”, [infographic]. [Internet]. Available at <http://www.asahi.com/photonews/gallery/infographics/page2_plant.html>

Asahi Shimbun, (2011), “双葉町民の避難状況 (The situation of evacuation in Futaba town)”, [infographic]. [Internet]. Available at <http://www.asahi.com/special/10005/TKY201103280574.html>

ASR. (2012). “Floating Tsunami Debris Tracking System (update: March 2012)”. [infographic]. [Internet]. Available at <http://www.asrltd.com/japan/debris.php>

Balaji, M. 2011. “Racializing pity: The Haiti earthquake and the plight of ‘others’”. Critical Studies in Media Communication, 28, no. 1: 50-67.

Barthes, R. 1977. IMAGE MUSIC TEXT. London: Fontana Press

BBC. (2011). “Japan crisis in maps”. [diagram]. [Internet]. Available at <http://www.bbc.co.uk/news/world-asia-pacific-12775846>

Berliner Morgenpost , (2011), “DER RETTUNGSVERSUCH... UND SZENARIEN, FALLS ER MISSLINGT (The scenario of the damage restoration… but, if it fails)” [infographic]. [Internet]. Available at <http://www.morgenpost.de/politik/article1573292/Die-erste-Explosion-im-Atomkraftwerk-Fukushima-1.html>

Bertin J., 1983, William Berg (Translator), Semiology of Graphics (Bertin, 1967). University of Wisconsin Press. WI.

Bild, (2010). “So schlimm wüten Russland-Feuer in radioaktiver Region (Bad influence of the raging fires in Russia by radioactive region)”. [infographic]. [Internet]. Available at <http://www.bild.de/news/2010/feuer-wuetet-in-radioaktiver-region-13597978.bild.html>

Boltanski, L. 1999. Distant Suffering: Morality, media and politics. Cambridge: Cambridge University Press.

Braun, C and S. Sergei, 1993, "Why is water blue?", Journal of Chemical Education, 70 (8): P. 612–614.

Brautigam, S. (2008). “Overnewsed but uninformed”. [diagram]. [Internet]. Available at <http://www.visualcomplexity.com/vc/project.cfm?id=576>

Buerk R., 2011. Tsunami hits north-eastern Japan after massive quake, BBC News [Internet]. Available at <https://www.bbc.com/news/world-asia-pacific-12709598>

Carr, N. 2010. The Shallows. London: Atlantic Books

Cernea, D., Weber, C., Ebert, A. and Kerren, A. 2015. “Emotion-prints: Interaction-driven emotion visualization on multi-touch interfaces”. SPIE Proceedings Vol. 9397: Visualization and Data Analysis.

Chai S., 2011, “Japan's quake shifts earth's axis by 25 centimetres”. Montreal Gazette. [Internet]. Available at <http://www.montrealgazette.com/news/Japan+quake+shifts+earth+axis+centimetres/4426356/story.html>

Chang K., 2011, Quake Moves Japan Closer to U.S. and Alters Earth's Spin, The New York Times. [Internet]. Available at <http://www.nytimes.com/2011/03/14/world/asia/14seismic.html>

Cheon H., 2011, 日 후쿠시마원전 20㎞권내 출입 완전 봉쇄, 헤럴드경제 [Internet]. Available at <http://biz.heraldcorp.com/view.php?ud=20110420000429>

Chernobyldoc. 2007. Chernobyl interviews: Interviews with people in Kiev about Chernobyl and how it effects their lives [Internet]. Available at <https://www.youtube.com/channel/UCwPeh8FtgmyXQeAk6qUH12Q>

Chornobyl Ministry of Ukraine. (1996). “Map of Ukraine contamination with cesium-137 as of 1996”. [diagram]. [Internet]. Available at <http://chornobyl.in.ua/uk/radioaktyvne-zabrudnennia.html>

Clark, M. et al. 2003, “Application of infrared thermography to the non-destructive testing of concrete and masonry bridges”, NDT&E International, Vol. 36, (2003), P. 265–275.

Clough, P. 2008. “The affective turn: Political economy, biomedia and bodies”. Theory, Culture & Society, 25, no.1: 1-22.

Cuckler K., 2010, ‘Data, Data Everywhere’ in The Economist [Internet]. Available at <https://www.economist.com/special-report/2010/02/25/data-data-everywhere>

Cuckler K., 2010, ‘Data, Data Everywhere’, The Economist. [Internet]. Available at <http://www.economist.com/node/15557443>

Cutietta, R. and J. Kelly, 1987, “A Comparative Study of Color Association with Music at Various Age Levels”, JRME, 1987, Vol. 35, No. 2, P. 78-91.

Dagbladet, (2011), “87 JORDSKJELVUTSATTE (87 EARTHQUAKE EXPOSED)” [infographic]. [Internet]. Available at <http://www.dagbladet.no/2011/03/17/nyheter/atomkraft/miljo/atomkatastrofe/erik_solheim/15850491/>

Dailymail, (2011), “America on radiation alert”, [infographic]. [Internet]. Available at <http://www.dailymail.co.uk/news/article-1366341/Japan-tsumani-earthquake-America-nuclear-accident-radiation-alert.html>

Dailymail, (2011), “Japan Radiation Levels”, [infographic]. [Internet]. Available at < http://www.dailymail.co.uk/news/article-1370113/Japan-earthquake-Fukushima-reactor-nuclear-leak-causes-radiation-levels-rocket.html>

Dailymail, (2011), “Radioactive plume“, [infographic]. [Internet]. Available at <http://www.dailymail.co.uk/news/article-1366920/Japan-earthquake-tsunami-UN-predicts-nuclear-plume-hit-US-Friday.html>

DANILOVA, M. 2008. “Chernobyl reactor to be buried in steel coffin”. York Dispatch. [Internet]. Available at <http://www.yorkdispatch.com/morebusiness/ci_9106060>

DER SPIEGEL, (2011), “The path of radiation and its effects on humans”, [infographic]. [Internet]. Available at <http://www.spiegel.de/international/world/fukushima-fallout-how-dangerous-is-japan-s-creeping-nuclear-disaster-a-753530.

