

Jomon Pottery Observed from the Point of View of Fluid Mechanics

Did Jomon People Discover Twin and Kármán Vortices?

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Abstract: It is said that the Jomon period began about 12,000 years ago and continued till about 2,500 years ago. The potteries of that age are known as Jomon pottery. Among them, a pottery discovered from the Umataka ruin in Niigata Prefecture in 1931 has an excellent shape. It is said that this pottery was made about 4,500 years ago. Jomon potteries of similar artistic styles have been discovered in various parts in Japan. These potteries have very nice shapes, but the pottery discovered from the Umataka ruin excels other potteries in its excellent proportion. From the shape of lip, it was named "Kaen pottery" meaning "Flame pottery". However, from the patterns of its lip and side wall, it is more appropriate to consider that they are related to water flow. In this report, this hypothesis is made clear by a visualization method using the pollen of cedar and pine trees, and computer simulation.

Keywords: Jomon pottery, Twin vortex, Kármán vortex, Surface floating tracer method, Computer simulation.

1. Introduction

It is known that the Jomon period began about 12,000 years ago and continued till about 2,500 years ago. The people who bore the culture are called "Jomon people" and the earthenware made by the Jomon people is called Jomon pottery. Jomon pottery of various shapes has been discovered in many parts in Japan. Among them, a pottery (left of Fig. 1) discovered from the Umataka ruin in Niigata Prefecture in 1931 has an excellent shape. This pottery was made about 4,500 years ago. Jomon potteries of similar styles have also been discovered in various parts in Japan. Although these potteries have very artistic patterns, the pottery discovered from Umataka ruin excels other

potteries in its excellent proportion.

From the pattern of the lip (opening part), it was named "Kaen pottery" ("Flame pottery") associated with burning fire. But from the patterns of their lip and side wall, it is more appropriate to consider that they are related to water flow. The pattern of the lip may have come from observation of ripples after a big wave breaking on a rock. Especially the splendid design on their side wall is the plastic arts patterned after the vortices that are observed downstream of reeds, piles, stones, etc. on a river.

The purpose of this report is to suppose that the patterns on the side wall of Jomon pottery are representing the fluid pattern watched by Jomon people and to reconstruct the formation of these patterns using the same visualization method as ancient time and the computer simulation.



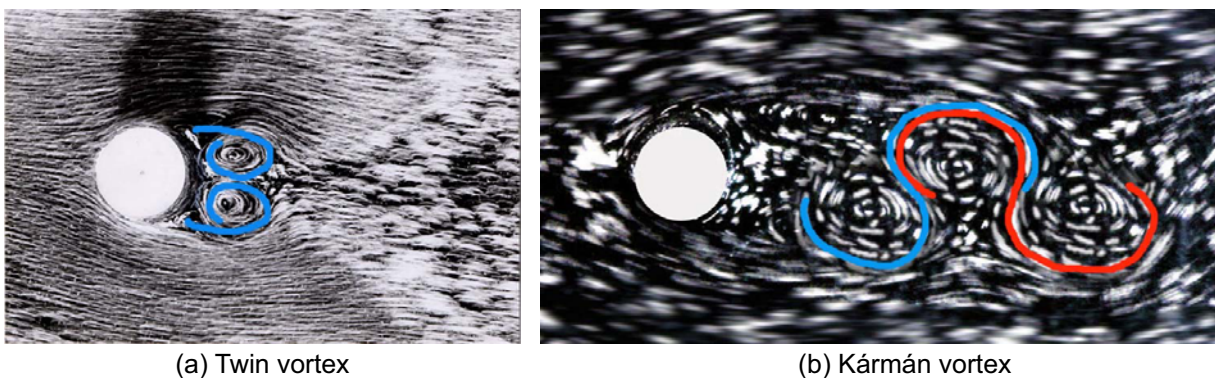
Umataka ruin Sasayama ruin
Fig. 1. Jomon pottery (Kaen pottery).

2. Visualization by the Jomon People

Figure 2 shows the enlarged upper side wall pattern of the left vessel in Fig. 1 (Kato, 1987a). The pattern of the opening part can be considered to reflect a fire flame, and it can also be considered to show big waves breaking onto rocks with following ripples. The pattern on the side wall is consisted of two kinds of vortex. One is so-called the twin vortex, each rotating in the opposite direction as shown in Fig. 3(a), and the pattern under the twin vortex is the plastic arts from Kármán vortex of alternately ranging vortices as shown in Fig. 3(b). Kármán vortex in Fig. 3(b) shows a S-shape on one occasion



Fig. 2. Enlarged pattern of Jomon pottery.



