【論文】

TEXTURE LACINESS IS AFFECTED BY LOCATION AND DIRECTION OF TEXTURES

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ABSTRACT

We performed two experiments to examine how the spatial arrangement of two texture triangles, large and small, affects texture laciness. The texture of the triangles consisted of either horizontal or vertical lines. With the smaller triangle included in the interior of the larger, the percept of two pseudo-transparent triangles in different depth planes occurs for some arrangements. Twelve undergraduates rated the stimuli generated on a color CRT display according to texture laciness. The first experiment showed that the location of the small triangle inside the large one affected the laciness. The second experiment showed that the effect of the triangle location varied depending on the texture direction of the triangles. The results demonstrated a strong coupled effect of location and direction of texture on perceived laciness, which indicates that the laciness is determined by perceptual organization of the textures in the display.

Key words : visual perception, transparency, texture, laciness, texture direction, spatial arrangement

Texture is an important factor to produce a realistic impression of the visual perception such as size, shape, colour, and position in space (Bergen, 1991). Watanabe and Cavanagh (1992) introduced “texture laciness,” to denote a transparency related in perception: When two textures overlap, we sometimes see one texture through the other in front of it instead of seeing a new texture region surrounded by the two other regions. Texture laciness points to a kind of pattern recognition related to transparency and texture, after Beck (1966) and Julesz (1975). However, laciness is still a relatively unexplored phenomenon. Watanabe and Cavanagh (1996) found three rules to experimentally determine laciness: First, laciness is stronger for more dissimilar 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 overlap between individual elements of the two textures hinders the texture decomposition, irrespective of the relative positioning. The rules were drawn from a viewpoint of the local difference between the stimuli.

Watanabe and Nakazato (2003) introduced a new viewpoint of gestalt, namely, the global form produced by the stimuli. They examined how spatial arrangement affected texture laciness from a gestalt viewpoint, namely, perceptual organization. Watanabe and Nakazato (2003) demonstrated that the compound outline produced by two texture squares affected laciness. They proposed that laciness occurs when the squares are perceptually organized into two squares.

In the present study, we explore the effect of the spatial arrangement on laciness in more detail. Stimuli in prior laciness studies always consisted of two partially overlapping texture squares of equal size (Watanabe and Cavanagh, 1992, 1996; Watanabe and Nakazato, 2003). In the real world, however, we experience texture laciness not only where two textures partially overlap, but also where one of the textures is included within the other, irrespective of texture shape. We, thus, prepared stimuli consisting of two texture triangles of equal texture, where the smaller triangle was always embedded within the larger one. We examined the effect of the location of the small texture inside the large one in Experiment 1, and the coupled effect of location and direction of texture in Experiment 2.

EXPERIMENT 1

We examined the effect of location of two texture triangles on perceived laciness. Triangles used were different in size, and the small triangle was included within the large one.

Method

Participants: Five male and seven female undergraduates from Kumamoto University participated. All had normal or corrected-to-normal vision. One of the participants experienced the experiment of laciness before, while the rest were new to the experiment.

Stimulus display: Stimuli were produced on a Nanao 19” color CRT display (T765, 1280 pixel × 960 pixel) controlled by an Apple computer (7627J/A). Fig. 1 shows the stimulus display used in the experiment. The display consisted of a pair of isosceles triangles different in size but equal in texture and shape with a vertex