Der Spiegel. (2011). “A Deadly Wave”. [diagram]. [Internet]. Available at <http://www.spiegel.de/international/world/fukushima-fallout-how-dangerous-is-japan-s-creeping-nuclear-disaster-a-753530.html>

Der Standard, (2014), “Übersicht über einstige (links) und aktuelle (rechts) evakuierte Zonen rund um das AKW Fukushima Daiichi. (Overview of former (left) and current (right) evacuation zones around the nuclear power plant in Fukushima Daiichi.)”, [infographic]. [Internet]. Available at <http://derstandard.at/1392686211483/Strahlungsbelastung-Japans-Behoerden-geben-Entwarnung-um-Fukushima>

Die Presse, (2011), “Erdbeben, Vulkane, Plattentektonik: Der„Ring of Fire“ (Earthquakes, volcanoes, plate tectonics: The "Ring of Fire)” [infographic]. [Internet]. Available at <http://diepresse.com/home/panorama/welt/641252/Geologie_Japan-liegt-auf-dem-Feuerring>

Die Zeit. (2011). “Wie viele Menschen leben im direkten Umkreis von Atomkraftwerken? (How many people live in the immediate vicinity of nuclear power plants?)”. [diagram]. [Internet]. Available at <http://opendata.zeit.de/atomreaktoren/#/de/>

Drucker, J and E. McVarish. 2013. Graphic Design History: A critical guide. New York: Pearson.

Ecoblog, (2013), “Nuclear Fallout Map”, [infographic]. [Internet]. Available at <http://www.ecoblog.it/post/14809/fukushima-un-anno-dopo-lenergia-che-muove-il-mondo-e-ancora-atomica>

El Mundo, (2011), “Crisis nuclear en Fukushima Terremoto en Japón”, [infographic]. [Internet]. Available at <http://www.elmundo.es/especiales/2011/terremoto-japon/terremoto_tsunami.html>

Ethan A. Huff. 2013. The evidence is clear: Fukushima radiation is still tearing up West Coast of USA, Natural News in Truth 11 [Internet]. Available at <http://truth11.com/2013/11/14/11-articles-on-the-global-threat-of-fukushima/>

Faro de Vigo, (2011), “Alerta nuclear en el país nipón (The nuclear alert in Japan)” [infographic]. [Internet]. Available at <http://www.farodevigo.es/noticias-hoy/intermedia/Japon/lunes.html>

Few, S. 2008. What ordinary people need most from information visualization today. Perceptual Edge: Visual Business Intelligence Newsletter.

Florida Eye Institute, “What is a cataract?”, [Illustration]. [Internet]. Available at <http://www.fleye.com/cataract-center/cataract-faqs/>

Fry, B.J. 2004. “Computational Information Design.” PhD dissertation, Program in Media Arts and Sciences, Massachusetts Institute of Technology.

Funnel Incorporated. “How Books are Made at Webcrafters Inc. – Madison, Wi USA”. [diagram] In: Klanten, R., et al. (2006). DATA FLOW. Berlin: Gestalten, p. 140

Futura Science, (2012), “Comprendre les Tsunamis ((Understanding of Tsunamis)”, [infographic]. [Internet]. Available at <http://www.futura-sciences.com/magazines/terre/infos/actu/d/geologie-fukushima-seisme-tsunami-itineraire-catastrophe-37220/>

Garcia-Retamero, R., & Cokely, E.T. (2013). Communicating health risks with visual aids. Current Directions in Psychological Science, 22 (5),

Garcia-Retamero, R., & Cokely, E.T., 2013, Communicating health risks with visual aids. Current Directions in Psychological Science, 22 (5),

Geological Survey. 2011. Magnitude 8 and Greater Earthquakes Since 1900, Geological Survey, [Internet]. Available at <http://earthquake.usgs.gov/earthquakes/eqarchives/year/mag8/magnitude8_1900_mag.php

Ghelfi, A. “Price and market penetration of consumer electronics over the past 50 years” [diagram] In: Klanten, R., et al. (2010). DATA FLOW 2. Berlin: Gestalten, p. 70

Grubbs, W. and N., Yahnke. (2007). “Patterns in Oscar movie”. [diagram]. [Internet]. Available at <http://www.pitchinteractive.com/infovis/abstract.html>.

HALL, J. 2013. “The 'toxic monster' is coming! Texas-sized floating island containing one million tonnes of junk from Japan tsunami drifting towards US”. The Independent. [Internet]. Available at <http://www.independent.co.uk/news/world/americas/the-toxic-monster-is-coming-texassized-floating-island-containing-one-million-tonnes-of-junk-from-japan-tsunami-drifting-towards-us-8922358.html>

Harle, J., 2016, Who will shape the future of the data society? [Internet]. Available at <https://phys.org/news/2016-10-future-society.html>

Helmholtz Centre for Ocean Research, (2011), “La Nube radioactiva de Fukushima está llegando a las costas de Canadá, Estados Unidos y México (Fukushima radioactive cloud is coming to the coast of Canada, US and Mexico)” [infographic]. [Internet]. Available at <https://indagadores.wordpress.com>

Huff, E.A. 2013. 11 Articles on the Global Threat of Fukushima [Internet]. Available at <http://truth11.com/2013/11/14/11-articles-on-the-global-threat-of-fukushima/>

