

# Human Characteristics of Figure Recognition in Tactile Feedback

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**Abstract.** In car, information presented to drivers is increasing and most of information is done using the visual and auditory displays. Presenting the information only to visual and auditory modes must cause drivers' cognitive overloads in the near future and it is necessary to find the way using other modes to reduce them. In this study, we especially focus on human tactile figure recognition of the train of sticking stimuli and examine the human characteristics of what kinds of figures people can recognize as the tactile feedback. We developed tactile device that expresses four figures. We found there are interactions between the interval time of each sticking and the figures and human has quite different mechanisms between the cases of the simultaneous sticking and the consecutive sticking in recognizing the figures.

**Keywords:** Tactile · Feedback

## 1 Introduction

Recently, in car, there is a lot of information presentation using vision, such as car navigation systems. The visual information is effective to transfer information fast and effectively. However, too much information in sight cause information overload, information is not transmitted well, and consequently, many traffic accidents must be caused by failing to transfer correct information. Presenting the information only to visual and auditory modes must cause the cognitive overloads in the near future and it is necessary to find the way using other modes to reduce them. In this paper, therefore, we focused on the tactile feedback. In this study, we especially focus on human figure recognition of the train of sticking stimuli and examine the human characteristics of what kinds of figures people can recognize as the tactile feedback. Assuming a car-driving environment, we give sticking stimuli to a calf not to disturb driving.

## 2 Related Works

Muhammad et al. [1] explored the impulsion and vibration properties of different tactile patterns. They prepared for 8 Braille-like patterns by 8 vibrating pins and investigated how many patterns people can identify each other. This experiment showed that

identification rate among 4 patterns is better than the one among 8 patterns, because the subjects could not memorized the 8 patterns. Shintani et al. [2] developed a tactile display to use small-sized solenoid that drives with low voltage and is mobile. However, in their research, the subjects only count the number of pins and do not examine the recognition of complicated figures.

### 3 The Device

We developed a device to give sticking stimuli (Fig. 1) to convey four kinds of figures by 9 solenoids: circle, cross, square, and triangle. The reason why we selected these figures is that those are used in most cultures and can be expressed with few pins. Furthermore, each figure mostly shares the common meaning with most cultures. The cross and triangle have a diagonal line, the square and triangle have the bottom. We don't adapt more complex figures than the circle, because the people must not be able to recognize them with tactile. We also do not prepare more than four patterns to reduce the loads by subjects' memorizing a lot of figures. The number of the pins used to draw each figure is 8pins, 5pins, 4pins, 3pins respectively. This device is attached on the calf of the subject.

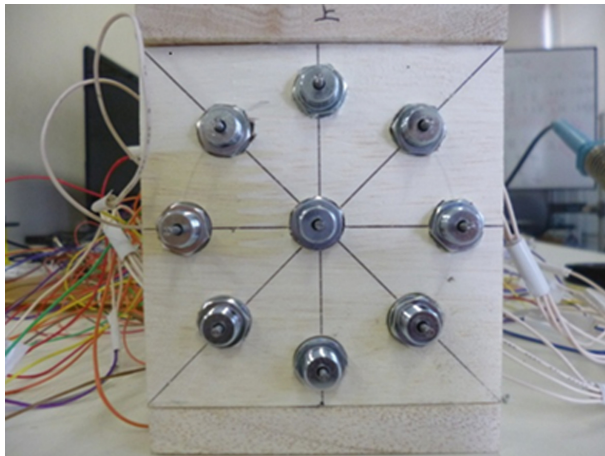
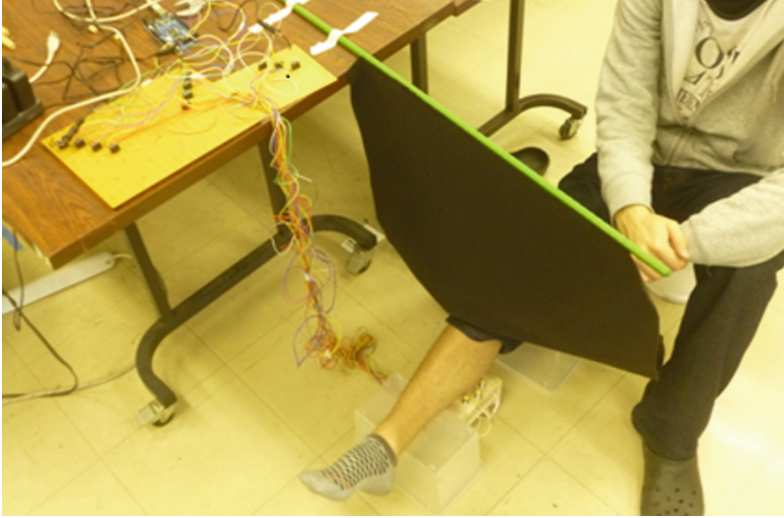


