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Original paper

Single-person Drill for Tsunami Evacuation and Disaster Education

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Abstract This paper described negative attitudes toward tsunami risk reduction seen among community residents due to the reappraisal of tsunami predictions by Japanese government agencies after the 2011 Great East Japan Earthquake. These negative attitudes can be simply summarized into three types: overly optimistic, overly pessimistic, and overly dependent. To cope with these issues, this paper introduced a new approach called "single-person drill" which specifically emphasized personal individual behaviors. The single-person drill is specifically proposed to alleviate these attitudes, for example by shifting tsunami risk reduction from the community level to the individual level. In addition, school children have participated in the drill by actually supporting the evacuees, disaster education thus was improved concurrently with intergenerational risk communication. Activities of both tsunami evacuation and disaster education are expected to make contributes to tsunami risk reduction.

Key words Tsunami predictions; Tsunami evacuation; Disaster education; Single-person drill

1. INTRODUCTION

The Great East Japan Earthquake measured 9.0 on the Richter scale and had a maximum seismic intensity of 7, making it the largest earthquake to hit Japan in recorded history. It originated in the Pacific Ocean east of Miyagi prefecture at 14:46 JST on 11 March 2011. The earthquake generated a huge tsunami with wave height exceeding ten meters in some areas, and a maximum run-up height exceeding 40 meters (Japan Meteorological Agency 2011). According to the report of Central Disaster Prevention Council (2011), the National Police Agency (2014), and the Reconstruction Agency (2014), current records list 15,885 fatalities, and 2,623 persons still missing. 263,392 persons are living in refuge facilities as of this writing. The total area inundated by the tsunami exceeded 560 km^2, which is comparable to the area of central Tokyo (621 km^2). 127,305 houses were completely destroyed, and 272,941 were partially destroyed.

The Reconstruction Agency (2011) estimated 16.9 trillion yen in direct financial damage, and that over 23 trillion yen would be needed for reconstruction over the next decade. The tsunami caused Japan and the international society to reflect on what tsunami risk reduction measures should be taken to protect lives and property from future disasters. This is an urgent issue in Japan's eastern coastal regions, where

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the likelihood of a catastrophic Nankai megathrust earthquake occurring within the next 30 years is estimated as 70% (Headquarters for Earthquake Research Promotion 2013).

Prompted by the Great East Japan Earthquake, the Cabinet Office of Japan immediately organized several institutions specifically to discuss appropriate countermeasures for a Nankai megathrust earthquake. Reports of these institutions present that the worst-case scenarios of inundated areas total 1,015 km^2, 1.8 times larger than those in the Great East Japan Earthquake. They predict that 124 municipalities would be inundated by a five-meter tsunami, and an additional 23 municipalities would be inundated by a ten-meter tsunami. The highest projected tsunami could reach 34 meters, and up to 323,000 fatalities are possible (Cabinet Office 2012). These reports aroused a great deal of concern from the public at large.

This paper talks about negative effects of the reappraised predictions of a Nankai megathrust earthquake and tsunami on community residents. For related countermeasures, the paper is mainly dedicated to describing the process of the single-person drill, a new approach for tsunami evacuation in local communities. The single-person drill is a form of action research conducted by researchers (research experts) and co-researchers (practice experts). In addition, as a collaborative participant in the action research, the first author played the role of both research and practice experts. In this paper, I report on the specific content of the action research by presenting its implementation process, contributions made by each participant, and the production process of multi-screen movies as research output. On the basis of this content, I analyze the essential meaning of continuous tsunami risk reduction, the formation and transformation of communities of practice, and the identities of its participants. I also discuss the importance of dialogue between researchers and co-researchers, and dialogue between the natural and human sciences.

The arrangement of this paper is as follows: Section 2 discusses the characteristics of tsunami predictions and subsequent negative attitudes. Drawing on previous studies on tsunami risk reduction and the present social situation in local communities, I explain why personal approaches are urgently needed. Then, Sections 3 and 4 give detailed information of the implementation process and results of the single-person drill. Section 5 discusses theoretical considerations from the perspective of production of artefact, practice, and identity. Section 6 analyzes the essential meaning of action research in tsunami risk reduction.

2. DISASTER PREDICTIONS

2.1 Characteristics of disaster predictions

There are two facets of disaster predictions: the objective matter of damage due to natural disaster, and the variable matter of how human society is affected by such damage.

Regarding the former, predictions are usually stated as something like, “It is supposed that an earthquake with an intensity of 7 on the Japan Meteorological Agency’s scale will occur, and a tsunami with waves exceeding 30 meters will arrive.” Such statements have no influence on the occurrence of a natural disaster. Natural disasters have their own characteristics of motion, independent of human activities. For example, the movement of tectonic plates or the sea will not change due to the reappraisal of predictions. In this sense, such predictions describe the “objective danger” of a natural phenomenon or its results on human society. Thus, this prediction type has the characteristics of “a neutral danger” (Yamori et al. 2005: 2-8).

Regarding the latter, predictions are usually presented as something like, “The most serious estimations predict as many as 323,000 deaths.” Such statements do influence the actual results of damage, because damage varies according to societal preparation. If more people have negative attitudes

toward tsunami risk reduction after hearing such predictions, damage could grow to exceed even the direst predictions. To some extent, such predictions depend on the decision-making and behavior of humans, and thus they have the characteristics of "an active risk" (Yamori et al. 2005: 2-8).

Examples of efforts toward changing the second prediction type have been seen in some municipalities in Japan, which include development of new countermeasures against tsunami risk reduction, and initiatives taken in motivating community residents to take part in tsunami risk reduction. Specifically, in Kochi prefecture government agencies published a third prediction type, which describes the potentialities to change the second prediction type. Another example of the second prediction type might be written as, "According to the current situation, if the rate of earthquake-proof houses is 74%, and the rate of immediate tsunami evacuation is 20%, meaning that 20% of residents immediately evacuate after an earthquake, then there will be almost 42,000 deaths." In contrast, the third prediction type might say, "If the above-mentioned rates were both improved to 100%, then, deaths due to building collapse and fire will be reduced to one-tenth of the worst-case prediction, and tsunami deaths will be reduced to one-sixth" (Kochi Prefecture 2013).

