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Visual Illusion and Aesthetic Preference: Some Common Stimulus Properties

1. Introduction

Beauty is felt when we perceive an object of particular proportions. It may be thus defined as a perceptual quality. That is, the sense of beauty is derived from stimulus properties (shape, colour, etc.) rather than from empathy and interpretation of a subject (Noguchi 2003). Further we can distinguish perceptual from cognitive beauty. When a work of art is evaluated, both these top-down and bottom-up factors contribute to an overall assessment, and it is impossible to completely separate one from the other. We can, however, following the pioneering work of Fechner (1865) in experimental aesthetics, use simple visual stimuli that hardly contain an associated meaning or learned context. By this we can minimize the influence of cognitive factors as much as possible. Such an approach allows for valid conclusions in that the resulting experience of beauty is closely related to the perceived properties of a stimulus.

Experimental phenomenology as represented by Schumann (1904), Rubin (1915/1921) and Katz (1935) has successfully described various perceptual phenomena in an elaborate and systematic way, thus clarifying the modes of appearance. Gestaltists further attempted to explore the mechanisms that generate perceptual processes and context effects ("illusions") by means of experimental phenomenology.

Gestalt theory emphasized that perceptual deviations from physical stimulus properties (such as found in visual illusions) were not exceptions in human perception; rather, they resembled basics laws or factors of perception (Koffka 1935). Consequently, the law of "good Gestalt" or Prägnanz tendency (Wertheimer 1923) could be applied to the mechanism underlying visual illusions. According to the Prägnanz tendency, the phenomenal character of a configuration changes towards greater balance. Conversely, when a configuration is split into two independent or single objects, these parts tend to separate from each other. By variation of the circle diameter within the Delboeuf figure, Morinaga (1935; Oyama et al 2005) clearly demonstrated assimilation and contrast as two modes of perceptual organization: When the two concentric circles are seen as a single unit, like a doughnut or a ring, the inner circle is overestimated or assimilated

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to the size of the outer circle (assimilation); and when the two circles are seen separately, the inner circle is underestimated (contrast); see also Ehrenstein et al. (2004).

Wertheimer's Prägnanz tendency assumes that figural components tend to be organized into the simplest most regular way possible under the prevailing stimulus conditions. A 'good' Gestalt is not necessarily present from the beginning, but parts become organized so that the particular whole can be established.

Gestalt psychology has contributed an extensive theoretical framework for studying visual illusions, but did not much engage in experimentally examining single visual patterns per se. However, the fact that a particular pattern of visual illusion occurs in its own unique perceptual structure marks it as an important area for study.

Lukiesh (1922) discovered a powerful illusion, in which two diagonals that are physically equal in length appear different due to the surrounding parallelograms (Fig.1). This is a striking example that demonstrates the influence of the whole or context on the part or individual components. The reason why the diagonal within the larger parallelogram is seen as much longer than the one within the smaller parallelogram is that the line (part) is endowed with the property of its surrounding (whole). Conversely, Rausch (1952) reported that under certain conditions (i.e. if one compares the reverse diagonal lines in Fig.1) the line inside the larger parallelogram is underestimated while the line inside the smaller parallelogram is overestimated.

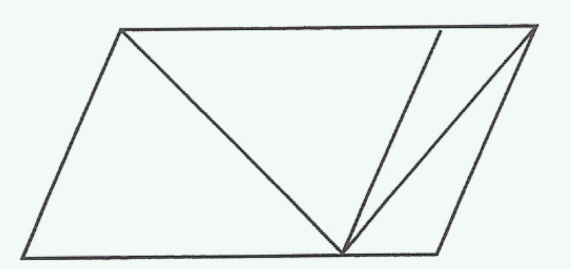

Fig. 1 Luckiesh's illusion: The diagonal in the large parallelogram, left, appears longer than the diagonal in the small one, right; metrically both diagonals are of identical length. Perceptually, partial size is hence influenced by the size of the whole (Luckiesh, 1922).

Metzger (1953, p. 162, Fig. 203) resolved this seeming contradiction by referring to the Prägnanz tendency. As a whole the parallelogram appears less slanted than it actually is. This tendency of the parallelogram to appear more upright is a manifestation of the tendency toward an orthogonal orientation (the parallelogram is then conceived as an obliquely distorted rectangle).

