Brain Enhancement Attempt Based on Visual Recognition

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Abstract

Cortical plasticity makes it possible to enhance the health and ability of the human brain through proper training task. In the present study, a visual interpolation task was proposed and two experiments were designed to evaluate it. In experiment 1, six subjects were asked to identify English letters, whose black pixels were partially erased to an erasure ratio by three kinds of erasure rectangle, displayed for short time periods. Its results shows the correct rate's descending trend with the increase of erasure ratio, the enlargement of erasure rectangle or the reduction of display time. In experiment 2, five subjects were asked to recognize the letters which were erased and displayed with the same parameters during three weeks, three times per week. The improvement in the correct rates approved the effectiveness of the task to brain enhancement.

Keywords: letter recognition, visual interpolation, cortical plasticity, brain enhancement.

1. Introduction

Brain, which interferes with nearly all the function of human body, is considered as the most complex and important part of the human body. It is desirable to develop and enhance the brain function so as to improve the human ability for life. Furthermore, it is reported that with the progress of aging, the incidence of brain disease such as senile dementia increase which reduces the quality of life in aged society [1]. Therefore, improvement of brain ability, maintenance of brain health and prevention of brain disease are becoming more and more necessary.

The human brain memorizes, reasons and concludes on the basis of the information from senses of vision, hearing, touch, smell and taste. Of all the senses, vision provides the most information which is about 83% [2]. In order to process and respond to visual information, most parts of the cerebral cortex such as visual cortex, parietal association area and frontal association area are engaged [3]. Therefore, it is possible to measure the brain's visual information process ability and check the health of brain parts associated with vision through proper visual stimuli. Moreover, it is also possible to activate the vision associated parts by presenting proper stimuli to the eyes in order to improve the health and ability of these parts. [4~7].

In this study, a method to enhance brain function through the human visual interpolation ability is proposed and validated. Visual interpolation ability is the ability that humans can recognize an object based on object parts. In order to study the human visual interpolation ability, an erased letter recognition task, in which an algorithm was designed to create incomplete letters, was presented. And on the basis of the task two experiments were designed to validate the effectiveness of the method.

2. Letter recognition task

A Hewlett-Packard Compaq nx9000 notebook computer was used for letter recognition task. LCD resolution was 1024 × 768 pixels, and color was 32 bits. Letters were extracted from the Microsoft Paint program installed in Windows 2000 environment. The font was MSP Gothic, and font size was 72. Letter color was black and the background was white. Letters were presented in the middle of 26 bitmap images of 128-pixels length and width. A program was developed to partially erase the letter images, display them, and record subjects' answers. The program interface and a representative letter image are shown in Fig.1.

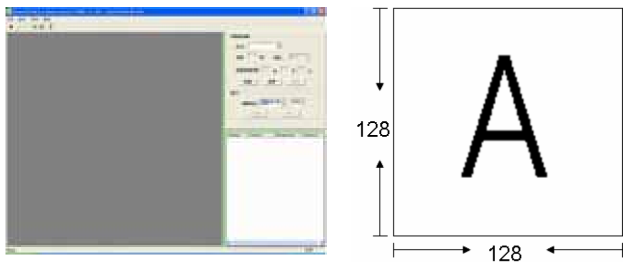


Fig.1 Program interface and letter image

The program used rectangles to partially erase the letters. Firstly, rectangle length, width, position over the letters, and gradient were randomly determined. Then black letter pixels covered by the rectangles were then erased. This procedure was continued until the ratio of the number of erased pixels to the number of the black pixels in the original image reached a predefined ratio.

2.1 Experiment 1

In experiment 1 erasure was categorized into three levels according to rectangle size: In the first level, the rectangle size was 1 pixel × 1 pixel. In the second level the rectangle length was 4 ~ 8 pixels and width was 2 ~ 4 pixels. In the third level the rectangle length was 8 ~ 16 pixels and width was 4 ~ 8 pixels. Taking R as example, these three levels of erasure are shown in Fig.2 in which L denotes the length, and W denotes the width of the rectangle. As can be observed, the higher the ratio, the more difficult the erased letter is to recognize. On the other hand, the bigger the rectangle, the wider the blocks of left black pixels are while the farther the remaining parts of the letter become.

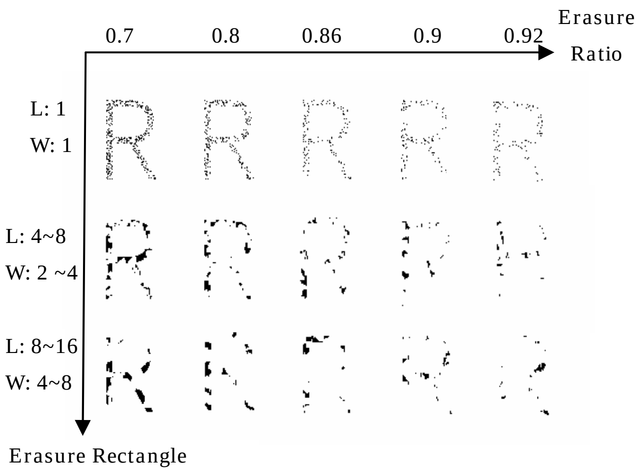


Fig.2 Erased letters in experiment 1 (R).

