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THE EFFECTS OF AN AREA OF AN OVERLAPPING REGION OF TWO TEXTURES AND THEIR COMPOUND OUTLINE ON TEXTURE LACINESS

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Three experiments were performed to examine how the spatial arrangement of two texture squares affected the occurrence of texture laciness, which is named by Watanabe and Cavanagh (1992). When two texture squares were presented with a part of them overlapping, one square is seen through the other in front of it for some arrangement. Varied were the area of the overlapping region of the squares and the compound outline produced by the squares. Ten undergraduates rated the stimuli generated on a color CRT display according to texture laciness. The experiments showed that the rating of laciness was higher where the compound outline of the squares was easily decomposed into two squares rather than where it was not. The area of the overlapping region did not produce any difference. The results indicate that texture laciness is affected by perceptual organization of the squares in the display.

Key words: visual perception, transparency, texture, laciness, outline

Texture adds a realitic impression to the visual perception of size, shape, colour, and position in space (Bergen, 1991). A new type of phenomenon related to texture was introduced by Watanabe and Cavanagh (1992). When two texture squares were presented with a part of them overlapping as shown in Fig. 1a, we see either of the two phases depending on the arrangement of the squares. In one phase, the overlapping region appears as a new region surrounded by two L-shaped regions as is shown in Fig. 1b. In the other phase, one square is seen through the other that is in front of it as is shown in Fig. 1c. Watanabe and Cavanagh (1992) called the latter of the phases "texture laciness."

Watanabe and Cavanagh (1996) examined experimentally what affected the ocurrence of texture laciness and they found that it abides by the following three rules: First, laciness occurs more strongly with the decreasing similarity between the elements of two textures; Second, the overlapping area tends to appear as a new texture when the elements of the two textures are the same; Third, the physical overlapping of the individual elements of the two textures hinders the texture decomposition, irrespective of the relative positioning.

Little has been known about texture laciness except some rules governing the occurrence of laciness which Watanabe and Cavanagh (1996) discovered. Watanabe and Cavanagh (1992, 1996) explored laciness from a rather microscopic viewpoint. The factors varying in their experiments were the thickness of the line elements of the textures

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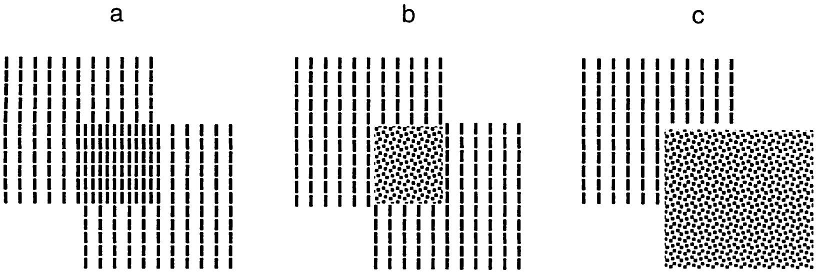

Fig. 1. Example of arrangement of two texture squares (a) and illustration used to teach subjects how to differentiate between the arrangement with a low rating for texture laciness (b) and that with a high rating (c).

and the way the line elements align and cross each other. A question arises from their experiment as to whether the laciness is affected by a more global factor of perceptual organization between the squares.

In the present study, we explore a new factor affecting the occurrence of the texture laciness from a viewpoint of perceptual organization. We examined the effect of the area of the two squares' overlapping region on laciness in Experiment 1, that of the compound outline produced by the squares in Experiment 2, and finally the effects of both the area of the overlapped region and the compound outline in Experiment 3. The index was the ratings of laciness which the subjects gave toward the stimuli.

EXPERIMENT 1

The present experiment examined whether the area of the overlapping region of the two squares with an equal texture affected texture laciness, where the squares were aligned on a diagonal.

Method

Subjects: The subjects were four male and four female undergraduates from Kumamoto University. All had normal or corrected-to-normal vision and were naive as to the experiment.