In a pioneering study by Oyama (1962) special Gestalt factors were applied to account for visual illusions. For example, the factor of similarity was examined in the Delboeuf figure (Fig. 2) by controlling hues of inner and outer circles so that two circles were same or different in hue: both of the two circles were red (or green), or the inner circle was red (or green) while the outer circle was green (or red). The amount of illusion did not depend on the variations in hue. Noguchi (2001) confirmed Oyama's finding in the Delboeuf figure and also in a related pattern by Morinaga and Noguchi (1966). However, he found that the amount of illusion decreased in the Ebbinghaus figure when the inner circle and surrounding circles differed in hue. This finding implies that the factor of similarity is effective in the Ebbinghaus size illusion, but not in the Delboeuf illusion. Furthermore, Noguchi and Fujii (1999) demonstrated that Gestalt factors of proximity and closure influenced Botti-like illusions. These studies confirm that the perception of geometric-optical illusions is differently influenced by Gestalt factors.

The present study concerns the relationship between visual illusion and aesthetic preference using the Delboeuf figure as its starting point. In Experiment 1, the size ratios of the inner and outer circles of the Delboeuf figure are systematically changed, and the amount of illusion and the degree of aesthetic preference are compared. Experiment 2 investigates the Jastrow figure as another typical case of part-whole interaction. Here the relationship between the illusion and aesthetic preference is studied as a function of the size ratios between the lower part of the upper fan-shape and the upper part of the lower fan-shape.

Experiments 1 and 2 aim to replicate the findings and conclusions by Noguchi (2003) as well as those of earlier studies (Morinaga, 1935, Ogasawara, 1952, Yatsuka, 1969).

In Experiment 3, we extend the investigation to a pattern by Ehrenstein (1925), composed of a square and multiple, superimposed concentric circles, to investigate the relationship between the amount of illusion and aesthetic preference. The number of concentric circles is varied systematically and the amount of illusion as well as of aesthetic preference is studied as a manifestation of the tendency towards good Gestalt or orthogonality as outlined above.

2. Experiment 1: Size Illusion and Aesthetic Preference in the Delboeuf Figure

2.1. Materials and Methods

2.1.1. Participants

A total of forty-one undergraduate and graduate students (between 18 and 33 years) participated in Experiment 1. Twenty participants assigned to task 1 (measuring visual illusion) and the remaining twenty-one participants to task

2 (measuring aesthetic preference). Each of them had normal or corrected-to-normal vision.

2.1.2. Test Patterns

All visual stimuli were drawn using a commercial computer program (Illustrator 8.0; Adobe). Standard test patterns were the Delboeuf figure. Two concentric circles served as test patterns. The inner circle was 40 mm in diameter, and the diameter of the outer circle varied in five steps: 45, 50, 62, 90 and 160 mm, resulting in size ratios (inner to outer circles) of 2/2.25, 2/2.5, 2/3.1, 2/4.5 and 2/8 (Fig. 2).

Five comparison patterns were chosen to measure the amount of illusion of the Delboeuf illusion with circle diameters of 38, 39, 40, 41, and 42 mm.

2.1.3. Procedure

Task 1. Participants were asked to match the size of the inner circle of the test pattern with the size of one of the comparison patterns. The viewing distance was about 20 cm. The test pattern and the comparison patterns were presented side by side. The center-to-center distance between the two patterns was approximately 30 mm. The right-left positions of two patterns were counterbalanced across participants in the task 1. One experimenter, who was unaware of the stimulus identity, presented the patterns in random order.

Task 2. A 7-point scale was used for aesthetic judgments of test patterns. Participants were asked to make aesthetic judgments for the pattern as a whole. Each test pattern was printed in black on a white horizontal A4 sheet. Participants sat in front of the paperboards at a distance of about 30 cm. Test patterns were presented in random order to each participant. Both the scale value of aesthetic preference and the amount of illusion were standardised to make clear comparisons between these two independent sets of data.

