



UNDERSTANDING DISORIENTATION THAT OCCURS IMMEDIATELY AFTER EARTHQUAKE

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Abstract

Many people who have experienced an earthquake report impaired cognitive functioning due to the drastic environmental changes that occur. This impairment can result in losing the ability to make calm judgments due to panic, losing one or more senses (taste, sight, touch, smell, and sound), or losing a sense of time. Overall, this impairment is known as disorientation, which is commonly understood as “a condition involving ‘narrowed vision’ and an inability to make objective judgments about surrounding events due to extreme stress resulting from a disaster.” Disorientation must be addressed because it may result in fatal behavior due to loss of proper judgment. To address this issue, it is first necessary for the public to become broadly aware of the possibility of experiencing disorientation. However, the concept of disorientation has not been fully clarified to date. This study thus aimed to characterize this experience by collecting and analyzing past disaster experiences.

Based on interviews with people who experienced severely damaging earthquakes, we identified “unusual actions and cognitive conditions.” We successfully extracted 10 main types of disorientation experiences and 44 subtypes. Then a cluster analysis identified three type categories: physiological tension, loss of self-control, and loss of situational awareness (see Fig. 1). We also performed cross-tabulation (Chi-squared test) to identify how disorientation types were related to attributes of the affected person and characteristics of earthquake.

Children under elementary school age showed a high tendency to feel fear, that is, to experience disorientation characterized by physiological tension. Therefore, when any physiological signs such as shaking or insomnia are observed, children should immediately receive mental health care. For disorientation characterized by the loss of self-control, there were some differences between subduction zone earthquakes and inland earthquakes. In cases of subduction zone earthquakes, loss of self-control often manifested as being desperate to care for oneself or others, and feeling panic that caused them to run out of houses or buildings. In cases of inland earthquakes, many people did not understand what happened and lost their sense of time. In addition, children under junior high school age and adults who were not involved in any emergency response activities showed a high tendency to run out of houses or buildings during the shaking caused by the earthquakes. To address this kind of disorientation, people should be required to learn the following decision-making process: “when one feels shaking caused by an earthquake, get under a table and protect one’s head.” Disorientation characterized by a loss of situational awareness was experienced more by males than by females. During earthquakes, males tended to feel as if it was the end of the world or to experience lethargy. Since such mental conditions are only experienced during disasters and not during everyday life, it is important for disaster management education to highlight the fact that everyone may encounter situations in which they must protect themselves while experiencing disorientation. Emergency drills should be conducted with this possibility in mind.

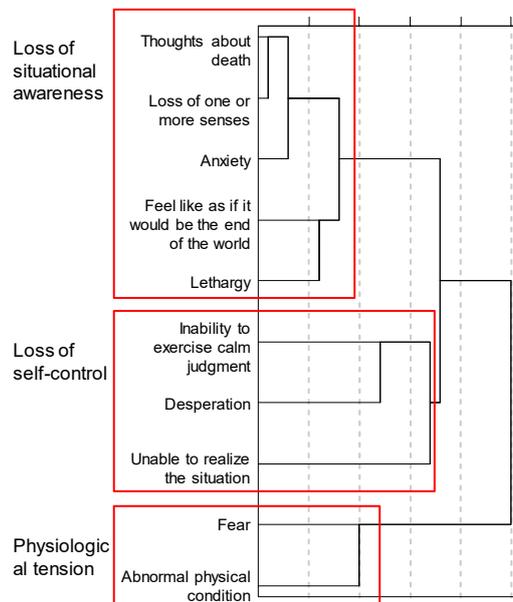


Fig. 1 – Cluster analysis of disorientation experiences (Ward clustering, squared Euclidean distance)

Keywords: cognitive functioning, concept of disorientation, cluster analysis, disaster management education

1. Background and objective of this study

Many victims of disasters have reported experiencing psychological states and/or behaviors that differ from normal due to drastic environmental changes. Such psychological states and behaviors are called "panic" or "disorientation." According to Nakajima et al. (2005), the term "panic" is defined as a "hysterical collective escape and confusion of people in fear and anxiety. It also means an urgent psychological state that has not been expressed as a behavior." [1] According to Kitahara et al. (2012), panic states are classified into two types: psychological and collective panic. The former is panic at the individual level, while the latter is at the group level. Psychological panic is a state in which a person feels powerless that he/she cannot do anything about the situation, even if the situation is not good for him/her. (...) On the other hand, the collective panic is commonly imagined with the term "panic." That is, it is a situation where many people who are present at a particular site take the same action at once without thinking about others. Consequently, the surrounding environment cannot respond to the collective behavior. [2]