The first and the second prediction types are interrelated. Releasing estimates of a neutral danger to the general public would probably cause an active risk. Similarly, when faced with an active risk, people likely require more detailed and accurate predictions of the neutral danger. Nonetheless, in areas where serious damage is expected, some community residents treat the second prediction type as a neutral danger. This is one reason for increased negative attitudes toward tsunami risk reduction. In the following subsection, negative attitudes are divided into three types, based on news reports, statistical survey data, and my ethnographic study in local communities.

2.2 Three types of negative attitudes

Three types of negative attitudes have been seen in community residents after the release of the reappraised results of tsunami predictions. The first negative attitude can be described as "overly pessimistic" to tsunami risk reduction. After a report by the Cabinet Office (2012), I heard many negative comments on tsunami risk reduction in local communities. For example, "They say a giant tsunami will arrive here. If it really comes, can't we just sit on top of the highest nearby mountain and cast our fishing lines into the tsunami? I will not make any further effort to prepare for the tsunami according to their predictions." I also heard comments by elderly persons such as "When the tsunami really comes, I would like to be swept away with my house."

Statistical evidence can be seen in the report of Nakamura et al. (2013). They conducted a survey in Shimoda and Kuroshio, both located in Kochi prefecture, where the highest tsunami over 34 meters is expected to arrive. Because the whole population of both areas would be affected by a tsunami, Nakamura et al. randomly selected 120 adults as informants. Results of the survey show that 10.8% of respondents (6.7% in Shimoda and 15.0% in Kuroshio) answered "Because predictions are so serious, I've started to believe it is meaningless to further prepare for tsunami risk reduction."

The second negative attitude can be described as "overly optimistic" regarding tsunami risk reduction. When I interviewed residents about their opinions of the serious predictions, some people said things like "I do not think a tsunami will come during my lifetime," "It does not make sense to think so seriously about the tsunami. What will be, will be," and "I think that such predictions of earthquakes and tsunamis are unnecessarily disturbing news to our general community residents." Similar opinions have also been seen in newspapers, such as "I have been told that tsunamis would come ever since I was a little child. Whatever happens, happens" (Mainichi Shimbun 2012).

The third negative attitude can be described as "overly dependent" to tsunami risk reduction. Comments related with this kind of attitude are represented by "There's nothing can I do about the predictions. I surrender. I hope that disaster experts and government agencies will give us a hand." Those

comments indicated a strong dependency on disaster experts and government agencies. For example, "I hope that safe evacuation shelters located at higher places will be constructed as soon as possible," "I hope that routes to evacuation shelters and bridges on the routes will be upgraded to withstand earthquakes as soon as possible," and "I hope that evacuation routes will be widened."

These three types of negative attitudes are interrelated. From the perspective of human psychological dispositions, Yamori (2013) argues that "When people are faced with titanic peril, they either become desperate or inclined to belittle the peril." This indicates that overly pessimistic and overly optimistic attitudes are two sides of the same coin. Furthermore, as overly pessimistic attitudes guide people to give up on taking action, and overly optimistic attitudes make people belittle taking action, overly dependent attitudes are thus easily formed. The eventual result is relying on experts and government agencies.

Disaster predictions must be calculated based on professional knowledge, and thus in general can be produced by only disaster experts and government agencies. However, there are two types of messages in the disaster predictions. One is the literal message of disaster predictions. The other is a meta-message implied by the disaster prediction. For example, a literal message says, "A tsunami has been observed. Please evacuate to higher places immediately." The implied meta-message is that "People like us produce and provide the predictions, and people like you receive those predictions and follow them to take action." Thus, if there are overly adversarial or overly dependent relationships between community residents and disaster experts or government agencies, disaster predictions will be presented as a neutral danger.

From the above discussion, it is clear to see that the problem of communication as one-way transfer that emerged during the Great Hanshin–Awaji Earthquake still existed at the time of the reappraised predictions for a Nankai megathrust earthquake. To cope with this problem, it is necessary to establish a method of "communication for mutual consensus-making." Specifically, disaster experts must transform their position from knowing risk and calculating neutral danger, to serving as partners who collaborate with community residents by sharing active risk. Community residents in turn must transform their attitudes toward disaster predictions, from only considering predictions as an unchangeable neutral danger to proactively taking part in reducing active risk (Yamori et al. 2005). Thus, in this paper, I propose that communication for mutual consensus-making between researchers and co-researchers is an action research. Specific contents of the action research are presented based on my ethnographic study in the following sections.

2.3 Previous studies on tsunami evacuation behavior

In this section, I talk about previous studies on tsunami evacuation behavior, based on which I show the methodology and research direction of this study. Studies on tsunami evacuation pay extraordinary attention to understanding the eventual results instead of the complicated process of human behavior. For example, there are studies that develop models of tsunami evacuation (Imamura et al. 2001), studies that make hazard maps based on the results of collaboration between community residents and disaster experts (Toyoda and Kanegae 2012), and studies that develop tsunami simulators to visualize the results of human behavior and property damage in an entire region (Katada and Kuwasawa 2006). With hazard maps or simulators, community residents can easily understand the overall situation of tsunami disasters such as dangerous places in the region and evacuation results, so these studies can potentially motivate disaster awareness in community residents. However, in these studies various parameters or disaster scenarios are given by researchers in advance. Though they can present the whole situation in an entire region, they cannot describe the concrete and complicated process or results of tsunami evacuation by individuals.

To cope with this shortcoming, Katada et al. (2011) suggest a new type of tsunami simulator. They define parameter categories in advance, but the data for each parameter are given directly by individual

participants. For example, they ask each participant about the evacuation start time or place and evacuation routes, and directly input answers into the simulator. Each result is thus calculated by the simulator in a manner highly similar to the actual situation of each participant. However, this method has potential to promote tsunami awareness among only participants with high interest in tsunami risk reduction, and cannot resolve the problem of how to change the attitudes of those who are reluctant to take part in tsunami risk reduction. Furthermore, because participants provide the parameters used in the simulator, they represent intent rather than action in an actual evacuation.

Considering these shortcomings of studies and practice of tsunami risk reduction, I intend to clarify concrete processes such as the time needed for evacuation, evacuation methods and routes, shelter utilization, and the effects of mutual help. This study attempts to suggest appropriate methods for overcoming negative pessimistic, optimistic, and indifferent attitudes through action research.