Huitt, W.G. and C.C. Shelia. 2005. An Overview of the Conative Domain, Educational Psychology Interactive. Valdosta: Valdosta State University. [PDF], http://www.edpsycinteractive.org/brilstar/chapters/conative.pdf

Ifeng, (2011), “日本核危机示意图 (The nuclear crisis in Japan)”, [infographic]. [Internet]. Available at <http://zt-hzrb.hangzhou.com.cn/system/2011/03/17/011271120.shtml>

Interactiondisignlab. (2011). “LE VECCHIE CENTRALI CHE SPAVENTANO L'EUROPA (OLD PLANTS that scare EUROPE)”. [diagram]. [Internet]. Available at <http://www.linkiesta.it/le-nostre-centrali-fan-piu-paura-della-nube-radioattiva>

International Atomic Energy Agency. 2006. Environmental Consequences of the Chernobyl Accident and their Remediation: Twenty Years of Experience, Vienna: IAEA.

ISRN, (2011), “The accumulation of Caesium estimated by MEXT”, [infographic]. [Internet]. Available at <http://gazettenucleaire.org/~resosol/InfoNuc/seismes/Japon2011/index05mai.html>

Japan Times, (2011), ":Radiation Reading Levels", [infographic]. [Internet]. Available at <http://apple101.com.my/?p=30113>

Jeon S., 2018, 日 후쿠시마 수산물 수입 금지 분쟁 WTO 상소, 조선일보. [Internet]. Available at <http://biz.chosun.com/site/data/html_dir/2018/04/09/2018040902283.html>

Jeong N., 2011, '히로시마 원자폭탄 168배' 일 원전사고 세슘 유출량', 한겨레. [Internet]. Available at <https://news.naver.com/main/read.nhn?mode=LSD&mid=sec&sid1=104&oid=028&aid=0002107789>

Jeong N., 2011, 일 원전 세슘방출량 '체르노빌 42%', 한겨레 [Internet]. Available at <https://news.naver.com/main/read.nhn?mode=LSD&mid=sec&sid1=104&oid=028&aid=0002116242>

Jones, H. et al. 2002, "Use of infrared thermography for monitoring stomatal closure in the field: application to grapevine", Journal of Experimental Botany, Vol. 53, No. 378, pp. 2249±2260, November 2002

JoongAng Ilbo, (2011), "후쿠시마 바닷물, 한국 오는 데 5년 (It takes five years for Fukushima sea waters to come to Korea)", [infographic]. [Internet]. Available at <http://article.joins.com/news/article/article.asp?total_id=5338742&ctg=1200>

Katal et al. 2013. 'Big data: Issues, challenges, tools and Good practices'. [Internet]. Available at <http://ieeexplore.ieee.org/document/6612229

Keen. S. 2010. Empathy and the Novel. New York: Oxford University Press.

Kikuya, et al., 2017. Alterations in physique among young children after the Great East Japan Earthquake: Results from a nationwide survey, (in Journal of Epidemiology 27(10) · May 2017)

Kim, S. 2011. "Body, Affect and New media" (신체, 어펙트, 뉴미디어. Korean Studies, 36 (3.30), pp. 5-31. Center For Korean Studies, Korean University.

Kommersant, (2011), " Хроника катастрофы После землетрясения и цунами внимание всего мира было приковано к событиям на АЭС в Фукусиме. (After the earthquake and tsunami, the

world pays attention to the accident of the Fukushima nuclear power plants.)", [infographic]. [Internet]. Available at <http://www.kommersant.ru/doc/1858566>

Kommersant. (2011). Основны; статьи экспорта и ИМПОРТА японии в 2009 году (The exports and imports of Japan in 2009). [infographic]. [Internet]. Available at <http://www.kommersant.ru/Doc/1605004>

Komsomolskaya Pravda, (2011), " Как образовалось цунами у побережья Японии (How the tsunami was formed at the coast in Japan)" [infographic]. [Internet]. Available at <http://www.kp.by/daily/25649/813708/>

Komsomolskaya Pravda, (2011), Росгидромет: «К 18 марта зараженное облако может приблизиться к Камчатке». (Roshydromet (Russian Federal Service for Hydrometeorology and Environmental Monitoring): "By March 18, infected cloud can come close to Kamchatka."), [infographic]. [Internet]. Available at <http://www.kp.by/daily/25652/816088/>

Komsomolskaya Pravda. (2011). "Стадии плавления активной зоны (The stage of melting core)". [diagram]. [Internet]. Available at <http://www.kp.ru/daily/25684.4/889397/>

Kosara, R., Cohen, S., Cukier, J. and Wattenberg, M., 2009, Panel: changing the world with visualization. In:IEEE Visualization Conference Compendium: Citeseer.

Kosara, R., Cohen, S., Cukier, J. and Wattenberg, M., 2009, Panel: changing the world with visualization. In:IEEE Visualization Conference Compendium: Citeseer.

Krysta, M. and J. Coyne. 2012. "CTBTO radionuclide detections in the aftermath of Fukushima and a necessity for improved source inversion algorithms". (Article for Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization, Vienna International Centre). [PDF]. Available at <http://www.ral.ucar.edu/nsap/events/fukushima/documents/Session2_Briefing3-Krysta.pdf>

Kwon J., 2013, '설마했는데' 일본산, 버젓이 국내산 둔갑, TV Chosun. [Internet]. Available at <https://www.youtube.com/watch?v=h1fzt52yrxI>

Kyodo News, 2011. 후쿠시마 제1원전 사고, 동일본대지진/ 1개월 특집(5), Kyodo News, [Internet]. Available at <https://www.47news.jp/korean/feature/2011/04/017610.html>

Kyodo News, 2012, "Compton Camera", [Internet]. Available at <http://www.47news.jp/korean/science/2012/03/038154.html>

La Razon, (2012), “De Japón a California (Japan to California)”,[infographic]. [Internet]. Available at <http://www.razon.com.mx/spip.php?page=imprimir_articulo&id_article=123930>

La razon. (2015). “Chernobil del Pacífico (Chernobyl of Pacific)”. [infographic]. [Internet]. Available at < http://www.razon.com.mx/spip.php?article187408>

Lakoff, G. and M. Johnson. 1980. Metaphors We Live By. Chicago: University of Chicago Press.

