

# The nature of the visual field, a phenomenological analysis<sup>☆</sup>



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## ABSTRACT

The visual field is the spatial form of visual awareness, that is, immediate visual experience ignoring qualities and meanings. Such an entity only exists in the discursive representation, for the awareness as such is quality and meaning throughout. Thus the discursive, formal treatment is necessarily limited. We identify a number of important distinctions of a geometrical nature. This description is confronted with experimental phenomenology, that is the psychology of the Gestalt Schools, and with well known principles of artistic practice. We also trace the connections with biology, especially ethology, aesthetics, and the field of cognitive science based upon Cassirer's concept of symbolic forms.

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## 1. Geometry of the visual field

In this paper we discuss the simultaneous structure of visual awareness, often referred to as the “visual field”. It is an operationally defined “geometry” (not in the conventional, formal sense), explored through experimental phenomenology [1].

We know the visual field only through immediate visual awareness, it has no existence outside of that. Although a twofold extended manifold (topologically a “plane”), it is evidently *very much unlike* your trusty Euclidean plane [4,8]. It has the topology of the disk, with an ill defined boundary. It has finite, graded resolution. Moreover, there is evidence that at any single location a range of resolutions is “active”. It manifests itself often differently from one glimpse to the next.

Although the visual field is familiar to everybody as part of immediate visual awareness, it is generally considered to have roots in the physiology of the “visual front end”, composed of eye, retina, primary visual cortex, and (according to choice) up to a few dozen “visual areas”.

Many scientists even go as far as to *identify* the visual field with the front-end. This is an unfortunate move. The relations between the “physical world” in front of the observer, the “optical structure”, that is the radiance incident upon the cornea, the “brain activity”, that are electrochemical processes in the skull of the observer, and the “visual awareness” that is part of the mind of the

observer, are ill, if at all, understood. Causal relations are not possible between the ontologically distinct levels of physics and mind. Here one relies on “bridging hypotheses” of various kinds. An example is the “isomorphism” hypothesis used in early Gestalt psychology [21]. The modern conviction that somatotopy explains the visual field [18] is essentially a variation on that. It is embarrassing in its naïveté. Thus the topic of the “geometry” of the visual field is a challenging one. It stands in need of formal development.

In this paper we intentionally circumvent the hairiest problems by using an abstract overall model of the genesis of visual awareness. This allows us to straddle the wide ontological gap in a simple, formal manner.

It is important to understand that the visual field is a mysterious place. This may not be so evident in focal vision, but it becomes immediately evident in attempts to experience eccentric vision. Fixate a point in the scene in front of you, and concentrate your mind on a location away from the fixation point. But make sure not *to look* at that location! Try to describe the best you can what is your visual awareness. This will be *hard*, very hard. Words are only somewhat useful here, sketching your experience as a simple doodle is perhaps more appropriate. The things you are aware of will be very difficult to describe, no matter how, and have only a fleeting existence.

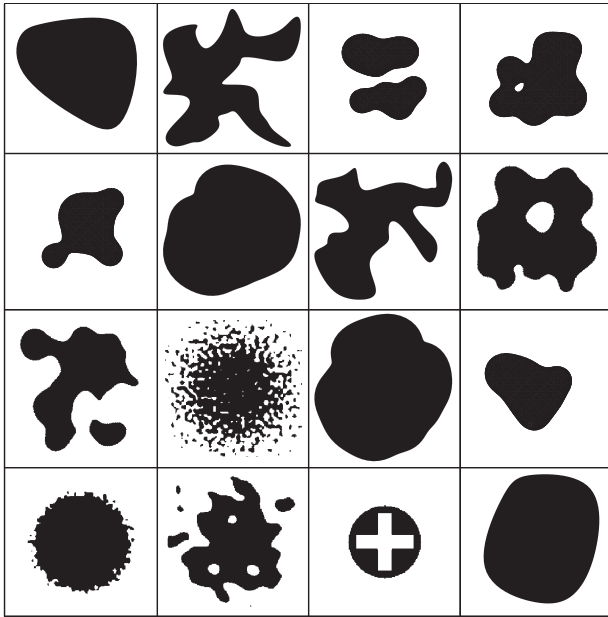
This experience is not particular to the eccentric visual field. It is not different in “vision proper”. For *mystery is everywhere*, although most people never notice [41–46].