Fig. 1. The prototype device

### 4 Experiment Environment

During all experiments we conducted in this study, the subjects were listening to music with a headset not to hear the sound of moving the solenoids and we also installed a curtain between the face and the foot to hides the device. The subjects put a foot on the stand and we put the device under a foot (Fig. 2).



**Fig. 2.** Experiment environment

## 5 Experiment I

### 5.1 Aims and Methods

Before investigating the human capability of figure recognition in drawing a figure one sticking after another, we should clarify how long the interval time between one sticking and the next one people can discriminate between them. It will be better if the interval time is shorter, because the information can be conveyed rapidly. Prior to the detail experiment, we conducted the subjective experiment to reduce the number of the interval range factors. The interval time we prepared is 0.05, 0.1, 0.2, 0.3, 0.4, and 0.5 s and asked the subjects whether they could discriminate two consecutive sticking. 10 subjects (9 men and 1 woman) were involved in this experiment. Their ages ranged from 20 to 23 years old. We attach the device to subject's calf directly. The drawn figure is only the circle here. In order to avoid habituation, we change the position of the initial point each pattern.

### 5.2 Results

Table 1 indicates each subject's answer whether he/she is able to discriminate two train of the sticking. It shows that in the interval time of 0.1 s and 0.05 s were too short. In the interviews after the experiment, some subjects claimed that too long intervals cause the difficulty to understand the figure while they could discriminate the movements. As a few subjects also claimed that 0.1 s was too fast. We, therefore, decided to investigate the time around 0.1 s and 0.2 s more detail in Experiment II.

**Table 1.** The result of experiment I

Second/Subjects	Subject1	Subject2	Subject3	Subject4	Subject5	Subject6	Subject7	Subject8	Subject9	Subject10	Average	1. recognizable 2. not recognizable
0.05	2	1	2	2	1	2	2	2	2	1	1.7	1
0.1	1	1	1	1	1	1	2	1	2	1	1.2	2
0.2	1	1	1	1	1	1	1	1	1	1	1.0	1
0.3	1	2	1	1	1	1	1	2	1	1	1.2	1
0.4	1	1	1	1	1	1	1	1	1	1	1.0	1
0.5	1	1	1	1	2	1	1	2	1	1	1.2	1

## 6 Experiment II

### 6.1 Aims and Methods

In the Experiment I, we found that the interval time longer than 0.3 s is too slow to convey information. The aim of Experiment II is to determine which duration is appropriate in giving sticking stimuli in more detail. In this experiment, we asked the subjects how many train of the pin hit consecutively. The interval time investigated here is 0.04, 0.05, 0.07, 0.1, 0.15, 0.2, 0.25 s and the number of hitting is 2, 3, 4, 5 times. So, 84 trials of 7(seconds)  $\times$  4(hit times)  $\times$  3(times) were presented to each subject in random order. Subjects (9 men and 1 woman) were involved in this experiment. Their ages ranged from 20 to 24 years old.