Stimulus display: Stimuli were produced on a Sony 17" color CRT display (CPD-G200J, 1280 pixel×960 pixel) controlled by an Apple computer (M6670J/A). Fig. 2 shows the stimulus display used in the experiment. The display consisted of a pair of squares with 4.6° of visual angle on each side with an equal texture against a white background. The texture consisted of vertical lines with 1.2' of visual angle in width and 16' in length. The luminances of each line and the background were about 2 cd/m^2 and 116 cd/m^2, respectively. The area of overlapping region of the squares was varied as follows: 2% of a square in A; 11% in B; 30% in C; 53% in D; and 77% in E. The two squares were aligned on a diagonal for all conditions.

Procedure: The subject sat at a table with his/her head located on a chin-rest and observed binocularly the stimulus display of about 57 cm distant from him/her. The subject was given a 3-minute adaptation to darkness. During that time, they were given an instruction on how to rate the stimuli.

They were then given practice and test tasks. In the practice task, the subjects observed each of the stimuli for the five conditions to obtain the criteria for rating laciness. In the test task, the subjects rated the stimulus from each condition vocally according to the appearence of laciness by a digit between 0 and 10. The subjects were asked to give a rating "0" when the central overlapping region appears to be a new texture

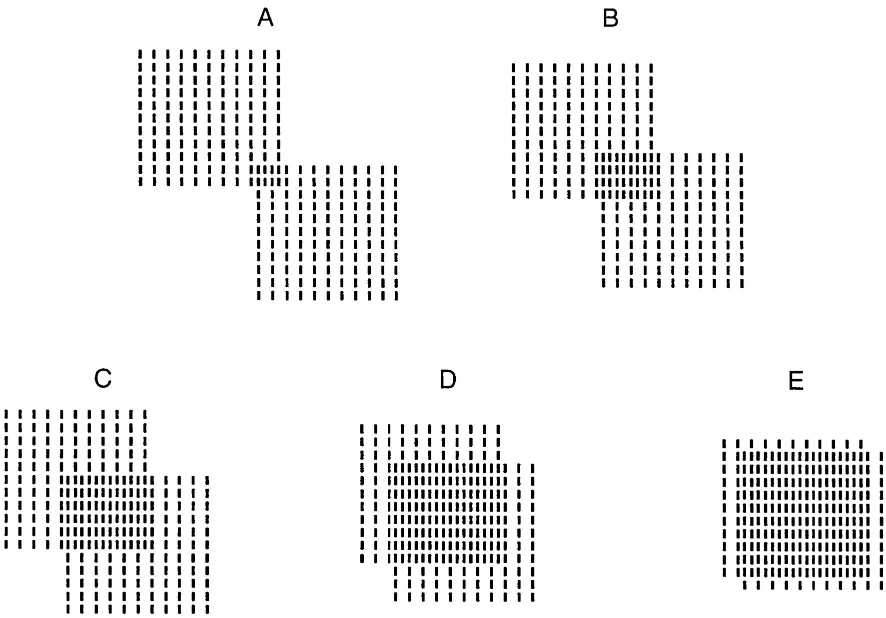

Fig. 2. Illustration of stimulus displays used in Experiment 1.

different from the two L-shaped textures surrounding it as in Fig. 1b. They were asked to give a rating "10" when both surrounding textures appear to continue into the central square as in Fig. 1c.

The test task was performed in ten blocks. Each block consisted of five test trials with a trial for each condition in random order. A three-minute rest was given every five blocks. The order effect was counterbalanced across the blocks and subjects. The subject was tested individually in a darkened room.

Results

The Mean ratings of laciness were used as data after being averaged for each subject through ten test trials in each condition. Fig. 3 shows the mean ratings averaged for eight subjects in each condition. As seen in Fig. 3, the ratings decreased with the increasing area of the overlapping region of the squares, the highest in the A condition and the lowest in the E condition.

