

環境認知を考慮した津波避難計画へ

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本稿では、津波時における避難行動に環境認知が与える影響を考察した研究について報告する。東日本大震災の前と後に千葉県御宿町において行なったアンケート調査結果を比較したところ、実際に避難した人は事前の調査で示された意向に反して少なく、避難したかどうかは自宅の空間的な位置によって大きく異なっていた。そこでスケッチマップ調査を行なった結果、道路と海岸線の位置関係の歪みや標高の過大評価など住民が認知している環境は実際の空間とずれている側面が見られ、危険な避難行動の一因となっていることが分かった。これらの結果は、有効な津波避難計画を立てる上で、住民の環境認知を理解することが重要であることを示唆している。

キーワード：津波、避難行動、環境認知、スケッチマップ、避難計画

Environmental Cognition and Tsunami Evacuation Planning

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This article focuses on the effects of residents' cognition of their local environment on evacuation behavior in the event of tsunami. We conducted questionnaire surveys and a sketch map survey in the coastal area of Onjuku town, Chiba prefecture. The results revealed that actual behavior was not consistent with the result of a similar survey conducted before the earthquake, decision-making was based on cognition of terrain, although it was not always correct, and some improper evacuation behavior were related to "distorted" cognitive map. These results suggest that understanding residents' cognitive environment is important to develop effective tsunami evacuation planning.

keywords: Tsunami, Evacuation Behavior, Environmental Cognition, Sketch Map, Evacuation Planning

Introduction

Because tsunami disasters occur in coastal regions, the impacted area can be roughly predicted. However, physical environmental features, such as topography or the road network, may influence human consciousness and evacuation behaviors against a tsunami.

Previously, we investigated the evacuation behavior of the residents of Onjuku, Chiba prefecture, where a large-scale tsunami warning was issued after the 2011 Great East Japan Earthquake (Ohno & Isagawa, 2012; Isagawa et al., 2012). In this article, we focus on the effects of environmental features on residents' behavior and reconsider evacuation planning for tsunami mitigation.

Onjuku is in the eastern part of the Boso Peninsula and borders the bay to the south. The central area of the town is located on lowlands (Fig. 1). In 2008, we conducted a questionnaire survey to investigate the evacuation behavior and risk perception of tsunamis in the coastal area of this town.

At the time of the 2011 earthquake, the meteorological agency expected large-scale tsunami runups over 10 meters high. However, the maximum tsunami height at Onjuku was 2.5 meters (Tsuji et al., 2011), and no one was hurt in this town. A picture taken by a resident shows that the tsunami runup in the river was strong (Fig. 2).

Why do people not evacuate?

To investigate how coastal residents behaved after the earthquake, which was expected to generate a massive tsunami, a questionnaire survey was conducted at the end of July 2011. Questionnaires were distributed to all 2,272 households in the same area as the 2008 survey, and 447 valid responses were received by mail.

In the 2008 survey, 95% of the respondents intended to evacuate. However, the 2011 survey revealed that only 40% evacuated during the actual event (*1). The 2011 survey also indicated that 90% of the residents were aware of the tsunami warning. Thus, the question becomes why did they not evacuate? The major reasons seem to be related to biased risk perceptions, such as their current altitude was sufficient (35%), the tsunami will not reach them (30%), and they were far enough from the sea (21%) (Isagawa et al., 2012).

Figure 3 shows the behaviors of the residents who were in their homes at the time of the earthquake. Behaviors differed according to spatial location. Figure 4 (a) shows the spatial distribution of residents who did not evacuate because they thought they were "at a high enough altitude." Even in the lowlands, some people felt they lived in a high altitude area. Figure 4 (b) shows the spatial distribution of residents who did not evacuate because they thought "far enough from the sea." Although most of the residents lived at least 500 meters