Le Figaro, (2011), “Les 149 réacteurs nucléaires européens (The 149 nuclear reactors in Europe)”, [infographic]. [Internet]. Available at < http://www.lefigaro.fr/conjoncture/2011/04/28/04016-20110428ARTFIG00756-nucleaire-la-course-contre-la-montre-des-stress-tests.php>

Le Figaro, (2012), 11 réacteurs a rlsque en Europe (Eleven reactors in risky situation in Europe)”, [infographic]. [Internet]. Available at <http://www.lefigaro.fr/societes/2012/08/16/20005-20120816ARTFIG00443-l-europe-se-penche-sur-la-securite-de-ses-reacteurs.php>

Le Parisien, (2011), “LES EFFETS DES RADIATIONS NUCLÉAIRES (THE EFFECTS OF NUCLEAR)”, [infographic]. [Internet]. Available at <http://www.leparisien.fr/tsunami-pacifique/la-progression-du-tsunami-dans-le-pacifique-11-03-2011-1353529.php>

Le Parisien, (2011), « La progression du tsunami dans le Pacifique (The progress of the tsunami in the Pacific)” [infographic]. [Internet]. Available at <http://www.leparisien.fr/tsunami-pacifique/la-progression-du-tsunami-dans-le-pacifique-11-03-2011-1353529.php>

Lee B.. 2016년. 일본산->국내산 원산지 속인 수산물 급증. YTN. [Internet]. Available at <https://www.youtube.com/watch?v=2DaHWwk7mpA,>

Lee H., 2015, 일본산 가리비 7톤, 원산지 위장해 들여오려다 적발, Media Today. [Internet]. Available at<http://www.mediatoday.co.kr/?mod=news&act=articleView&idxno=123869#csidx10eb43710aa6ec98e84674c6cf2a905>

Lee H., 2017, 후쿠시마 수산물 수입 재개되나... 원산지, 다른 국가로 조작 우려. 한국일보. [Internet]. Available at <http://m.hankookilbo.com/News/Read/201710190412888309>

Lee M., 2013, 일본산 꽁치가 '타이완산'으로…검역 강화 필요, SBS. [Internet]. Available at <https://news.sbs.co.kr/news/endPage.do?news_id=N1002081212&plink=COPYPASTE&cooper=SB

SNEWSEND>

Lee S. 2013. “후쿠시마원전, 세슘·스트론튬 1일 600억㏃ 배출", 연합뉴스 [Internet]. Available at <https://news.v.daum.net/v/20130919101805144>

Lettera43, (2011), “Gli effetti delle radioazioni sul corpo umano. (The effects of radiation on human body.)”, [infographic]. [Internet]. Available at <http://www.lettera43.it/benessere/11028/conseguenze-atomiche.html>

Levy, B. and M. Anderson. 2008. “Individual differences in the suppression of unwanted memories: The executive deficit hypothesis”. Acta Psychologica 127 (3), pp. 623–635.

Libération, (2011), “Ce qui s’est passé dans la centrale de Fukushima (What happened in the Fukushima plant)” [infographic]. [Internet]. Available at <http://www.liberation.fr/monde/2011/03/15/menace-nucleaire-au-japon-nouveaux-incidents-a-la-centrale-de-fukushima_721746>

Libération, (2011), “Centrale de Fukushima - Daiichi La situation lundi 21 mars 2011 (The situation of Daiichi, Fukushima on Monday, 21st of March, 2011)” [infographic]. [Internet]. Available at <http://www.liberation.fr/terre/2011/03/22/fukushima-l-electricite-en-partie-retablie-dans-la-salle-de-controle-du-reacteur-3_723398>

Libération, (2011), “REALITY CHECK” [infographic]. [Internet]. Available at <http://sciences.blogs.liberation.fr/home/2011/06/fukushima-un-rapport-de-lacadémie-des-sciences-1ère-partie.html>

Liu, H., Selker, T. and Lieberman, H. 2003. “Visualizing the Affective Structure of a Text Document”. CHI ’03 Extended Abstracts on Human Factors in Computing Systems (CHI EA ’03), pp. 740-741. New York: ACM Press.

Maga. J. 1974, “Influence of color on taste thresholds”, Chemical Senses and Flavor, No. 1, 1974, P. 115-119.

Manovich, L. 2010. What is Visualization?, [PDF]. Available at: <http://manovich.net/index.php/projects/what-is-visualization>

Massumi, B. 2009. “Of micropolitics and microperceptions”. Inflexions: A Journal for Research-Creation, 3 (October), pp. 183-275.

Massumi. B. 2002. Parables for the Virtual: Movement, Affect, Sensation. Durham NC: Duke University Press.

Mayo Foundation for Medical Education and Research (MFMER), “Pulmonary fibrosis”, [Illustration]. [Internet]. Available at <http://www.mayoclinic.org/diseases-conditions/pulmonary-fibrosis/home/ovc-20211752>

McCosker, A. 2013. “De-framing disaster: affective encounters with raw and utonomous media”. Continuum: Journal of Media & Cultural Studies, Volume 27, Issue 3, pp. 382-96, London: Routledge.

McCoy, K. 1995. “Graphic Design in a Multicultural World”. (Ed. Bennett, A.), Theory and research in Graphic Design 2006, New York: Princeton Architectural Press.