The data was analyzed by using a one-way ANOVA. The main effect of the area of the overlapping region was significant ($F(4, 28)=62.34$, $p<.01$). The lower test was performed on the data by using a Fisher's least significant difference test. A significant difference was obtained between each pair of the five conditions except for a pair of the C and the D (LSD=1.449, $p<.01$).

Discussion

The result showed that texture laciness occurred strongly by decreasing the area of the overlapping region. However, the result can be explained not only by the area, but also by the compound outline produced by the squares. According to Gestalt law, grouping can be determined by the factor of good continuation (Koffka, 1935). For

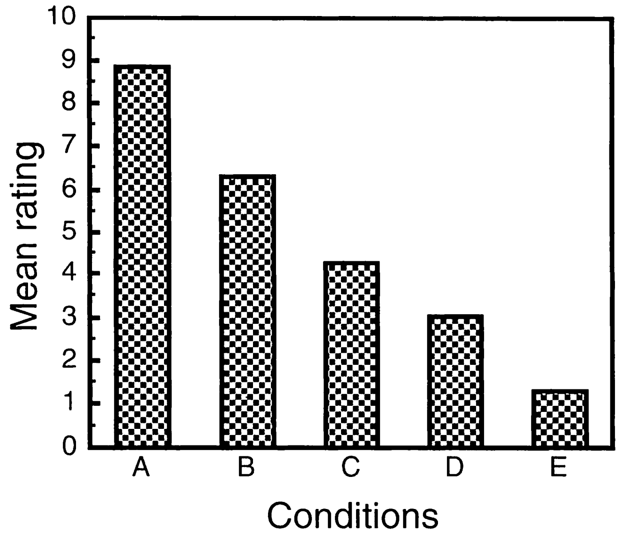

Fig. 3. Mean rating for texture laciness in each condition of the area of the overlapping region of two texture squares (Experiment 1).

example, some elements, which constitute a good continuation together with other elements, make a group together. The factor of good continuation applys to Experiment 1 in the following way. In condition A, since the compound outline was discontinuous, the squares grouped into two parts and were easy to be decomposed into two squares, resulting in a high rating of texture laciness for the condition. In the E condition, since the compound outline of the squares was nearly continuous, the two squares grouped into one figure and were difficult to be decomposed into two squares, resulting in a low rating for the condition. We, therefore, have to determine whether the compound outline affects laciness in Experiment 2.

EXPERIMENT 2

The present experiment was performed to determine whether the compound outline produced by two texture squares affected texture laciness, where the area of overlapping region of the squares was almost constant.

Method

Subjects: The subjects were the same eight subjects who had participated in the first experiment.

Stimulus display: Stimuli were produced on a color CRT display in the same way as in the first experiment. Fig. 4 shows the stimulus display used in the experiment. The display consisted of a pair of the same squares as used in Experiment 1. The following seven conditions were prepared by varying the arrangement of the squares against a white background: The A and G conditions were prepared as stimuli in which the compound outline produced by the squares will not be decomposed easily into two squares. The B, C, D, E, and F conditions were prepared as stimuli in which the compound outline will be decomposed easily into two squares. The horizontal and vertical sizes of the overlapping region of the squares were as follows in

