# GESTALT-ORIENTED PERCEPTUAL RESEARCH IN JAPAN: PAST AND PRESENT*

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## 1. Introduction

Gestalt-oriented research was established in Japan around 1930 (Lewin & Sakuma, 1925; Sakuma, 1932-1940; Takagi, 1933). Abundant experimental studies were carried out in the following decades, but unfortunately they suffered a heavy blow from World War II. Reviews of experimental psychology in those days were published in English by Nozawa and Iritani (1963), Yuki (1965), Tanaka (1966), Oyama, Sato & Suzuki (2001), or in Japanese by Takagi (1949), Ogasawara, (1950), Kakizaki and Suenaga (1971), Noguchi (1973), or Sakuma (1999). Here we briefly review early studies and introduce recent ones that are closely related to Gestalt-oriented perceptual research.

## 2. Studies on geometrical optical illusions

### *2.1 Overview of the study of visual illusions in Japan*

Early Japanese experimental psychologists around the 1930's were interested in visual illusions, and preferred geometrical illusions (size illusions, orientation illusions, position illusions). This preference has been inherited by subsequent generations so strongly that visual illusions have been one of the most active research areas in Japan. Oyama (1960) reviewed approximately seventy Japanese studies on visual illusions that were reported before 1960. His review paper has been frequently cited. For example, Robinson (1972 / 1998), who extensively reviewed visual illusions, referred to a variety of studies conducted in Japan based upon Oyama's review. Recent studies of visual illusions were listed in a book written in Japanese entitled "Handbook of the Science of Illusion" (Goto & Tanaka, 2005). Moreover, a special issue entitled "Optical illusions" (edited by Tadasu Oyama and Takuo Goto) was published in 2007 in *Japanese Psychological Research* (Vol. 49, No.1, pp.1-85). This journal is the official English-written journal of the Japanese Psychological Association.

### *2.2 Basic findings on the Müller-Lyer illusion*

Kido (1927a, 1927b) examined the Müller-Lyer illusion (Figure 1a). He revealed that when the length of oblique lines was kept constant and the smaller the angle of oblique lines was, the larger the illusion. Moreover, he examined Benussi's (1906) proposal that the illusion magnitude tends to be constant as far as the whole configuration remains constant even if the size of the image is changed. However, in agreement with Heymans (1896), Kido showed that the illusion magnitude gradually decreased as the size of the image increased.

* Unfortunately the first author passed away in 2006 with leaving a preliminary draft which we have tried to complete and finish as much in his sense as possible.

Further studies by Ihara and Kido (1934) and Yanagisawa (1939) demonstrated that the illusion dramatically changed from underestimation to overestimation when inward oblique lines were detached from both ends of the induced line (Figure 1b). As the distance increased, the underestimation of the induced line in the inward figure decreased and changed into the overestimation. On the other hand, the overestimation in the outward figure was reduced with increasing distance.

It should be noted that in contrast with the original Müller-Lyer figure, the inward figure was more overestimated than the outward figure under some conditions of separation between the end of the induced line and the vertex. In Morinaga's (1941) study, the induced line was fractioned into seven parts of physically equal lengths and the apparent length of each part was observed. The five intermediate parts appeared to be of the same length whereas the remaining two parts that were connected to oblique lines appeared to be longer or shorter than the five intermediate ones, see Figure 1c, a modification from Morinaga's figure. This suggested that illusion is observed primarily in the area adjacent to the vertex of oblique lines.

Yokose and Kawamura (1952) measured apparent displacement of dots near to an angle, and they obtained a map of displacement vectors. Yokoyama and Kawai (1956) asked their participants to estimate the length of a line which was placed between both vertices, and found that the illusion decreased as the line left the vertex (see Figure 1c).

These findings disagreed with the idea that all parts of the induced line are overestimated or underestimated at an equal rate in the Müller-Lyer illusion, but the parts that are directly connected to the vertices mainly cause the illusion. Some parts in the inward image are actually overestimated , as shown in Figure 1c.

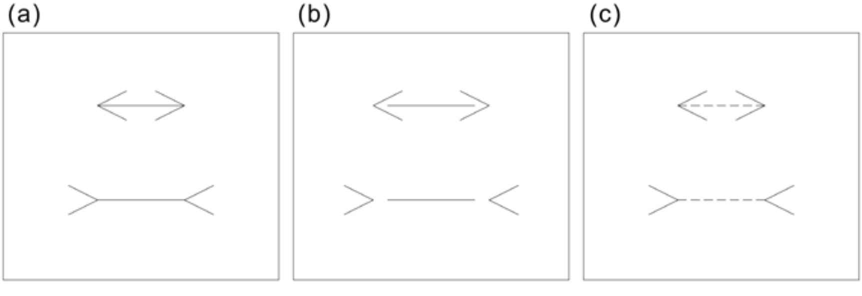


Figure 1. (a) Müller-Lyer illusion. A horizontal line appears to be shorter than it is when oblique lines are attached inward (upper image), while a horizontal line appears to be longer than it is when oblique lines are attached outward (lower image). In this panel, the horizontal line of the lower image appears to be longer than that of the upper one though they are the same in length. (b) When the oblique lines leave the end of the horizontal line, the illusion magnitude decreases for both images. (c) The illusion occurs strongly in the narrow parts of the horizontal line that are directly connected to the oblique lines. In the upper image, the fragments connected to the oblique lines appear to be shorter than the rest; in the lower image, those appear to be longer than the rest. Some fragments in the inward image are overestimated.