(a) Twin vortex

(b) Kármán vortex

Fig. 3. Vortex behind cylinder.

and its inverse S-shape on another occasion. These twin vortex and Kármán vortex cannot be produced by fire flame nor by its smoke.

It is very likely that the Jomon people watched the twin vortex and Kármán vortex appearing in the flow behind reeds, piles, stones, etc. with floating particles like pollens of cedar and pine trees, fallen leaves, petals, etc. acting as tracer as shown in Fig. 4 (Kato, 1987b). Then, they copied the flow pattern on the Jomon pottery. Figure 5 shows the pattern of another Jomon pottery. This pattern shows a clear S-shape vortex (Kato, 1987c).



Fig. 4. Jomon people watching vortex.



Fig. 5. S-shape vortex.

3. Reproduction of Visualization by Jomon People

3.1 Natural Tracer

Figure 6 is the photograph showing the state of heavy pollen coming from cedar forests. Pollen also comes from pine tree forests as shown in Fig.7. In the Jomon period, many forests existed, so that it is conjectured that these pollens acted as fine tracers on the surface of rivers and streams, and the Jomon people watched the vortex behind the reeds, stones and piles on a river visualized by these pollens as shown in Fig. 4.



Fig. 6. Pollen of cedars comes from a forest.



Fig. 7. Pollen of pine trees comes from a forest.

The fallen leaves and petals floating on the water surface also played a role of elegant tracers. An example is shown in Fig.8 where a meandering flow and vortices are visualized by fallen leaves of larch trees as tracers (Visualization Society of Japan, 1993).

In this manner, the surface floating tracer method must have been used to observe flow patterns unintentionally by the Jomon people.

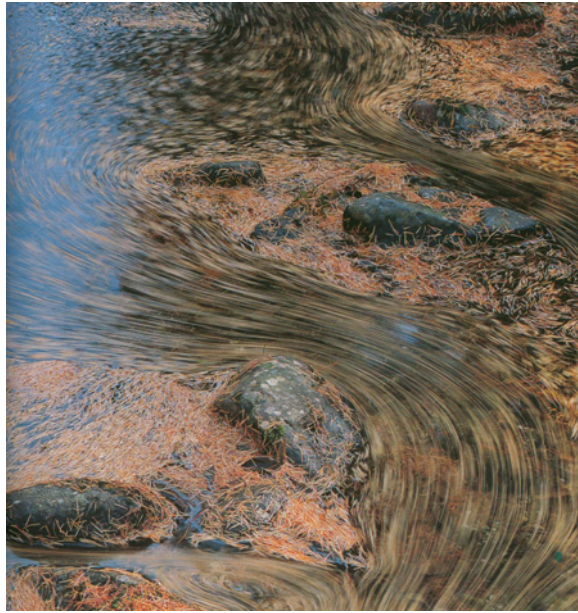


Fig. 8. Fallen leaves of larch tree floating on the surface of Azusa-river.

3.2 Experimental Apparatus

3.2.1 Open type water channel

An experiment of visualization was performed using the open type water channel as shown in Fig.9. The measuring part of this channel has length: 1800 mm, width: 300 mm and depth: 300 mm. The flow velocity can be changed from 0 to 100 mm/s by adjusting the flow control valve.

3.2.2 Recirculation type water tank

The recirculation type water tank as shown in Fig.10 was used for the experiment. The size of measuring part of this tank is length: 500 mm, width: 280 mm and depth:200 mm. The flow velocity can change from 0 to 80 mm/s.

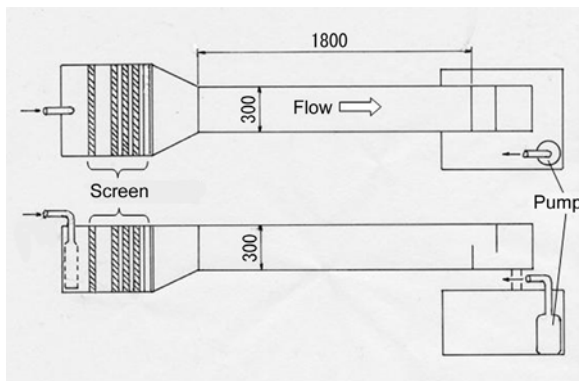


Fig. 9. Open type water channel.