A psychological state of panic at the individual level is defined with the term "disorientation." Originally, this was a psychiatric term that meant "a person's mental state in which he or she may not know the time, location, surrounding people, or current situation properly." [3] It is also used to describe a psychological condition of a person who encounters a natural disaster as "a condition involving narrowed vision and an inability to make objective judgments about surrounding events due to extreme stress resulting from a disaster." [4]

This study focuses on disorientation, which is an individual's psychological condition, immediately after an earthquake. Many people who have experienced an earthquake have reported impaired cognitive function due to drastic environmental changes. This impairment can result in losing the ability to make calm judgments due to panic, losing one or more senses (sight, sound, smell, touch, or taste), or losing the sense of time. These are reported anecdotally in many stories told by earthquake victims. Disorientation must be addressed because it may result in fatal behaviors due to impaired judgment. To address this issue, the origin of disorientation must be understood. Because disorientation is not fully understood, this study aims to elucidate the entire picture of disorientation by collecting and analyzing past disaster experiences.

2. Method

This study collected the experiences of victims in four major earthquakes with a maximum seismic intensity of 7, which is the highest intensity level in Japan. These are the 1995 Southern Hyogo Prefecture Earthquake (also known as the Great Hanshin-Awaji Earthquake, hereinafter referred to as the "1995 Hyogo Earthquake"), the 2004 Niigata Prefecture Chuetsu Earthquake (hereinafter referred to as the "2004 Niigata Earthquake"), the 2011 Pacific Coast of Tohoku Earthquake (also known as the Great East Japan Earthquake, hereinafter referred to as the "2011 Tohoku Earthquake"), and the 2016 Kumamoto Earthquake. In addition, to understand the disorientation occurrence in unusual situations such as wartime, we collected victims' experiences of three major earthquakes that occurred during the Asia-Pacific War or the time of confusion immediately after the War and are considered to have seismic intensities equivalent to the current level 7: the 1944 Showa Tonankai Earthquake, the 1945 Mikawa Earthquake, and the 1946 Showa Nankai Earthquake. Although these earthquakes occurred before 1949, which is when the current seismic intensity classification was established, previous studies have shown that these earthquakes had shaking with intensities equivalent to the current level 7. Of these seven earthquakes, the 1944 Showa Tonankai Earthquake, 1946 Showa Nankai Earthquake, and 2011 Tohoku Earthquake were subduction zone earthquakes. The remaining were inland earthquakes.

Victims' stories were collected by examining 33 reference materials to extract 250 cases that provided detailed accounts of individual psychological states and behaviors immediately after an earthquake [5]-[37]. We extracted a series of sentences describing one victim's experiences as one case. We subsequently highlighted keywords in the collected stories using Microsoft Word's highlight function and assigned each story a short title to represent the experiences. We found many similar psychological conditions and behaviors. We then categorized the cases using the short titles.

3. Results

3.1 Disorientation extracted from the collected cases

Of the 250 collected cases, victims' psychological states and behaviors immediately after an earthquake were categorized into 3 general clusters, 10 categories, and 44 subcategories (Fig. 2). The 10 categories are: "unable to realize the situation" (could not understand what happened), "inability to exercise calm judgment" (panicked or blacked out), "desperation" (became desperate to care for oneself or others), "abnormal physical condition" (felt dizziness, palpitations, or body shaking), "loss of one or more senses" (did not feel any pain or hunger), "anxiety" (felt anxious or helpless), "feel like it is the end of the world" (lost the sense of reality and that the world was ending), "thinking about death" (felt as if he/she was close to death), "lethargy" (felt lethargic), and "fear" (afraid of an earthquake and/or aftershock). The most frequently observed disorientation type in all cases is "fear" (55.6%) (Fig. 3). This is followed by "unable to realize the situation" (42.8%), "inability to exercise calm judgment" (42.4%), "abnormal physical condition" (37.2%), and "desperation" (34.4%).