### *2.3 Figure-ground organization theory*

Hayami and Miya (1937) attempted to explain the Müller-Lyer illusion from the viewpoint of figure-ground organization. According to this theory, oblique lines appear to compose the contours of a "figure". Triangular figure areas are observed at both ends. The triangular areas include both ends of the induced line in the inward figure, while they do not in the outward figure. Their assumption was that the extent of a "figure" would be underestimated more than that of a "ground". This entails that the inward image is expected to be underestimated more than the outward one.

This theory, however, was criticized by Morinaga (1941). He demonstrated that the illusion was also observed in the pattern that the inward image was placed in the ground area and the outward image was placed in the figure area (Figure 2).

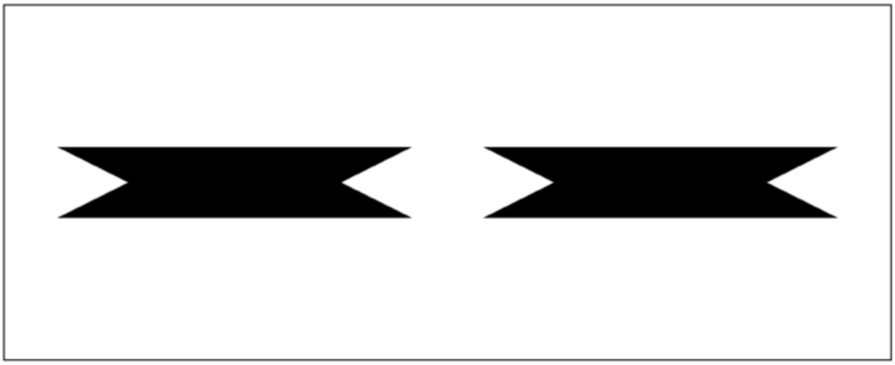

Figure 2. Morinaga's demonstration of the Müller-Lyer illusion, in which the outward black areas appear as *figures*, whereas the white interspace assumes *ground* character.

### *2.4 Field of retinal induction*

Motokawa (1950), a neurophysiologist, proposed the model called the "field of retinal induction" to explain the Müller-Lyer illusion, which was mapped by measuring electrical excitability in the retina and was displayed as the vector area around oblique lines. He discovered that the steep decrease of induction in the area near the vertices and this steep gradient in induction was assumed to play the role of the imaginary end of the induced line. His claim was supported by Nakagawa (1958) who found that the change in electrical excitability correlated well with respective psychophysical measurements of the illusion.

### *2.5 Psychophysical (or perceptual) induction*

Obonai (1933) related a variety of illusions including the Müller-Lyer, Oppel-Kundt and Delboeuf patterns to his theory of psychophysical (or perceptual) induction. According to this theory, visual illusions (including contrast and assimilation of brightness and color) result from psychophysical induction based on the outcomes of physiological excitation and inhibition processes induced by stimulus patterns (Obonai, 1954, 1977). Obonai's induction theory resembled Köhler's field theory as Köhler (1965) acknowledged, though Köhler's theory further assumed electric current flows in the brain (Köhler, 1938).

## 3. Morinaga's paradox of displacement

*3.1 Vector-field theory*

Yokose (1956, 1957) tried to explain many visual illusions by his vector-field theory, which seemed to be greatly influenced by Köhler's field theory. For several kinds of geometrical illusions, the predicted displacement largely agreed with the measured one. Morinaga (1954, 1957), however, argued that geometrical illusions could never be accounted for by merely measuring the displacement of each point composing the figure by giving the following famous examples.

*3.2 Morinaga's paradox, Type I*

As shown in Figure 3a, the distance between the vertices of the inward image is underestimated, while the distance between the vertices of the outward image is overestimated. This figure essentially reflects the classic Müller-Lyer illusion. However, if the same figure is viewed in the vertical direction, the vertical alignment of vertices appears to be opposed to the distortion as would be expected by dot-displacement theories of the Müller-Lyer illusion (Figures 3b and 3c).

This inconsistency was called the "paradox of displacement" by Morinaga and Ikeda (1965). Although Morinaga proposed this paradox to argue against the vector-field theory, this positional effect has been extensively studied and referred to as the "Morinaga misalignment" illusion (Day, Bellamy & Norman, 1983; Day & Kasperczyk, 1985; Hotopf & Brown, 1991; also see Restle, 1976).