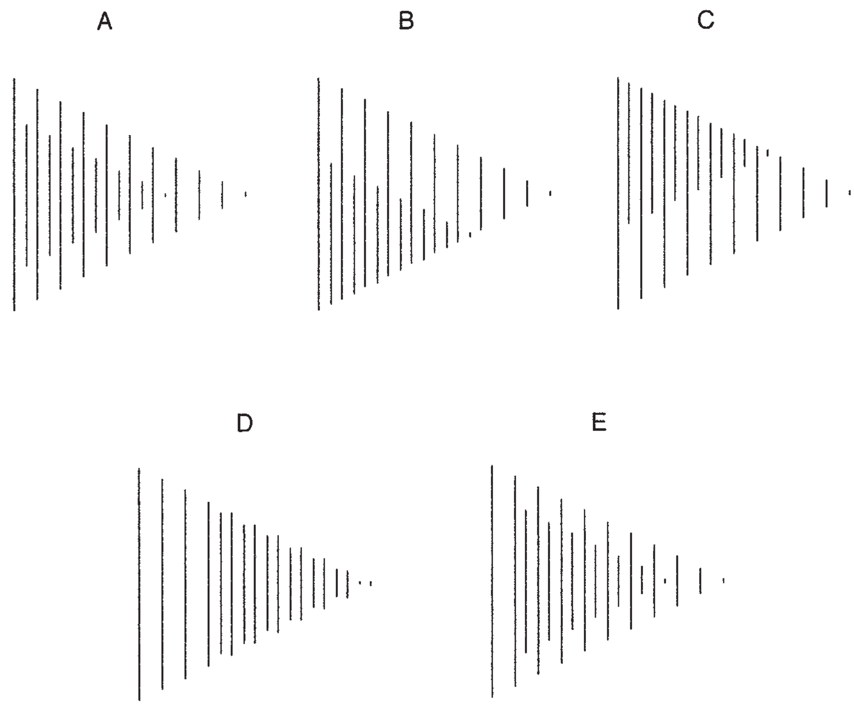

Fig.1 Illustration of stimulus displays used in Experiment 1.

angle of 50° against a white background. The small triangle was about 53% of the large one in area. The side was 2.7°, 3.1° and 3.1° in visual angle for the small triangle, while 3.7°, 4.2° and 4.2° for the large triangle. The texture consisted of vertical lines with a width of 1.5 ′of visual angle and 16′ between the lines. The triangles were located so that individual lines of one triangle did not overlap with those of the other triangle and maintained an equal distance between the lines of the other triangle. The luminances of lines and the background were 0.3cd/m^2 and 156cd/m^2, respectively.

Controlling the number of the sides close to each other in the small and large triangles, we varied the location of triangles as follows: The small triangle was adjacent to one side of the large triangle in condition A, while adjacent to two sides of the large triangle in conditions B, C, and D. The small triangle was centered on the large one in condition E.

It was found that texture laciness occurs when two texture figures easily decompose into two figures (Watanabe and Cavanagh, 1996; Watanabe and Nakazato, 2003). According to Gestalt law, elements close to each other group together (Koffka, 1935). Proximity of sides between the triangles will thus hinder their decomposition into separate triangles, resulting in decreased laciness. We predict that the rating of laciness will decrease with increasing the number of sides close to each other between the triangles.

Procedure: Participants sat at a table with their heads secured on a chin-rest and observed binocularly the stimulus display at a viewing distance of 57 cm. The participant was given three minutes to adapt to darkness. During the time, they were instructed on how to rate stimuli.

They were allowed to practice and given test tasks. In the practice task, participants observed each stimulus for the five conditions to obtain the criteria for rating the laciness. In the test task, participants rated the stimulus from each condition vocally according to the appearance of the laciness by a digit between 0 and 10. The participants gave a rating “0” when both triangles appeared on the same plane. They gave a rating “10,” when the triangles appeared on different planes, that is, if one of the triangles appeared to be pseudo-transparent and located in front of the other triangle.

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

Results

Mean ratings of laciness were used as data after being averaged for each participant through ten test trials in each condition. Fig. 2 shows the mean ratings averaged for twelve participants in each condition. As seen in Fig. 2, the rating for D was lower than each of the A, B, C, and E condition, while there was not a clear difference among A, B, C, and E.

The data was analyzed by using a one-way *ANOVA*.

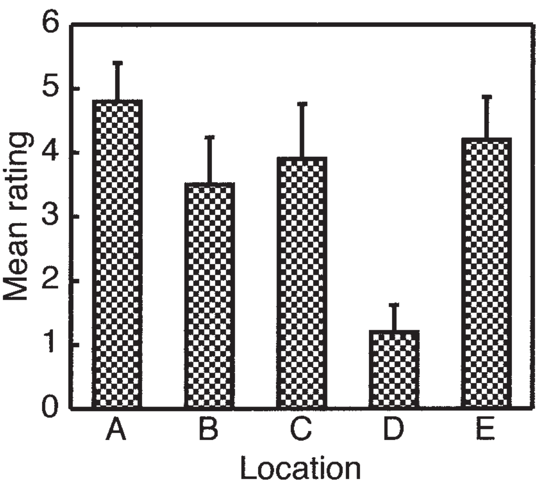

Fig.2 Mean rating for texture laciness in each condition of the location of two texture triangles (Experiment 1).

The main effect of the location was significant (F (4, 44) = 10.25, $p < .01$). The post-hoc test was performed on the data by using a Fisher's least significant difference test. A significant difference was obtained between D and each of the A, B, C, and E conditions, while there was no significant difference between each pair from the A, B, C, and E conditions (LSD = 1.676, $p < .01$).