Six students at Kochi University of Technology served as volunteer subjects. Subject age was 20-30 years. Vision was normal or corrected to normal. In the experiment, firstly, a letter is chosen. Secondly, it was erased and displayed in the center of the screen for a short period. And then a dialog was presented for the subject to select an answer and next letter will be erased and displayed. If the subject was not sure whether the letter was correctly identified, he or she was instructed to skip to the next letter. Experiments were completed in 3 days, one erasure level per day. Five levels of erasure ratios (0.7, 0.8, 0.86, 0.9 or 0.92) were set at each erasure level, and the display duration was set to 300 ms, 200 ms and 100 ms at each erasure ratio. Thus the experiment was divided into 45 sections according to three parameters: rectangle size, erasure ratio and display duration. In each section, 26 letters were selected and recognized at a random order.

2.2 Experiment 2

In experiment 2, the rectangle length was set to 1 ~ 16 pixels and width was set to 1 ~ 8 pixels. Erasure ratios were the same to those of experiment. Display duration was set to 200ms. Erased letters used in experiment 2 was illustrated in Fig. 3. The procedure was the same to that of experiment 1.

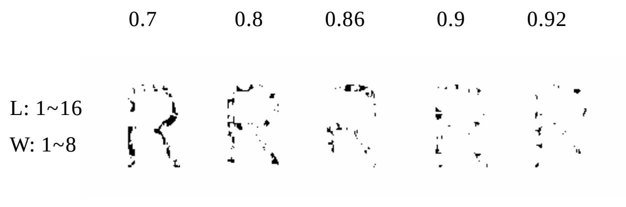


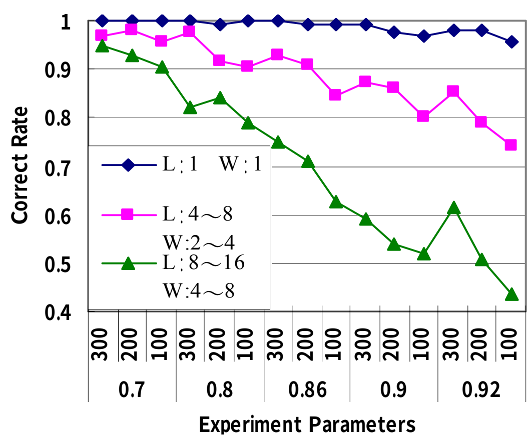
Fig.3 Erased letters in experiment 2 (R)

Five students at Kochi University of Technology served as volunteer subjects. Subject age was 20-30 years. Vision was normal or corrected to normal. Experiment 2 was finished in three weeks in order to examine changes of the subject's correct rates. In each week, the subjects can choose 3 days between Tuesday and Thursday optionally.

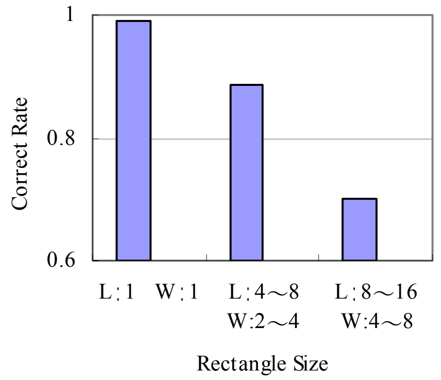
3. Results

3.1 Experiment 1

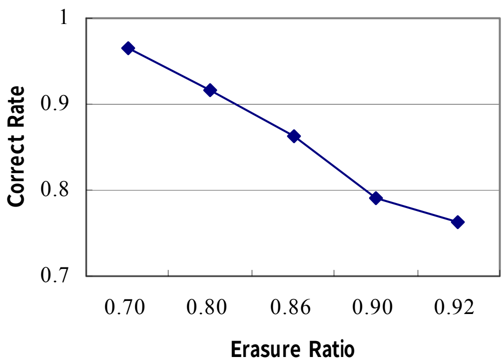
The results of Experiment 1 are shown in Fig.4. Six subjects' average correct rates of each section are plotted as a function of the experimental parameters in Fig.4a. And the average correct rates of different rectangle sizes, erasure ratios and display durations are plotted in Fig.4b, Fig.4c and Fig.4d respectively. In Fig.4b, the correct rate decreased with the increase of rectangle size. In Fig.4c the correct rate almost linearly decreased as the erasure ratio increased. The correct rate also decreased with the reducing of display duration as is shown in Fig.4d.