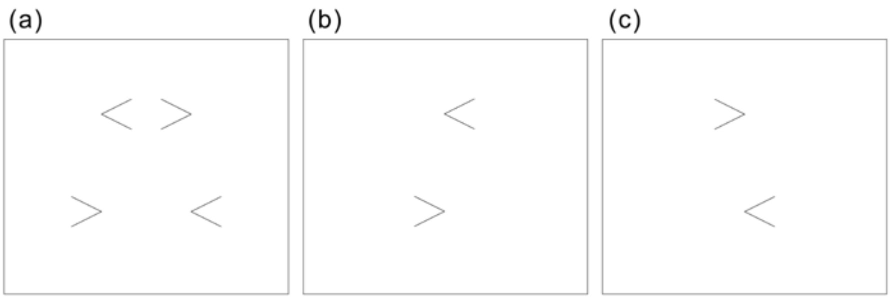


Figure 3. Morinaga's paradox, Type I (size illusion vs. position illusion). (a) The Müller-Lyer illusion remains even if the horizontal line is not real but subjective. On the other hand, the perceived alignment of the tips is reversed (Morinaga misalignment illusion) when the observer pays attention to either the left half (b) or the right half (c).

*3.3 Morinaga's paradox, Type II*

Morinaga (1957) also revealed such a paradox of displacement in simplified Zöllner figures such as Figure 4a. The two vertical lines appear to be tapered downward. However, as seen in Figure 4b, the distance between the upper two points, which correspond to the upper ends of the vertical lines, appears shorter than the distance between the lower two.

Morinaga and Ikeda (1965) demonstrated this type of paradox in the Hering illusion, too. Although the Hering illusion refers to apparent outward curvature of two straight lines (Figure 5a), virtual lines connecting dots appear to curve inward (Figure 5b).

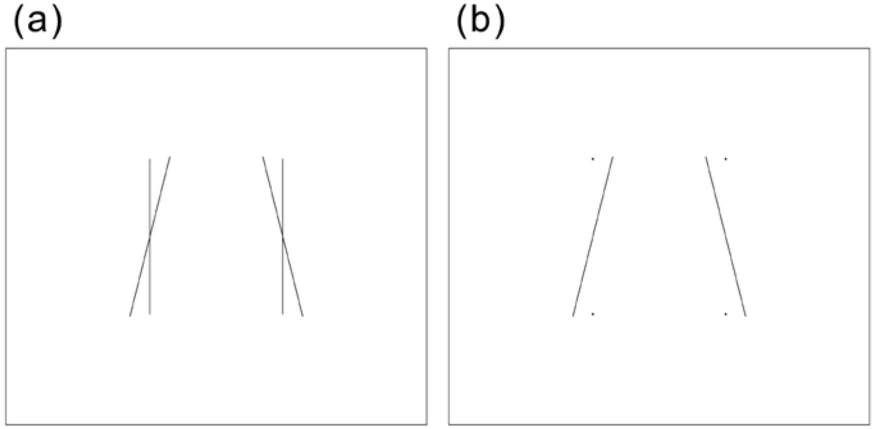


Figure 4. Morinaga's paradox, Type II (orientation illusion vs. size illusion). (a) The Zöllner illusion. The two vertical lines appear to tilt as if they are tapered downward. (b) On the other hand, the perceived distance between the line ends of each horizontal pair is reversed when dots are drawn at the ends of the vertical lines. The upper distance appears to be shorter than the lower (size illusion). As observed by one of the present authors (Kitaoka) the position illusion accords with the size illusion and is rather clear when the observer pays attention to either the left half or right half, in which the left alignment appears to tilt clockwise while the right counterclockwise.

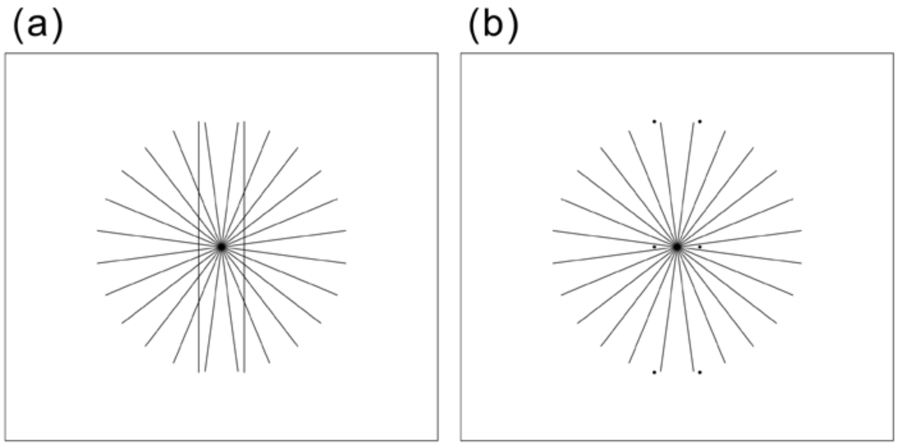


Figure 5. Morinaga's paradox, Type II. (a) The Hering illusion. The two vertical lines appear to bulge outward. (b) Conversely, the virtual line connecting the line ends and the middle point of each vertical line appears to curve inward.