MEO, N. 2013. “'It was like a science-fiction movie': Chernobyl - site of the world’s worst nuclear accident revisited”. The Independent. [Internet]. Available at <http://www.independent.co.uk/news/world/europe/it-was-like-a-sciencefiction-movie-chernobyl--site-of-the-worlds-worst-nuclear-accident-revisited-8925141.html>

Morton. T. 2013. Hyperobjects: Philosophy and ecology after the end of the world. Minneapolis: University of Minnesota Press.

Na K., 2018. 숫자로 보는 서울대학교 <12> 외국인 구성원 수 2116, Seoul National University Alumni Association. [Internet]. Available at <http://www.snua.or.kr/magazine/view.asp?gotopage=1&startpage=1&mgno=&searchWord=&mssq=02005000&seq=13674>

National Post, (2011), “disaster in Japan: The quake”, [infographic]. [Internet]. Available at <http://news.nationalpost.com/news/graphics-explaining-japans-nuclear-reactor-disaster>

National Post, (2011), “Graphics: Explaining Japan’s nuclear reactor disaster” [infographic]. [Internet]. Available at <http://news.nationalpost.com/news/graphics-explaining-japans-nuclear-reactor-disaster>

National Post, (2011), “Rescuers amid the ruins”, [infographic]. [Internet]. Available at <http://news.nationalpost.com/news/graphics-explaining-japans-nuclear-reactor-disaster>

Naz, K. and E. Helen, 2004, “Relationship between Color and Emotion: A Study of College Students”, College Student Journal, v38, No 3, p396, Sep 2004

NBC News, (2011), “A 1-year-old boy is re-checked for radiation exposure after being decontaminated in Nihonmatsu, Fukushiima prefecture, on March 14.”, [Photo]. [Internet]. Available at <http://www.nbcnews.com/slideshow/news/triple-tragedy-for-japan-42480443>

NBC News, (2011), “A line of residents seeking water snakes across the playground of a school in Sendai, Miyagi prefecture, on March 13, two days after the earthquake.”, [Photo]. [Internet]. Available at < http://www.nbcnews.com/slideshow/news/triple-tragedy-for-japan-42480443>

NBC News, (2011), “A woman cries while sitting on a road in the devastated city of Natori, Miyagi prefecture, on March 13.”, [Photo]. [Internet]. Available at <http://www.nbcnews.com/slideshow/news/triple-tragedy-for-japan-42480443>

NBC News, (2011), “A woman whose house was washed away loses control of her emotions on March 29 as she talks about the disaster that befell her hometown of Kesennuma, Miyagi prefecture.”, [Photo]. [Internet]. Available at <http://www.nbcnews.com/slideshow/news/triple-tragedy-for-japan-42480443>

NBC News, (2011), “Lunch is served Monday at an evacuation center where hundreds of homeless are staying in Rikuzentakata, Japan.”, [Photo]. [Internet]. Available at <http://www.nbcnews.com/id/42201148/ns/world_news-asia_pacific/t/when-can-we-go-home-tsunami-survivors-ask/#.WVe2JsaqGEI>

NBC News, (2011), “Members of Japan Self-Defense Force pray over the body of a tsunami victim in Onagawa, Miyagi prefecture, on March 20.”, [Photo]. [Internet]. Available at <http://www.nbcnews.com/slideshow/news/triple-tragedy-for-japan-42480443>

New York Times, “Japan’s Assessment of Radiation Around the Plant”, [infographic]. [Internet]. Available at <http://www.nytimes.com/2011/03/20/world/asia/20japan.html>

New York Times, “Pneumonia - Adults (Community Acquired)”, [Illustration]. [Internet]. Available at <http://www.nytimes.com/health/guides/disease/pneumonia/overview.html>

New York Times, “Predicted tsunami wave heights”, [infographic]. [Internet]. Available at <http://www.nytimes.com/interactive/2011/03/11/world/asia/maps-of-earthquake-and-tsunami-damage-in-japan.html?ref=asia>

New York Times, (2011), “Radiation Exposure", [infographic]. [Internet]. Available at <http://www.nytimes.com/interactive/2011/12/06/world/asia/Conditions-at-Fukushima-Plant-Improve-But-Return-Home-Will-Take-Years.html>

New York Times, (2011), “Shifting plates and rising water”, [infographic]. [Internet]. Available at <http://www.nytimes.com/interactive/2011/03/11/world/asia/maps-of-earthquakecand-tsunami-damage-in-japan.html?ref=asia>

New York Times. (2011). “Voices of Fukushima’s Evacuees”, [infographic]. [Internet]. Available at <http://www.nytimes.com/interactive/2011/12/06/world/asia/Voices-of-Fukushima-Evacuees.html?ref=asia>

News 24, 2011, Tsunami spares Philippines, Indonesia, News 24. [Internet]. Available at <Archiveshttps://www.news24.com/World/News/Tsunami-spares-Philippines-Indonesia-20110311.cnt>

NIH (National Cancer Institute), “Adult acute myeloid leukemia (AML) is a type of cancer in which the bone marrow makes abnormal myeloblasts (a type of white blood cell), red blood cells, or platelets.”, [Illustration]. [Internet]. Available at <https://www.cancer.gov/types/leukemia/patient/adult-aml-treatment-pdq>

NNHSphysics, “Effects of Radiation on Health”, [Photo]. [Internet]. Available at <http://nnhsphysics.wikispaces.com/Effects+of+Radiation+on+Health>

NOAA. (2011). “Japan (Tohoku) tsunami, March 11, 2011: Maximum wave amplitudes”. [diagram]. [Internet]. Available at <http://www.noaa.gov/features/03_protecting/japantsunami_oneyearlater.html>