2.2. Results and Discussion

The results are shown in Figure 2. Both the standardised aesthetic preference and illusion were presented as a function of the size ratios of two concentric circles. As the size ratio increased, the amount of the illusion increased, reaching a maximum at size ratio of 2 to 3.1, to then decrease. Similarly, the degree of aesthetic preference changed as an inverted V-shaped function with the peak at 2 to 3.1. These results imply a rather close relationship between the illusion and the aesthetic preference. The inverted V-shaped function conforms with the results on Oppel-Kundt grids, Oppel-Kundt circles, and Helmholtz radials obtained by Noguchi and Rentschler (1999; see also Noguchi, 2003) who introduced complexity as an experimental variable.

The tendency for aesthetic preference is maximal when the outer circle is not too small and not too large, i.e. intermediate and balanced is called 'central tendency of aesthetic preference'.

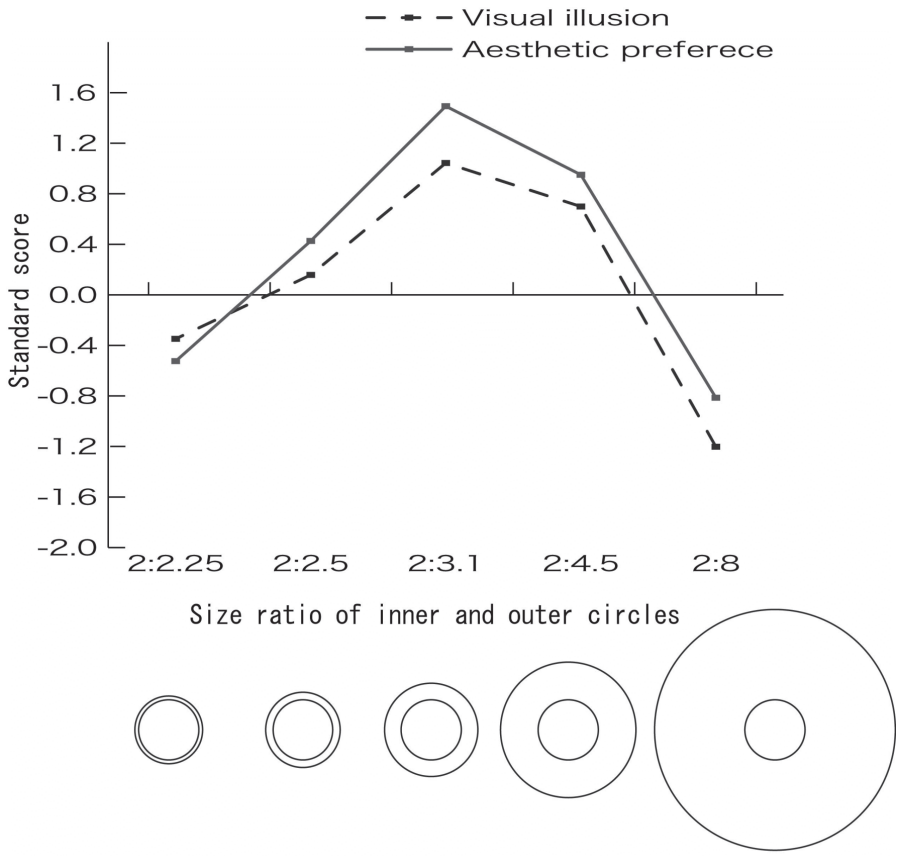

Fig. 2 The relationship between visual illusion and aesthetic preference in the Delboeuf figure.

3. Experiment 2: Area Illusion and Aesthetic Preference in the Jastrow Figure

3.1. Materials and Methods

3.1.1. Participants

Forty-eight undergraduate and graduate students (between 18 and 33 years) with normal or corrected-to-normal vision participated in Exp. 2. Twenty participants were assigned to task 1, and the remaining participants to task 2 for measuring aesthetic preference.

3.1.2. Test Patterns

Visual stimuli were obtained as in Exp. 1. The Jastrow figure and its variations were used as test patterns. The length of the outer arc of a fan-shaped figure was changed in six steps: 48, 32, 14, 12, 6 and 0 mm. The length of the inner arc was always 34 mm (Fig. 2).

Five comparison patterns served to measure the amount of illusion with fan-shaped figures being 90%, 95%, 100%, 105%, and 110% of the standard.

