

Mechanism of visual information processing of geometric patterns

Mikiko Kumamoto, Tsutomu Shimono and Keiichi Mitani

Department of Behavioral Pediatric Dentistry,
Graduate School of Medicine and Dentistry, Okayama University
2-5-1 Shikata-cho, Okayama 700-8525, JAPAN

Abstract Brain activation is known to occur in the process of visual recognition, but the details of the mechanism are still unknown. In this study, we examined the behavioral and visual scanning patterns of rats to investigate the effectiveness of visual recognition of a triangle as visual stimulus in the Progressive Relaxation Method¹⁾. The results indicated no difference in the rats' residence time between an inverted and upright triangle when the figures were displayed. For the gazing pattern, the rats gazed more at the right side of the inverted triangle (angled upwards to the right) than at the left side (angled upwards to the left). The opposite result was seen for the upright triangle with the rat gazing more at the left than the right side. The cause for this difference in the gazing frequency is in the angulation of the side, angled upwards to the right or left, rather than the location of the side, situated on the left or right. Furthermore, the gazing time for an inverted triangle was longer than that for an upright triangle, clearly indicating the effect of location of the upper-right angled side on the frequency of gazing. These results suggest the possibility of a high level of ease and preference in rats for visual scanning of an inverted triangle and its right side.

Key words

Amenity,
Dental fear,
Intermittent stimulus,
Progressive Relaxation Method,
Visual environment,
Visual stimulus

Introduction

Studies related to dental fear, a universal problem in dental treatment, have been conducted mainly in the Western. Milgrom *et al.*²⁾ and Kleinknecht *et al.*³⁾ have reported that 76% and 75%, respectively, of the people in the United States have some type of dental fear. Additionally, Domoto and Weinstein have reported that approximately 80% of the surveyed subjects in Japan have dental fear⁴⁾. Many studies have concluded that this type of dental fear is the primary hindrance to patients' receiving dental treatments⁵⁾. An improvement in the amenities of the treatment rooms, for example placement of decorative plants or usage of fragrance, has been implemented as one method of relieving dental fear.

We examined the application of the Progressive Relaxation Method, which was developed by Edmund Jacobson and modified by Mitani *et al.*, to relieve patients of their dental fear, namely extreme mental strain. The characteristic of this method is the requirement for an intermittent stimulus in order to effectively transition from the state of mental and physical strain to that of relaxation. Eye movement and muscular tension in the hands have been shown to be effective stimuli. Hubel and Wiesel used macaque monkeys and chicks to clearly show that the striate body, the primary visual cortex, responded best to a line segment in a specific orientation⁶⁾. However, the most effective orientation differed by cells which are called "directionally-selective cells". They function in an innate way and degenerate with disuse⁷⁾. Hubel, Wiesel, and Stryker did not state whether or not the degree of inclination of a straight line could cause the difference in visual interest⁸⁾.

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Mitani *et al.* showed that rats directed more visual interest toward a horizontal line than a vertical line^{9,10}. In addition, Hebb stated that a line angled upward to the right excites one class of neurons in the cortex, and a line angled upward to the left or a horizontal line each excites a different class of neurons¹¹. From these findings and their own experiment using rats, Mitani and Xu indicated that the rats' visual interest in a triangle is innately and significantly stronger than interest in a circle. Kumamoto *et al.* demonstrated rats' preferences for an inverted triangle over an upright triangle and for a line angled upwards to the right over the left¹².

In this study, we displayed to rats figures of Kenneth Noland's painting "The 17th step", which satisfied the requirements of the results from previous studies¹², as a stimulus and examined rats' behaviors. We hoped that the results of this study will indicate a possible application of visual stimuli such as angled lines and triangles in patient's visual environment as intermittent stimuli in the Progressive Relaxation Method to relieve patients

of their dental fear.

Materials and Methods

We used 8-week old Wistar rats that had no learning experience of specific geometric pattern recognition. Their average weight was 249 g. The purchased rats were raised in a breeding box in a dark room at 21°C with 58% humidity. The rats were habituated to the experimental environment beginning three days prior to the start of the experiment.

The displayed figure was Kenneth Noland's 1964 painting "The 17th Step" (Figs. 1a to c). The base of the large inverted triangle was 18.7 cm and that of a small inverted triangle was 9.35 cm. The small inverted triangle was rotated 180° to give the small upright triangle. The large and small inverted triangles are similar triangles and the right side is slightly longer than the left side. Therefore, the apex angle of the inverted triangle is to the left of the perpendicular bisector of the base. Data analysis was performed using the chi-squared test.