NOAA/NWS/West Coast and Alaska Tsunami Warning Center. 2011. Tsunami Warning and Advisory. [Internet]. Available at <https://www.webcitation.org/5y2aPSHnh?url=http://wcatwc.arh.noaa.gov/2011/03/11/lhvpd9/07/messagelhvpd9-07.htm>

Nucleus Medical Media, “Thyroid Cancer”, [Illustration]. [Internet]. Available at <http://conditions.healthgrove.com/l/1013/Thyroid-Cancer>

OÖN & APA. (2011). “So kommt es zur Kernschmelze in einem Siedewasserreaktor (core meltdown in a boiling water reactor)”. [diagram]. [Internet]. Available at <http://www.nachrichten.at/nachrichten/weltspiegel/Japan-Kernschmelze-und-Plutonium-im-Boden;art17,584640>

Pacific Tsunami Warning Center, 2011, Warning Statement, Pacific Tsunami Warning Center. [Internet]. Available at <http://ptwc.weather.gov/text.php?id=hawaii.2011.03.11.073148>

Park H.. 2013, 아베 “오염수 완전 차단” 뻔뻔 주장에 日서도 “질렸다”, 동아일보. [Internet]. Available at <http://news.donga.com/List/Se/3/all/20130909/57561812/1>

Patton J., 2013, This is a map of modeled tsunami sea surface elevations. [Internet]. Available at <http://earthjay.com/?page_id=910>

Pflugbeil, S., Henrik Paulitz, Angelika Claussen, Inge Schmitz-Feuerhake. 2011. Health Effects of Chernobyl 25 years after the reactor catastrophe. IPPNW and GFS Report, April 2011.

Playfair, W. (1786). “Chart Showing the Value of the Quarter of Wheat in Shillings & in Days Wages of a Good Mechanic [i.e., smith, mason, carpenter] from 1565 to 1821”. [diagram] In: Tufte, E. F. (2001) The Visual Display of Quantitative Information. Connecticut: Graphics Press, p. 34.

Playfair, W. (1801). “The Population & Revenues of the Principal Nations of Europe”. [diagram] In: Tufte, E. F. (2001) The Visual Display of Quantitative Information. Connecticut: Graphics Press, p. 44.

REUTERS, (2011), “JAPAN HUMANITARIAN SITUATION”, [infographic]. [Internet]. Available at <http://www.dailymail.co.uk/news/article-1367473/Elderly-hospital-patients-left-die-Japans-nuclear-zone-400-000-fight-survive-tsunami-humanitarian-crisis.html>

REUTERS, (2011), “ΠΑΓΚΟΣΜΙΟΙ ΠΥΡΗΝΙΚΟΙ ΣΤΑΘΜΟΙ (The nuclear power plants in the world)”, [infographic]. [Internet]. Available at <http://www.newsbeast.gr/world/arthro/139359/fovos-gia-ta-purinika-ergostasia/>

Reuters. (2011). “Fukushima Radiation Readings”, [diagram]. [Internet]. Available at <http://www.dailymail.co.uk/news/article-1371616/Fukushima-Fifty-shun-sleep-food-water-battle-Japan-nuclear-crisis.html>

RIA Novosti. (2011). “Радиационная обстановка на Дальнем Востоке, направление И скорость ветра (The radiation spread depending on the direction and the speed of the Far East wind)” [diagram]. [Internet]. Available at <http://ria.ru/jpquake_mm/20110315/354242966.html>

Robin Kinross, R. 1989. “The Rhetoric of Neutrality”. (Ed. Margolin, V. 1989), Design Discourse: History/theory/criticism, pp. 131-143. Chicago: University of Chicago Press.

Rosen, M.A. 2012. “Effects of the Fukushima nuclear meltdowns on environment and health”. [PDF]. Available at <http://www.ippnw.de/commonFiles/pdfs/Atomenergie/FukushimaBackgroundPaper.pdf.>

Seal, C. 2004, Researching society and culture, p.181, SAGE

Sevodnya. (2010). “Маршрут экскурсии по Зоне (Tour itinerary in the Zone)”. [infographic]. [Internet]. Available at < http://www.segodnya.ua/ukraine/v-chernobyle-zapretjat-khodit-v-mini-jubkakh-i-myt-ruki-horjachej-vodoj.html>

Simon Rogers. 2013. John Snow's data journalism: the cholera map that changed the world. [Internet]. Available at <https://www.theguardian.com/news/datablog/2013/mar/15/john-snow-cholera-map

Sircus M., 2013, News You Don’t Want to Read About Fukushima, [Internet]. Available at <http://northerntruthseeker.blogspot.co.uk/2013/08/the-fukushima-nuclear-disaster-news-you.html>

Sircus, M. 2013. News You Don’t Want to Read About Fukushima. [Internet]. Available at <http://northerntruthseeker.blogspot.co.uk/2013/08/the-fukushima-nuclear-disaster-news-you.html>

Slote, M. 2007. The Ethics of Care and Empathy. New York: Routledge.

Smith M, 2014, Fukushima Radiation Fallout Rumors Debunked. Liberty Voice. [Internet]. Available at <http://guardianlv.com/2014/01/fukushima-radiation-fallout-rumors-debunked/>

Smith, M. 2014. Fukushima Radiation Fallout Rumors Debunked. [Internet]. Available at <http://guardianlv.com/2014/01/fukushima-radiation-fallout-rumors-debunked/>

Sovetskaya Belorussia. (2011). “Что будет сделано в пострадавших от аварии на Чернобыльской АЭС регионах Беларуси (What will be done to the victims of the Chernobyl accident regions of Belarus)”. [infographic]. [Internet]. Available at <http://www.sb.by/peredovitsa/article/prezident-unizhatsya-i-prosit-nikogo-ne-budem.html>

Spence, I. 2005. “No Humble Pie: The Origins and Usage of a Statistical Chart”. Journal of Educational and Behavioral Statistics, Winter 2005, Vol. 30, No. 4, pp. 353–368.