3.1.3. Procedure

Task 1. As in Exp. 1, participants were asked to match the size, in this case of the lower fan-shaped test patterns with the size of one of the comparison patterns.
Task 2. A 7-point scale was used for aesthetic judgments of the test patterns. Participants were asked to make aesthetic judgments for the pattern as a whole. The procedures were the same as those used in experiment 1.

3.2. Results and Discussion

The scale values of aesthetic preference and the amount of the illusion were standardized. As shown in Figure 3, the standard scores of the illusion were plotted as functions of the length of the outer arc. The size-contrast illusion was the smallest with the outer arc of 14 cm; it changed to size assimilation if the outer arc was less than 14 cm. Disregarding the direction of the size illusion (assimilation or contrast), the absolute amount of illusion or aesthetic preference was plotted as a function of the length of the outer arc. The resulting two curves show rather similar inverted V shapes, implying a rather close relationship between the illusion and the aesthetic preference.

Similar to the Delboeuf illusion, the Jastrow illusion concerns the perception of size or area. However, in the former, the size assimilation is more dominant than size contrast, whereas in the latter, assimilation and contrast are balanced, and this balance is also reflected by aesthetic preference.

4. Experiment 3: Shape Illusion and Aesthetic Preference in the Ehrenstein Figure

4.1. Materials and Methods

4.1.1. Participants

Of a total of thirty-two participants (between 18 and 30 years with normal or corrected-to-normal vision) were tested in this experiment, twelve were assigned to Task 1 and twenty to Task 2.

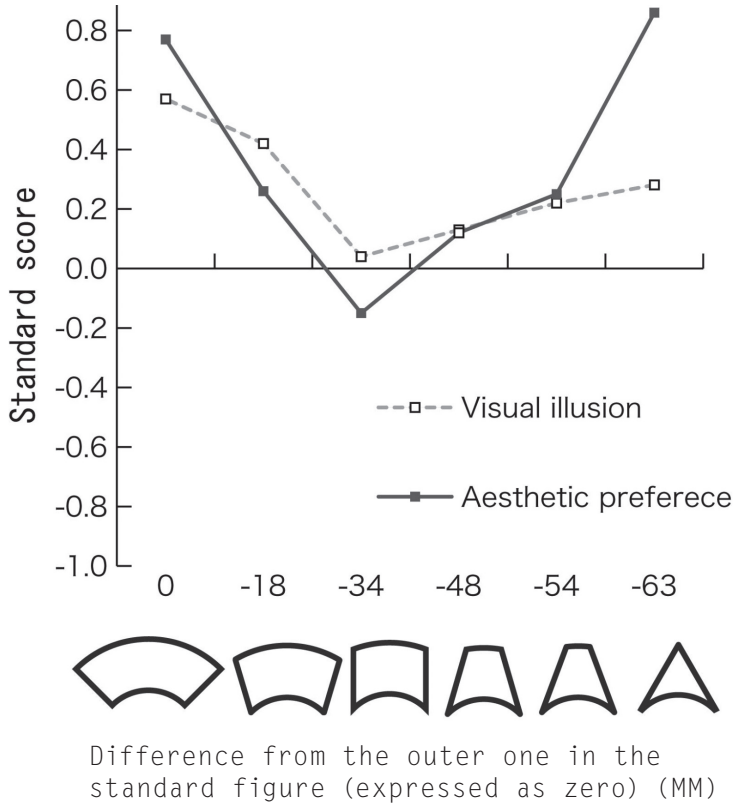

Fig. 3 The relationship between visual illusion and aesthetic preference in the Jastrow figure.

4.1.2. Test Patterns

Stimuli were produced as in Experiment 1. The Ehrenstein figure consisting of a square within multiple concentric circles was varied circles from 87 to 17 mm in diameter. The number of concentric circles placed between these the largest and the smallest circle was varied in six steps: 1, 3, 7, 13, 19, and 30 (Figure 4). The 21 and 32 circles conditions are not depicted here, since individual circles would be hardly to be seen in Fig. 4, but merge to a more or less homogeneous structured gray surface. However, real stimuli presented on A4 size were large enough for each circle to be seen. Five comparison patterns served to measure the amount of illusion of shape distortion. The comparison figure was a square of 60 mm^2. Squares varied in their curvedness in that the central point of their contour lines was placed at the position of 0.5, 1, 1.5, or 2 mm inside relative to that of the straight lines to make curve of comparison figures. The curves were Bézier curves made by placing the middle point of the lines at a point inside.

