Annual Bulletin of Institute of
Psychological Studies. 2004, Vol.7, 1-8.

論 文

# The *Prägnanz* tendency in 3–dimensional patterns

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## Abstract

This paper examines the *Prägnanz* tendency in 3–dimensional patterns in relation to the tendency to convexity. Past studies on *Prägnanz* have been carried out mainly with exemplification of 2–dimensional configurations. It would seem worth studying how the *Prägnanz* tendency would emerge in the case of 3–dimensional patterns and whether the tendency to convexity would also prevail. Two convex–concave patterns were used in this study, and the observers' reports were collected on how the patterns were perceived, with monocular and binocular views.

On both the patterns, monocular views led to the perception of uniform patterns instead of the convex–concave configurations, while binocular views sometimes led to the veridical perception.

In conclusion, the *Prägnanz* tendency was recognized in 3–dimensional patterns. The tendency to convexity was also observed.


*Key words : Prägnanz tendency（プレグナンツへの傾向）, 3-dimensional pattern（3次元パターン）, tendency to convexity（凸への傾向）*

## 1. Introduction

One of the most important principles of gestalt organization, which were proposed by gestalt psychologists, is *Prägnanz*. The *Prägnanz* tendency or the law of *Prägnanz* is generally defined as follows:

Psychological organization tends always to be as "good" as the prevailing conditions allow.

In a previous paper, the author reviewed researches on *Prägnanz*, scrutinized the definition of *Prägnanz*, and tried to clarify its conceptual ambiguity (Uemura, 1989). In the discussion included in the previous paper, the definition by Gaetano Kanizsa and Riccardo Luccio (1986) was found worth noticing. These authors argued about the ambiguity of the definition, and pointed out that on the one hand the notion of *Prägnanz* intended by Gestalt psychologists is a descriptive definition concerning the characteristics of an event which is "singular" ("ausgezeichnet"), and, on the other hand, an interpretative definition of a process in which the events tend to evolve not at random, but according to some well defined principles. The latter may refer to either a tendency toward a singular result or a tendency toward simplicity and economy of the process resulting in the stability of the outcome, or both.

### 1.1 Studies on Prägnanz

*Prägnanz* was first suggested by Wertheimer in 1912, who proposed the notion more clearly as the "gute Gestalt" (good form, figural goodness) and the "*Prägnanz Tendenz*" (*Prägnanz* tendensy) in 1923. After Wertheimer, Köhler(1920, 1969), Koffka(1935), Metzger(1953, 1975), and Kanizsa(1975,1979) discussed the principal aspects of *Prägnanz* and demonstrated persuasively various examples, in which the *Prägnanz* tendency was realized.

Even though the concept of *Prägnanz* provides convincing exemplification of phenomena, it has been criticized for its difficulty in allowing experimental and numerical verification, and thus for its difficulty in predicting and controlling phenomenal outcomes, unlike the law of grouping, e.g. the factor of proximity and the factor of similarity. Palmer(1999) stated in summary: *Prägnanz* was a radical notion when it was proposed, one that was probably well ahead of its time; unfortunately, however, gestalt theorists have never managed to formulate an explicit theory of shape perception based on it.

* Thanks are due to Tsuguya Shimizu, Graduate School of Science and Technology, Chiba University, for preparing the figures.

In order to answer the criticism and to improve the notion, theoretical and experimental analyses have been carried out (Kopfermann, 1930; Hochberg & Brooks, 1960; Rausch, 1966; Bear, 1973; Stadler, *et al.*, 1979; Hüppe, 1984; and others).

One of those analyses is the information-theoretical approach. It appreciated the importance of figural goodness for perception of shape, because "good" figures might be processed more efficiently by the visual system than "bad" figures. Garner(1974) gave strong support to this view, and demonstrated, through his experimental studies, that we can perceive the physical identity of "good figures" more quickly than "bad" ones, that we can remember "good" figures more accurately than "bad" ones, and that we can describe "good" figures in fewer words than "bad" ones.