Fig. 1 Bird's eye view of Onjuku



Fig. 2 Whirlpool of the tsunami

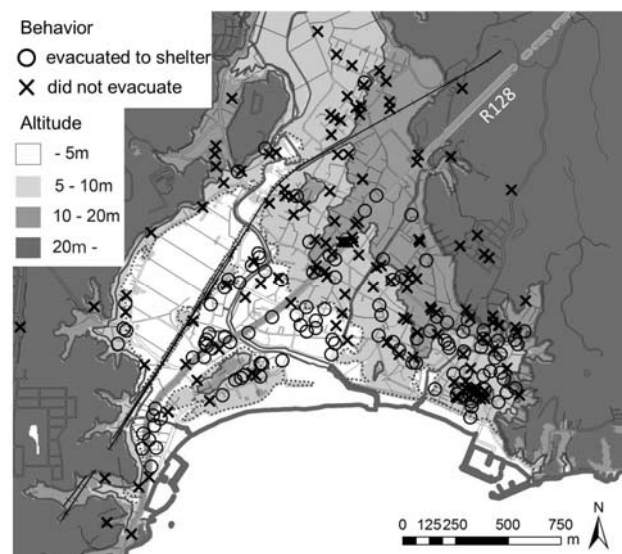


Fig. 3 Behavior after the earthquake

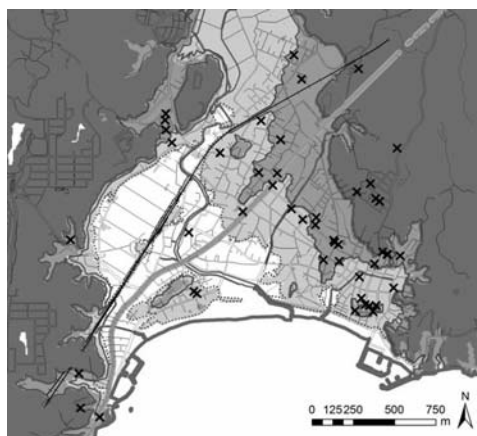
from the sea, some residents who lived about 200 meters from the sea believed that they were “far enough from the sea.” (*2)

How does environmental cognition affect evacuation behavior?

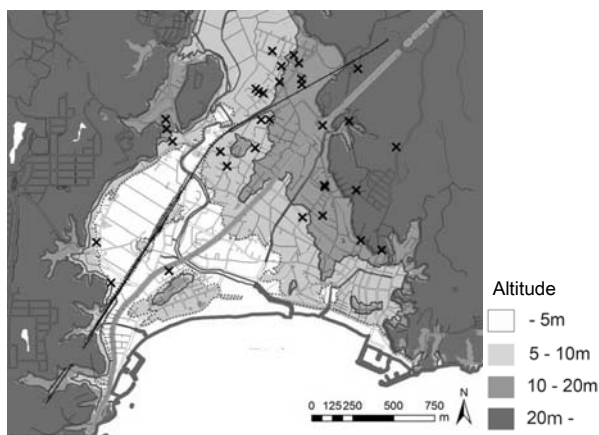
The results of the questionnaire suggest that there are discrepancies between the residents’ cognitive and physical environments. To extract residents’ cognitive environment of the town, we conducted a sketch map survey (Lynch, 1960) in November 2012 at community meeting places in the coastal area. Each participant was asked to draw a quick map of Onjuku town on A3 size white paper. We received maps from 35 persons.

Although the main road, National Route 128, runs diagonal to the coastline in Onjuku (See Fig. 3), nearly half of the participants recognized a spatial relation simpler than the actual one. Figure 5 shows two typical

examples of such cognition. Twelve participants drew the road almost parallel to coastline, while four drew it almost orthogonal. Most of the participants who drew it orthogonally live in the eastern part of the town, whereas those who drew it parallel live in the western part or center of the town. As for contour lines, participants who live in eastern part of the town tended to overestimate the altitude of the town (Fig. 6). These tendencies

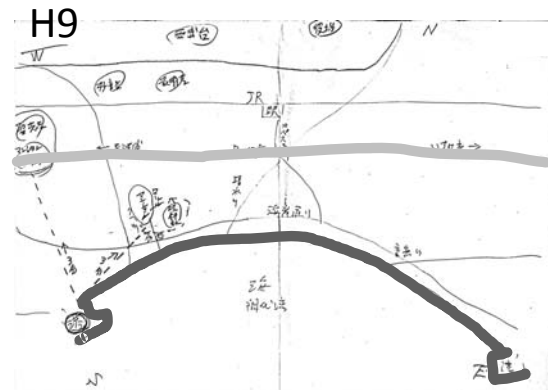


(a) “at high enough altitude”

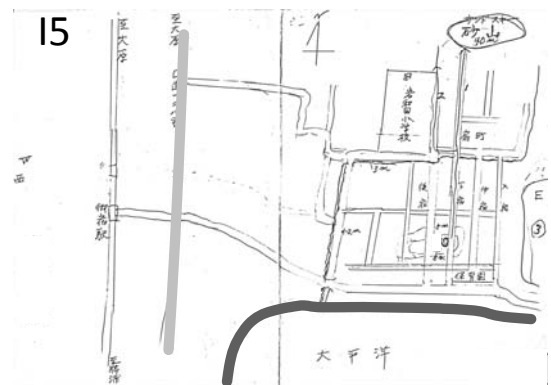


(b) “far enough from the sea”