Specifically, drawing on the traditional approaches to disaster education and tsunami evacuation that have been thoroughly developed in the field of disaster prevention, I suggest a new approach called the single-person drill. Results of the single-person drill are edited into multi-screen movies based on collaboration among tsunami experts who study the mechanisms of tsunami occurrence, computer graphics experts who make videos for TV broadcasting, and researchers who study human behavior.

3. THE SINGLE-PERSON DRILL

3.1 Ethnographic study field

Over the last three years, I have performed ethnographic studies of tsunami risk reduction in Okitsu village of Shimanto town, Kochi prefecture (Fig.1). Until now, I have visited Okitsu 30 times and stayed there for almost 80 days in total.

Okitsu is made up of three small communities: Omuro, Urabun, and Gobun. The only transportation line is Road No.52, which is a classic example of a narrow, winding mountain road, and has more than 140 curves in its 18 km length (Photo 1). The road can easily be shut down by a landslide or an earthquake.

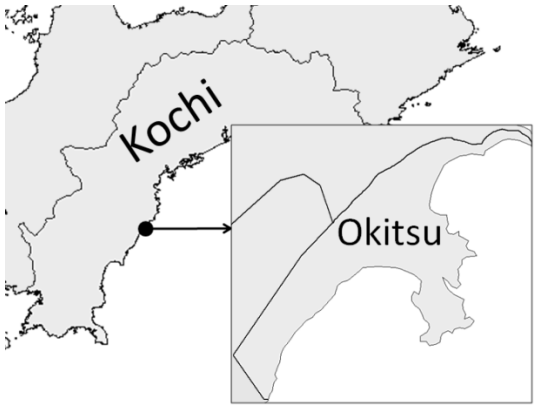

Fig.1 Okitsu village

Photo 1 Okitsu village (The front is the Pacific Ocean. On both sides of the mountain, there are two fishing ports. A line appear indistinctly is the narrow mountain Road No.52) (Sun et al. 2014)

A main challenge in Okitsu comes from the serious impact of being hit by a tsunami. According to the latest reports by Kochi Prefecture (2012), an earthquake of intensity 6-upper on the Japanese Meteorological Agency scale will cause a tsunami that will flood residential areas within 15 minutes. The maximum run-up height of tsunami waves is expected to exceed 25 meters. As mentioned in Section 2.2, the tsunami predictions have resulted in three negative attitudes among community residents. To cope with these problems, I collaborated with the Okitsu Elementary School in developing the single-person drill. I served as a coordinator to some extent, for example by motivating people to participate in the drill, visiting community residents' homes, taking part in village events, and studying with students in disaster education classes.

3.2 Outline of the single-person drill

During a single-person drill a single evacuee, typically an elderly person with a global positioning system (GPS) device, heads from home to a designated evacuation shelter. A group of school students record the drill process as a lesson regarding disaster education. All the records of the drill are summarized into multi-screen movies, which are collaboratively made by school students, tsunami experts, CG experts, and other researchers. The movies are used as disaster education tools at Disaster Education Symposium held by the Okitsu Elementary School. Participants include students, evacuees, community residents, government officers, researchers, and journalists.

Photo 2 shows tools used in the single-person drill: two video cameras, one stopwatch, and one GPS device. During the drill, five students make up one group to support a single evacuee. Two students serve as video recorders A and B. The other three students serve as time recorders, interviewers, and note takers (Photo 3). The students are called drill supporters. Fourteen fifth- and sixth-grade students at Okitsu Elementary School were divided into three drill supporter groups, named the Omuro Group, the Urabun Group, and the Gobun Group.

Photo 2 Tools used in single-person drills

Photo 3 Performing a single-person drill (Sun et al. 2013)

3.3 Implementation processes

There are four steps to the single-person drill. The first is a brief introduction, which confirms issues such as where the evacuee will take shelter during an earthquake, whether the evacuee should take an emergency kit, and which routes and shelters will be used. We also explain the three remaining drill steps. After confirmation, the evacuee receives GPS device for recording the evacuation route taken.

The second step is a short interview. The interviewer asks for information such as the evacuee's name, age, hobbies, and considerations for tsunami risk reduction. This allows the evacuee and supporters to

become somewhat familiar with each other before the actual evacuation.

The third step is a simulated evacuation. The time recorder says “earthquake” to announce the occurrence of an earthquake and the start of the evacuation. For the first 100 seconds, it is supposed that movement is impossible due to strong tremors. During this time the evacuee takes shelter under a table or other stable furniture. After 100 seconds the time recorder announces a second message, “The earthquake is over. Evacuate immediately,” and the evacuee leaves home. Some evacuees take emergency kits containing items such as food, water, and flashlights.

During the evacuation, video recorder A stays close enough to the evacuee to capture facial expressions, while video recorder B maintains a certain distance to capture the surrounding situation. The time recorder uses a stopwatch to record times required to reach significant locations, which are logged on a worksheet with “where” and “when” columns. For example, the time recorder might write “police station: 3 min 43 s,” “intersection: 4 min 1 s,” or “telegraph pole: 5 min 20 s.” The interviewer walks alongside the evacuee, asking occasional questions such as “Can you evacuate if this bridge collapses during an earthquake?” “What do you think of the hand rails along this steep path?” and “How are you feeling at this moment?”

The note taker also observes the surrounding situation, and writes down information related to the drill. Example notes might be “The evacuee looks very tired now,” “I think this is a dangerous place because the surrounding clay tiles may collapse,” or “On a rainy day, it is better to wear comfortable shoes that won’t slip.” When the evacuee arrives at an evacuation shelter, the time recorder announces, “Arrival at destination,” and all the recording devices are turned off.

The fourth step is an interview survey. The evacuee and supporters retrace the route taken to check for dangerous places along the evacuation routes. When they return to the point of departure, the single-person drill is complete.

3.4 Products: Multi-screen movies

Recorded results of the single-person drill are summarized into multi-screen movies by a collaboration of students, tsunami experts, CG experts, and other researchers through three editing processes.

Photo 4 shows images from a created movie. Panels in the upper left and bottom right are camera stills shot from two angles. The upper-right panel shows two kinds of messages; messages from the evacuee are placed above those by students. The bottom-left panel shows GPS tracking information overlaid on a geographic information system (GIS) map that is part of a computer animation of a simulated tsunami. On the GIS map, a dot represents the evacuee’s location during the drill, and a red line shows the evacuation route. A timer at the center of the movie presents the elapsed time during the drill. The contents of the four panels are displayed in synchronization with the timer. Detailed information of the editing processes is described below.