### 6.2 Results

**Table 2.** Percentages of the correct answers

Second/Times	2	3	4	5
0.04	86.7	26.7	6.7	3.3
0.05	73.3	33.3	16.7	0.0
0.07	76.7	43.3	10.0	13.3
0.10	80.0	70.0	33.3	13.3
0.15	80.0	56.7	66.7	36.7
0.20	60.0	36.7	66.7	46.7
0.25	50.0	36.7	70.0	53.3

Table 2 shows that, all correct rates in train of two stimuli were high in all interval time and the correct rate in train of 3 sticking was especially high in the only case of 0.1 s. When interval time is 0.25 s, the correct rate was the best in 4 and 5 times. These results indicate the appropriate interval time depends on how many pins are used to draw a figure and it is necessary to change the interval time by the number of a pin. Table 2 shows that a percent of correct answers is not high, because there are individual differences. We conduct third experiment based on the result.

## 7 Experiment III

### 7.1 Aims and Methods

The third experiment was conducted to investigate the human tactile characteristics of figure recognition. The figures used in this experiment are a circle, a square, a triangle and a cross. The pins were activated one by one to the counterclockwise direction in the circle, the square, the triangle (Fig. 3). The conditions for the interval time were 0 s (simultaneous), 0.1 s, and 0.25 s. So, 36 trials of 3(seconds) × 4(shapes) × 3(times) were presented the subjects in random order and 15 subjects were involved. The subjects were asked kind of figure was presented.

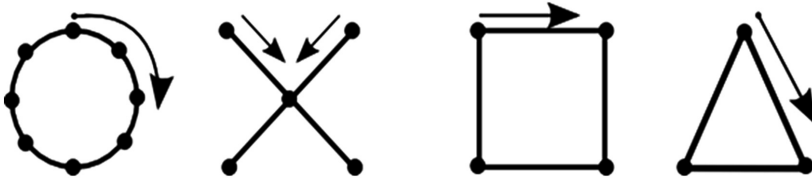


Fig. 3. How to move the pin each figures

### 7.2 Results and Considerations of the Correct Rates

Table 3 shows the results of the correct rates of each figure in each interval time. We analyzed the data by ANOVA to examine about the relationships between the interval time and the figure recognition ( $p < 0.05$ ). The results showed that there are interactions between the interval time and the figures and it is consistent with the results in the second experiment.

Table 3. The correct rate of each figure

Second / Figure	○	×	□	△
0s	11.1	24.4	24.4	40.0
0.1s	71.1	24.4	26.7	42.2
0.25s	88.9	17.8	40.0	24.4

Before the experiment, we assumed that cross must be the most recognizable figure and its correct rate must be the highest among the figures, because the cross is only the figure which the center pin is used to draw. However, the correct rate of cross is the lowest in all figures. The most of subjects claimed that it was difficult to recognize the stick of the center pin. We must investigate this reason in the future. Table 3 also shows that the correct rate of the circle is especially high when it is drawn sequentially

while the one is especially lowest in case of simultaneous sticking. Moreover, the correct rate of square is high when interval time is 0.25 s and triangle is high when interval times are 0 s and 0.1 s. These results mean that each figure has each appropriate interval time to make people recognize it and, to convey a figure by tactile, easy an appropriate interval time should be set up for each figure.

### 7.3 The Way of Mistakes of Each Figure for the Other Figures

The correct rates of all figures were not better than we had expected. To investigate the reason and what sorts of misrecognition happened, we consider about which figures the subjects mistook each figure for.

#### Case of Interval Time 0 s

**Table 4.** The rates of mistakes of each figure when interval time is 0 s

	○	×	□	△
○		22.50	35.00	42.50
×	17.65		29.41	52.94
□	5.88	20.59		73.53
△	7.41	29.63	62.96	

In Table 4 vertical rows mean the figures that we presented and each lateral column means the error rates the subjects answered by misrecognizing the figure presented in the case of simultaneous sticking. It shows that all figures were recognized as the triangle by mistake most frequently, the square in the second, the cross in the third, and the circle in the least. This means all figures tend to be mistaken for the figure using fewer pins than the presented. It is known that the threshold of the human ability of the discrimination of two-point stimuli on the calf is 3-4 cm. As the distance among the pins on our devise is a little closer than the two-point threshold, the subjects might not be able to discriminate the adjoining stimuli of the pins and recognize two stimuli as one. We will discuss about this matter in the Considerations.