4.1.3. Procedure

Similar to Experiments 1 and 2, two tasks were given to participants: *Task 1* required the participants to match the curvature of the distorted square of the test pattern with the curvature of one of the comparison patterns, *Task 2* used a 7-point scale for aesthetic judgments of test patterns as a whole. The procedures were the same as those used in experiment 1 and 2.

Moreover, we measured aesthetic preference of single components of the respective Ehrenstein figure to investigate whether aesthetic judgment could be explained by a summation of single components by asking the participants to make aesthetic judgments of either concentric circles or squared shapes, respectively.

4.2. Results and Discussion

The results are shown in Fig. 4, where the amount of illusion and standardized aesthetic judgment are presented as a function of the number of circles in the Ehrenstein figure. The amount of illusion (I) was calculated as follows:

$$I = (D / L) \times 100 \quad (1)$$

D: deviation from the straight side lines
L: length of a side of the squared shape

Both the amount of illusion and aesthetic judgment of the Ehrenstein figure follow an inverted V-shaped function. These results imply a strong correlation between visual illusion and aesthetic preference is seen in not only the figure generating size or area illusion but also in the Ehrenstein figure resulting in shape or distortion illusion.

We also tried to clarify whether aesthetic judgment could be explained by a summation of single components of the Ehrenstein figure, concentric circles or shape (distorted square), using multi-regression analysis:

$$Y = aX_c + bX_s + k \quad (2)$$

Y: aesthetic preference for the Ehrenstein figure as a whole
X_c: aesthetic preference of concentric circles
X_s: the aesthetic preference of shape (distorted square)
a, b: standardized partial regression coefficient
k: constant

Whereas the regression was significant itself, the R^2 value was not ($F_{2,117} = 7.04$, $p < .01$; $R^2 = 0.11$), indicating that the aesthetic judgment or preference for the Ehrenstein figure cannot be derived from 'the sum of components or parts', but only from the 'figure as a whole'.

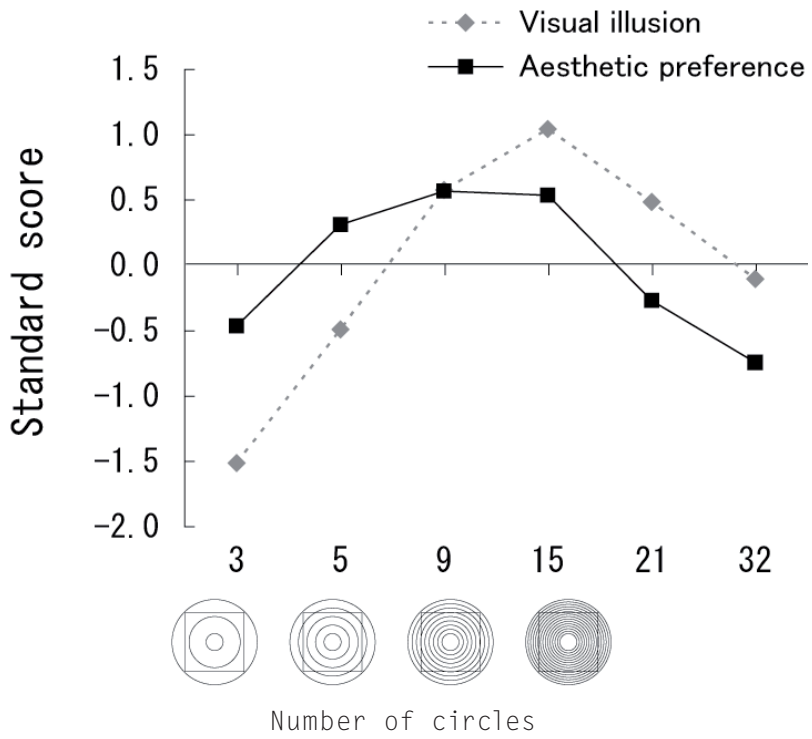

Fig. 4 The relationship between visual illusion and aesthetic preference in the Ehrenstein figure