From the viewpoint of the information theory, two questions have been raised. First, what factors determine how "good" a given shape appears to be; and second, how figural goodness can be related to our perception of shape. Palmer (1999) classified the information theory into the classical information theory (e.g. studies by Attneave, 1954; Hochberg and MacAlister, 1953; Garner 1974; Garner and Clement, 1963; Palmer, 1978, 1982) and the structural information theory. The structural information theory, formulated by Leeuwenberg (Leeuwenberg, 1971; Buffart & Leeuwenberg, 1983), provides a method for constructing different shape descriptions of the same object and for relating them to the *Prägnanz* tendency.

### 1.2 *Prägnanz* and the tendency to convexity

In discussing the role of regularity in perceptual organization, Kanizsa (1975, 1979) illustrated an example of "good" form by Sander (1928) (Figure 1). If figures A and B of Figure 1 are shifted till they just touch each other as in C, then at the moment of contact, they appear to change into two partially overlapping figures, viz. a circle and a hexagon. The apparent segregation of segments of the original figures occurs, because two new figures are more regular, more symmetric, and simpler than the original figures A and B. However, this segregation does not seem solely due to the regularity of the resulting

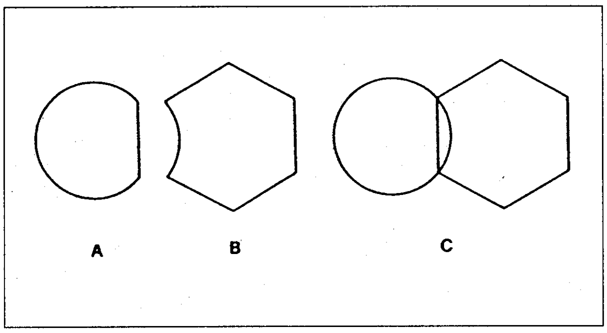


Figure 1. An example of segregation (1).

The configuration C is not perceived as the combination of A and B. Instead, it appears as a circle and a hexagon partly overlapped (Sander, 1928, from Kanizsa, 1979).

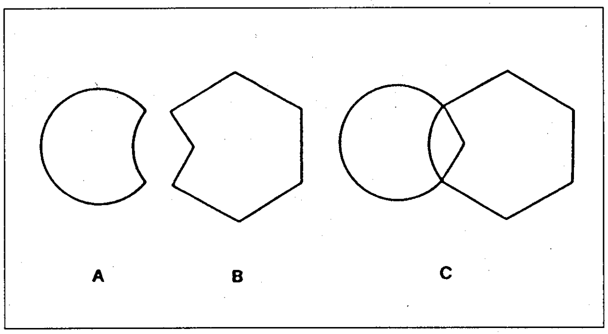


Figure 2. An example of segregation (2).

The configuration C is not perceived as the combination of A and B. Instead, it appears as two convex figures partly overlapped. In this case, however, the two apparently overlapping figures are not structurally "consistent" (Kanizsa, 1979).

figures. The relevant factor could be a "tendency to convexity". Figure 2, also illusrated by Kanizsa, shows that, if the same procedure as in Figures 1 is applied, then at the moment of contact, an exchange of segments appears to happen between figures A and B, though in this case two overlapping figures in C are not so regular as in Figure 1. Two figures which appear segregated from the original figures A and B are partly curvilinear and partly rectilinear, and hence each figure is not "consistently" structured in itself. A possible factor of this apparent segregation could be the "tendency to convexity", i.e., a preference of forms with convex boundaries to those with concave boundaries.

Kanizsa (1979) also discussed the factors of organization in "figure-ground" differentiation. He illustrated that, though the factor of symmetry is generally a prevailing factor, symmetry no longer

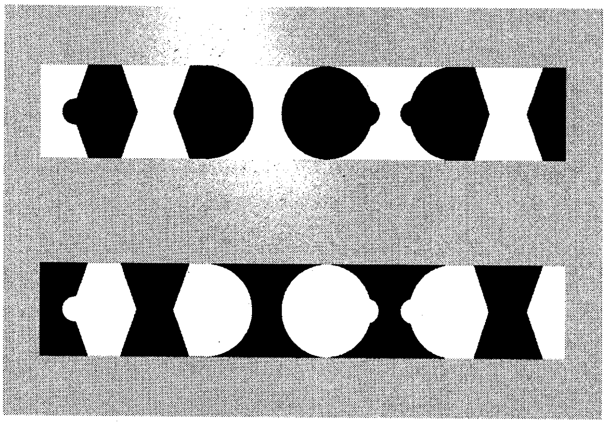

Figure 3. Convexity prevails over symmetry in an example of "figure-ground" differentiation (Kanizsa, 1979).