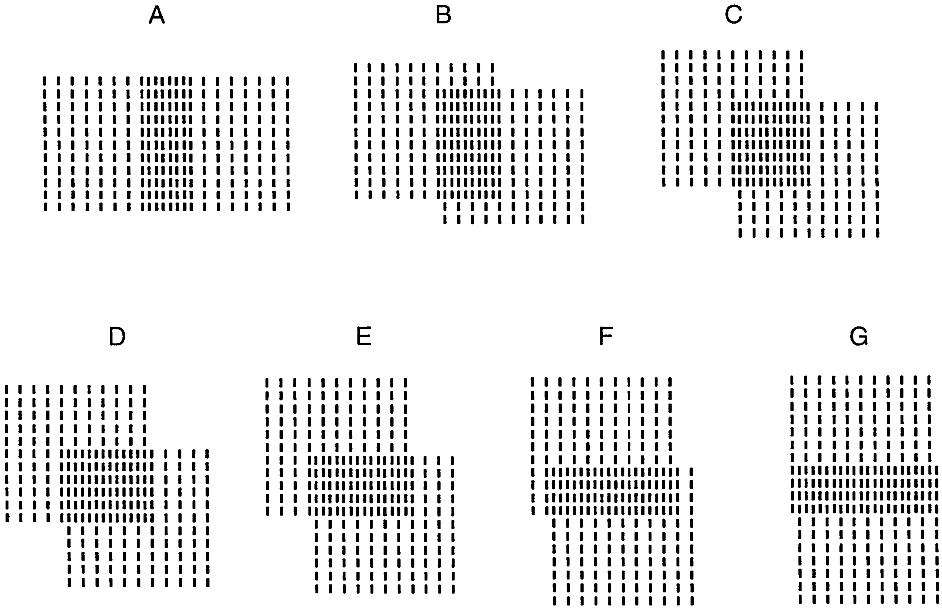

Fig. 4. Illustration of stimulus displays used in Experiment 2.

the visual angles of: 1.36°×4.6° in A, 1.67°×3.75° in B, 2.16°×2.9° in C, 2.5°×2.5° in D, 3.04°×2.05° in E, 3.85°×1.62° in F, and 4.25°×1.47° in G. The area of the overlapping region of the squares was kept at almost 30% of the square.

Procedure: The subjects were given a practice task for obtaining the criteria for rating texture laciness, and then a test task in ten blocks. Each block consisted of seven test trials with a trial for each condition in random order. The subjects rated the stimulus for each of the seven conditions according to the laciness. The procedure was the same as in the first experiment except for the changes above.

Results

The mean ratings of the laciness were used as data after being averaged for each subject through the ten test trials in each condition. Fig. 5 shows the mean ratings averaged for eight subjects in each condition. As is seen in Fig. 5, the ratings were lower in the A and G conditions than those in the B, C, D, E, and F conditions.

The data was analyzed by using a one-way ANOVA. The main effect of the arrangement was significant ($F(6, 42)=12.25, p<.01$). The lower test was performed on the data by using a Fisher's least significant difference test. A significant difference was obtained between each pair of the A condition and each of the B, C, D, E, and F conditions, and between each pair of the G condition and each of the B, C, D, E, and F conditions (LSD=1.618, $p<.01$), respectively.

Discussion

The ratings were larger in the B, C, D, E, and F conditions where the compound outline was easily decomposed into two squares, rather than in the A and G condition where the outline was not. The result showed that the compound outline produced by the

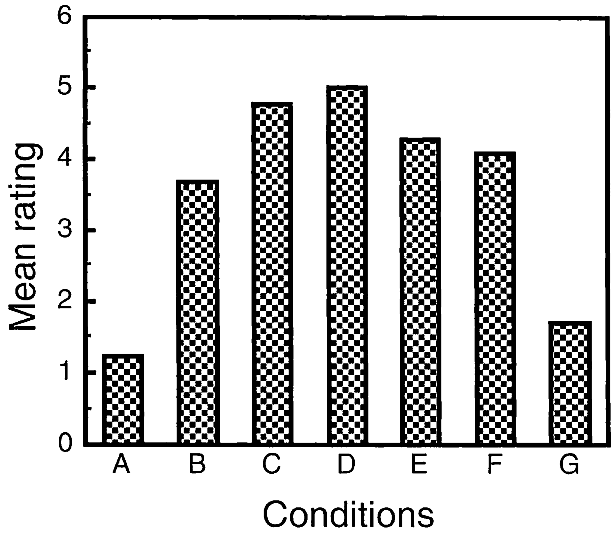

Fig. 5. Mean rating for texture laciness in each condition of the arrangement of two squares of texture (Experiment 2).

texture squares affected texture laciness. However, the result does not explain completely that obtained in Experiment 1. There is still a possibility remaining that the area may have affected laciness together with the outline in Experiment 1. To examine this posibility, we have to examine whether the area of the overlapping region of the squares affects texture laciness, keeping the effect of the outline as small as possible in Experiment 3.

