Art and Visual Perception
by Rudolph Arnheim

Notes by Frederic F. Leymarie

September 12, 2001

Contents

The following consists of fundamental notions and interesting ideas and examples extracted (in most part) from Rudolf Arnheim's wonderful book [1].

"Vision is not a mechanical recording of elements but rather the apprehension of significant structural patterns." (p. 6)

---

1 Balance

"Visual experience is dynamic". (p. 11)

Psychological Forces : What a person perceives is not only an arrangement of objects, colors, shapes, movements and sizes, but, perhaps first of all, an *interplay of directed tensions*. The latter are inherent in any percept. Because they have magnitude and direction they are called *psychological forces*.

Example 1.1 (Dark disk within a square) *Imagine a black disk positioned within a square (with a black boundary and white interior or background). If the disk is positioned slightly away from the center of the square, the assymetry of the scene is perceived as a "tension": the disk strives toward the center of the square (see Fig. 1, p. 10). In the vicinity of a boundary the disk is attracted towards it (see Fig. 2, p. 12).*

Structural Skeleton : The disk, in the previous example, is influenced not only by the boundaries and the center, but also by the *axes of symmetry* (see Fig. 3, p. 13).[1] In general, any location which coicides with a feature of the structural skeleton introduces an element of stability, which may be counteracted by other factors.

The structural skeleton serves as a *frame of reference* by helping determine the role of each pictorial element within the balance system of the whole (more on this subject in § 2.5, p.8).

Balance : The corners and the center are "magnets of unequal power". The point of balance between a corner and center lies somewhat closer to the corner, as if the center was stronger. Psychological, as physical, systems exhibit a very general tendency to change in the direction of the lowest attainable tension level (see Fig. 4, p. 15).

The Percept as a Potential Field : The percept is really a *continuous field* of forces. It is a dynamic landscape, in which lines (of the structural skeleton) are actually ridges slopping off in both directions. These ridges are centers of attractive and repulsive forces, whose influence extends through their surroundings, *inside* and *outside* the boundaries of the figure (e.g., the square; see Fig. 3, p. 13). There is no point free from these forces. "Restful" points are in balance under tension.

[1] This is like the Medial Axis of Harry Blum explored in Computer Vision as a framework for representing shape and its significant geometric features.

Static measurements define only the "stimulus", *i.e.*, the message sent to the eye by the physical world. But the life of a percept — its expression and meaning — derives entirely from the activity of the perceptual forces. *Any line* drawn on a sheet of paper, is *like a rock thrown into a pond*. Seeing is the perception of action.

1.1 What are Perceptual Forces ?

Every aspect of a visual experience has its physiological counterpart in the nervous system (p. 17).

Physiological Field Processes : The nature of these brain processes is such that they can be thought of as *field processes* where interactions between the parts and the whole are a general phenomenon.

1.1.1 Visual Weight

Visual weight can be generated by many factors.

Dynamic effect : Visual weight is always a *dynamic* effect, but the tension [it produces] is not necessarily oriented along a direction within the picture plane.

Position's influence : Weight is influenced by "location". E.g., a pictorial object in the center can be counterbalanced by smaller ones placed off-center. According to the *lever principle*, the weight of an element increases in relation to its distance from the center.

Depth's influence : The greater the depth an area of the visual field reaches, the greater the weight it carries. Why is that? Perhaps due to a *counterbalancing effect to foreshortening*. Also, it is possible the the "volume of empty space" in front of a distant part carries weight.

Size's influence : Other factors being equal, the larger the object, the "heavier" it is perceived to be.

Color's influence : Red is "heavier" than blue, and *bright* colors are "heavier" than dark ones. E.g., a black area must be made larger than a white one to counterbalance it; this is due in part to irradiance, which makes a bright surface look relatively larger.

Intrinsic interest : Because of its formal complexity, intricacy, or other peculiarity, a visual area may look heavier.

Isolation : Makes for weight; e.g., the moon in an empty sky.

Shape's simplicity : The more regular ("simple") a shape, the heavier (e.g., circles or squares). *Compactness*, *i.e.*, the degree to which mass is concentrated around its center, seems also to produce weight.