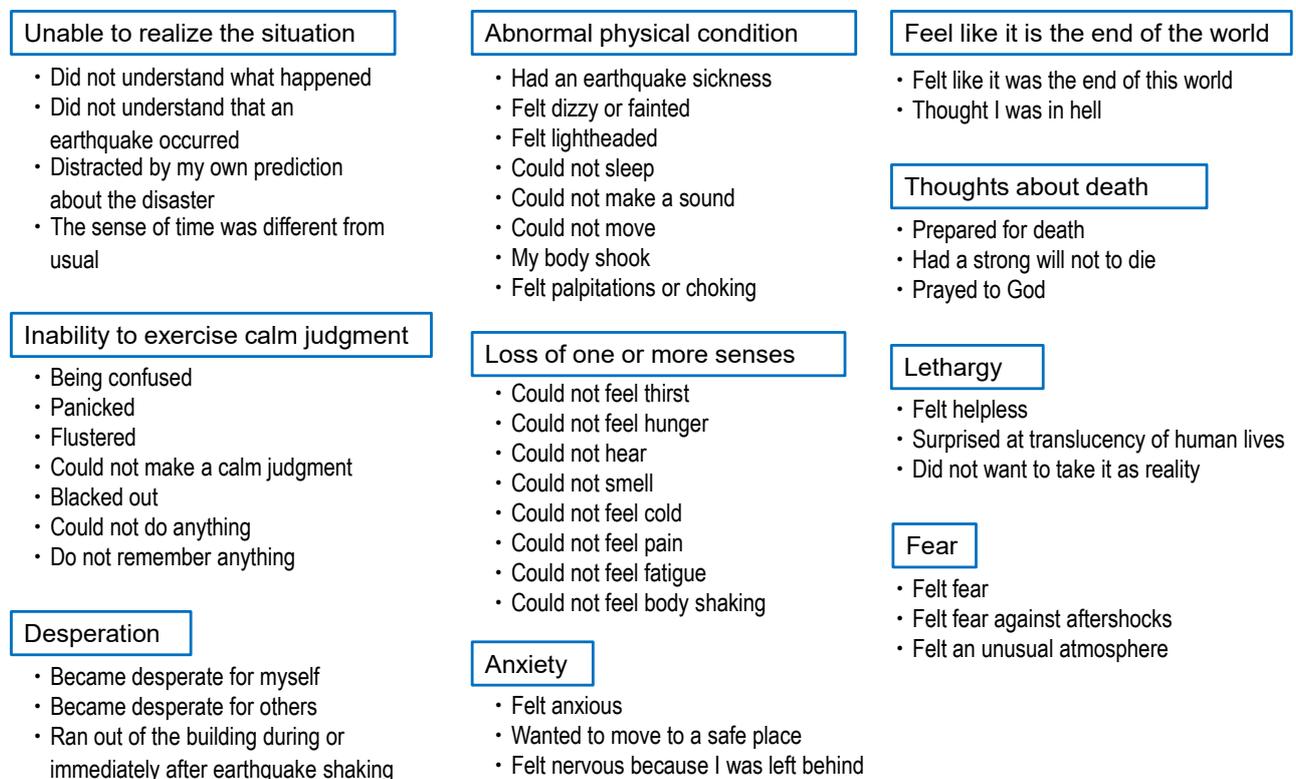


Fig. 2 – Disorientation extracted from the victims' experiences (10 categories and 44 subcategories)