EXPERIMENT 3

The present experiment was performed to determine whether the area of the overlapping region of the two squares affected texture laciness, where the effect of the compound outline produced by the squares was kept as small as possible.

Method

Subjects: The subjects were the same six subjects who had participated in the former experiments plus two additional subjects who were undergraduates from Kumamoto University. All had normal or corrected-to-normal vision and were acquainted with the type of the experiment.

Stimulus display: Stimuli were produced on a color CRT display in the same way as in the former experiments. Fig. 6 shows the stimulus display used in the experiment. The display consisted of a pair of the same squares as used in Experiment 1. The following four conditions were prepared by varying the arrangement of the squares against a white background. The A, B, and C conditions were produced by varying the area of the overlapping region of the squares, 10% of the square in A, 30% in B, and 80% in C, respectively. The three conditions were prepared to examine the effect of the area of the overlapping region, keeping the effect of the compound outline almost the same. The D condition was prepared so that the compound outline would be decomposed more easily into two squares than the other three conditions. In the D condition, the area of overlapping region was the same as the B condition.

Procedure: The subjects were given a practice task for obtaining the criteria for rating texture laciness,

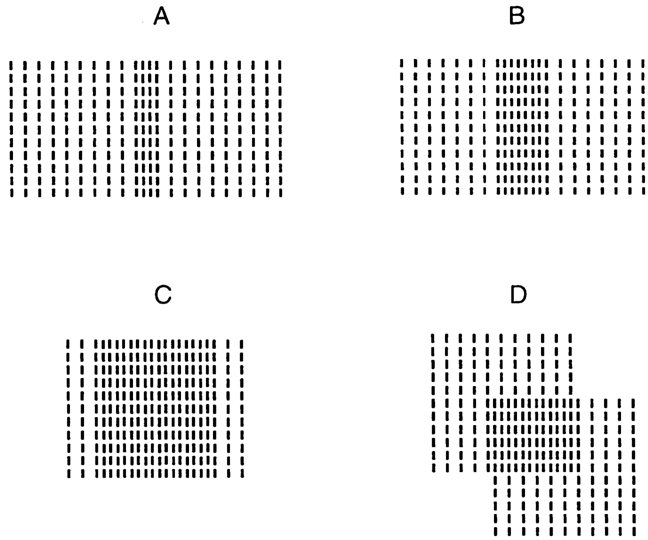

Fig. 6. Illustration of stimulus displays used in Experiment 3.

and then a test task in ten blocks. Each block consisted of four test trials with a trial for each condition in random order. The subjects rated the test stimulus for each of four conditions according to texture laciness. The procedure was the same as in the first experiment except for the changes above.

Results

The Mean ratings of the laciness were used as data after being averaged for each subject through ten test trials in each condition. Fig. 7 shows the mean ratings averaged for eight subjects in each condition. As is seen in Fig. 7, the rating was higher in the D condition than those in the A, B, and C conditions. There was little difference in the rating among the A, B, and C conditions.

The data was analyzed by using a one-way ANOVA. The main effect of the arrangement was significant ($F(3, 21)=14.04$, $p<.01$). The lower test was performed on the data by using a Fisher's least significant difference test. A significant difference was obtained between each pair of the D condition and each of the A, B, and C conditions (LSD=2.237, $p<.01$). There was no significant differece between each pair of conditions from the A, B, and C.