Photo 4 Screenshot from a multi-screen movie (Sun et al. 2014)

3.4.1 The first editing process

During the first editing process, tsunami experts collaborate with CG experts to create the content for the panels in the upper left (close-up video recordings by camera A), bottom right (medium-distance recordings by camera B), and bottom left (GPS data overlaid on a GIS map). Tsunami experts run a tsunami simulation to calculate the movement of a tsunami in Okitsu based on the worst-case scenario published by the Cabinet Office. CG experts transform the results of the tsunami simulation into a computer graphics animation. The animation is overlaid with the GPS data, and superimposed on the GIS map in the bottom-left panel. Then, the timer is placed at the center of the movies. This allows community residents to easily visualize the overall situation of the single-person drill. For example, it is very easy to grasp how long it takes evacuees to arrive at a bridge, or where the first place to be inundated by a tsunami will be.

3.4.2 The second editing process

During the second editing process, CG experts and I collaborate to place messages from the evacuee in the upper-right panel of the movies. Notes recorded by the note taker and the interviewer are both used. The message format, suggested by the CG experts, stipulates that single messages are limited to two rows, with no more than 10 Japanese characters in one row. This allows timely presentation of message content, and furthermore motivates viewer consciousness of the tsunami disaster and encourages students to give more suggestions regarding tsunami risk reduction. Examples of editing such messages are as follows:

Evacuee: “I’m not afraid to go through tunnels on evacuation routes when I’m running to the evacuation shelter as fast as I can” → “Don’t be afraid, just keep running”

Evacuee: “This road seems too narrow for three people to pass at one time. When an earthquake occurs, this might cause a bottleneck” → “Walk in a single file on narrow roads”

3.4.3 The third editing process

During the third editing process students, CG experts, and I work together to edit messages from students and add them to the upper-right panel. Student supporters of the single-person drill greatly contribute to this editing. Using the unfinished movies, they carefully review their supporting activities and respond to evacuee messages by giving opinions on evacuee behavior and tsunami risk reduction in Okitsu. For example, they give encouraging messages to the evacuees, and point out that it is necessary for the whole village to think about the problem of evacuating the elderly. Examples of their messages and responses are as follows:

Evacuee: Don’t be afraid, just keep running.

Students: When evacuating at night, bring a flashlight.

Evacuee: Walk in a single file on narrow roads.

Students: Wider roads are safer.

Messages from evacuees are presented above those from students, which are presented 5 seconds later because they are responses. Total presentation times are 20 seconds for evacuee messages and 15 seconds for student messages, after which both simultaneously disappear. When all messages have been added, the multi-screen movie editing process is complete.

3.5 Results of the single-person drill

As yet, students of Okitsu Elementary School have participated in two single-person drills, on 26 June

2012 and 28 November 2012. A total of 13 hours of integrated study period have been used for the drill. Specifically, 3 hours were used for tool operation training, 4 hours for drill implementation, two hours for editing messages, and 4 hours for presenting the multi-screen movies at Disaster Education Symposium. Eight residents participated in the single-person drill, including two couples. Because couples simultaneously participated in the drill, we produced six pieces of multi-screen movies. Approximately 35 journalists covered either the drill implementation or the movie presentations. There were also several interviews with schoolteachers about the single-person drill.

The time allocated to integrated study period is limited, so students cannot freely take part in the single-person drill. I therefore stayed in Okitsu in May 2013, October 2013, and January 2014 to independently conduct single-person drills with community residents. Only one video camera was available for these drills, so the implementation process was somewhat simplified. To differentiate between the two types of drills, I refer to the original one as the "basic single-person drill," and the simplified one as the "simplified single-person drill."

To date, 24 community residents have participated in the simplified drill. Results of the drills were recorded as paper records. One side of a paper record presents all categories of information shown in the multi-screen movies, such as departure place, evacuation routes, evacuation shelters, time used for the drill, help among neighbors, and messages from evacuees and supporters. The other side presents two screenshots from a computer animation of a simulated tsunami overlaid with GPS data. The paper records are used to give feedback to evacuees.

After taking part in the single-person drill, some evacuees became clearly more interested in tsunami risk reduction. For example, some participated in an annual evacuation drill conducted by Okitsu Volunteer Organizations for Disaster Prevention, or in evacuation drills for students at Okitsu Elementary School. During these drills, some participants went to different evacuation shelters to practice evacuating secondary or tertiary shelters when primary shelters are inaccessible. Most participants recorded evacuation times using their own watches.

The time needed for each single-person drill varies with factors such as evacuee health, distance to an evacuation shelter, and weather conditions. Generally speaking, the full single-person drill from step one to step four requires at least 30 minutes, and in some cases even required 4 hours. Evacuees with a high interest in participating in local events were willing to spend more time for step four. In contrast, some evacuees were unwilling to use so much time on drills, due to work demands.

4. CONTINUOUS IMPROVEMENTS IN TSUNAMI RISK REDUCTION

In this section, I discuss continuous improvement to tsunami risk reduction seen in Okitsu resulting from the single-person drill and production of the multi-screen movies.

4.1 Development of the single-person drill

Though the single-person drill focuses on individuals, many other activities are inevitably interwoven, such as disaster education, general disaster prevention, academic studies, and journalistic activities. All of these activities and related participants are thus bound together by the single-person drill to form a larger collaborative activity. In such activities, researchers become partners collaborating with community residents through sharing active risk. Community residents also initiated taking part in reducing active risk. In this section I focus on collaborative activities, discussing the importance of forming relationships in tsunami risk reduction.

Intimate relationships among single-person drill evacuees have been confirmed. For example, some

evacuees recommend neighbors as drill candidates. Other evacuees aided elderly neighbors incapable of independent evacuation. This is a mutually concerned relationship between two people who care for each other, as typically seen among family members. This relationship has been suggested as an effective means of promoting disaster prevention (Yamori 2014). Figure 2 gives a concrete example of a mutually concerned relationship formed in the single-person drill, from which it is easily to see a snowball effect on the increase of evacuees. Meanwhile, it indicates that the single-person drill is not an isolated activity, but one that continuously develops through evacuee contributions.