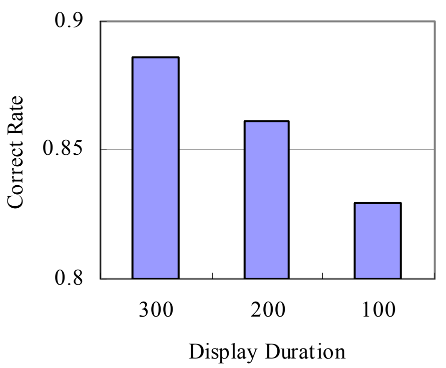
(a) Correct rates of different experiment



(b) Correct rates of different erasure levels



(c)Correct rates of different erasure ratios



(d)Correct rates of different display durations

Fig.4 Results of experiment 1

3.2 Experiment 2

Five subjects' average correct rates of each day in the 1st, 2nd, and 3rd weeks are listed in Table.1, Table.2, and Table.3 respectively. The total average correct rates of the 1st, 2nd, and 3rd weeks were 0.73, 0.79, 0.81 respectively. The increment of correct rate during each week gradually decreased. And that the ninth day's correct rate was lower than that of the eighth day. Compared with correct rate of the third day in the previous week, the correct rate of the first day in the current week decreased. The change in the correct rate shows that the correct rate increased during every week while it decreased after 3 or 4 days break.

Table.1 1st week

	0.7	0.8	0.86	0.9	0.92	Avg
1	0.83	0.75	0.67	0.57	0.53	0.67
2	0.87	0.87	0.73	0.67	0.55	0.74
3	0.94	0.85	0.79	0.68	0.67	0.79

Table.2 2nd week

	0.7	0.8	0.86	0.9	0.92	Avg
1	0.96	0.89	0.79	0.62	0.55	0.76
2	0.95	0.88	0.85	0.68	0.61	0.79
3	0.95	0.88	0.85	0.73	0.65	0.81

Table.3 3rd week

	0.7	0.8	0.86	0.9	0.92	Avg
1	0.91	0.88	0.78	0.75	0.61	0.78
2	0.97	0.89	0.85	0.78	0.7	0.83
3	0.97	0.9	0.85	0.68	0.62	0.80

4. Discussion

In the present study, the human visual interpolation ability and the training of the ability was studied through a visual interpolation task using erased letter.

Humans recognize and remember objects according to their features, which are usually correlated [8, 9]. When being erased, a letter's features are reduced as well as the correlations between the features. When recognizing an erased letter, the features of the image are sampled from the remnant black pixels and compared with the memorized features, and a decision is made based on similarity [10]. Therefore, as the erasure ratio increases, more features are erased (Fig.2), leading to a decrease in correct identification rate (Fig.4a, Fig.4c). On the other hand, when the rectangle size was 1 pixel × 1 pixel, the remnant black pixels symmetrically distributed in the erased letter images (Fig.2), it is easy for the human visual system to process the information, such as edge detection and shape recognition, so that nearly all the features can be sampled, which resulted in high correct rates close to 1. As the rectangle size increases, the distribution of remnant black pixels becomes asymmetrical in bigger blocks, which makes it difficult to sample the features from the remnant black pixels [11]. At the same time, features that can not be sampled also increases. So the correct rate decreased in the experiment (Fig.4a, Fig.4b). The bigger the rectangle, the farther the parts of the erased letter become, which reduced the correlations between the remaining features (Fig 2). And the smaller the rectangle, the more easily edge and shape detection can be accomplished, which may also contribute to the increase of correct identification rate [12]. It is suggested that although the visual category of the stimulus shortly after visual processing has begun (e.g., 75 - 80 ms), decision making does not complete until 150 ms after stimulus is presented [13]. It takes time to transmit and process visual information in the brain. Therefore, when the display duration was prolonged, the features that can be sampled during the duration increased and the correct rate also improved (Fig.4a, Fig.4d).

Cortical plasticity endows the brain with the ability to adapt to stimulus it receives. And it makes it possible to enhance the brain ability through proper training. The changes in brain activity that occur as humans learn new perceptual skill through perceptual learning has been reported by several studies [14]. In this study, enhancement of the subjects' recognition ability was indicated by increase of correct rate in experiment 2. The results also suggested that the training should be done successively n order to keep the correct rate at a high level because the average correct rate declined after 3 or 4 days break in the experiment.

5. Summary

In this study, a brain enhancement method through the human visual interpolation ability was proposed. We analyzed the human visual interpolation ability using an erased letter recognition task. The results showed that as features and correlations between features in letter images were destroyed by erasing and as the display duration was shortened, the correct rate decreased. And we examined the changes in correct rate during a three-week task. The results indicated the possibility to improve human cognition ability through the human visual interpolation ability.

It has been reported that perceptual skill learning has been associated with increased activity in the inferior temporal and fusiform gyri as skill is acquired and activity of the caudate nucleus during skill learning [14]. In future work, we plan to measure and image the hemoglobin levels dynamically in the brain during the visual interpolation task in order to find out the regions that engage in the human visual interpolation.

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