Here is an exercise that will prove this to you. Sit in front of a bookcase at such a distance that you are just unable to read the booktitles, whereas you are well aware of the lettering and so forth. Try to draw exactly what you see. This exercise is like Chinese torture, at least if you play it honestly. Yet this type of mystery is what your vision deals with on a regular basis. “Understanding vision” certainly implies that you can deal with what goes on here. At this particular stage in history

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**Fig. 1.** Here are some “points”. Of course, a “point” is a *point* only at a scale when its internal structure is ignored. The internal structure still gives the point an identity. The possibilities are infinite. Something is a “point” if your psychogenesis designates it that. A point may “explode” into structure when you scrutinize.

no one can, which is why it is—or at least, should be—an important frontier of science.

The simultaneous presence in your awareness evidently is of some “geometrical” nature. But it is a geometry that is hard to describe. Even being able to discuss the phenomenology should count as important progress. Here we give it a try, for better or worse. Any little headway—even just grasping the magnitude of the problem—is certain to be useful.

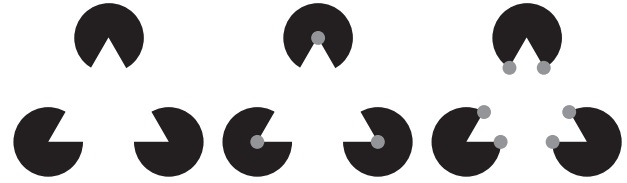
### 1.1. Geometrical configurations

“Configurations” are entities like triangles, circles, irregular “blobs”, and so forth. “Geometrical configurations” are structures composed of points, and lines, that satisfy certain constraints. In this section we deal exclusively with such geometrical configurations.

#### 1.1.1. Fiducial geometrical elements

The basic geometrical elements are uniform areas, and local marks (to be amplified below). A common uniform area in daily life is the blue sky. It is a single non-composite entity, that is to say, it is by no means composed of points, or pixels. In a digital photograph the blue sky is “made up” of blue pixels. In visual awareness there is no such notion.

In the simplest cases, which are rare, the local marks have no further structure, and may be considered “points”. Geometrically, a point is fully characterized by its location. As Euclid has it “a point is that which has no parts”. The fact that one ignores its internal structure makes it a point [4,19]. However, only the fact that there usually is an internal structure makes it possible to *identify* the point. A bit like our university town Leuven on a map of the world. It gives the point its individuality (see Fig. 1). As said above, there are no points in the blue sky, this is because that would violate [26] Identity of Indiscernibles. Other than internal geometrical structure, a point might have qualities, e.g., color. We are not concerned with qualities here. A point is thus created by “placing” it. It is an intentional entity.



**Fig. 2.** At left the famous Kanizsa triangle [20]. It shows a depth layering that will be discussed later in the paper. Here it is of interest that the gray points in the figure at center are “intentionally placed”, whereas the points indicated in the righthand figure do not exist in this manner.

To place a point is an intentional act of psychogenesis.<sup>1</sup> Psychogenesis starts as a mere “hallucination”, and gains existential power when it completes “reality checks” in the visual front end [3]. The “placing” is relative to other matter in the visual field, which also has “evidence” of some kind in the visual front end (see Fig. 2). Visual awareness is a purely mental affair, whereas the “evidence” in the visual front end is based upon patterns of electrochemical activity, the world as you—or rather some brain scientist—might find inside your skull. Brain activity is physical structure, in principle not different from footprints in the sand of a beach. The “meaning” of such patterns is again due to psychogenesis. One is dealing with a circular process here. Psychogenesis “accounts for” front end activity by adjusting its hallucinations in a suitable manner. This explains why it increases your biological fitness.

Psychogenesis is a systolic process, that delivers updates at a rate of about a dozen a second [3]. Thus it just keeps up with the volatile, continuously overwritten, contents of the front end buffers. The updates are in legato style, thus it is not possible to identify individual “frames” as in a video clip. Thus time is continuous, although the “moments”, as recorded by an external observer, have finite duration. We will succinctly speak of “beats”, no moment implying a discrete structure.

The beats of psychogenesis occur phenomenologically as glimpses of immediate visual awareness. Awareness “just happens” to you, there is nothing you can do about it. Actually, it would be better to drop the “to you”, because immediate awareness does not involve a notion of “self”, although we would not press this point.