Discussion

First, we showed that texture laciness occurred with triangles as with squares and even when one of two texture figures was included in the other. The result indicates that laciness is a common visual phenomenon observed in a variety of situations in the real world.

Second, we showed that the occurrence of laciness is affected by the small triangle location in the large triangle. Counter to our prediction, laciness was not affected simply by the degree of adjacency of the small and large triangles, namely the number of close sides between the triangles. The only clear finding obtained was that the rating was lower for the D condition than any other condition. The difference between D and the other four conditions becomes apparent upon scrutiny of Fig 1. We notice that the side (outline) of the small triangle, namely the boundary between the small and large triangles, is physical within the large triangle for the D condition, while one or more of the sides are illusory for the other conditions. Such a difference in perceptual organization among the conditions might have been produced not only by the location of the triangles we controlled, but also the direction of texture, which we did not expect beforehand. We will examine the effect of the location on laciness together with the direction of texture in Experiment 2.

EXPERIMENT 2

We examined how location of the small texture triangle inside the large one affect perceived texture laciness together with texture direction.

Method

Participants: The participants were the same twelve participants 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. 3 shows the stimulus display used in the experiment. The display consisted of a pair of isosceles triangles different in size but equal in texture and shape with a right angle against a white background. The small triangle was about 30% of the large one in area. The side was 2°, 2° and 3° in visual angle for the small triangle, while 3.7°, 3.7°, and 5.5° for the large triangle. The triangles were located so that individual lines of one triangle kept an equal distance between those of the other triangle without overlapping with those of the other triangle.

We introduced two variables. The first variable was the texture direction: horizontal or vertical. The direction of the texture line was horizontal or vertical depending on the condition. The texture consisted of lines with the same width and the same distance between the lines as in Experiment 1. The second variable was the location of the small texture triangle on the baseline of the large one inside it: A, B, C, D, and E. The small triangle fitted in the left angle inside the large triangle for condition A, while fitting into the right angle in condition E. In both conditions A and E, the small triangle was adjacent to two sides of the large triangle, similar to conditions B, C, and D of Experiment 1. The small triangle was located at the center on the baseline of the large one in condition C. The arrangement of condition A of Experiment 1 was thus emulated here. In condition B, the small

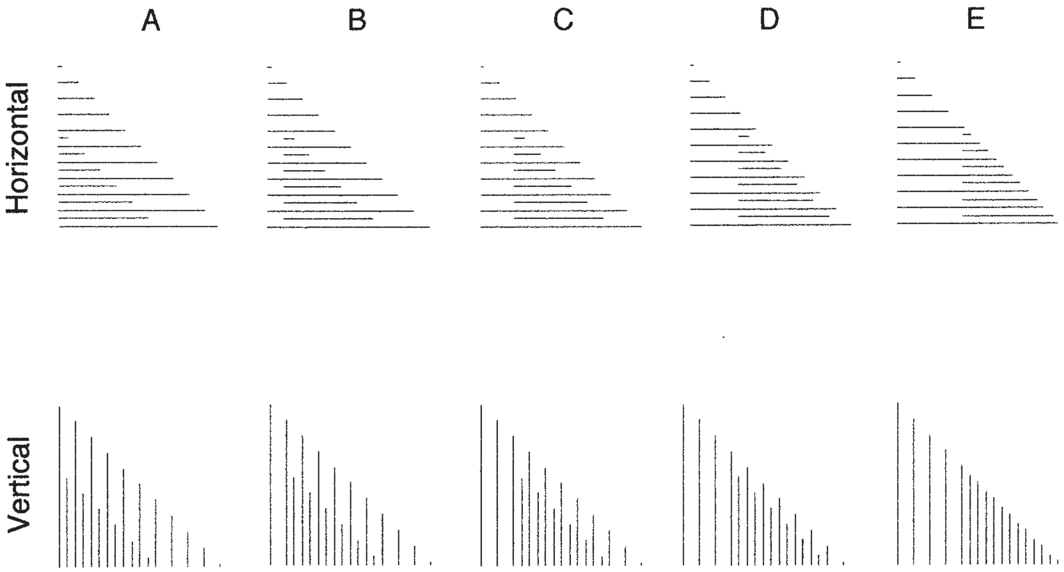

Fig.3 Illustration of stimulus displays used in Experiment 2. Rows: the texture direction of two triangles, Horizontal and Vertical. Columns: the location of the triangles, A, B, C, D, and E.

triangle was located at a location intermediate to conditions A and C, while in condition D, it was intermediate to conditions C and E.