Spence, I. and H. Wainer. 2001. William Playfair. Statisticians of the Centuries. New York: Springer.

STUK. (2014). The visualizations of “LASKEUMAA (fallout)” and “SYÖPÄESIINTYVYYS (PREVALENCE OF CANCER)”. [infographic]. [Internet]. Available at < http://www.stuk.fi/sateily-ymparistossa/elintarvikkeet/fi_FI/radioaktiiviset_keino/>

Süddeutsche Zeitung (2011), “Die Atomkraftwerke in Deutschland und ihre Restlaufzeiten. (The

nuclear power plants in Germany and their conditions)" [infographic]. [Internet]. Available at <http://www.sueddeutsche.de/wissen/sicherheit-deutscher-kernkraftwerke-kurzschluesse-blitze-und-flugzeugabstuerze-1.1071571>

Süddeutsche Zeitung, (2011), "Kernkraftwerke in Osteuropa (Nuclear power plants in Eastern Europe)", [infographic]. [Internet]. Available at <http://www.sueddeutsche.de/wissen/akws-in-osteuropa-kettenreaktionen-in-der-erdbebenzone-1.211950>

Süddeutsche Zeitung, (2011), „Prognostizierte Windrichtungen um Japan. Zum Vergrößern (Prediction of the flow of wind around Japan)" [infographic]. [Internet]. Available at <http://www.sueddeutsche.de/wissen/atomkatastrophe-in-fukushima-der-wind-darf-nicht-drehen-1.1071617>

Suzuki, A., Josselyn, S. A., Frankland, P.W., Masushige, S., Silva, A. J. and Kida, S. 2004. "Memory Reconsolidation and Extinction Have Distinct Temporal and Biochemical Signatures". Journal of Neuroscience 24 (20), pp.4787-4795.

Takano S., 2017, 사고발생 6년 지난 후쿠시마 그 상처의 깊이는…, 대한민국 정책 브리핑. [Internet]. Available at <http://www.korea.kr/news/contributePolicyView.do?newsId=148843865>

Tamino, G. "Thermohaline Belt". [diagram] In: Klanten, R., et al. (2010). DATA FLOW 2. Berlin: Gestalten, p. 15

Taylor, J. 1998. Body horror: Photojournalism, catastrophe and war. Manchester: Manchester University Press.

The Chosun Ilbo, (2011), "방사성 오염물질이 동해로 못 오는 이유 (The reason that radioactive contaminants cannot come to the East Sea in Korea)", [infographic]. [Internet]. Available at <http://news.chosun.com/site/data/html_dir/2011/03/23/2011032300201.html>

The Chosun Ilbo, (2011), "환태평양 지진대 인근의 원자력발전소 및 주요 원전 사고 현황 (The number of nuclear power plants and major accidents which occurred in the past close to the Pacific Ring of Fire)", [infographic]. [Internet]. Available at <http://biz.chosun.com/site/data/html_dir/2011/03/15/2011031500323.html >

The Chosun Ilbo, (2011), "후쿠시마 원전 방사성물질 확산과 인근 주요 도시 인구 (The spread of radioactive materials and the population of the major cities near the Fukushima nuclear power plant)",

[infographic]. [Internet]. Available at <http://inside.chosun.com/site/data/html_dir/2011/03/16/2011031600575.html>

The Chosun Ilbo. (2011). “명태유통경로 (The distribution channel of Pollack)”. [infographic]. [Internet]. Available at <http://news.chosun.com/site/data/html_dir/2011/04/01/2011040101316.html>

The Daily Telegraph, (2011), “Fukushima Daiichi Nuclear Power Plant”, [infographic]. [Internet]. Available at <http://www.dailytelegraph.com.au/news/world/magnitude-quake-strikes-japan/story-e6frev00-1226023669061>

The Dong-a Ilbo, (2011), “일본 세슘 오염 지도 (Caesium contamination map of Japan)” [infographic]. [Internet]. Available at <http://news.donga.com/view.php?id=Print_Donga%7C3%7C20111115%7C41880542%7C1>

The Dong-a Ilbo. (2011). “후쿠시마 제1원전 3호기 냉각 작전 (Fukushima Dai-ichi Nuclear Power Plant Unit 3 cooling operation)”. [infographic]. [Internet]. Available at < http://www.kommersant.ru/Doc/1605004>

The Jakarta Post, 2011, Tsunami destroys houses in Jayapura, The Jakarta Post. [Internet]. Available at <https://www.webcitation.org/5x8nZ4NKe?url=http://www.thejakartapost.com/news/2011/03/12/tsunami-destroys-houses-jayapura.html>

The Mirror, (2011), ”京津豫菠菜 检出微量碘-131 (Detection of Iodine-131 in spinach in Beijing, Tianjin, and Henan)” [infographic]. [Internet]. Available at <http://www.fawan.com/Item/157622.aspx>

The Mirror, (2012), ”日核污染金枪鱼 惊现美国 (Japanese nuclear-contaminated tuna discovered America)”, [infographic]. [Internet]. Available at <http://www.fawan.com/Item/157622.aspx>

The Times, (2011), “What is radiation?”, [infographic]. [Internet]. Available at <http://www.thetimes.co.uk/tto/science/article2946796.ece>

The Wall Street Journal, (2011), “Radiation Migration”, [infographic]. [Internet]. Available at <http://www.wsj.com/articles/SB10001424052702303395604577432452114613564>