*3.4 Morinaga's paradox, Type III*

Furthermore, Morinaga (1956, 1959) demonstrated that in the Ebbinghaus illusion, underestimation of a circle surrounded by larger circles (Figure 6a), was not reduced by eliminating the proximal parts of the larger circles (Figure 6b), but changed into overestimation if the distal parts of the larger circles were eliminated (Figure 6c). This finding disagreed with the idea that this illusion might be explained with displacement due to the so-called "field forces" or apparent positional shifts (see also Ehrenstein & Hamada 1995).

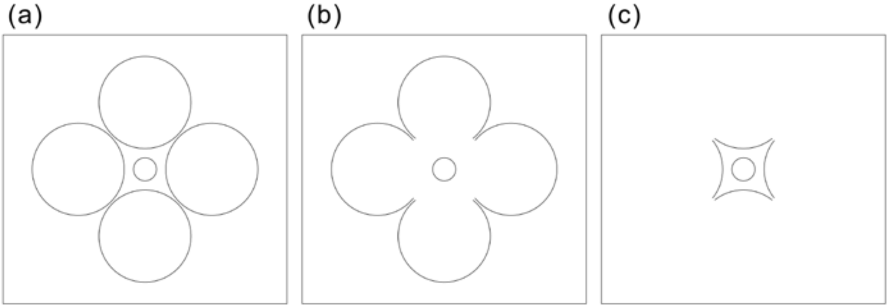


Figure 6. Morinaga's paradox, Type III (size contrast vs. size assimilation). (a) The underestimation effect of the Ebbinghaus illusion. The circle surrounded by larger circles appears to be smaller than it is. This effect is not given from the proximal parts of the larger circles as suggested by the vector-field theory. (b) When their proximal parts are removed, the underestimation effect of the Ebbinghaus illusion remains. (c) If their distal parts are removed, the inner circle appears to be larger than it is.

*3.5 What Morinaga's paradox means*

Morinaga's paradox Type I and Type II suggests that size, orientation and position belong to different dimensions. Morinaga and Ikeda (1965) claimed that it is necessary to clarify which dimension the observer pays attention to during inspection of an illusory figure. The proposal of Morinaga's paradox indeed preceded the recent neurophysiological finding that the brain consists of functional modules.

Morinaga's paradox Type III casts doubt on the predominant belief that any visual illusion might be explained by assuming apparent positional shifts through visual processing. This doubt supports his Gestalt-oriented idea that size or orientation cannot be simply substituted by positional information.

## 4. Gestalt phenomenological viewpoints

*4.1 "Perceptual structure" theory*

Morinaga (1935) systematically studied the Delboeuf (concentric circles) illusion from his viewpoint of Gestalt theory, and obtained clear-cut results, as listed below:

(1) As the diameter of the outer circle is increased, overestimation (size assimilation) of the inner circle first rapidly increases to reach a maximum at the diameter ratio (outer circle to inner circle) of 3:2, to then decrease gradually and change to underestimation (size contrast) at ratios of approximately 5:1 or 6:1.

(2) As the center of the outer circle is displaced from that of the inner circle, overestimation (size assimilation) in the inner circle gradually decreases to reach zero when the contour of the outer circle crosses the center of the inner circle, and changes to underestimation (size contrast) when the two circles are further separated from each other.

(3) When two circles are presented at different distances from the observer in the same visual direction with the inner circle being closer to the observer, overestimation (size assimilation) in the inner circle decreases and turns to underestimation (size contrast) with increasing distance between circles; conversely, underestimation (size assimilation) in the outer circle decreases and changes to overestimation (size contrast).

(4) When presenting the two circles successively (in small steps starting from simultaneous presentation) with the larger circle preceding the smaller one, overestimation (size assimilation) in the inner circle gradually turns to underestimation (size contrast).

From these results, Morinaga concluded that size assimilation between two circles occurs when they are perceived as a whole or unified percept, like a doughnut or a ring, while size-contrast occurs when they are viewed as two separated percepts. He then suggested that the "perceptual structure" of how the observer views and organizes stimulus patterns determines the final perceptual outcome.

Morinaga's emphasis of "perceptual structure" in visual illusion is based on perceptual organization or grouping. Whether we have a unified percept or two separated percepts should be determined by Gestalt factors. In this respect, we should refer to Oyama's (1962) study on the factor of similarity on the Delbouef illusion. Oyama obtained large assimilation effects in concentric circles of different colors (red and blue) as well as those of the same color (e.g., red and red or blue and blue). He then claimed that the perceptual grouping of the outer and inner circle is not necessary for this illusion.