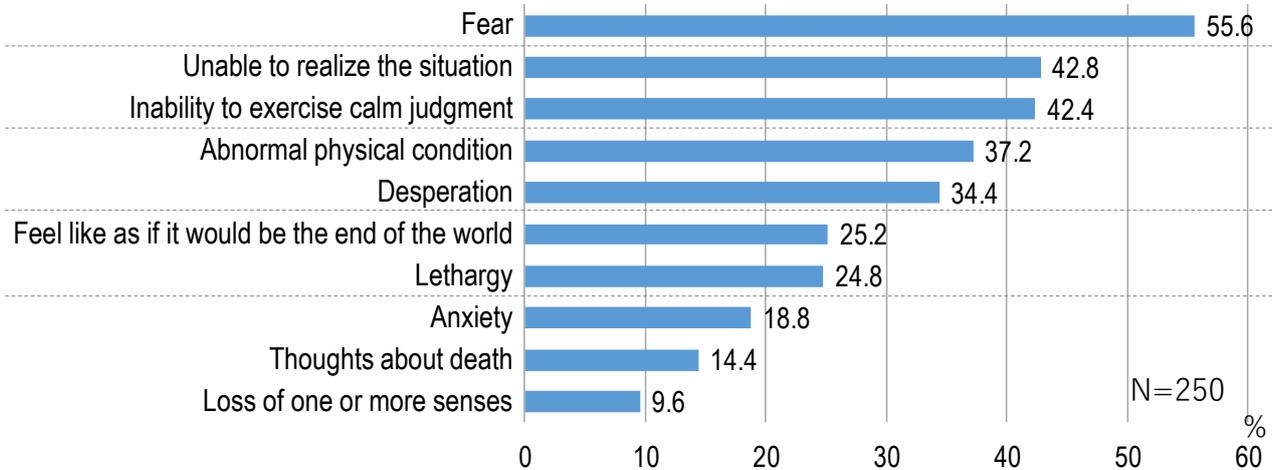


Fig. 3 – Proportion of occurrence of the different types of disorientation (10 subcategories) in the collected cases (n=250)

Cluster analysis with the Ward's method and the squared Euclidean distance was performed on these categories. Three clusters were identified (Fig. 1). The first cluster is "loss of situational awareness," which includes the categories of "loss of one or more senses," "thinking about death," "anxiety," "feel like it is the end of the world," and "lethargy." The second one is "loss of self-control," which includes the categories of "inability to exercise calm judgment," "desperation," and "unable to realize the situation." The third is "physiological tension," which includes categories of "fear" and "abnormal physical condition."

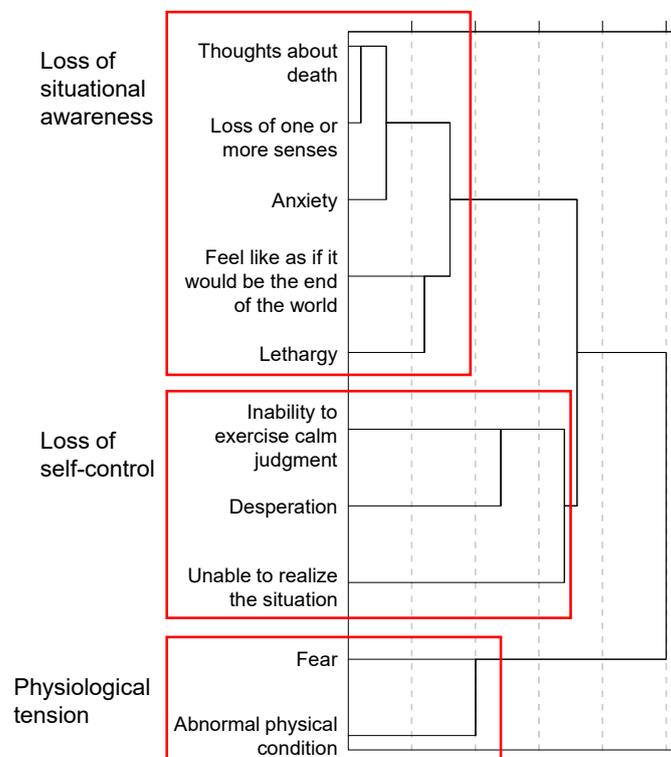


Fig. 1 – Cluster analysis of disorientation experiences (Ward clustering, squared Euclidean distance) (re-post)

These three clusters are also found in a 1999 questionnaire survey of victims of the 1995 Southern Hyogo Prefecture Earthquake. This questionnaire survey randomly sampled victims from the official resident register [38] and included a total of 18 psychological states and behaviors, which are commonly observed in earthquake victims. The participants were asked to check items that they experienced on the day of the earthquake.

Cluster analysis on the questionnaire responses identified three clusters: "physiological tension" (did not feel a sense of hunger or sleepiness), "loss of self-control" (felt strong fear so that they did not know which was safer inside or outside), and "loss of situational awareness" (just wanted to escape from the site while recognizing the possibility of death). The fact that there are many results observed in both the quantitative questionnaire survey and the qualitative analysis conducted in this study shows that the three types of disorientation that occur on the day of a major earthquake can be generalized to a certain extent.