Fig. 10. Recirculation type water tank.

3.3 Vortex behind an Obstacle

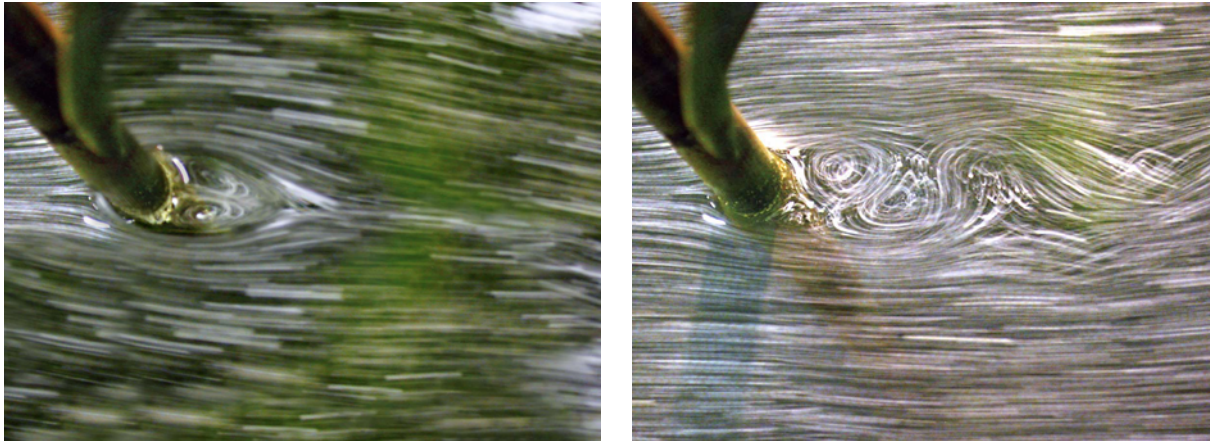
3.3.1 Vortex behind a reed beside a river

As 4500 years ago, the vortex behind a reed stem was visualized with the recirculation type water tank with the pollen of cedar and pine trees as tracer. The results are shown in Fig. 11. Figure 11(a) is

the twin vortex which is very similar to (almost the same as) the pattern on the upper side of the Kaen pottery. Figure 11(b) is the Kármán vortex corresponding to the pattern on the lower side of the Kaen pottery. The flow velocity of Fig. 11(b) is slightly faster than that of Fig. 11(a).

If a person who observed two kinds of vortex on a river and copied them to the pottery was one of the Jomon people, it will be a romantic imagination.

It is understood that Kármán vortex can be watched appearing as a S-shape or a inverse S-shape depending on view points.



(a) Twin vortex

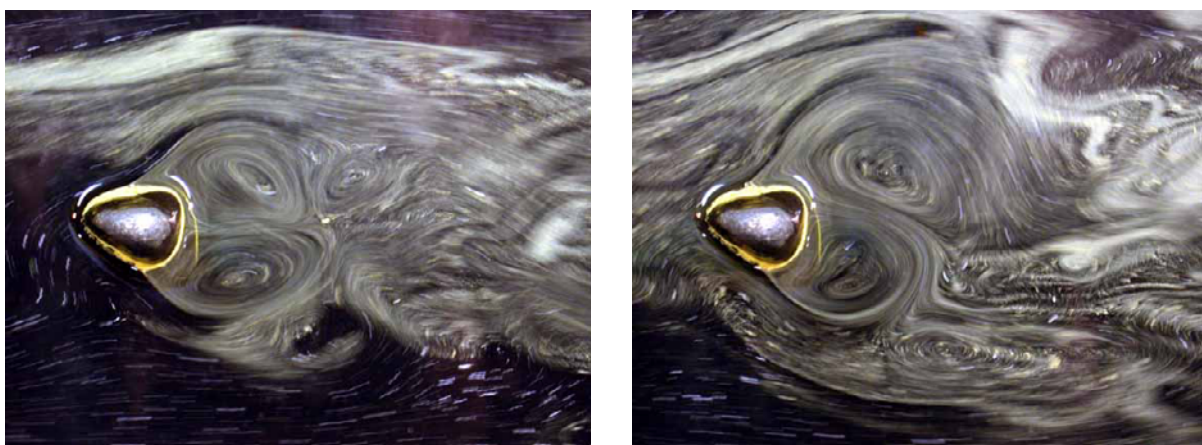
(b) Kármán vortex

Fig. 11. Vortex behind a reed stem beside a river visualized using pollen of pine trees.