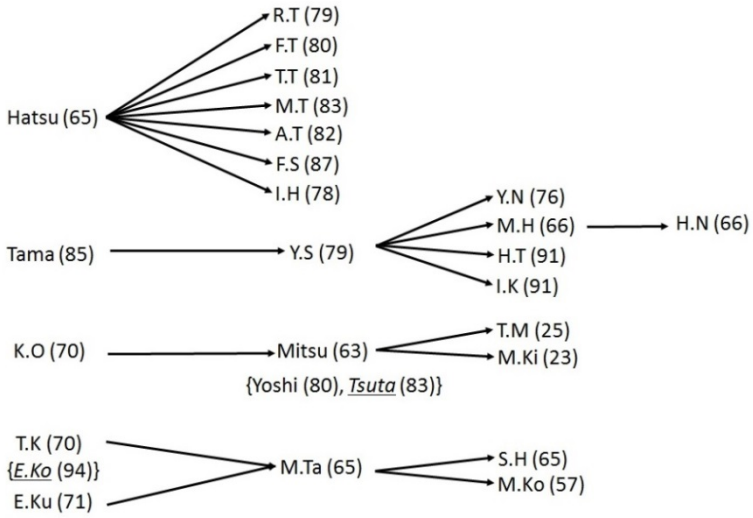

Figure 2. Mutually concerned relationships[4]

News reports furthermore introduced the single-person drill to other areas, establishing a relationship between Okitsu community residents and outsiders. As an example journalists from Kahoku Shimposha not only reported on the single-person drill in detail, but also put it into practice in a Miyagi prefecture community, where it was conducted as part of an activity aimed at promoting disaster prevention in areas affected by the Great East Japan Earthquake. During that drill grandparents and grandchildren walked together to evacuation shelters, both to check evacuation routes and to motivate risk communication between generations. To date, 27 people have participated in the drill (Sudo et al. 2013). In addition, the Osaka Station of the Japan Broadcasting Corporation reported on a single-person drill conducted in Okitsu in a television show about disaster education (NHK 2012). Such influential news reports have helped translocate single-person drill to other local practices, thus giving rise to inter-local practices (Sugiman 2013).

The two types of relationships in the single-person drill, those among community residents and those between insiders and outsiders, are interrelated. Insider contributions to the single-person drill become resources for outsiders to develop new activities, while outsider encouragement and concern become incentives for insiders to continue the drill. This relationship can be seen clearly in the following

[4] In the form of "A (60)," A is the evacuee's name, and 60 is the evacuee's age. All the names listed on the figure are evacuees in the single-person drill. In the form of "A→B," B participated in the single-person drill due to the recommendation of A. Furthermore, Mitsu evacuated Yoshi and Tsuta during his own evacuation drill, and so do T.K and E. Ko. Note that names in the form of "*C*" indicate evacuees needing help but who did not actually take part in the drill. In such cases other evacuees went to evacuate them and so elapsed times were calculated during the attempt. In addition, listing the names and ages of all participants is one of the most important features of the single-person drill. Permission has been obtained from the participants for inclusion of personal information in this study.

comments given by an evacuee:

Some friends phoned me after I participated in the drill, and said, "I saw you on TV. You look so young, and so strong."… Also, some relatives called me from Osaka. It's so nice. I feel so good. …When my grandchild participated in the evacuation drill for students, I climbed up to the evacuation shelter with her. My niece recorded our movements using her own camera. I think I have shortened my arrival time by several minutes … From now on, I will go to the shelter every day just for a walk. (Tama, 85 years old, 29 January 2013)

4.2 Application of multi-screen movies

Students who served as supporters during the single-person drill gave presentations at Disaster Education Symposium that convenes at Okitsu Elementary School, attended by all students there, students from Okitsu Junior High School, community residents, government officers, journalists, and disaster experts. The following excerpt from one presentation is good evidence of the students' learning outcomes:

We supported Tama in her single-person drill. Tama is 85 years old. She lives in the Urabun community. There are some dangerous places near her house, such as clay tiles on roofs that might collapse after an earthquake. There are also dilapidated houses along her evacuation routes, so it is important to consider optional routes to the nearby evacuation shelter.

It was raining heavily on the evacuation day, so moss on the steep evacuation routes got really slippery. It is necessary to do cleaning and maintenance of the routes regularly. We also think elderly persons should be sure to have comfortable, non-slip shoes, in case they need to evacuate.

This content is included in the multi-screen movies, and when read aloud by students, it can be heard without reading the captions in the upper-right panel, which might be difficult for elderly individuals with poor eyesight. Thus the presentation helps such viewers to better understand the movies, and also enhances active risk communications between generations.

In the presentation, evacuees also actively share their experiences with other community residents. Matsu, who is 65 years old, said, "I was greatly encouraged by the students. I think I have shortened almost two minutes from the time I require to get to the evacuation shelters." M. Kajihara, who is 80, said, "I forgot to turn off the gas in the kitchen before the evacuation." This indicates reflection on the single-person drill process and consideration of appropriate measures during tsunami evacuation. Other residents, too, seemed highly motivated by the single-person drill. After the presentation, they immediately indicated their enthusiasm, saying they would like to participate again to help support students. This again confirms a mutually concerned relationship. After watching a computer animation of tsunami, some residents indicated better understanding of the damage a tsunami would cause, and wanted to know how long it would take a tsunami to arrive at their house.

5. THEORETICAL CONSIDERATIONS

In this section, I make some theoretical considerations regarding collaborative activities between researchers and co-researchers by discussing the significance of the single-person drill and the functions of multi-screen movies in tsunami risk reduction. During the single-person drill, three concepts appear as important, which are artefact, practice and identity.

5.1 Artefact

Artefacts can be physical objects such as computers or tables, or symbolic ones such as Halloween or Christmas. When these symbolic objects reappear frequently or repeat over time, they gradually become stable objects that have the same functions as physical ones (Sugiman 2006). In the field of disaster prevention, artefacts indicate infrastructure construction such as sea levees, evacuation shelters, highly earthquake-resistant buildings, and countermeasures against disaster such as hazard maps, community disaster maps, and evacuation wisdom. For example, organizations such as the Committee for Cooperation in Disaster Prevention, whose objective is to make policies to protect citizens' lives and properties, can be viewed as artefacts. Traditional wisdom regarding tsunami evacuation such as the tsunami *tendenko* can be classified as an artefact as well.