prevails when symmetry and convexity compete with each other,. This is shown in Figure 3, where the less symmetrical regions are convex and the more symmetrical regions concave, and where convexity prevails over symmetry. Kanizsa and Gerbino(1976) reported that in 90% of observations less symmetric convex regions were perceived as the "figures".

### 1.3 Phenomenal observation

Paolo Legrenzi and Paolo Bozzi wrote in the foreword of Kanizsa's seminal work (1979) as follows: in the world of research, the prevalent experimental method consists of the operation chain "model – verification – correction of the model – reverification – formulation of alternative models – reverification" as the basic structure; however, at times it becomes necessary to break this paradigmatic circle and to seek the natural, primary source of the phenomena, i.e. the visual experience of ordinary seeing; thus the scheme can be outlined as the procedure "theory – observation of everyday experience – discovery – laboratory verification – correction of theory", which applies in many of Kanizsa's successful investigations.

Kanizsa's procedure, described as above by Legrenzi and Bozzi, is still significant in psychological studies of visual perception and interdisciplinary research on vision and arts.

## 2. Observation of 3-dimensional patterns*

The purpose of this paper is to examine the *Prägnanz* tendency in 3-dimensional patterns in relation to the tendency to convexity. The observation patterns were chosen as images from the concave or convex structures in the architectural space in everyday environment. Studies on *Prägnanz* have been carried out mainly with exemplification of 2-dimensional configurations. Observations on 3-dimensional configurations would seem worth doing, as such configurations are abundant in our visual environment. One may ask how the *Prägnanz* tendency will emerge in the case of 3-dimensional patterns, and whether the tendency to convexity will prevail also in 3-dimensional patterns.

### 2.1 Method

2.1.1 Apparatus

Observations were carried out in a darkroom, using a closed chamber 157cm long, 95cm high, and 90cm wide, as shown in Figure 4 (side view). The walls of the chamber were covered with black velvet cloth. A partition in black color was installed in the chamber. The observer (O) looked through single- or double-eyeholes and through a round aperture window(A) of the partition which restricted the observer's visual field to 12.5° (diameter-wise). The pattern(P) was placed on the farthest wall of the chamber, with the pattern's center at the same level as the observer's eyes. The pattern was illuminated by 4 fluorescent lamps (10W, TOSHIBA Colorviewer, FL-10N-EDL), which were placed on the rear surface of the partition along each of the four sides. Thus the lamps were not visible to the observer.

* A part of this observation was reported by Uemura (1989).

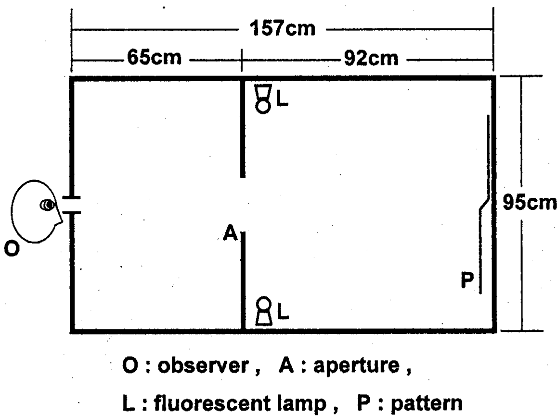


Figure 4. Schematic diagram of the apparatus (side view).

2.1.2 Observers

Four staff members of a psychology department participated as observers.

2.1.3 Stimuli

Various 3–D patterns were used as the targets of observation. Among these, the results of observations on two patterns (Figure 5) are reported in this paper. Each pattern was made of white craft paper, and had a vertical tube– or pipe–like form in the middle, with the diameter of 4cm. Four outer edges of the pattern were not visible to the observer.