3.3.2 Vortex behind a stone on a river

Using the open type water channel and the recirculation type water tank as shown in Figs. 9 and 10, the vortices behind various shapes of stones were visualized using the pollen of cedar and pine trees by the same method as 4,500 years ago.

The visualization results behind the stones using the pollen as tracer are shown in Figs. 12,13 and 14. The vortices shown in Figs. 12(a), 13(a) and 14(a) are the twin vortex of opposite rotating direction. The vortices shown in Figs. 12(b), 13(b) and 14(b) are the S-shape Kármán vortex with alternately ranging vortices. The flow velocity of the latter is faster than that of the former.



(a) Twin vortex

(b) Kármán vortex

Fig. 12. Vortex behind a stone on a river visualized using pollen of pine trees (1).

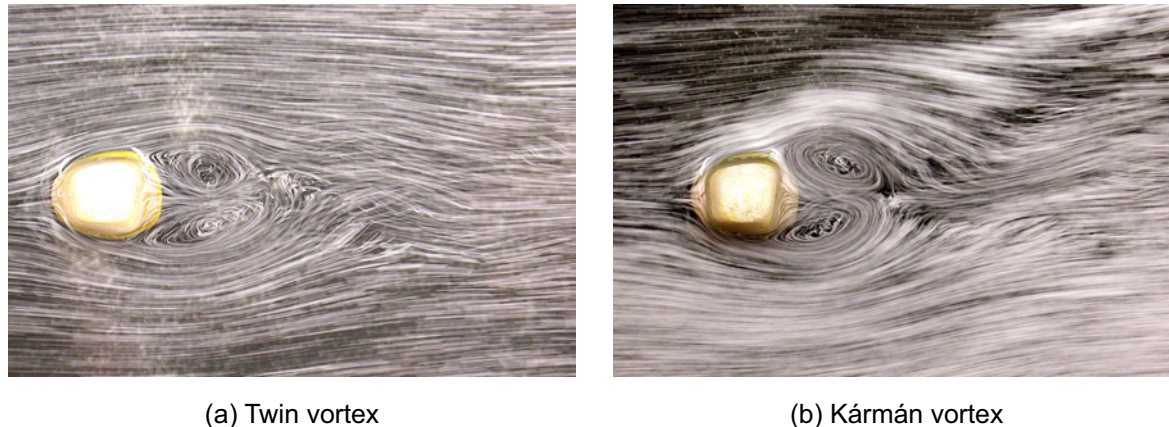


Fig. 13. Vortex behind a stone on a river visualized using pollen of pine trees (2).

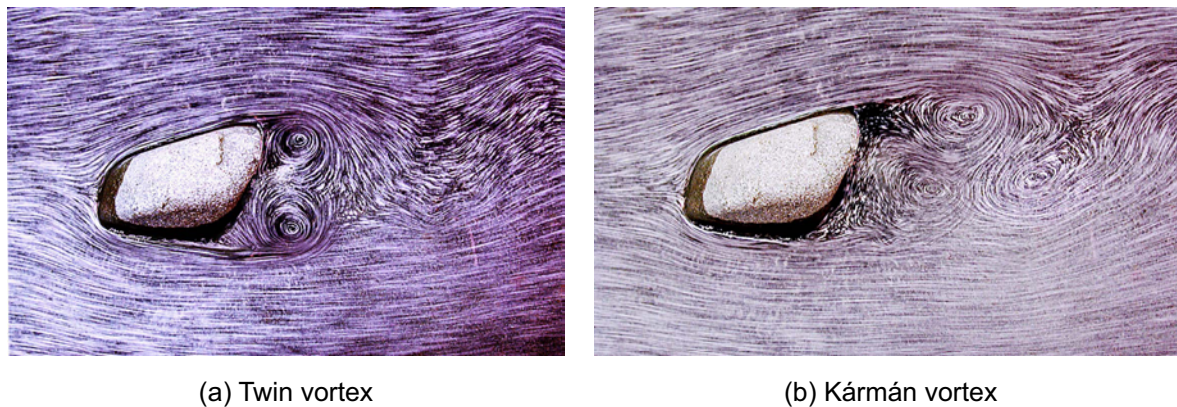


Fig. 14. Vortex behind a stone on a river visualized using pollen of cedars.