3.2 Basic attributes used in this study

Of the collected cases ($n=250$), the number of cases that occurred in subduction zone earthquakes were 1944 Showa Tonankai Earthquake, 35 cases (14.0%); 1946 Showa Nankai Earthquake, 41 cases (16.4%); and 2011 Tohoku Earthquake, 45 cases (18.0%); while the numbers for the inland earthquakes were 1959 Mikawa Earthquake, 25 cases (10.0%); 1995 Hyogo Earthquake, 56 cases (22.4%); 2004 Niigata Earthquake, 28 cases (11.2%); and 2016 Kumamoto Earthquake, 20 cases (8.0%). While collecting these cases, we ensured equal representation from earthquakes other than the 1995 Hyogo Earthquake and the 2011 Tohoku Earthquake, which occurred in relatively recent years and caused huge human and material damage.

Regarding gender, 125 victims were male (50%), 88 were female (35.2%), and 37 were unknown (14.8%). We estimated the participants' gender based on their names. Unisex names were classified as "unknown." Regarding age, for the majority of the cases (148 cases, 59.2%) the victims' ages were unknown, while 15 victims (6.0%) were ≤ 9 , 58 (23.2%) were 10–19, 8 (3.2%) were 20–29, 3 (1.2%) were 30–39, 4 (1.6%) were 40–49, 2 (0.8%) were 50–59, and 12 (4.8%) were 60 or older. When the victims were elementary, junior high, or high school students, their grades and ages are specified because their stories were provided with information about their schools. Because adults tend not to specify their age, most victims with an "unknown" age are considered to be adults. The cases include 34 professional firefighters (13.6%) and 10 community fire unit personnel (4.0%). These victims are collectively referred to as "disaster responders (44 cases, 17.6%)."

3.3 Trends in disorientation by attribute

To characterize the disorientation occurrence, trends in disorientation were identified by basic personal attributes (gender, age, and whether they are a disaster responder) and the characteristics of earthquakes (inland or subduction-zone earthquake, and whether the earthquake occurred in wartime or peacetime). Table 1 shows the results for attributes with higher tendencies toward a certain type of disorientation. The statistical significances were determined by the chi-square test based on cross-tabulation of the basic attributes and types of disorientation.

Table 1 – Attributes that shows a higher tendency to experience each type of disorientation

		Sex	Age	Disaster responder or not	Peacetime or wartime	Earthquake type
Loss of situational awareness	Thoughts about death					subduction zone *
	Loss of one or more senses					
	Anxiety				peacetime *	
	Feel like as if it would be the end of the world	male **		disaster responder **		
	Lethargy	male **		disaster responder **	peacetime **	
Loss of self-control	Inability to exercise calm judgment				peacetime *	
	Desperation				wartime *	subduction zone *
	Unable to realize the situation	male **		disaster responder *	peacetime *	inland *
Physiological tension	Fear		12 or younger *	others **		
	Abnormal physical condition					

*: $p < .05$, **: $p < .01$, blank: n.s.

3.3.1 Gender and whether the victim is a disaster responder

Males are more likely to experience three types of disorientation than females: "feel like it is the end of the world" (male, 35.2% vs female 17.0%, $X^2(1)=8.5$, $p < .01$), "lethargy" (male, 34.4% vs female 15.9%, $X^2(1)=9.0$, $p < .01$), and "unable to realize the situation" (male, 52.8% vs female 34.1%, $X^2(1)=7.3$, $p < .01$). Similarly, disaster responders are more likely to experience the following types of disorientation: "feel like it is the end of the world" (disaster responders, 43.2% vs others, 21.4%, $X^2(1)=9.2$, $p < .01$), "lethargy" (disaster responders, 52.3% vs others, 18.9%, $X^2(1)=21.6$, $p < .01$), and "unable to realize the situation" (disaster responders, 56.8% vs others, 39.8%, $X^2(1)=4.3$, $p < .05$). On the other hand, non-disaster responders are more likely to experience "fear" (disaster responders 36.4% vs others 59.7%, $X^2(1)=8.0$, $p < .01$). The fact that males and disaster responders exhibit the same disorientation types may be partly because all disaster responders were male in this study.