The single-person drill applied flexibly small-scale artefacts such as video cameras and GPS device to the utilization of existing large-scale ones. Single-person drills also aided production or replication of many new artefacts through the collaboration of various participants, such as the multi-screen movies and the Disaster Education Symposium. The single-person drill can thus shift comparatively large-scale artefacts from the whole community level to the personal individual level; when a resident actually climbs up to an evacuation shelter, the existential meaning of the shelter is changed in the resident's mind from that of a simple physical artefact to one of vital existence. Community residents who have never been to evacuation shelters may hold a mental image of successful tsunami evacuation being impossible, and may have given up on the idea of evacuation. Actually visiting evacuation shelters with students forces realization of the possibility of evacuation, transforming the mental image of large-scale artefacts. The drill also significantly contributes to the improvement of evacuation facilities, because the evacuation experience reveals the strength and weakness of the facilities.

5.2 Practice

Practice is the source of coherence of a community. Wenger (1998) proposes that in a community of practice, relationships between practice and community have three dimensions: the mutual engagement of participants, the negotiation of a joint enterprise, and the development of a shared repertoire. He points out that the most crucial characteristic of communities of practice is a "shared practice", which indicates co-participation in practice, or practical co-engagement. In the field of disaster prevention, a practice can be seen as efforts made by disaster experts to promote resilience of local communities against disaster. Similarly, practitioners in local communities taking part in the activities of community kitchens to prepare for refugee life can also be seen as a practice. From the same point of view, when community residents collaborate with local government agencies to discuss the construction of new evacuation shelters or proposals to fix furniture inside their houses, this too be seen as a community of practice.

Because the single-person drill specifically emphasizes the importance of actual behavior by each participant, it also functions to shift the focus of tsunami risk reduction practice from the community level to the individual level. I consider this an effective way of overcoming the negative attitudes described above, by recasting tsunami evacuation from a general, non-urgent condition as a specific, concrete task that can be accomplished by individual residents.

The single-person drill promotes co-learning of tsunami risk reduction among intergenerational participants. The drill also combines active intervention of researchers in the community and the neutral research activity of collecting data such as evacuation behavior and facility effectiveness. Collaborative practice between researchers and co-researchers is expected to overcome problems often seen in community-based disaster prevention activities, such as insufficient collaboration between community residents and disaster experts and over-dependency on infrastructure and experts.

The single-person drill involves people and artefacts that had not previously taken part in tsunami risk reduction, and former strangers become partners in collaborative activities. As an example, producing the

multi-screen movies combined evacuee behavior and academic activities to produce artefacts. The movies revealed information such as frequently used evacuation routes and places where brick walls should be removed to improve evacuations. The single-person drill thus produced or reproduced tsunami risk reduction practices and artefacts when community residents collaborated with government officers to upgrade dilapidated bridges or widen narrow evacuation routes.

5.3 Identity

Identity in practice is defined socially, not merely because it is reified in a social discourse of the self and of social categories, but also because it is produced as a lived experience of participation in specific communities (Wenger 1998). In the field of disaster prevention, when a Disaster Prevention Committee in a local community plans tsunami evacuation drills, various practitioners are expected to be involved. Examples include workers who constructing evacuation shelters, community leaders implementing the drill, and participating community residents. Through the practice, new problems or new evacuation methods are likely found. For example, people who have never participated in drills may join other family members and enjoy the drill very much. Thus, identities of these practitioners are transformed because of the newly created relationship with artefacts and other members.

Disaster prevention practices should provide an appropriate stage for collaboration between community residents and disaster experts, which can eventually reconstruct and reproduce the identities of all the participants (Yamori 2009). The single-person drill has gradually changed community attitudes regarding disaster, transforming residents' self-view as one who will need help to one of being someone who will take initiative in reducing active risk. Disaster experts and government agencies have also recast themselves as people who know risks by calculating neutral danger, to one of partners who collaborate with community residents by sharing active risk.

Regarding identity transformations in students and community residents, it is clear that the single-person drill provides a good chance for students to participate in tsunami risk reduction by managing the drill process as disaster education. During the drill, students take detailed notes about the whole evacuation situation from their own perspectives. After the drill, they participate in producing encouraging messages to evacuees and discussing problems and shortcomings of the overall evacuation process. This kind of disaster education provides a new approach to fostering supporters rather than mere survivors in a disaster. Students, who had never taken part in real disaster prevention activities, because they are usually conducted by adults, became important participants providing significant support roles, rather than token positions. The single-person drill provided them with leading roles that reproduce their identities in tsunami risk reduction.

The single-person drill easily evokes awareness of such roles, because every movement of the evacuees is recorded by video cameras. Conversely, when elderly evacuees are surrounded by young students they realize that others care for their safe evacuation, motivating them to recognize their responsibilities regarding tsunami risk reduction. These are essential meanings in tsunami risk reduction, but have largely been neglected before. For those who always had a high interest in tsunami risk reduction, verification of their behaviors using the sophisticated technology of disaster studies can motivate them to think of more appropriate countermeasures against disasters and applying them to future activities.

For example, the above-mentioned evacuee Tama, who climbed up to an evacuation shelter, said she would rather be flooded away with her house, because "it is really hard for me to evacuate." After the drill, with support from the researchers, her family members continued to encourage her, even complaining that "If you do not evacuate during a tsunami, we'll think that you don't love us." This is typical means of disaster prevention based on a mutually concerned relationship. A half year later Tama actively participated in the evacuation drill for students, climbing up to the evacuation shelter with her grandchild. According to video records taken by her family members, Tama reduced her evacuation time

by almost two minutes. Furthermore, Tama declared that "From now on, I will go to the shelter every day just for a walk."

Weakness due to advanced age can reduce confidence in elderly persons like Tama, causing them to give up on countermeasures against a future tsunami. However, the single-person drill specifically urges the elderly to play leading roles in tsunami risk reduction. This can greatly encourage the elderly, by sending messages such as "Do not surrender to a tsunami, and do not belittle its force as well," "Do not rely on others, but think of countermeasures for yourself and your family," and "You cannot resolve all problems at once, so try to clear obstacles one at a time."