Discussion

The ratings were almost the same among the A, B, and C conditions, although we set the difference in the area of the overlapping region between the largest and the smallest a little larger than in Experiment 1; The largest and the smallest areas were 10% and 80% in Experiment 3, while 11% and 77% in Experiment 1. The result showed that the area of the overlapping region did not affect texture laciness when the effect of the compound outline produced by the squares was kept constant. The rating for the D condition was higher than that for the B condition even though both conditions were kept equal in the

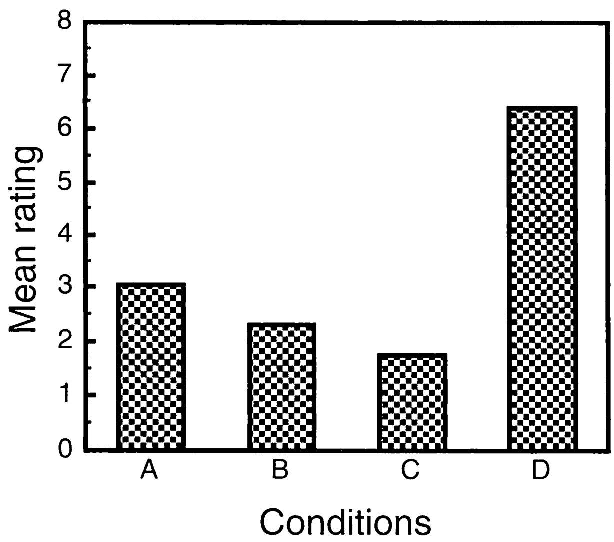

Fig. 7. Mean rating for texture laciness in each condition of the arrangement of two squares of texture (Experiment 3).

area of the region. The results showed that all the effects obtained in Experiment 1 were due to the compound outline produced by the squares.

The results of our study added a new factor which affected texture laciness. The compound outline produced by two texture squares affected texture laciness. Lack of continuation in the outline produced by the squares helped them to be decomposed into two squares, resulting in strong texture laciness. On the contrary, good continuation hindered the squares to be decomposed into two squares, resulting in weak texture laciness. The factor is supported by good continuation based on Gestalt law, and therefore depends on the perceptual organization of all the elements which constitute the stimuli. Watanabe and Cavanagh (1996) showed that the occurrence of texture laciness increased with the decreasing similarity in width of the line elements of the squares between the squares. In their study, both dissimilarity between the squares helped the squares to be decomposed into two squares, resulting in strong texture laciness. The results also indicate that texture laciness was supported by similarity based on Gestalt law. From the results, we conclude that texture laciness occurs when the squares are decomposed into two squares by the help of perceptual organization.

Texture laciness is a type of phenomenon related to pattern perception. Pattern perception has been studied traditionally from two contrasting appproaches: the structuralist and the Gestalt (Sekuler & Blake, 1994). The structuralist approach attenuates the importance of elements over the whole they construct for pattern perception. On the contrary, the Gestalt approach attenuates the whole over the elements since the whole is not a simple aggregate of the elements. Both approaches are inherited to recent approach on pattern perception, namely, the information processing approach that regards a human as a type of information processing system. Treisman and Gelade

(1980) proposed the feature integration theory in which visual stimuli are processed in two steps: parallel and serial. Visual world is first analyzed for features like color, line curvature, and length, in parrarel globally, and next scrutinized for a particular local part serially in more details based on the results of the prior processing. Leeuwenberg and Buffart (1978) developed a new approach to understand figural goodness, the central concept of the Gestalt approach, by using terms from information processing: code and information load. Code is a concept to describe a simplified percept of a shape, while information load is a measure to determine one from possible percepts for the shape. The approach may be useful to explain figural goodness more simply than the Gestalt approach. Both information processing approaches provide us with a framework for understanding texture laciness as well as a useful method to explore the laciness.

Texture laciness is a phenomenon related to texture. Watanabe and Cavanagh (1996), therefore, started their experiments referring to researches on texture by Beck (1966) and by Julesz (1975) who studied experimentally what feature determines texture segregation. Texture laciness is also related to transparency since both phenomena are similar in that one of the figures appears in front of it through the other when they are presented adjacent to each other. A knowledge has been accumulated on pattern perception like texture and transparency. The knowledge will be useful to study texture laciness together with the framework of research that a new approach proposed for pattern perception. We have just begun to study texture laciness and, thus, we have too few experimental data with us to understand the phenomenon. We need more experimental studies to explain how texture laciness occurs in more detail on the basis of the knowledge related to texture laciness.

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