4. Jomon People Discovered Twin and Kármán Vortices

From the visualization experiment, it was made clear that the twin vortex and Kármán vortex observed behind the reeds, piles, stones, etc. on a river during the Jomon period are exactly the same as those visualized today. The Jomon people must have watched twin vortex and Kármán vortex on the river. Of course, there is no record to confirm this statement, but the first discoverer of these vortices should be one of the Jomon people about 4,500 years ago.

5. Numerical Simulation

5.1 Numerical Calculation

The equations for conservation of the continuity equation and Navier-Stokes equations are used for the fundamental equations. For the computation of these fundamental equations, the general purpose fluid analytical software, "Fluent", is used. In this software, the discretized equations are obtained by integrating the fundamental equations about each control volume, and are solved by pressure velocity coupling algorithms. The measured flow velocity was used as the inlet boundary condition.

5.2 Vortex behind a Reed beside a River

The vortex behind a reed stem was calculated by the computer simulation. The results are shown in Figs. 15(a) and (b). Figure 15(a) shows the twin vortex and Fig. 15(b) shows the Kármán vortex.

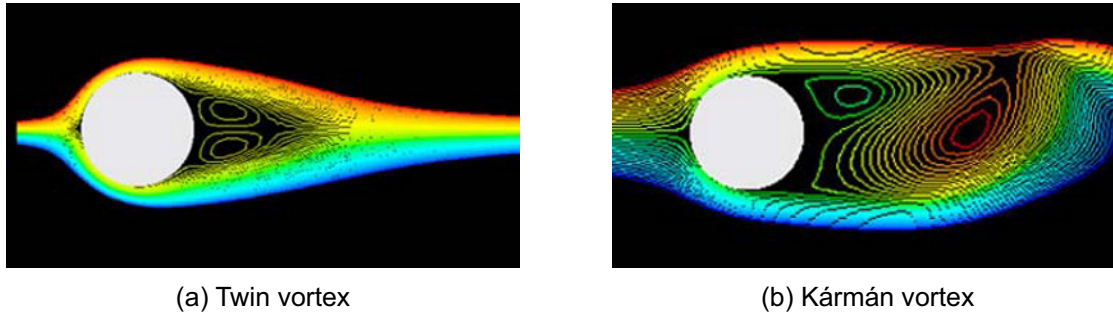


Fig. 15. Vortex behind a reed stem beside a river by computer simulation.

5.3 Vortex behind a Stone on a River

The numerical simulation was performed on the flow around the stones of the same shapes as in the previous experiments. The results are shown in Figs. 16, 17, 18. In each figure, (a) shows twin vortex and (b) shows Kármán vortex.

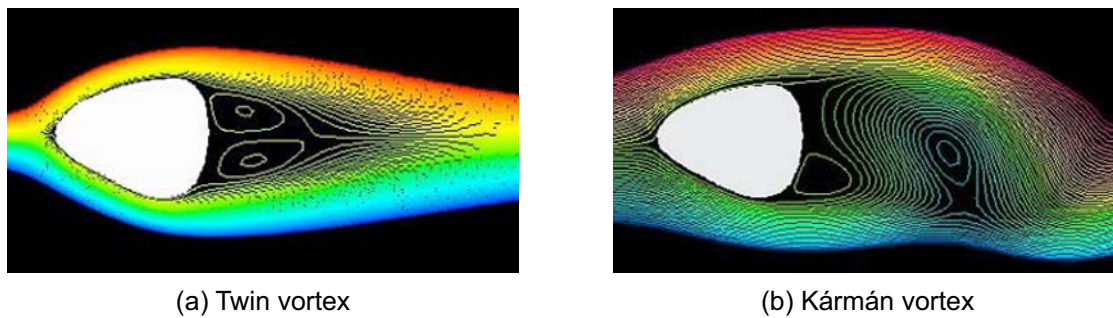


Fig. 16. Vortex behind a stone on a river by computer simulation (1).