Recently, Noguchi (2002) confirmed Oyama's finding, using three concentric circles in addition to two concentric circles, and using the null method to measure the amount of illusion. However Noguchi found the similarity in color plays an important role in the Ebbinghaus type of size-contrast illusion, because the size-contrast illusion almost disappears when the inner and outer circles were drawn with different colors. From these two different types of the Gestalt similarity factors between size-assimilation and size-contrast may be distinguished according to differences in their figural characteristics. That is, two concentric circles (Delbouef illusion) tend to be organized as a unified whole even if they are drawn with different colors, while surrounding circles and the surrounded circle (Ebbinghaus illusion) tend to be separated into two different groups when they are drawn with different colors.

### *4.2 Figural after-effects*

As Oyama, Torii, and Mochizuki (2005) pointed out, Morinaga's (1935) study on the Delboeuf illusion, especially investigation of the temporal conditions of circle presentation as has been described above, greatly influenced the following Japanese studies on figural after-effects in the 1950s and led them to great success (for review, see Oyama, 1978; Sagara & Oyama, 1957). Morinaga's result was confirmed by Ikeda and Obonai (1955), varying stimulus onset asynchrony and the size ratio of the two circles. They showed a gradual transition from simultaneous illusion to figural after-effect. It should be noted that Morinaga's (1935) study even preceded Köhler's (1940) concept and study of figural after-effects.

Japanese studies of figural after-effects preferred circles as stimulus pattern, whereas rectangular figures were preferred by Köhler and Wallach (1944). The studies with circles showed the diameter ratio between circles was an important determinant of figural after-effects, not the absolute separation as concluded by Köhler and Wallach (1944). The maximal underestimation and overestimation occurred when the diameter ratio of two circles, *i.e.* inspection (adaptation) and test figures, was 2:1 and 1:2, respectively, regardless of the absolute size of the stimulus circles.

Although there are some differences between these two phenomena (Delboeuf illusion and figural after-effects), *e.g.* the direction of effects (assimilation vs. contrast) or numerical values of the ratio for maximal effects (3:2 for the Delboeuf illusion vs. 2:1 for figural after-effects), the principle of ratio relations could be adequately applied to both the illusion and figural after-effect (Ikeda & Obonai, 1955; Oyama, 1956). This suggested the involvement of the same mechanism underlying them. Oyama et al. (2005) reviewed the pioneering studies in the 1930s on perception and concluded that these fruitful outcomes of Japanese studies on figural after-effects were largely inaugurated by Morinaga's (1935) outstanding research.

### *4.3 Perceptual constancy*

Perceptual constancy, especially size constancy, has long been a preferred concern by experimental psychologists in Japan. We think that these studies were strongly influenced by Gestalt psychology.

Akishige (1958) wrote a review paper on perceptual constancy, which referred to approximately sixty studies on size constancy prior to the 1950s. Already, in the 1930s, Akishige (1932), Ibukiyama (1933), Ogasawara (1933, 1935) and other investigators had examined the effects of distance cues, space structure, reality of stimulus objects, or observers' characteristics on size constancy.

Akishige (1932) examined size constancy in a 17 year old man, who had lost the sight in his left eye 200 days after birth. He showed nearly the same degree of size constancy as was seen for normally sighted participants in an articulated situation. In homogeneous or poorly articulated situations, however, his ability of size constancy was lower than the normally sighted participants in binocular observation, though it was higher than in their monocular observation. Akishige concluded that binocular parallax or convergence is not essential for size constancy but spatial articulation is important for this phenomenon. Following this study, Akishige and his collaborators continued to carry out a series of experiments on perceptual constancy for nearly thirty years (Akishige, 1958).

On the other hand, Ogasawara (1935) was interested in the effect of binocular cues on size constancy, using photographic stereograms of two white balls. The near ball was slightly larger than the far one in the photographs. When the observer watched them using a stereoscope, the far ball appeared larger than the nearer one. Ogasawara thought that size constancy appeared. He manipulated stereograms in various ways, *e.g.* changing lateral disparity between the balls and the articulation of the background. Based on careful phenomenological observations, he concluded that convergence and the apparent depth of the balls were important for size constancy in stereoscopic vision.

This methodologically important study of Ogasawara had been disregarded until Katori and Suzukawa (1963) reexamined this study more systematically. Using the method of transposition or the ratio-matching method (Oyama, 1959) to determine the apparent relative size they confirmed Ogasawara's (1935) finding.

### *4.4 Hypothesis of diffusive forces*

Wada (1955, 1956) demonstrated that the distance or extent which was interrupted by lines of the same properties always appeared greater than the distance which was interrupted by alternation of two kinds of line, *e.g.* black and gray, long and short, thick and thin, or solid and dotted. He hypothesized that there would be diffusive forces, by which a figure is expanded as a whole, in addition to cohesive forces and restraining forces proposed by Orbison (1939). Wada speculated that in the Oppel-Kundt illusion, the effect of diffusive forces dominated over that of cohesive and restraining forces, and that diffusive forces are even stronger in homogeneous figures than in heterogeneously structured patterns.