Shape's orientation : Vertically oriented forms seem heavier than oblique ones.

Knowledge's influence : Seems to have little influence, if any, on visual weight.

1.1.2 Visual Direction

The direction of visual forces is determined by many factors.

Weights attraction : Attraction exerted by the weights of neighboring elements.

Structural skeleton : Directions along the axes of the structural skeleton of a shape.

Subject matter : E.g., the direction in which the eyes (of a portrait) are pointing.

Movement : E.g., objects moving simultaneously toward each other or toward the same point.

1.1.3 Top versus Bottom

Claim 1.1 *The higher one must be lighter.*

That is, weight in the upper part of perceived space counts more than in the lower part.[2] E.g., "a perfect square when viewed vertically appears too high", but "the illusion does not appear to exist in the circle" [5, p.45].

Environmental orientation : The objective, physical vertical (gravitational) direction.

Retinal orientation : The (purely) "view-centered" orientation.

Note that, although weight counts more in the upper part of visual space, we are accustomed to experiencing the normal visual situation as "bottom-heavy", *i.e.*, the bottom is usually more "crowded" than the top.

Visual illusions

Consider the letter "S" or the numbers "8" and "3". If we invert them, *i.e.*, S , 8 and Ɛ , then we become conscious of the difference in the upper and lower parts [5, p.45]. See also the number "3" of Fig. 14, [1, p.31]. Similarly, consider an inverted "$\top$", *i.e.*, "$\perp$" or a "silk hat". Even if the horizontal and vertical lines have the same length, the vertical one appears much longer (see Fig. 4 & 5, [5, p.46-7]).

---

[2] It is not known whether the distribution of visual weight differs depending on, e.g., whether we see a picture on the wall - "environmental direction" - or on the table - "retinal orientation" (p.30).

1.1.4 Right versus Left

- Pictures are "read" from left to right.
- The diagonal that runs from bottom left to top right is seen as ascending, the other as descending.
- Any pictorial object looks heavier at the right side of the picture.
- The observer subjectively identifies with the left, and whatever appears there assumes greater importance. E.g., the left side of the stage.
- Pictorial movement toward the right is perceived as being easier.

1.1.5 The Pseudo-Thermodynamics of Mind

The principle of *entropy*, *i.e.*, the second Law of thermodynamics, asserts that in any isolated system, each successive state represents an irreversible decrease of energy.

Principle 1.1 (Basic (Gestalt) Law of Visual Perception) *Any stimulus pattern tends to be seen in such a way that the resulting structure is as simple as the given conditions permit.*

However, in visual perception one observes an interaction between an active counter-principle ("energetic life force") and the tendency towards balance (more on this in Chapter IX on *Dynamics*).

2 Shape

Claim 2.1 (Global over local) *The overall structural features are the primary data of perception, not the individual details.*

What is Shape ? Perceptual shape may change considerably when its spatial *orientation* or its *environment* changes. Visual shapes influence one another. The shape of an object is determined not only by its boundaries; the *skeleton of visual forces* created by the boundaries may, in turn, influence the way boundaries are seen. Shape also depends on *memories* or experiences we've had with a particular object. The shape of an object is depicted by the *spatial features* that are considered *essential*.

2.1 Simplicity for Shape

Simplicity here is *quantitatively* measured in terms of *structural features* not in terms of number of elements or patterns. Simplicity requires a correspondence in structure between meaning and tangible pattern, what Gestalt psychologist called "isomorphism".

Example 2.1 (Figural goodness) *[3]*
"The smaller the amount of information *needed to define a given organization as compared to other alternatives, the more likely that the figure will be so perceived."*

Hochberg used three quantitative (perceptual) features in his study:

1. The number of *angles* enclosed within the figure.
2. The number of different angles divided by the total number of angles.
3. The number of continuous lines.

But, "the perceptual experience of looking at a figure cannot be described [simply] as the sum of the perceived components" (p.58). Furthermore, it is not *absolute* simplicity that we are interested in, but *relative* simplicity which implies parsimony and orderliness.