***Pattern 1 (Figure 5-1)*** Half of the pipe was cut out vertically in such a way that, faced with the observer, the upper half was concave and the lower half convex. At the midpoint, where the concave and convex forms meet, a tilted ellipse was formed.

***Pattern 2 (Figure 5-2)*** There were three convex parts and three concave parts, arranged alternately, with five tilted ellipses in–between.

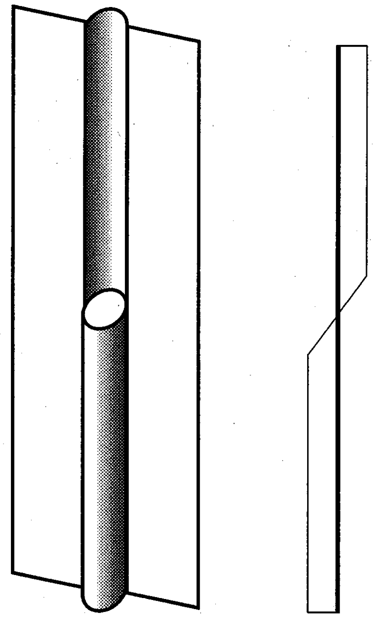

Figure 5-1 Pattern 1

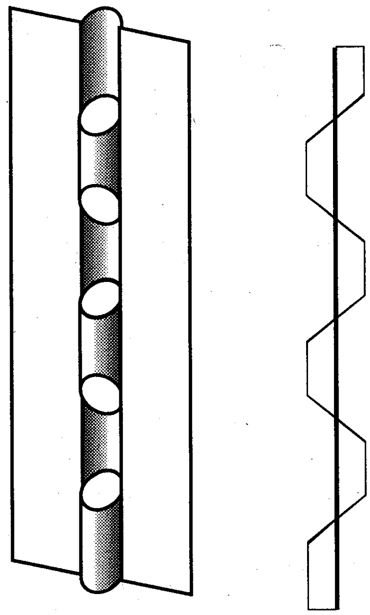

Figure 5-2 Pattern 2

Figure 5. Observation patterns.

Each right figure is a side view, which indicates the convex and concave parts of the pattern.

2.1.4 Procedure

Observers' verbal reports were collected on the appearance of the patterns.

There were four illumination directions towards the pattern, as mentioned above under Apparatus (2.1.1), which were determined by the location of lamps; vis., the top side [U], the bottom side [D], the left side [L], and the right side [R] of the rear surface of the partition. Among these four illuminating conditions, the results of observations in [U] and [D] conditions are reported here.

Observations were conducted first with the monocular (M) view, and then with the binocular (B) view. Luminance of the ellipse in Pattern 1 and three of the ellipses in Pattern 2 with the same tilt as that of Pattern 1 was ca. 70cd/m$^2$ in condition [U], and ca. 50cd/m$^2$ in condition [D]. Luminance of the other two ellipses in Pattern 2 was ca. 50cd/m$^2$ in condition [U], and ca. 70cd/m$^2$ in condition [D].

### 2.2 Results

Verbal reports on the appearance of Pattern 1 and Pattern 2 are shown in Tables 1 and 2. The encircled numbers in some columns indicate the dominance order of the appearance.

The typical modes of appearance of Pattern 1 were as follows (with abbreviations used in Table 1).

(1) a pipe with a vertically attached disc at the center of the pipe (p) .
(2) a pipe with a concave hemispheric part (an open mouth in a pipe) at the center of the pipe (p + m)
(3) a pipe with a round window at the center of the pipe (p + w)
(4) a concave half pipe with a vertically attached disc at the center (c– h–p)
(5) the pattern perceived veridically (V)

The typical modes of appearance of Pattern 2 were as follows (with abbreviations used in Table 2):

(1) a transparent pipe with five tilted elliptic discs (lighter or darker in lightness) (tp–p)
(2) a pipe with five round windows (p + w)
(3) a concave half pipe with five tilted elliptic discs (lighter or darker in lightness) (c–h–p)
(4) the pattern perceived veridically (V)

The main features of the results given in these tables may be summarized below.