## 5. Space-time interaction

### *5.1 Korte's third law*

Ogasawara (1936) investigated the meaning of spatial separation in Korte's third law of apparent motion which states that an increase in spatial separation between two successively presented stimuli was accompanied by an increase in the temporal interval to obtain optimal apparent motion. He tried to clarify whether spatial separation of Korte's third law meant separation within the retinal image or the separation at the perceptual level.

Measuring the critical temporal interval for the various spatial separations with different viewing distances under light and dark conditions, he found that the critical time interval increased with perceptual rather than retinal separation under light-adapted conditions, whereas it varied with the retinal separation in dark-adapted conditions. As Attneave (1974) pointed out, Ogasawara's study antedated to some extent the studies by Corbin (1942) and Attneave and Block (1973).

### *5.2 Motion phenomena in audition*

Apparent motion, such as the optimal, partial or the phi phenomenon first studied in the visual domain (Wertheimer 1912) may be observed analogously for a pair of tones exposed at different locations in space (Hisata, 1934). Even before, Hirose (1933) demonstrated non-spatial auditory motion phenomena for the pitch of tones (also see Yuki, 1965). Two tones of different frequencies presented alternately by means of an electrical oscillator were, under optimal frequencies of alternation, perceived as a single tone moving up and down continuously in pitch, whereas physical transition of sound frequency was abrupt.

Hirose systematically varied the pitch difference between two stimulus tones and the frequency of alternation and found “successive”, “optimal”, ”partial”, and “pure phi” phases of motion impression in pitch, similar to those phases that Wertheimer (1912) had demonstrated in vision. Based on these results, he concluded that apparent motion is not restricted in the spatial dimension and criticized the classical system of perceptual attributes in its overemphasis of space. This idea inspired Oyama (1997) to compare apparent motion within other visual dimensions (color, brightness, shape and size; see also Oyama et al., 2005).

### *5.3 Interdependence of vision and audition*

The dependence of perceptual extent on time has been investigated by presenting three stimuli in succession with equal spatial intervals, but with unequal temporal intervals. For example, if the time interval between the first and second stimulus is shorter than that between the second and third stimulus, the perceived intervals undergo a corresponding change (Helson & King, 1931). This dependence of space on time was named the “tau” effect by Helson (1930).

Japanese psychologists have made an important contribution to studies of the tau-effect in detail (Abbe, 1937a, 1937b; Hirose 1933; Hisata, 1934). For auditory motion, Hisata (1934) observed that the phenomenal distance of motion decreased with decreasing time interval. Accordingly, Hirose (1933) found that the pitch interval between the two tones also sounded narrower with increasing speed of alternation between the two tones.

### *5.4 "S-effect" (kappa effect)*

In 1935 and 1936, Abe and Abbe discovered independently that the space-time interaction could be interchanged. When a flash of a light bulb was followed by the next flash at a long spatial distance, the time interval appeared to be increased. Abe (1935) called this phenomenon “S-effect”, to denote the reversal of the tau effect, which is now known as “kappa effect” (Cohen, Hansel & Sylvester, 1953; Price-Williams, 1954). By re-examining the study by Gelb (1914), who denied the existence of a reversal, Abe was able to show that it actually occurred under conditions similar to those of the tau-effect.

Abbe (1936) showed that this reversal occurred most clearly under conditions of beta motion. However in some conditions that were sufficient to cause the tau-effect, the S-effect did not occur. Abbe therefore concluded that the S-effect is not just a reversal of the tau-effect.

Recently, Masuda, Wada and Kimura (2007) examined how the kappa-effect would be affected by perceived gravity given in the cast-shadow situation (Kersten, Mamassian & Knill, 1997). They found that the position of the cast shadow indeed influenced the kappa-effect, suggesting its non-retinal origin.

## 6. Transparency

The study of apparent or perceptual transparency has played an important role in Gestalt-oriented studies in Japan (Morinaga, 1952; Noguchi, 2007) as well as in Europe (Fuchs, 1923; Koffka, 1935; Kanizsa, 1966; Metelli, 1967). Most reports stressed the importance of the lightness relationships between the "overlapping" area and its neighboring areas (Morinaga, 1950; Oyama & Nakahara, 1960; Kozaki, 1969; Noguchi & Motoki, 1972), in which areas that are similar in lightness tend to appear to be transparent and in front of the others, referring to or implying the Gestalt law of similarity. Perceived illuminance was pointed out as an important factor (Noguchi & Motoki, 1972; Soga, Motoki & Noguchi, 1995) with "white transparency" positively correlated to illuminance and "black transparency" negatively correlated. Areas having a long border appeared to be more frequently transparent than those with a short one (Morinaga and Noguchi, 1962), a characteristic similar to the Petter effect (Petter 1956; Kanizsa 1979; Shipley & Kellman 1992). Vertically or horizontally aligned areas appear to be more frequently transparent than obliquely aligned ones (Morinaga, Noguchi & Ohishi, 1962).