I now discuss identity transformations in disaster experts and governmental officer. These persons calculate tsunami estimates by running simulations that rely on parameters such as the earthquake epicenter, its seismic intensity, the evacuation speed, and the reception rate of evacuation warnings. These studies focus on whole communities or multiple large regions, rather than individuals. However, as discussed in Section 2.3, there are limitations on applying these studies to promoting disaster prevention awareness, and to individual activities in particular.

Researchers in the single-person drill not only take the neutral position of distributing research results to community residents, but also become collaborative partners with community residents in considering appropriate and effective countermeasures. For example, evacuating alongside community residents frequently uncovers new facts that simulations do not account for, such as unexpected walking paces among the elderly, or behaviors related to helping others. Participation in the single-person drill and careful recordkeeping thus provides researchers with valuable data related to human behavior. Disaster experts and government agencies thus reproduce their identities by collaborating with community residents and transforming their positions from thinking about only academic studies to caring about the betterment of their co-researchers.

5.3 Functions of the multi-screen movies

Multi-screen movies are produced based on the collaboration of various participants, which provide a platform for linking and visualizing human behavior during tsunami evacuations and tsunami flooding. Owing to the collaborative efforts put into the production of the movies, two types of dialogues were achieved. One is between disaster experts and community residents, and the other is between the natural and human sciences. Here, dialogue means the dynamic transformational positions between neutral danger and active risk to promote tsunami risk reduction.

5.3.1 Dialogue between disaster experts and community residents

Tsunami experts and CG experts made professional contributions in editing the movies. Their responsibilities are developing sophisticated tsunami simulation models, inventing tsunami animations with high accuracy, and editing the four synchronized parts of the movies. The evacuees presented the methods, routes, and time needed for evacuation. All of these elements are vital parameters in tsunami evacuation. The video records and student notes are also flexibly used in the editing process.

Ushiyama (2008) argues that local disaster prevention should not be restrained to just community-based activities, but must also be tested based on professional skills and developed to the level of scientific knowledge with guaranteed practice. The single-person drill is an example of the latter. Although experts did strongly influence the editing process, it would be dangerous or even damaging to the community residents without being backed up by accurate tsunami simulation calculations. The movies can be seen as artefacts that generate dialogue between actual and professional practices as conducted by disaster experts and community residents.

5.3.2 Dialogue between the natural and human sciences

The content shown in the multi-screen movies was produced by actual evacuee behaviors. For example, the upper-left and bottom-right panels display every movement during the evacuation. The message content shown in the upper-right panel is produced by evacuees and students during editing. At the bottom left are evacuation methods and other elements that are the results of decision-making by participants. The movie contents are thus produced based on the human sciences.

In contrast, the design process of the movies is based on advanced technologies. Specifically, developing models of the tsunami simulation required applying the latest tsunami predictions given by the Cabinet Office. The worst-case scenarios shown in the movies were scientifically calculated by setting coordinate systems, epicenter, mesh sizes, and various scenarios in advance. Such preconditions allow running tsunami simulations to predict damage over time. Sophisticated technologies in the field of disaster prevention and CG production are thus merged into the movies.

A problem with current disaster prevention methods is that, while many studies have been conducted from the perspective of social sciences, their methodologies are borrowed from the natural sciences. Such studies clearly separate researchers and research subjects, so that the former can objectively observe the latter. However, if studies of social sciences simply change their focus from natural phenomena to human phenomena, and consider only topics outside of natural sciences, social sciences can never keep pace with the natural sciences (Yamori 2009). In this sense, implementation of the single-person drill and the production of multi-screen movies can be seen as an initiative step toward tackling this problem.

6. CONCLUSION

In this paper, I discussed collaborative activities in the single-person drill based on the theory of communities of practice. I also described the function of multi-screen movies from the perspectives of two research stances. It is necessary to know that relations between theory and practice in the human sciences are always mutually influenced. For example, through descriptions and discussions of the single-person drill by journalists or researchers, activities of tsunami risk reduction in Okitsu were immensely changed by outsiders, from the perspective of Okitsu residents. Thus theory (e.g., tsunami predictions) is not a fixed object, but rather changed by the development of practice. Conversely, functions of practice are to verify the rationality of theory and to reconstruct it.

Finally, the single-person drill of course cannot solve all problems. While the drill emphasizes collaboration between disaster experts and community residents, on some occasions students and evacuees have been put in subordinate positions. Also, focusing on personal behaviors and considering concrete countermeasures are very effective in overcoming limitations in tsunami risk reduction, but difficulties exist in implementation processes. For example, one significant problem is that some elderly adults are incapable of independently evacuating, and it is very difficult to appoint specific people to aid their evacuation. In addition, though the multi-screen movies have great influence in motivating people to participate in tsunami risk reduction, the production cost is relatively high, making it difficult to make evacuation movies for every evacuee. These problems led to modifying the single-person drill to a simplified form. Also, with the newly constructed solar street lamps in Okitsu, plans for carrying out single-person drills during night time are under discussion. I will continue to do this evacuation drill and to verify whether it is suitable for tsunami risk reduction in regions along the Nankai trough.

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REFERENCES

Cabinet Office. (2012, March 31). Nankai trough no kyodai jishin ni yoru shindo bunpu–tsunamidaka ni tsuite (daiichi ji hokoku) [The first report on estimates of the distribution of seismic intensity and the height of tsunami waves of a Nankai megathrust earthquake]. Retrieved from http://www.bousai.go.jp/jishin/nankai/model/

Central Disaster Prevention Council. (2011, May 28). Konkai no tsunami higai no gaiyo [Summary of the tsunami damage]. Retrieved from http://www.bousai.go.jp/kaigirep/chousakai/tohokukyokun/1/pdf/3-2.pdf

Headquarters for Earthquake Research Promotion. (2013, May). Nankai trough no jishin katsudo no choki hyoka (daini ban) ni tsuite [Long-term evaluation of Nankai trough earthquake movement (Second edition)]. Retrieved from http://www.jishin.go.jp/main/chousa/13may_nankai/

Imamura, F., Suzuki, T., and Taniguchi, M. (2001). Development of a simulation method for the evacuation from the tsunami and its application to Aonae, Okushiri Is., Hokkaido. *Journal of Natural Disaster Science*, *20*(2), 183-195.