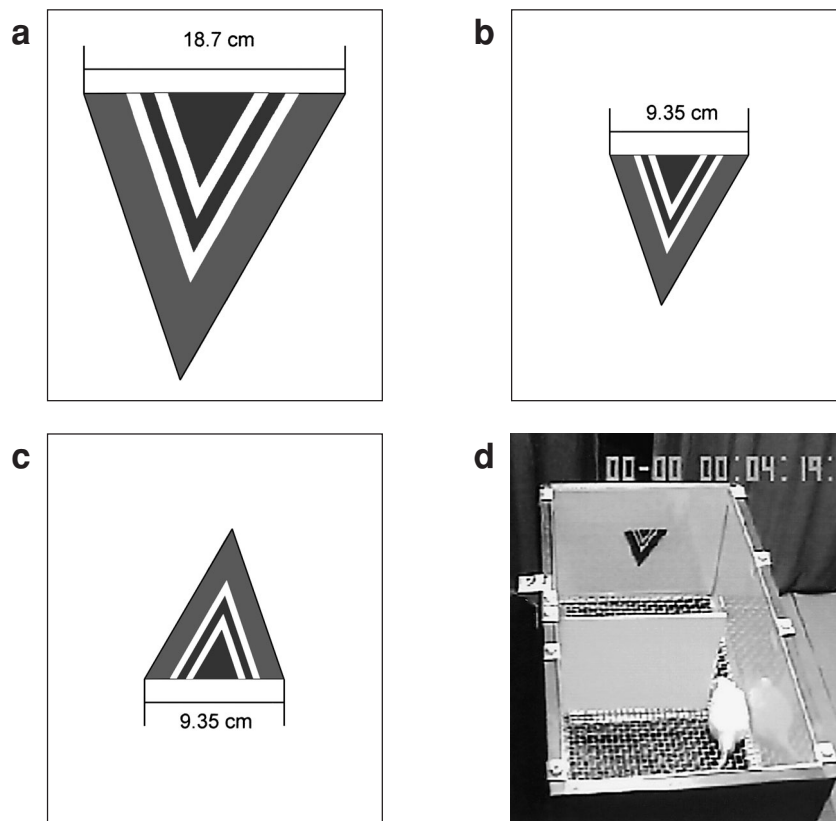


Fig. 1 Scheme of displayed triangles and breeding box

a: Large inverted triangle **b:** Small inverted triangle **c:** Small upright triangle **d:** photograph of breeding box

Experimental Methods

Visual scanning tests were given in a “visual-scanning test box” with an outer diameter of 70×40×40 cm. This box was divided into two spaces or rooms (A and B) by a wall (Fig. 1d) and had a 10 cm long connecting passageway to the right facing the figure-display room. The figure was displayed in one room and the rat was released for five minutes from the other room. The rat’s behavioral pattern was monitored using a video camera. An image was taken every 1/10 sec and framed in fours (30-30-40 msec) using a videotimer (Model VTG-33, For-A Co., Ltd., Japan). These images were used to analyze the effect of the inverted or upright triangle on rats’ residence time and gazing time.

Results

The effect of form of displayed triangle on residence time

To perform the behavioral analysis of rats’ preference

towards a specific triangle, we placed the rat in a breeding box and measured the residence time in room A where the triangle was displayed. As a result, we observed no effect of the displayed triangle form on the residence time: 116739.5 ± 14561.4 msec for the large inverted triangle, 116874 ± 14071.7 msec for the small inverted triangle, and 115410 ± 13562.3 msec for the small upright triangle (Fig. 2).

The effect of form of displayed triangle on visual scanning pattern

In order to investigate if there were any differences in the visual scanning pattern among the triangles, we examined the gazing frequency for each side of the triangles (right side, left side, and base) (Table 1). As indicated in Figure 3, we defined gazing as a rat turning its head toward the apex of the triangle near the wall where the figure is displayed or moving its head parallel to the sides of the triangle. When the large or small inverted triangle was displayed, the rats gazed at the right side only, 10 out of 10 times. On the other hand, for the upright triangle, out of 7

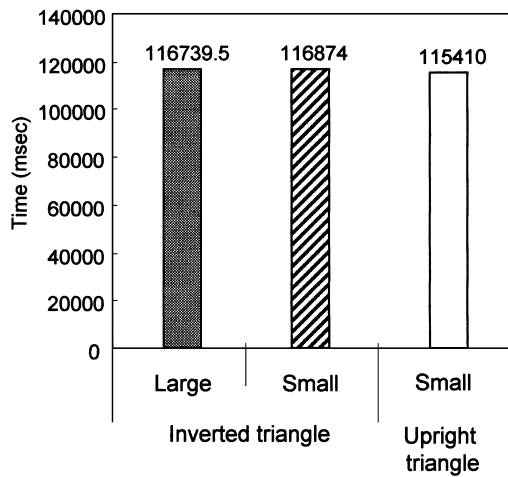


Fig. 2 Residence time in room where inverted or upright triangle was displayed

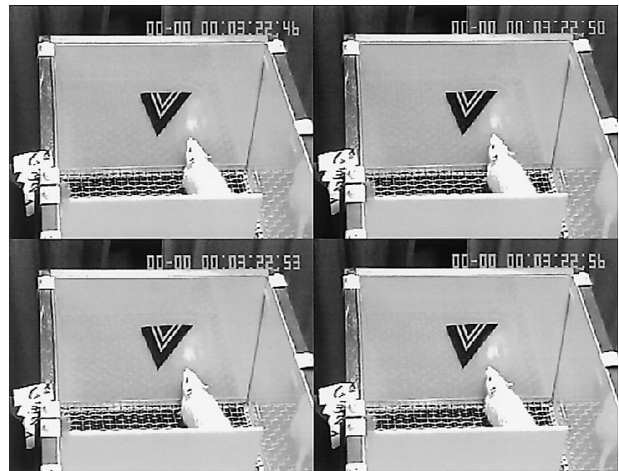


Fig. 3 Sequential photographs of triangle-gazing rats (40-30-30 msec)