Recently, apparent transparency has been phenomenologically classified into two types, unique transparency and bistable transparency, depending on the arrangement of contrast polarity around X-junctions (Adelson & Anandan, 1990; Anderson, 1997). We consider this phenomenal principle to be a new one among the Gestalt factors. Kitaoka (2005) proved that the luminance-based arithmetic model (Gerbino, Stultiens, Troost & de Weert, 1990; Gerbino, 1994) can fully explain this phenomenal principle. Moreover, Kitaoka phenomenally classified apparent transparency into object transparency and full-layer transparency, and found that object transparency is preferred. He also added a new factor that the combination of dark areas appears to be transparent more frequently than the combination of light areas.

Finally, we propose a new idea that the notion of apparent transparency can fully explain the figure-ground characteristic of the watercolor illusion. The watercolor illusion (or watercolor effect) is a long-range color spreading (or assimilation) illusion (Pinna, Brelstaff & Spillmann, 2001; Pinna, Werner & Spillmann, 2003) (Figure 7a). The watercolor illusion is accompanied by strong, stable figure-ground segregation, in which the area surrounded by lighter (e.g. orange) wavy lines appears to be *figure* while the area contoured by darker (e.g. purple) wavy lines appears to be *ground*. Pinna (2005) argued that this figure-ground effect cannot be explained with the Gestalt factor of similarity because combination of different colors also works. We, however, focus on the achromatic aspect of the watercolor illusion since this illusion largely depends on luminance (Devinck, Delahunt, Hardy, Spillmann & Werner, 2005). Actually the area surrounded by lighter wavy lines appears to be *darker* than the area contoured by darker wavy lines (Figure 7b). This appearance can be attributed to a possibly novel image showing apparent transparency as shown in Figure 7c. In this image, the disk always appears to be transparent or translucent. This characteristic is called "unique transparency" (Adelson & Anandan, 1990; Anderson, 1997), which is characteristic in Metelli's (1974) figure of transparency (Figure 7d). There is a strong resemblance between Figures 7c and 7d. Thus, we suggest that the strong, stable figure-ground segregation in the watercolor illusion should depend on unique transparency, not color.