Japan Meteorological Agency. (2011, April). (Furoku ni) 2011 nen tohoku chiho taiheiyo oki jishin ni yoru kakuchi no shindo [(Appendix 2) Seismic intensity in areas affected by the Great East Japan Earthquake]. Retrieved from http://www.data.jma.go.jp/svd/eqev/data/2011_03_11_tohoku/0311_shindo.pdf

Katada, T., Kanai, M., Hosoi, K., and Kuwasawa, N. (2011). Issues of implementations to be intended for only applicants for bousai seminar: According to seminar to guide how to evacuate from tsunamis. *Journal of Japan Society of Civil Engineers*, *67*(1), 1-13.

Katada, T. and Kuwasawa, N. (2006). Development of tsunami comprehensive scenario simulator for risk management and disaster education. *Journal of Japan Society of Civil Engineers*, *62*(23), 250-261.

Kochi Prefecture. (2012, December 10). Kochiken ban daini dan, Nankai trough no kyodai jishin ni yoru shindo bunpu–tsunami shinsui yosoku ni tsuite [The second report on estimates of the distribution of seismic intensity and the height of tsunami waves of a Nankai megathrust earthquake and tsunami in Kochi prefecture]. Retrieved from http://www.pref.kochi.lg.jp/soshiki/010201/nannkai-3.html

Kochi Prefecture. (2013, May 15). Kochi ken ban Nankai trough kyodai jishin ni yoru higai sotei ni tsuite [Damage estimates of a Nankai megathrust earthquake in Kochi prefecture]. Retrieved from https://www.pref.kochi.lg.jp/soshiki/010201/higaisoutei-2013.html

Mainichi Shimbun. (2012, April 1). Nankai trough jishin: Saidai tsunami 20 m cho ni shogeki, shikisha “hinan basho yori takaku ni” [Nankai megathrust earthquake: A great shock by the predicted highest tsunami waves over 20 m, analysts suggest “upgrading evacuation shelters to higher places”].

Nakamura, I., Amano, A., Fujiyoshi, Y., Mizukami, T., Nakamori, H., Amano, N., Mishima, K., Yamazaki, T., Hoshikawa, T., and Tanihara, K. (2013). “Nankai trough kyodai jishin” no higai sotei ni kansuru jyumin no ishiki to hanno: Digital hoso kenkyukai shimoda shi Kuroshio cho chosa kara [Residents’ consciousness and response to damage predictions of a Nankai megathrust earthquake: Survey results in Shimoda and Kuroshio by Digital Broadcasting Workshop]. *Proceedings of the 15th Conference of Japan Society for Disaster Information Studies*, 192-195.

National Police Agency. (2014, April 10). Tohoku chiho taiheiyo oki jishin no higai jyokyo to keisatsu sochi [Great East Japan Earthquake damage and police measures]. Retrieved from http://www.npa.go.jp/archive/keibi/biki/higaijokyo.pdf

NHK. (2012). Bokutachi ga tsukuru "furusato no mirai" [The future of hometown built by school children]. Retrieved from http://www.nhk.or.jp/sonae/mirai/program_yamori01/index.html

Reconstruction Agency. (2011, August 11). Higashi nihon daishinsai kara no fukko no kihon hoshin (Higashi nihon daishinsai fukko taisaku honbu kettei) [Fundamental reconstruction policy after the Great East Japan Earthquake (Reconstruction Head Office's decision)]. Retrieved from http://www.reconstruction.go.jp/topics/000056.html

Reconstruction Agency. (2014, April 25). Zenkoku no hinansha no kazu [Number of refugees in Japan]. Retrieved from http://www.reconstruction.go.jp/topics/main-cat2/sub-cat2-1/20140425_hinansha.pdf

Sudo, Y., Takahashi, T., and Higashino, S. (2013). Chiiki to tomoni kangae kodo suru bosai–gensai hodo no torikumi: Junkai workshop "Musubi Juku" to "Inochi to chiiki wo mamoru campaign" [Approaches to disaster prevention report through collaboration with local community: Round workshop of "Musubi Juku" and "Campaign for protecting lives and communities"]. *Proceedings of the 15th Conference of Japan Society for Disaster Information Studies*, 44-45

Sugiman, T. (2006). Group dynamics. In T. Sugiman (Ed.), *Group dynamics in communities* (pp.19-86). Kyoto: Kyoto University Press.

Sugiman, T. (2013). *Group dynamics nyumon: Soshiki to chiiki wo kaeru jissen gaku* [An introduction to group dynamics: Applied studies of transforming organizations and communities]. Kyoto: Sekaishisosha.

Sun, Y., Kondo, S., Miyamoto, T., and Yamori, K. (2014). New approaches to tsunami teduction: Single-person drill and multi-screen movie. *Journal of Information Disaster Studies*, *12*, 76-87.

Sun, Y., Yamori, K., and Kondo, S. (2013). Disaster education based on community of practice: A case study in Okitsu, Kochi Prefecture. *Journal of Integrated Disaster Risk Management*, *3*(1), doi:10.5595/idrim.2013.0056

Toyoda, Y. and Kanegae, H. (2012). A study on effects of participatory disaster map making to community-based disaster risk reduction. *Ritsumeikan International Affairs*, *35*, 25-43.

Ushiyama, M. (2008). Gakusai teki bosai kenkyu no "ba" toshite no jyumin sankagata bosai katsudo [Resident participatory activities in the "field" of interdisciplinary research]. *Proceedings of the 45th Integrated Symposium of Journal of Natural Disaster Science*, 51-52.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. NY: Cambridge University Press.

Yamori, K. (2009). *Bosai ningen kagaku* [Human science for disaster reduction]. Tokyo: University of Tokyo Press.

Yamori, K. (2013). Sotei wo uso ni suru tame ni: "Change" wo shien suru [Change estimates into a lie: How to support this "change"]. *Journal of Information Studies*, *11*, 14-19.

Yamori, K. (2014). Korekara no korekara: Kinmirai no bosai kisho jyoho [The future in the future: Meteorological information in disaster prevention in the near future]. *Journal of Disaster Information Studies*, *12*, 47-51.

Yamori, K., Kikkawa, T., and Ajiro, T. (2005). *Bosai game de manabu risk communication* [Learning risk communication through a gaming approach]. Kyoto: Nakanishiya Shuppan.