The Wall Street Journal, (2011), “Shaky Ground”, [infographic]. [Internet]. Available at

<http://www.wsj.com/articles/SB10001424052970204010604576596321581004368>

The Wall Street Journal, (2011), “Status Report”, [infographic]. [Internet]. Available at <http://www.wsj.com/articles/SB10001424052748704013604576248204196506240>

The Wall Street Journal. (2011). “Passing Pills”. [diagram]. [Internet]. Available at <http://www.wsj.com/articles/SB10001424052970204010604576596321581004368>

The Washington Post, (2011) “How dangerous is the radiation?”, [infographic]. [Internet]. Available at <http://www.washingtonpost.com/wp-srv/special/world/japan-nuclear-reactors-and-seismic-activity/>

The Washington Post, (2011), “Fukushima plant radiation”, [infographic]. [Internet]. Available at <http://www.washingtonpost.com/world/2011/09/01/gIQAUvpQvJ_graphic.html>

The Washington Post, (2011). “Recent quakes in Japan”. [diagram]. [Internet]. Available at < http://www.washingtonpost.com/wp-srv/special/world/recent-earthquakes-in-japan/>

The Washington Post, (2011). “Yearly radiation dose”. [diagram]. [Internet]. Available at < http://www.washingtonpost.com/world/off-limits/2011/11/19/gIQAdmobcN_graphic.html>

The Washington Post. (2011). “Nuclear plants at risk”. [infographic]. [Internet]. Available at <http://www.washingtonpost.com/wp-srv/special/world/nuclear-plants-at-risk/>

Toker, G. R. 2012. Holographic Interferometry: A Mach–Zehnder Approach. Florida: Taylor and Francis Group

Tube Graphics. “Ice Hockey and Bobsleigh “. [diagram] In: Klanten, R., et al. (2006). DATA FLOW. Berlin: Gestalten, p. 138

Tufte, E.R. 1990. Envisioning Information. Connecticut: Graphics Press.

Tufte, E.R. 1997. Visual Explanations: Images and Quantities, Evidence and Narrative. Connecticut: Graphics Press.

Tufte, E.R. 2001. The Visual Display of Quantitative Information. Connecticut: Graphics Press.

Tufte, E.R. 2006. Beautiful Evidence. Connecticut: Graphics Press.

Unknown designer and year. “A map which represents route stalkers use in exclusion zone”. [infographic]. [Internet]. Available at < http://chornobyl.in.ua/uk/stalker-chernobyl-zone.html>

Unknown designer. (2008). “Населені пункти де мешкають самосели (inhabitants in exclusion zone)”. [infographic]. [Internet]. Available at <http://chornobyl.in.ua/samosel.html>

USA TODAY. (2012). “Electoral vote tracker”. [diagram]. [Internet]. Available at <http://www.usatoday.com/interactives/news/politics/electoral-vote-tracker>

Ware C., 2012, Information Visualization: Perception for Design, Elsevier, London

Washington Post, (2011), “Anatomy of the earthquake”, [infographic]. [Internet]. Available at <http://www.washingtonpost.com/wp-srv/special/world/japan-earthquake.html>

Yasunari et al. 2011. “Caesium-137 deposition and contamination of Japanese soils due to the Fukushima nuclear accident”, PNAS, April 2011, vol. 108, No. 18.

Yomiuri newspaper, (2011), “4月１０日までの警察庁や各県のデータを元に読売新聞が作成。避難者数は県外からも含め各県内の避難所にいる人の数 (The Number of the evacuees who are still staying in shelters until 10th of April)” [infographic]. [Internet].

Yomiuri newspaper, (2012), “当面維持される、飲食物の暫定規制値 (The provisional regulation values of food and drink)” [infographic]. [Internet]. Available at <http://www.dailymail.co.uk/news/article-1367473/Elderly-hospital-patients-left-die-Japans-nuclear-zone-400-000-fight-survive-tsunami-humanitarian-crisis.html>

Yomiuri newspaper. (2011). “福島第一原発１号機原子炉の現状 (The current situation of Fukushima Daiichi Nuclear Power Plant Unit 1 reactor”. [diagram]. [Internet]. Available at <http://www.47news.jp/47topics/e/248788.php>

Yomiuri newspaper. (2012). “福島第一原発で作業員が身につける防護服 (Protective clothing that workers wear in Fukushima Daiichi nuclear power plant)”. [infographic]. [Internet]. Available at <http://www.asahi.com/special/10005/TKY201106100688.html>

Yomiuri newspaper. (2012). “福島の３河川、汚染調査へ海への広がり解析，金沢大 (The analysis of the spread of pollution from Fukushima three rivers to ocean, Kanazawa Univ.)”. [diagram]. [Internet].

Available at <http://www.asahi.com/special/10005/TKY201106100688.html>

Yomiuri, (2011), “東北地方と首都圏を結ぶバスの運行状況（4日）(The routes of buses that connect Tohoku to the metropolitan areas)”, [infographic]. [Internet]

Yomiuri, (2011), “被災地の現状。 死者数などは17日22時現在。 避難者数は17日18時現在 (The current situation of the affected areas. The statistic of the dead until 22:00, 17th of April and that of the evacuees until 18:00, 17th of April)” [infographic]. [Internet].

Yoo D., 2013. "후쿠시마 원전, 세슘·스트론튬 1일 600억㏃ 배출", SBS. [Internet]. Available at <https://news.v.daum.net/v/20130919110306557>

平成 23 年3月 地震·火山月報(防災編) Monthly Report on Earthquakes and Volcanoes in Japan March 2011. Japan Meteorological Agency

平成23年（2011年）東北地方太平洋沖地震　について（第63報）. (PDF). [Internet]. Available at <http://www.jma.go.jp/jma/press/1203/08b/201203081600.html>