Males and disaster responders often perform work directly related to human lives such as rescue activities in a community that drastically changed due to an earthquake. Such rescue activities often result in shock and stress and may be the origin of disorientation. A firefighter who performed rescue activities in the 1995 Hyogo Earthquake said, "after the earthquake, it took time to understand the hell in front of me. I thought 'I must be having a bad dream now' many times. Before then, no matter what disaster I encountered, I was proud of my job, rescuing, helping, and extinguishing fires with my colleagues. However, the earthquake completely changed my perspective. I lamented at my inability to respond to those who came to me for help and felt fear against the menace of nature." [29] This interview indicates that the firefighter experienced the disorientation of "unable to realize the situation" (cannot understand the tragic situation of their community that drastically changed due to earthquake), "lethargy" (feeling that they cannot help the situation with their abilities), and "feel like it is the end of the world" (feels like living in a horrible dream). It

should be noted that even in peacetime, disaster responders, who are regularly trained on disaster responses, are likely to experience some type of disorientation, demonstrating that disaster responders should receive enhanced stress management training.

3.3.2 Age

Next, we analyzed the cases by dividing into different age groups. Three quarters of children 12 years or younger experienced "fear" (children 12 years or younger, 75.9% vs. 13 years or older, 52.9%, $X^2(1)=5.5$, $p<.05$). Intense fear due to a disaster may lead to traumatic experiences and cause symptoms such as PTSD (post-traumatic stress disorder) and panic disorder. In particular, it should be noted that unstable psychological conditions in children can directly lead to changes in behavior (e.g., not eating, sleeping, or playing). If a child shows physical signs such as tremors and insomnia, prompt action by adults is necessary. Children's anxiety can be mitigated when surrounding adults remain close to them and listen to their stories. If the symptoms do not improve, consultation with a doctor or nurse is necessary to receive appropriate treatment.

An analysis on the subcategories shows that children age 15 or younger are more likely to experience "got out the building during or immediately after earthquake shaking," which is a subcategory of "desperation" (children age of 15 or younger, 33.3% vs age of 16 or older, 15.9%, $X^2(1)=7.0$, $p<.05$). Similarly, disaster responders have a significantly lower tendency to experience "ran out of the building during or immediately after earthquake shaking" (disaster responders, 4.5% vs others, 21.8%, $X^2(1)=7.1$, $p<.01$). One third of children under junior high age and one fifth of disaster responders ran out of the building during or immediately after earthquake shaking instead of taking actions to protect their lives such as getting under a desk or other solid structure. Such inappropriate actions are accompanied by increased risks of severe injury or death (e.g., hit by collapsed concrete-block wall, roof covering materials, or utility poles, falling objects due to earthquake shaking, and traffic accidents due to the rushed evacuation). To avoid these risks, it is important to educate people on a defined decision-making process. Such a decision-making process means having a preliminary action plan (a personal rule on actions to be taken), like "when XX occurs, we do YYY," for each envisaged crisis situation. Specifically, a series of information-processing steps are necessary starting with recognizing certain information, making a decision, and taking an action. Educating people is important so that they can implement these information-processing steps as quickly as possible. For an earthquake, learning the following decision-making process, "when one feels shaking caused by an earthquake, get under a table and protect one's head" may be effective.

3.3.3 Earthquake type

Victims of subduction zone earthquakes are more likely to experience two types of disorientation: "thinking about death" (subduction zone earthquakes, 19.0% vs inland earthquakes, 10.1%, $X^2(1)=4.0$, $p<.05$) and "desperation" (subduction zone earthquakes, 42.1% vs inland earthquakes, 27.1%, $X^2(1)=6.2$, $p<.05$). On the other hand, victims of inland earthquakes are more likely to experience "unable to realize the situation" (subduction zone earthquakes, 34.7%, vs inland earthquakes, 50.4%, $X^2(1)=6.3$, $p<.05$).