Table 1 Gazing frequency for the sides of the triangles

Triangle type	Right side	Left side	Base	Total
Large inverted	10	0	0	10
Small inverted	8	2	0	10
Small upright	2	5	0	7

trials the rats gazed 2 times at the right side and 5 times at the left side. These results suggest that the gazing frequency of an angled line is not affected by the location (right or left) but the angulation (angled upwards to the right or left).

Rat gazing time during the experiment

The rats gazed longer at the large inverted triangle than the small inverted triangle with a gazing time of 3461.4 ± 1067.3 msec and 2942.9 ± 997.5 msec, respectively. However, there was no significant difference ($P < 0.1$) between them. The gazing time for the small upright triangle was 1075 ± 381.3 msec which was significantly shorter than that for either inverted triangles ($P < 0.01$) (Fig. 4).

Discussion

In our study, we have clearly showed that the rats visually scanned inverted triangles longer than an upright triangle during a given experimental period and gazed at the right side of the inverted triangle longer than the left side. These results suggest a strong possibility of rats' ease of visual scanning and preference for an inverted triangle and its right side. The rats simultaneously moved their bodies and line of sight, and they gazed at the right side of the inverted triangle while their bodies were to the left of the base angles of the triangle. The behavioral analyses of the mechanism of such actions are as follows. When gazing at the left side of the upright triangle, the rat needed to position its body farther to the left than the left end of the triangle base to

activate its neural-muscular pathway for the right field of vision. Similarly, for gazing at the right side of the triangle, the rat needed to position its body farther to the right than the right end of the triangle base to activate its neural-muscular pathway for the left field of vision. These behaviors require more work and time for and control of physical movements than for recognition of an inverted triangle. On the other hand, for gazing at an inverted triangle, the rat needed to position its point of vision slightly to the right of both left and right base angles for accurate perception. However, we frequently observed a rat sitting down at a certain site and scanning right and left sides of the triangle by vicarious trial and error (VTE). Additionally, if the rat stopped VTE, the rat could perform with ease its scanning which activated the neural-muscular pathway for the right field of vision for a relatively long period of time. An inverted triangle had a stronger visual stimulatory effect with more ease than an upright triangle based on the above innate mechanism of the neural-muscular pathway. For gazing at a central horizontal line, when the rat gazed at the base of the upright triangle, its line of sight was lower than the median. In this situation, the ocular muscles hardly showed any strain. However, when scanning the base of the inverted triangle, the rats needed to strongly contract the ocular muscles. Better results can be obtained by temporarily straining the muscles first to attain relaxation.

Many of the previous relaxation methods guided subjects to only relax their bodies and mind. Therefore, there are no stimulating objects in many hospital lobbies and lounges of elder care facilities and instead there are supposedly calming objects such as pleasant paintings. In this environment the mind and muscles of patients and seniors will continue to relax. Continual relaxation is not beneficial to one's health. According to unpublished data (Mitani *et al.*), rats showed circles became ill more easily and had shorter life than those showed triangle. We believe that a certain amount of intermittent and not continual stimulus is important in order to effectively attain good relaxation. Naturally, the stimulus level has to be low enough so as not to negatively affect one's health.

The dental clinic can improve the amenity by intermittently displaying to pre-treatment patients the painting of Kenneth Noland used in this study on a monitor in the waiting room or near the examination chair. This study suggests the possibility

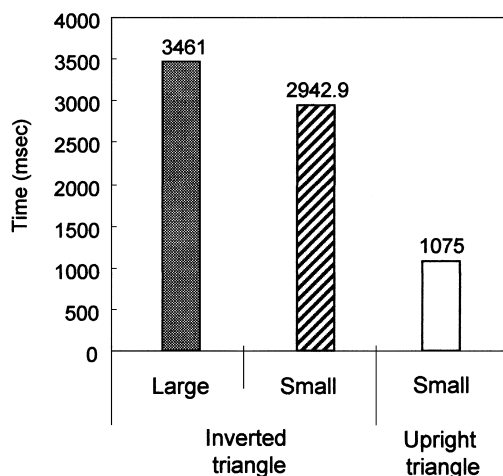


Fig. 4 Times of gazing inverted or upright triangle

of achieving effective relaxation by giving such temporary strain to patients.

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