***Pattern 1***

1. The monocular view did not produce the veridical pattern, in either of the illuminating conditions [U] or [D]. Instead, it led to illusory results indicating the same appearance for both the upper and lower parts of the pattern. More specifically: condition [U] produced the appearance of either a convex pipe with a disc (p), or a concave half pipe with a disc (c–h–p); and condition [D] produced the appearance of either a convex pipe with an open mouth or a window (p + m, p + w), but sometimes a concave half pipe with a disc (c–h–p).
2. The binocular view produced sometimes the veridical pattern. The dominant observations, however, were again the same appearance for the upper and lower parts of the pipe, namely, condition [U] led to a concave half pipe with a disc (c–h–p), and condition [D] to a convex pipe with a window (p + w).

***Pattern 2***

1. The monocular view did not produce the veridical pattern, in either of the illuminating conditions [U] or [D]. Instead, it led to illusory results indicating the same appearance for both the upper and lower parts of the pattern. More specifically: condition [U] produced the appearance of a transparent convex pipe with elliptic discs (tp–p), or that of a concave half pipe with elliptic discs (c–h–p); and condition [D] produced most frequently the

TABLE 1 Results of observation on Pattern 1.

Condition [U]

| obs. | A.W. | J.M. | L.O. | U.G. |
|---|---|---|---|---|
| M | c–h–p | ① p<br>② c–h–p | ① p<br>② c–h–p | c–h–p |
| B | c–h–p | c–h–p | c–h–p | ① V<br>② p |

Condition [D]

| obs. | A.W. | J.M. | L.O. | U.G. |
|---|---|---|---|---|
| M | p + m | c–h–p | p + m | ① p + w<br>② c–h–p |
| B | ① p + w<br>② V | ① V<br>② c–h–p | ① p + w<br>② V | ① p + w<br>② c–h–p |

obs: observers
M : monocular view , B : binocular view
The other abbreviations are explained in detail in the text.

TABLE 2 Results of observation on Pattern 2.

Condition [U]

| obs. | A.W. | J.M. | L.O. | U.G. |
|---|---|---|---|---|
| M | tp–p | c–h–p | tp–p | ① c–h–p<br>② tp–p |
| B | ① V<br>② tp–p | ① c–h–p<br>② V | ① V<br>② tp–p | c–h–p |

Condition [D]

| obs. | A.W. | J.M. | L.O. | U.G. |
|---|---|---|---|---|
| M | tp–p | c–h–p | tp–p | ① p + w<br>② c–h–p |
| B | ① tp–p<br>② V | ① V<br>② tp–p | ① tp–p<br>② V | V |

obs: observers
M: monocular view, B: binocular view
The other abbreviations are explained in detail in the text.

appearance of a convex pipe with elliptic discs (tp–p), or with windows (p + w).

2. The binocular view led to the perception of the veridical pattern in about half of the observations. Otherwise, the non–veridical results indicated the same appearance for all the parts of the pattern: condition [U] led to the dominant appearance of a half pipe with elliptic discs (c–h–p); and condition [D] led to the appearance of a transparent pipe with elliptic discs (tp–p).

### 2.3 Discussion

Using two 3–dimensional patterns, our observations indicated that the monocular view did not produce the veridical pattern, and led to the perception of uniform patterns instead of the convex–concave configurations, while the binocular view produced sometimes the veridical pattern, as stated in section 2.2 above. The *Prägnanz* tendency was recognized and the tendency to convexity was also observed.

Those results are discussed below, with reference to the previous studies published by other workers.

#### 2.3.1 *Prägnanz* and the tendency to convexity

Biederman (2003) questioned the relation between the *Prägnanz* tendency and the tendency to convexity. He pointed out that no studies had yet been made on the relative functional roles of these tendencies, and proposed a hypothesis in answers to this question.

We shall first mention relevant analyses carried out so far on the object recognition and then discuss his assumption.

#### 2.3.2 Analyses on the object recognition

When we recognize complex objects and surfaces, we also recognize their distinct parts. How does the visual system distinguish the parts from the structural characteristics of the whole object ?

There are two ways to parse an object into parts at the most basic level, namely, using shape primitives or boundary rules (Palmer, 1999). A set of parts are first identified by either ways, and higher–level parts can then be constructed by the grouping principles proposed by gestalt psychologists.