5. General Discussion

As has been demonstrated by Rentschler and co-workers (1999) aesthetic experience is determined by regularity, i.e. symmetry, in that the human perceptual system in exploring structural order is rewarded by positive feelings such as that of beauty. As is clearly seen in perceptual organization, there is a tendency to create order even where there is no order in reality. Kakuzuo Okakura (1906), a Japanese art critic, emphasized the importance of 'the beauty of incompleteness' by insisting that humans tend to actively respond to incomplete arrangements by completing them mentally.

When the stimulus is an arrangement where the order is too easy or too obscure to discern, it lacks aesthetic attractiveness. This means that beautiful objects should have an intermediate, not too simple or complex, order. Conforming with previous findings (Noguchi & Rentschler, 1999), the present study shows that in figures generating geometrical-optical illusions we prefer figures with a medium range of stimulus complexity rather than figures that are too simple or too complex. Both the amount of illusion and the degree of aesthetic judgment are especially high when the arrangement of the stimulus is moderately complex

(central tendency). In Experiments 1 and 2, the amount of illusion and aesthetic preference showed the central tendency. These results correspond to previous studies that investigated the importance of the moderately complex arrangement of the stimulus on aesthetic preference. The visual system represents an ordered and stable percept even when input sensory data is complex. To make order from complexity, a basic principle of beauty is itself the function of the perceptual system and may in part explain the appeal of optical-art as epitomized by Bridget Riley.

Furthermore, Rentschler et al. (1999) found that aesthetic preference depends on subjective estimates of the shape of the figure, suggesting two processing mechanisms of the visual system. One relies on phylogenetically predisposed, stimulus driven ("bottom-up") mechanisms, which prefer regularity of visual information. The other relies on individual learning and experience and depends on various contexts. Thus, the visual system has a basic phylogenetically predisposed tendency to create regularity and stability in the world, but is further influenced by individual contexts and experiences.

Arnheim (1990) considered the importance of Gestalt factors in aesthetic experience, but was reluctant as to whether aesthetic quality could be explained by an elemental approach. While we share his view in principle, we show some possibilities that the nature of aesthetic experience might be approached by an investigation of the relationship between aesthetic preference and perceptual structure. Note that there are further possibilities that the issue of aesthetic preference can be understood through investigating neural activity (Spillmann 2007). The proposed scientific approach to aesthetic preference should not be mistaken to explain aesthetics for its own sake. The finding of general perceptual laws of vision should rather play the role of complementing rather than substituting aesthetics. Moreover, it might be possible to contribute paradoxically to protect the dignity of beauty, if we were able to define the limits between areas that can be approached scientifically and areas that cannot.

The present study shows a striking resemblance of the extent of aesthetic preference and of perceived illusion of size, area, and shape, both elicited by the same geometric patterns. Interestingly, this resemblance is neutral to the dimension of assimilation and contrast. This refers to the fundamental role of the respective spatial arrangement of objects so that they are perceived as beautiful. This was thoroughly investigated by Morinaga (1934) who concluded that the factors that govern an overall sense of balance, such as a central point or symmetry, also govern aesthetic arrangement. Perceptual balance thus may play an important role in aesthetic preference as well as in visual illusion. Well-balanced perceptual organizations might allow for strong interactions between stimulus components, which become manifested at the same time as giving rise

to visual illusions and aesthetic preferences. This might be in the same line with the Prägnanz tendency.

In Experiment 3, we found by using multi-regression analysis that aesthetic preference was not to be derived from 'the sum of components or parts', but only from 'the figure as a whole'. This firmly supports a Gestalt-like interpretation of the present findings as in other aesthetic investigations, recently stressed by Spillmann (2007) and Noguchi et al. (2007, 2008).