Principle 2.1 (Parsimony) *(p.59)*
"One hypothesis is said to be simpler than another if the number of independent types of elements in the first is smaller than in the second".

2.1.1 Simplification Demonstrated: Effect of Distance

According to Lucretius, "when far off we see the foursquare towers of a city, they often appear to be round", and Leonardo da Vinci observed that when a human figure is seen from afar, he "will seem a very small round dark body."

Thus, distance weakens the stimulus to such an extent that the perceptual mechanism is left free to impose upon it the *simplest possible shape*, *i.e.*, the *circle*. Note that, *distance in time* as much the same effect as distance in space.

2.2 Sharpening

The tendency to reduce the number of structural features and thereby to simplify the pattern is not the only one at work, "other tendencies are active as well." (p.66)

Sharpening : The opposite to simplification, where instead of reducing the number of structural features, discrimination of the existing ones is made more clearly.

E.g., if a pattern is slightly asymmetric, one may "perceptually" make it *more symmetric* (*i.e.*, simplification by "leveling") or, on the contrary, make it *more asymmetric* (*i.e.*, "sharpening" of the percept) (see Fig. 40, p. 66).

Principle 2.2 ((Gestalt) Law of Prägnanz) *Superordinate tendency to make perceptual structure as clear-cut as possible.*

The Law of Prägnanz encompasses both tendencies of sharpening and simplifying.

2.2.1 Leveling and Sharpening

"Leveling" is characterized by properties such as unifcation, enhancement of symmetry, reduction of structural features, repetition, dropping of non-fitting detail, elimination of obliqueness. Leveling involves a *reduction of the tension* inherent in the visual pattern.

"Sharpening" enhances differences, stresses obliqueness. Sharpening increases the tension inherent in the visual pattern.

Leveling and sharpening in general occur together in the same drawing.

Example 2.2 (Painting styles) Classicism *tends toward simplicty, symmetry, normality and the reduction of tension.* Expressionism *heightens the irregular, the asymmetrical, the unusual, the complex, and strives for the increase of tension.*

2.3 Parts

Goethe said "appearance and segregation are synonyms".[3]

Genuine parts : Sections representing a segregated subwhole within the total context.

Pieces : Mere portions, *i.e.*, sections segregated only in relation to a limited local context or to no inherent breaks in the figure at all.[4]

"The appearance of any part depends, to a greater or lesser extent, on the structure of the whole, and the whole, in turn, is influenced by the nature of its parts." (p.78) The geneticist Waddington said [8]:

> ... whole skeletons have a "quality of completeness"; the single bones have only "a certain degree of completeness". Thus, the shape of a part carries implications about the other parts to which it is attached, and when isolated it is "like a tune which breaks off in the middle."

[3] "Erscheinung und Entzweien sind synonym."

[4] Compare these definitions of "parts" and "pieces" to Ben Kimia's notion of "parts" (and necks) and "limbs" [4, 7].

2.4 Similarity

Grouping by similarity occurs in time as well as space. Any aspect of percepts - shape, size, brightness, color, spatial location, movement, etc. - can cause grouping by similarity, but comparisons make sense only when they proceed from a common base

Grouping versus Splitting : Grouping proceeds "from below" (*i.e.*, a *bottom-up* or local process), while splitting or subdividing proceeds "from above" (*i.e.*, a *top-down* or global process).

Conjecture 2.1 (A possible process for grouping: Diffusion) *Paul Weiss suggested using diffusion for the grouping of dots, this to explain the percept of stars constellation (see Fig. 60, p.84). Weiss asked: does a "similar dynamic interaction pattern in human's brain has guided his interpretation" of the constellation? [9]*

Virtual boundaries : These can be created by grouping "end-of-lines" (see Fig. 61, p.85) or think of the "sun illusion" (or Ehrenstein illusion).