Inland earthquakes have a shallow epicenter and cause strong shaking in a narrow area, resulting in enormous damage to people and property. These sudden and drastic changes in the environment make it difficult for a person to understand what is happening and to understand that an earthquake occurs in a short time period, which may be a reason that many victims experience "unable to realize the situation." In many cases, such a delay in understanding the situation leads to belated actions to protect their lives. Hence, it is important to develop a disaster response plan, repeatedly conduct disaster response drills, and prepare a business continuity plan during non-disaster times. On the other hand, victims of subduction zone earthquakes are more likely to experience "thinking about death" (accepting the possibility of death) and "desperation" (getting too desperate to care for themselves and others). Although the collected cases are inherently "experiences of people who survived the disaster," such survivors might experience disorientation

of being hit by earthquake shaking for a longer time than that of inland earthquakes as they are desperate to escape from the shaking or damage resulting from disasters such as earthquakes and tsunamis.

3.3.4 Whether the earthquake occurs in peacetime or unusual time such as wartime or immediately after war

Next, we analyzed the cases by whether the earthquake occurred during (1) peacetime or (2) wartime or time of confusion immediately after a war (hereinafter referred to as "wartime"). For earthquakes during peacetime, the following four types of disorientation were more likely to occur: "anxiety" (peacetime, 23.5% vs wartime, 11.9%; $X^2(1)=5.3$, $p<.05$), "lethargy" (peacetime, 35.6% vs wartime, 8.9%; $X^2(1)=22.9$, $p<.01$), "inability to exercise calm judgment" (peacetime, 49.0% vs wartime, 32.7%; $X^2(1)=6.6$, $p<.05$) and "unable to realize the situation" (peacetime, 48.3% vs wartime, 34.7%; $X^2(1)=5.0$, $p<.05$). On the other hand, during wartime, victims were more likely to experience "desperation" (peacetime, 28.2% vs wartime, 43.6%; $X^2(1)=6.3$, $p<.05$).

This difference may be due to the fact that victims during wartime have a sense of crisis due to continuous attack by an enemy country and the resulting unusual everyday life. A victim of the 1944 Tonankai Earthquake said, "in those days, air raid alerts were issued every day in the daytime and we evacuated from classrooms during a class daily. (...) Every time an air raid alert was issued, we evacuated. I think those daily evacuation experiences were a great help for our disaster response in an earthquake. Although I was a young child, I had a sense of crisis and was able to respond to an earthquake." [24] The report shows that a continuous sense of crisis and daily evacuation due to air raids help people develop the capabilities to respond to earthquakes. For example, it may be beneficial to apply existing crisis management schemes for more frequent hazards such as crimes, traffic accidents, and health management that occur at an individual or society level, to disaster prevention and management.

4. Conclusion

This study analyzed cases of disorientation collected from past earthquake victims' stories to understand the general characteristics of disorientation that occurs immediately after an earthquake. Disorientation cases are classified into 3 clusters, 10 categories, and 44 subcategories. The three clusters ("loss of situational awareness," "loss of self-control," and "physiological tension") are also observed in a randomly sampled questionnaire survey of the 1995 Hyogo Earthquake victims.

We also analyzed the relationships between the categories and subcategories as well as the attributes for each cluster. Males and disaster responders are more likely to experience three types of disorientation: "feel like it is the end of the world," "lethargy," and "unable to realize the situation" due to the rescue activities in an unusual environment immediately after an earthquake. Elementary school aged or younger children are likely to feel "fear," while junior high school aged or younger children are likely to "run out the building during or immediately after earthquake shaking." Moreover, victims of inland earthquakes, which cause intense shaking in a narrow area, are more likely to be "unable to realize the situation." On the other hand, victims of subduction zone earthquakes, which cause prolonged shaking that requires countermeasures against a tsunami, are more likely to "think about death" and experience "desperation." Victims during peacetime are more likely to experience "anxiety," "lethargy," "inability to exercise calm judgment," and "unable to realize the situation" in contrast to victims during wartime, who have a continual sense of crisis and perform evacuations due to air raids on a daily basis.

Clarifying the entire picture of disorientation can not only help understand the characteristics of people's psychological states and behaviors immediately after a disaster, which differ from those in non-disaster times, but also help determine countermeasures against such disorientation. To prepare for future disasters, it is important for people to understand that disorientation can occur easily. To overcome disorientation, people should devise a disaster action plan by defining decision-making processes



(recognizing, making decisions, and acting) for envisaged dangerous situations. Future efforts will include developing education and training about disasters and devising disaster action plans.

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