Aesthetic feelings do not simply arise from somewhere within the self, but typically result from an interaction between the self and its environment (Noguchi, 2003). Hence, it is important to approach beauty (as the metric properties of perception as shown in visual illusions) by studying the relationship between illusory deviations from the stimulus input and aesthetic preference within the same framework. The result that aesthetic judgment could not be explained by the summation of components of the Ehrenstein figure shows the importance of a holistic approach. Therefore we should concentrate on Gestalt qualities, especially on an "emotion-like" subclass of them, the qualities of essence ("*Wesensqualitäten*", see Metzger, 1954/2001) which we feel or meet in the phenomenal world when we consider the relationship between visual illusion and aesthetic preference (see also Noguchi 2003, 2007).

It seems that every perception obeys the Gestalt rules, and aesthetic judgment is a prime example for it rather than an exception. If so, it should be most promising to approach beauty by studying within a general framework of perceptual structure.

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Summary

Three experiments were designed to bridge between experimental aesthetics and visual psychophysics. The amount of either the illusion or the aesthetic preference were assessed independently and compared for the same geometrical pattern, using the Delboeuf, Jastrow and Ehrenstein figures. Aesthetic preference and illusory amount were found to co-vary, both resulting in an inverted V-shaped function across the stimulus variations for all three patterns. Moreover, multi-regression analysis was used to test whether aesthetic preference might result from summation of single components of the Ehrenstein figure. It was found that the aesthetic preference was not an additive sum of single components, but rather a compound effect of 'the figure as a whole'. Thus a Gestalt approach in the study of aesthetic experience and seen deviations from the stimulus input within a common perceptual framework seems to be most promising.

Keywords: Aesthetic preference, visual illusion, central tendency, perceptual structure.

Zusammenfassung

Drei Versuche dienten dem Zweck, zwischen experimenteller Ästhetik und visueller Psychophysik zu vermitteln. Der jeweilige Grad der Sehtäuschung bzw. der ästhetischen Bevorzugung wurde dabei unabhängig voneinander für dasselbe geometrische Muster bestimmt. Verwendet wurden hierzu die Figuren von Delboeuf, Jastrow und Ehrenstein. Für alle drei Täuschungsmuster kovariierten ästhetische Bevorzugung wie auch Täuschbarkeit im Sinne einer umgekehrt-U-förmigen Beziehung zur Reizvariation. Mit Hilfe einer mehrfachen Regressionsanalyse wurde für die Ehrenstein-Figur zusätzlich geprüft, ob sich die ästhetische Bevorzugung hierbei additiv aus den einzelnen Figurkomponenten ableiten lässt. Dies war jedoch nicht der Fall. Vielmehr fand sich eine Verbundwirkung der „Figur als ganzer". Eine gestalttheoretische Betrachtungsweise der ästhetischen Erlebnisse wie auch der von der Reizvorlage abweichender Seheindrücke erscheint somit innerhalb eines gemeinsamen Untersuchungsrahmens als höchst aussichtsreich.

Schlüsselwörter: Ästhetische Bevorzugung, Sehtäuschung, zentrale Tendenz, Wahrnehmungsstruktur.

References

Arnheim, R. (1990): Beauty and the brain: Biological aspects of aesthetics. *Leonardo 23*, 144-145.

Ehrenstein, W. (1925): Versuche über die Beziehungen zwischen Bewegungs- und Gestaltwahrnehmung. [Experiments on the relations between the perception of motion and form/gestalt]. *Zeitschrift für Psychologie 96*, 305-352.

Ehrenstein, W.H., Hamada, J. & Paramei, G.V. (2004): Size induction: Stimulus and brain correlates, in Oliveira, A.M. et al. (Eds.) (2004): *Fechner Day 2004: Proceedings of the 20th Annual Meeting of the International Society for Psychophysics* (pp. 70-75). Coimbra, Portugal: ISP.

Fechner, G.T. (1865): Über die Frage des goldenen Schnittes. *Archiv für die zeichnenden Künste 11,* 100-112.

Katz, D. (1935): *The world of colour.* London: Kegan Paul.

Koffka, K. (1935): *Principles of Gestalt psychology*. London: Routledge & Kegan Paul.

Luckiesh, M. (1922): *Visual Illusions. Their causes, characteristics and applications.* New York, NY: Dover Publications (reprint 1965).

Metzger, W. (1953): *Gesetze des Sehens*. Frankfurt am Main: Kramer.