#### Case of Interval Time 0.1 s

**Table 5.** The rates of mistake of each figure when interval time is 0.1 s

	○	×	□	△
○		38.46	46.15	15.38
×	52.94		35.29	11.76
□	18.18	27.27		54.55
△	19.23	57.69	23.08	

Table 5 indicates that the tendency shown in the case of simultaneous sticking is disappeared and the subjects often mistook the cross for the circle and the square for the triangle in the case of interval time 0.1 s.

Case of Interval Time 0.25 s

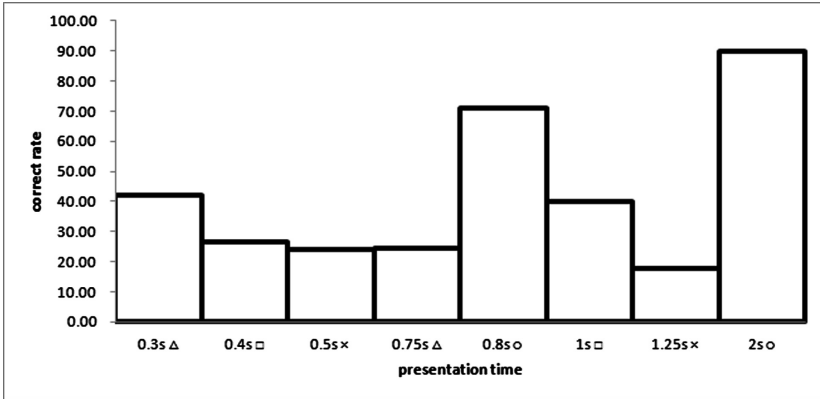
**Table 6.** The rates of mistakes of each figure when interval time is 0.25 s

	○	×	□	△
○		40.00	40.00	20.00
×	62.16		27.03	10.81
□	40.76	25.93		33.33
△	11.76	35.29	52.94	

Table 6 shows the results of case 0.25. This result is similar to the case of 0.1. The subjects often mistook the cross for the circle and the square for the triangle. This means the mechanisms of human tactile recognition are quite different between the simultaneous and the sequential drawings.

## 8 Considerations

First of all, we got quite different the results between the cases of the simultaneous sticking and successive sticking in recognizing the figures. While, in the case of simultaneous sticking, the subjects tended to mistake a figure for the figures which are drawn with fewer pins than the ones actually presented, this phenomena were disappeared in the case of the successive sticking. If our device is too small and the pin is arranged too close to each other beyond the two-point discrimination threshold, the same phenomena must be observed. This means that human has quite different mechanisms between the cases of the simultaneous sticking and the successive sticking in recognizing the figures. As, in the experiment III, the figures has the different number of sticking to draw and the subjects might judge the figures simply by counting the number of sticking. Actually some subjects said that they did so. To investigate this issue, we examine that the relationship between the correct rate and the time to draw one figure. The presentation time is calculated by multiply interval time and the number of pins (Fig. 4).



**Fig. 4.** The correct rate of each presentation time

If they count the number of sticking, longer interval time would be easier for them to count. However, Fig. 4 shows that both correct rates of the circle are high and the interval time doesn't affect the results. This means the subjects did not count the number of sticking and the total presentation time, but discriminated the characteristic of each figure.

## 9 Conclusion and Future Work

In this study, we examined the human abilities and characteristics of the tactile figure recognition. In the experiments, we found that each figure has each suitable duration time to draw. This means each figure has each appropriate interval time to make people recognize it and, to convey a figure by tactile, easy an appropriate interval time should be set up for each figure. Furthermore, we also found that human has quite different mechanisms between the cases of the simultaneous sticking and successive sticking in recognizing the figures. At this moment, however, we do not clarify the detail mechanisms about it. So, we should try to do it in the near future.

## References

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