Multiple choices : When there is a choice between several "paths" of grouping, the spontaneous preference is for the one that carries on the *intrinsic structure* most consistently. E.g., in the case of having a choice between several possible continuation for lines (touching or crossing each other), the intrinsic structure used to select a "path" appears to be *curvature* (see Fig. 63, p.86).[5]

Global similarities : "Going beyond the relations between parts, one arrives at similarities definable only in reference to the whole pattern." *Symmetry* is such a similarity.

2.5 The Structural Skeleton

"Although the visual shape of an object is largely determined by its [outline], the *boundaries cannot be said to be the shape*." In "speaking of *shape* we refer to two quite different properties of visual objects:

1. the actual boundaries [or outlines], and
2. the structural skeleton created in perception by [the] material shapes, but rarely coinciding with them."

Delacroix said that in "drawing an object, the first thing to grasp about it is the *contrast of its principal lines."* [2]

[5]This is very relevant to the work of Zucker *et al.* on building support for curve traces via the use of tangent and curvature classes, and the constraint of co-circularity [6].

Example 2.3 (Triangular shapes (pp. 93-94)) *Different triangles have distinctly different visual characters, which cannot be inferred from their actual shape, but only from the structural skeleton their shape creates by induction (see Fig. 73, p. 94). The resulting skeleton of each triangle derives from its contour through the "law of simplicity": the* resulting skeleton is the simplest structure obtainable with the given shape.

The same structural skeleton can be embodied by a great variety of shapes (p.95). But, think of the associated radius function, ρ, of Blum's SAT. The same (structural) skeleton with different ρ will correspond to different objects; these objects might be said to fall in the same *symmetry class*. That is, they are part of an equivalence class in term of their symmetry structure, but they may have different size or width properties (given by ρ).

Claim 2.2 (Multiple percepts from one stimulus) *If a given visual pattern can yield two different structural skeletons, it may be perceived as two totally different objects.*

Example 2.4 (The duck-rabbit paradox) *This is a (famous) drawing which can be seen as the head of a duck looking to the left or as that of a rabbit looking to the right. But, note that "this particular drawing allows for two contradictory, but equally applicable, structural skeletons pointing in opposite directions", which appears to resolve/explain the paradox of having two percepts from one single stimulus. (p.95)*

3 Form

References

[1] Rudolf Arnheim. *Art and Visual Perception: A Psychology of the Creative Eye*. University of California Press, Berkeley, CA 94720, U.S.A., 1974. New version; expanded and revised edition of the 1954 original. 508 pages.

[2] E. Delacroix. *The Journal of Eugene Delacroix*. Number C335 in A Viking compass book. Viking Press, 1972. 762 pages. Translated from the French by Walter Pach. Illustrated with reproductions of drawings by the artist.

[3] J. Hochberg and E. McAlister. A quantitative approach to figural "goodness". *Journal of Experimental Psychology*, pages 361–364, 1953.

[4] B. B. Kimia, A. Tannebaum, and S. W. Zucker. Toward a computational theory of shape: An overview. pages 402–407, 1990.

[5] M. Luckiesh. *Visual Illusions: Their Causes, Characteristics & Applications*. Explaning Science Series. Dover, NY, 1965. 252 pages. Unabridged and unaltered republication of the original 1922 D. van Nostrand edition. With a new introduction by William H. Ittelson.

[6] P. Parent and S. W. Zucker. Trace inference, curvature consistency and curve detection. *IEEE Trans. on PAMI*, 11(8):823–839, August 1989.

[7] Kaleem Siddiqi, Kathryn J. Tresness, and Benjamin B. Kimia. Parts of visual form: Ecological and psychophysical aspects. *Perception*, 25:399–424, 1996.

[8] C. H. Waddington. The character of biological form. In Lancelot Law Whyte, editor, *Aspects of Form: A Symposium on Form in Nature and Art*, pages 43–52. Lund Humphries, London, England, 2^{nd} edition, 1968. 254 pages.

[9] Paul A. Weiss. One plus one does not equal two. In Gardner C. Quarton, Theodore Melnechuk, Francis O. Schmitt, et al., editors, *The Neurosciences: A Study Program*. Rockefeller University Press, 1967. 962 pages.