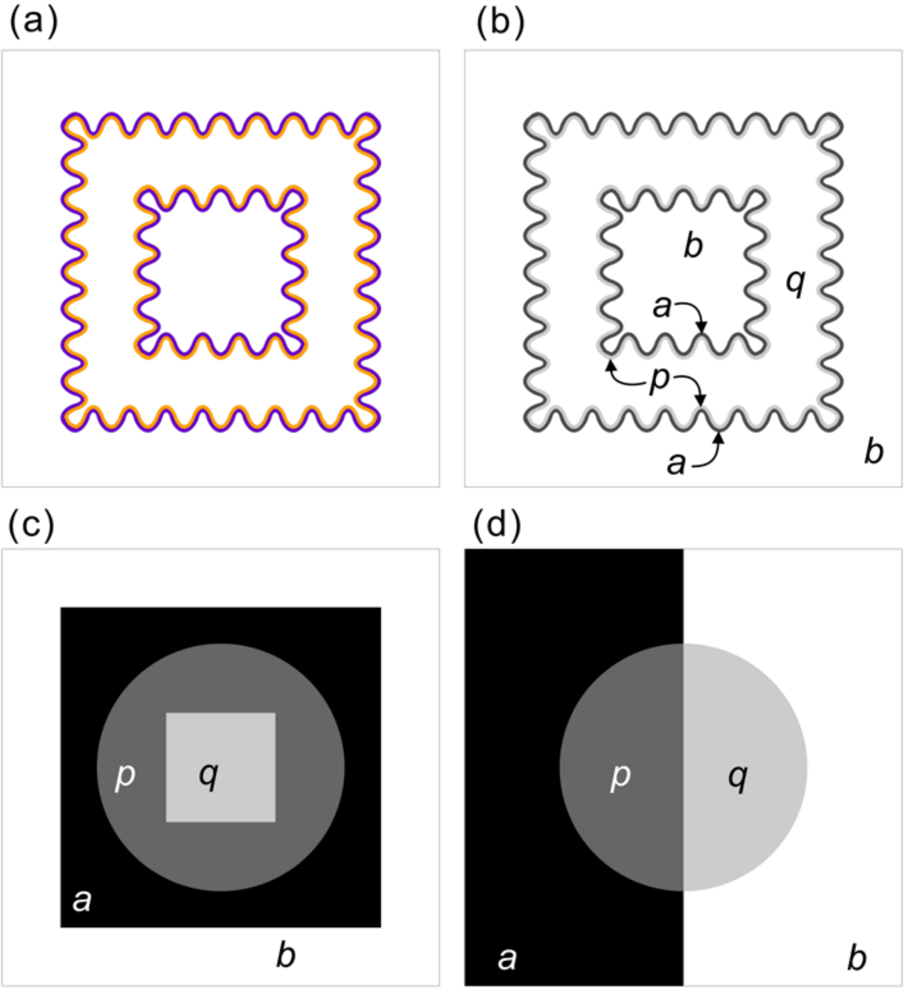


Figure 7. Watercolor illusion and apparent transparency. (a) The watercolor illusion. The corridor area appears to be tinted orange, to be veiled, and to be *figure*. (b) Achromatic watercolor illusion. The corridor area *q* appears to be veiled, to be darker than the surround *b* though they are the same in luminance, and to be *figure*. The alphabets *a*, *b*, *p* and *q* correspond to those shown in (c) or (d). (c) A possibly novel image of apparent transparency. It appears that a black square bearing a square window in the center is placed on the white background, and that a translucent disk appears to be in front of the black square and to cover the window entirely. The disk always appears to be transparent in front, *i.e.* unique transparency (Adelson & Anandan, 1990; Anderson, 1997). (d) Metelli's figure demonstrating unique transparency. The disk always appears to be transparent in front.
(for the original colors see http://psy.ritsumei.ac.jp/~akitaoka/NoguchiMSfiguresGT.html).

## 7. Other phenomena

Sumi (1995) examined the bounce effect of changing the speed of targets. For small differences in speed, the bouncing just tended to be more frequent than the pass (stream) appearance, whereas for high speeds, only the bouncing effect was observed. Sumi concluded that the Gestalt factor of symmetry contributed more strongly to the bounce effect than does the factor of smoothness.

Kano (1995) further examined the effect of occlusion over the crossing point on the cross (stream) effect. The larger the occluder, the less frequently the cross appeared, indicating that this effect should be related to the Gestalt factor of good continuation, as Hayashi (1990a; see discussion, Rausch 1990, Hayashi 1990b) had suggested.

Kiritani (1994) examined the determinants of the clarity of anomalous surface in the Kanizsa square and found that clarity depended on size constancy rather than on the viewing distance and was further positively related to the proportion between real edges and illusory contours. She concluded that the Gestalt factor of closure was essential in generating an anomalous surface.

The relationship among illusory contours, apparent brightness and depth was studied by Watanabe and Oyama (1998) using the causal inference method. Their findings suggest the prime importance of illusory contours. Yoshino and Noguchi (2002) compared the visual search of a subjective-contour image from fragmental images with that of a fragmental image from subjective-contour images. They found that for the former the reaction time was constant as the number of the distracters changed while for the latter the reaction time increased as the number of the distracters increased. They concluded that subjective contours should be represented by an early visual mechanism.

Taya, Ehrenstein and Cavonius (1995) examined the Munker-White effect under stereoscopic viewing conditions and observed that the effect is enhanced if the patterns are presented stereoscopically so that the grey bars appear either behind the grating, in which case they are seen as a rectangle that is occluded by the white bars of the grating (amodal completion), or in front of the grating, so that they form a transparent rectangle. This was explained in terms of object perception: contrast enhances differences between an object and its surroundings, whereas assimilation reduces differences within an object.

### Acknowledgement

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### *Summary*

The Gestalt-oriented perceptual research in Japan is selectively reviewed from its beginnings in 1930 to the present. Special emphasis is given to visual illusions, space-time interaction, including auditory motion phenomena, and perceptual transparency. The three types of Morinaga's paradox are documented as an outstanding contribution which is apt to

inspire recent neurophysiological evidence for flexible, module-like brain functioning. Further we try to link figure-ground segregation based on Pinna's watercolor effect to perceptual transparency.
**Keywords:** Perceptual research, Gestalt-oriented, history, Morinaga's paradox, Pinna's watercolor effect

### *Zusammenfassung*

Die gestalttheoretisch bestimmte Wahrnehmungsforschung Japans wird von 1930 bis zur Gegenwart behandelt. Der Überblick greift dabei markante Schwerpunkte heraus: Optische Täuschungen, Raum-Zeit-Interaktionen (einschließlich akustischer Bewegung) und anschauliche Durchsichtigkeit (Transparenz). Ausführliche Darstellung finden (mit ihren drei Figurvarianten) die als Morinaga-Paradox bekannt gewordenen verblüffenden Erscheinungen der Raumwahrnehmung. Morinagas herausragender Beitrag betrifft auch die moderne Hirnforschung, die eine flexible, Modul-gestützte Arbeitsweise des Gehirns bestätigt. Aktuelle Forschungsbeispiele bilden die Bemühungen, Faktoren der Figur-Grund-Abhebung (bedingt durch Pinnas Wasserfarben-Effekt) mit denen der Transparenz zu verbinden.

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