Metzger, W. (1954/2001): *Psychologie – Die Entwicklung ihrer Grundannahmen seit der Einführung des Experiments*, revised 2nd. Ed. 1954; 6th reprint, Wien: Krammer-Verlag.

Morinaga, S. (1935): Conditions for size-assimilation and –contrast, in *Festschrift for Dr. Masuda*, pp. 28-48. Tokyo: Iwanami (In Japanese).

Morinaga, S. & Noguchi, K. (1966): Perceptual constancy and the system of reference. *Psychologische Forschung 29*, 149-160.

Noguchi, K., Wada, Y., Masuda, T., Tsuzuki, D. & Yoshino, D. (2007): Perceptual organization of form: "Seeing shape", in Noguchi, K. (Ed)(2007): *The Psychology of Beauty and Kansei: A New Horizon for Gestalt Perception,* 253-278. Tokyo: College of Humanities and Sciences, Nihon University.

Noguchi, K., Yoshino, D., Kimura, A., Mitui, K., Cha, J. & Kaneko, H. (2007): Perception and aesthetic experience: "Seeing beauty", in Noguchi, K. (Ed)(2007): *The Psychology of Beauty and Kansei: A New Horizon for Gestalt Perception*, 375-424. Tokyo: College of Humanities and Sciences, Nihon University.

Noguchi, K., Kitaoka, A. & Takashima, M. (2008): Gestalt-oriented perceptual research in Japan: Past and present. *Gestalt Theory 30*, 11-28.

Noguchi, K. & Rentschler, I. (1999): Comparison between geometrical illusion and aesthetic preference. *Journal of Faculty of Engineering Chiba University 50, 2,* 29-33.

Noguchi, K. (2001): The third approach to perception: Experimental phenomenology and empirical aesthetics. *Psychological Research, Nihon University 22*, 20-25. (in Japanese, with English summary).

Noguchi, K. (2003): The relationship between visual illusion and aesthetic preference – An attempt to unify experimental phenomenology and empirical aesthetics. *Axiomathes 13*, 261-281.
Noguchi, K. & Fujii, T. (1999): Gestalt factors in geometrical illusion: In case of Botti type figure. *Journal of Faculty of Engineering Chiba University 50*, 35-37. (in Japanese, with English summary).
Ogasawara, J. (1952): Displacement-effect of concentric circles. *Japanese Journal of Psychology 22*, 224-234.
Okakura, K. (1906): The book of tea. Tuttle Pub, (reprint 1956).
Oyama, T. (1962): The effect of hue and brightness on the size-illusion of concentric circles. *American Journal of Psychology* 75**,** 45-55.
Oyama, T., Torii, S. & Mochizuki, T. (2005): Pioneering studies in the 1930s on perception; A historical background of experimental psychology in Japan. *Japanese Psychological Research 47,* 73-87.
Rausch, E. (1952): *Struktur und Metrik figural-optischer Wahrnehmung*. Frankfurt am Main: Kramer.
Rentschler, I., Jüttner, M., Unzicker, A. & Landis, T. (1999): Innate and learned components of human visual preference. *Current Biology 13*, 665-671.
Rubin, E. (1921): *Visuell wahrgenommene Figuren*. Copenhagen: Gyldenalske. (Original Danish, 1915).
Schmann, F. (1904): Einige Beobachtungen über die Zusammenfassung von Gesichtseindrücken zu Einheiten [Some observations on the grouping of visual impressions into wholes]. *Psychologische Studien 1,* 1-32.
Spillmann, L. (2007): Artists and vision scientists can learn a lot from each other, but do they? *Gestalt Theory 29,* 13-39.
Yatsuka, N. (1969): *Experiments on the JASTROW illusion*. Honors thesis. College of Arts & Sciences: Chiba University. (in Japanese with English summary).
Wertheimer, M. (1923): Untersuchungen zur Lehre von der Gestalt. *Psychologische Forschung 4*. 301-350.

The third author, **Professor Kaoru Noguchi,** passed away on July 25th, 2006 without seeing this publication. We have tried to finish as much in his sense as possible. We dedicate the present study with our deepest sympathies and gratefulness.

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