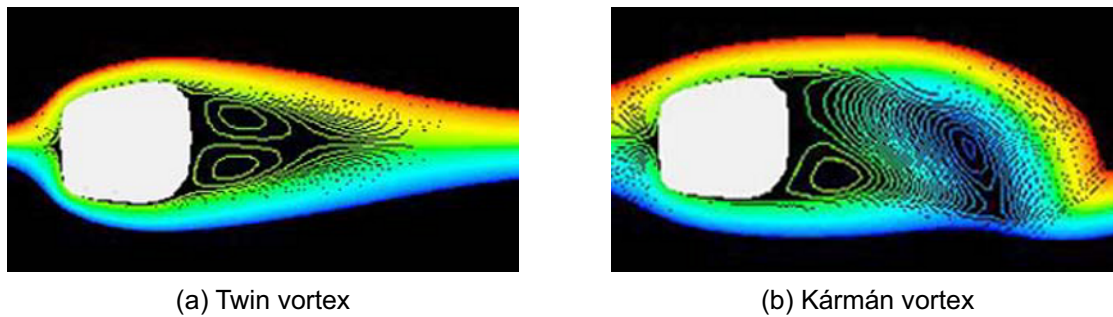


Fig. 17. Vortex behind a stone on a river by computer simulation (2).

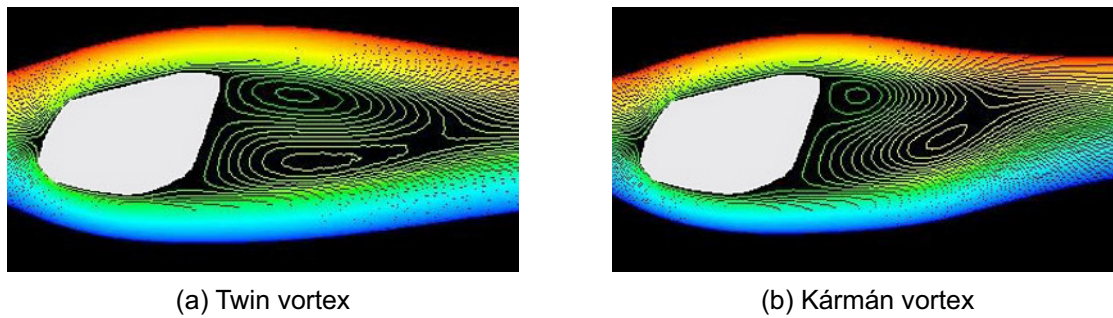


Fig. 18. Vortex behind a stone on a river by computer simulation (3).

6. Conclusion

- (1) The pattern of Jomon pottery on its lip appears to illustrate large water waves breaking on the rocks with accompanying ripples.
- (2) It is suggested that the splendid pattern on the side wall of Jomon pottery was the plastic arts from twin vortex and Kármán vortex that could be visualized in the downstream of reeds, piles, stones, etc. on a river by floating particles like pollens, fallen leaves, petals, etc.
- (3) The mechanism of forming the twin vortex and Kármán vortex was made clear by the numerical simulation.
- (4) It was proven that the pattern of Jomon pottery could be based on the vortices created by the water flow. However, the traditional conception of the fire flame needs to be respected. We, therefore, propose that potteries of this kind should be called “Kaen-Suimon pottery” implying “Flame-Water Pattern pottery”, and the combined twin and Karman vortices should be termed as “Jomon vortex”.

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Author Profile



Yasuki Nakayama: He received his Ph.D. in Mechanical Engineering from Waseda University in 1963. He joined National Railway Technical Research Institute and conducted many research projects. He then became a Professor of Tokai University, responsible for education and research on fluid mechanics. He received Medal with Purple Ribbon from the Emperor of Japan, and many distinctions and awards for his outstanding research. He was a Visiting Professor of Southampton University, UK, President of the Visualization Society of Japan, and a Director of the Japan Society of Mechanical Engineering. At present, he is serving as President of the Future Technology Research Institute and a Guest Professor of the Japan Healing Science Institute.



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