Fig. 4 Position of the residents who did not evacuate based on the physical environmental features



(Parallel)



(Orthogonal)

Fig. 5 Typical examples of the spatial relation between the coastline and the main road

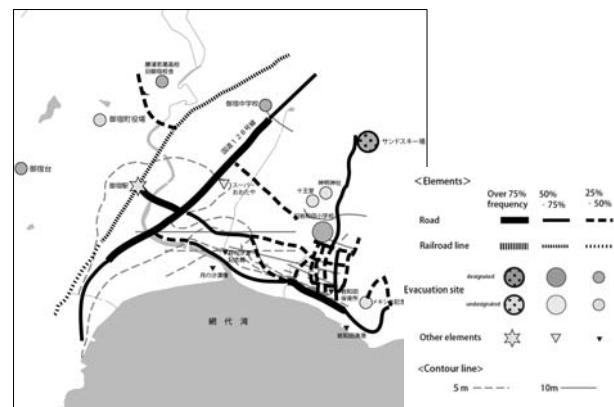
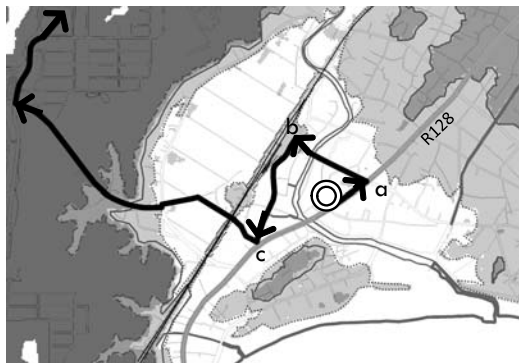


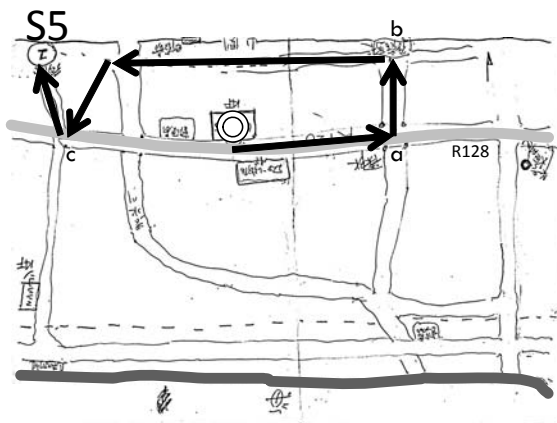
Fig. 6 Illustrated elements of the residents who live in the eastern part of town

suggest that the relationships between elements in the local area are extended to broader ones.

With these “distorted” cognitive map, how do residents evacuate during an emergency? Figure 7 shows an example evacuation route chosen by one resident during the 2011 earthquake. Although he intended to travel away from the sea, he actually approached it. In his cognitive map, route 128 parallels the coastline. This case clearly demonstrates how a “distorted” cognitive map may cause an improper route choice.



(Evacuation route on a physical environment)



(Evacuation route on a cognitive map)

Fig. 7 Example of improper evacuation with a “distorted” cognitive map

Conclusion

The actual evacuation behaviors were inconsistent with the results of a questionnaire survey conducted prior to the earthquake, demonstrating the importance of devising an evacuation plan that residents can execute.

In this case, many residents did not evacuate although they had received the disaster information. Decision-making was based on physical environmental features, such as altitude or distance from the sea.

However, their cognition was not always correct.

Using the sketch map method, some characteristic tendencies of environmental cognition were extracted. Although some of these results correspond to previous studies on cognition (e.g. Canter, 1977), our study suggests that effective mitigation measures against natural disasters need understanding of how people recognize their environment. The tsunami evacuation plan should include informing residents of the actual structure of the town and the appropriate direction for evacuation.

Notes:

*1 In this survey, each respondent was asked to describe the sequence of their behavior. Whether evacuated or not is based on their description.

*2 The areas which are less than 10m-high or less than 1km from the sea can be judged as inundation area according to the 8m-high tsunami simulation which is conducted by the local government.

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