Procedure: The participants were given a practice task for obtaining the criteria for rating the laciness, and then a test task in ten blocks. Each block consisted of ten test trials with a trial for each condition. The participants rated the stimulus for each of the ten 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 participant through the ten test trials in each condition. Fig.4 shows the mean ratings averaged for the twelve participants in each condition. As is seen in Fig. 4, the effect of the location depends on texture direction. For the horizontal direction, the ratings were lower for A and E condition than for B, C, and D condition. There was a clear difference neither among B, C, and D, nor between A and E. For the vertical direction, the rating was lower in condition E than any other condition, while there was little difference among A, B, C, and D condition.

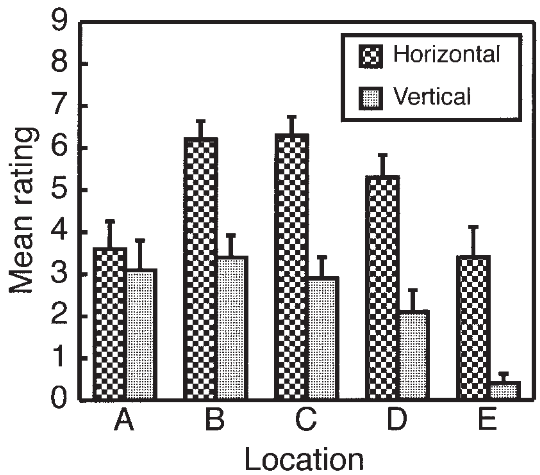

Fig.4 Mean rating for texture laciness in each condition of the location of two texture triangles: A, B, C, D, and E; Parameter is the texture direction: Horizontal and Vertical (Experiment 2).

The data was analyzed by using a 2 (texture direction) × 5 (location) *ANOVA*. Significant main effects of texture direction and location were obtained (*F* (1,

11) = 50.00, $p < .01$; F (4, 44) = 22.72, $p < .01$) as well as a significant interaction effect of texture direction with location (F (4, 44) = 7.56, $p < .01$). The post-hoc test was performed on the data by using a one-way *ANOVA* and a Fisher's least significant difference test for each condition of the texture direction to examine an interaction effect in more details. For the horizontal condition, the main effect of the location was significant (F (4, 44) = 23.99, $p < .01$). A significant difference was obtained when A was paired with each of B, C, or D, and also when E was paired with each of B, C, or D (*LSD* = 1.066, $p < .01$). There was a significant difference neither within B, C, and D, nor between A and E. For the vertical condition, the main effect of the location was significant (F (4, 44) = 10.99, $p < .01$). A significant difference was obtained when E was paired with each of A, B, C or D, while there was no significant difference within A, B, C, and D (*LSD* = 1.370, $p < .01$).

Discussion

We reproduced the effect of texture location on texture laciness and showed that the effect varied greatly depending on texture direction.

For the horizontal condition, we obtained similar results to those in Experiment 1. The rating was lower in A and E with two adjacent sides, than in B, C, and D with only a single adjacent side. Starting Experiment 1, we predicted that the rating of laciness will decrease with the increasing number of adjacent sides. The results were compatible with the prediction.

For the vertical condition, the rating was lower for condition E than any other condition, while there was no difference among the four conditions. We again notice here that the outline of the small triangle for E was physical within the large triangle, while one of the outline was illusory for A, B, C, and D. The spatial organization of E in Experiment 2 was almost the same as D in Experiment 1, in that the outline of the small triangle was physical within the large triangle. In addition, the small triangle fits in the large one since the two sides of the small triangle are close to those of the large one.

Based on the results, we explain how location of texture triangles and direction of texture affected laciness. First, adjacency of sides between the triangles will hinder the triangles to decompose into separate triangles, resulting in decreased laciness. Second, direction of texture affects laciness only when the small figure fits in the large one. Laciness decreased when the direction of texture makes the side of the small triangle physical within the large one, while not when the direction makes it illusory.

Texture laciness is a phenomenon brought to attention by Watanabe and Cavanagh (1992, 1996). Watanabe and Nakazato (2003) demonstrated that spatial arrangement of texture figures affected laciness. We expanded the understanding of this phenomenon by investigating the effect of spatial arrangement where a small figure was included within a larger figure. We found a new factor, texture direction, which affected laciness in tandem with location of texture figures. The results demonstrated a strong effect of perceptual organization of texture figures on laciness.

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