According to the shape–primitive approach, any object can be divided into primitives. The approach proposed by Biederman (1987) assumes that an object can be specified in terms of spatial arrangements of a limited number (less than 50) of primitives, volumetric 3–dimensional components, which he named as "geons", a shortend term coined from "geometric ions". Biederman estimates that most objects may be successfully recognized on the basis of only two or three parts, drawn from the totality of the geons involved in their specified relations. The geons can be distinguished from each other from most viewpoints, even when they are partially occluded. The object itself may be complex, but the parts themselves are simple, and can be identified from arbitrary orientations in depth.

According to the boundary rules approach, on the other hand, an object can be divided into parts by applying a set of rules that specify where part boundaries are located. The boundary rules work directly on the whole object, without specifying the nature of the resulting parts beforehand.

The analysis of visual parsing proposed by Hoffman and Richards (1984), was based on a geometric property of a complex multipart object, with one part penetrating another. The key property, "transversality regularity", refers to the fact that, when one part penetrates another, they tend to meet in concave discontinuities, places where their composite surface is not smooth, but angles sharply inward toward the interior of the composite object. These discontinuities are used to divide an object into parts.

#### 2.3.3. The assumption proposed by Biederman

Biederman's geon theory proposes that we can understand the *Prägnanz* tendency and the tendency to convexity in terms of fundamental processes by which complex objects are decomposed into convex regions at the points of matched cusps according to the transversality regularity. Such decomposition yields simple convex parts segmented between the concavities. He claims that geon theory leads to the expectation that the shape recognition proceeds most efficiently when the parts are *prägnant*. *Prägnanz* and convexity may reflect the operation of perceptual mechanisms designed to infer a 3–dimensional world from parts segmented from a 2-dimensional retinal images. In this manner, complex shapes and objects, even unfamiliar to us, can often be decomposed into simple parts. The transversality regularity holds that, whenever two shapes are interpenetrated, they will produce a pair of matched cusps (upper part of Figure 6). He claimed that the perceptual organization reflects the transversality regularity, and that, if complex objects are decomposed at matched cusps, one is left with regions (or parts) that are convex (lower part of Figure 6). He thus proposed the principle as follows:

> "A cusp that is formed by the combination or interpenetration of shapes – and which would make a figure complex– is interpreted as a property of the join, not of the component parts of a figure. Convex shapes will tend to be judged as simpler than shapes with concavities".

He emphasized that this principle will not depend on familiarity with the object in question.

Biederman concluded: The process that is important for understanding both *Prägnanz* and convexity is shape decomposition for purposes of recognition.

Biederman did not specifically relate their work to the *Prägnanz* tendency in 3–dimensional configurations such as used in the observations reported in the present paper, though, the appearance of the convex, uniform "pipe" observed on the both patterns might perhaps be interpreted as the results of visual processing of cusps, which are made at the joining points of vertical and elliptic surfaces in the pattern.

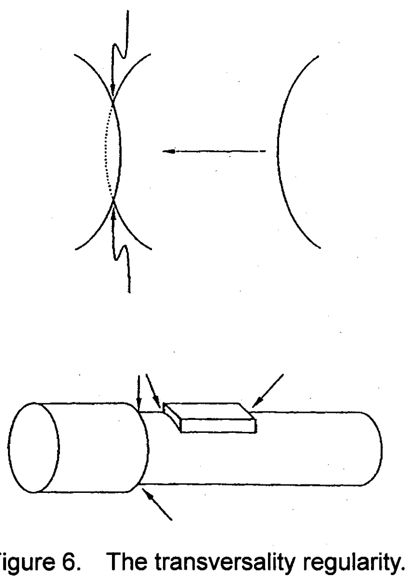

Figure 6. The transversality regularity.

A pair of arrows (upper part) indicates the matched cusps (slightly modified from Biederman, 2003).

Observations reported in the present paper indicate the existence of the *Prägnanz* tendency and the tendency to convexity, even though the scope of the stimuli and conditions investigated is limited. To verify the *Prägnanz* tendency in 3–dimensional configurations more rigorously, further observations and experiments should be continued.

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