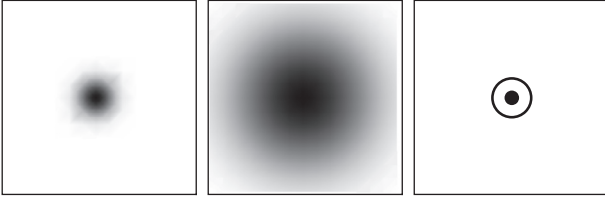
A “point” of the visual field is thus a formal, intentional entity. It may or may not re-occur at the next beat of the psychogenetic process. If it does, it is still a novel creation, it does not “endure”. The continued being of a point is due to its recreation from beat to beat. The psychogenetic process tries to account for the front end activity best as it can. Its “reality checks” are bound to yield slightly different results from beat to beat, even if the scene is fixed. This is modeled by treating a point as a *stochastic* element.

We use an isotropic normal distribution, and draw a fresh location at every beat. The center of the distribution may be regarded as the goal of the intentional act, whereas the sample may be regarded as the result after the “reality check”. This is how the physical world, through the physiology of the front end, appears to modulate awareness, an empty notion, because psychogenesis “modulates” itself.

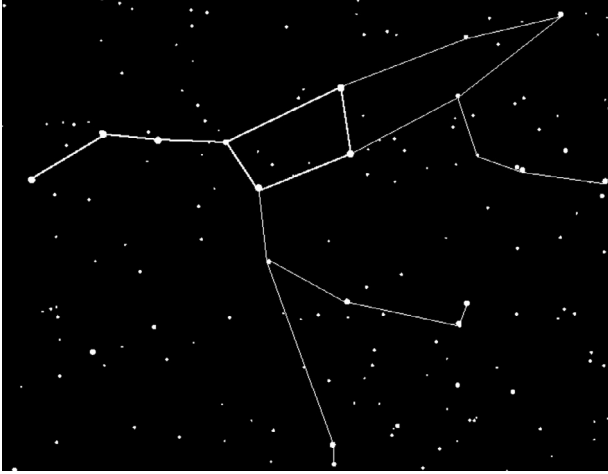
Over some time span one meets with various instances of the point that statistically define a “fuzzy” [57] point-like entity. We sometimes speak of “fuzzy points”, and by that will refer to the distribution of successive instantiations of a single fiducial point. (See Fig. 3.)

Such a system has the advantage that psychogenesis may ignore optical structure, and that it may hallucinate structure for which no front-end structure is present at all, a frequent occasion in daily life. On the whole, vision is bound to promote the agent’s fitness—in the

<sup>1</sup> Notice that we use “psychogenesis” in preference to the more conventional term “microgenesis”. This usage should hardly be objectionable, since alternative uses of psychogenesis play no role here.



**Fig. 3.** At left a small, at center a large point (threatening to fill the frame!). In this representation, the blacker, the more point there is. Either point is formally represented with the iconic point at right. This symbolic point is just an abstract representation, it has *no size* the way real points have.



**Fig. 4.** The constellation *Ursa major* (“the big dipper”). The “Brückenlinien” (“bridge lines”) of the Gestalt psychologists have been independently seen by cultures all over the globe. In that sense they are “real” enough.

biological sense—though. The process creates a “reality” that is likely to subserve efficacious actions [16].

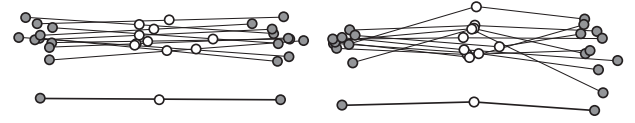
Intentional points may have two degrees of freedom. In simple terms, they may be shifted left-right and/or up-down. In case some constraint is active, the freedom may be less, even zero. If there is non-zero freedom, the point will be called a “fiducial point with so and so many degrees of freedom”.

#### 1.1.2. Bound geometrical elements

Some geometrical elements are purely intentional, in that they do not rely on a reality check in the front end at all. Perhaps the simplest example is a line through two points. We may assume the points to be fiducial points with two degrees of freedom. We draw a line through the points as in Euclidean geometry. There is no need to do any reality checking, the points take care of that. One might say the line is “freely invented”—a psychologist would say “amodal”, or “hallucinated”—which is why we speak of a “bound geometrical element”. It is determined when the points have been placed, hence “bound”. One often believes to see such bound lines between the luminous points of a stellar configuration like the big dipper (*Ursa major*, see Fig. 4 [34]).

From one beat of psychogenesis to the next the points are replaced with fresh ones, thus the line varies too. However, it never fails to pass exactly through the points. This is a trivial fact because the line is *defined* as an intentional element that passes through the points. It is an “ideal” geometrical element.

Over some time span one meets with various instances of the line that statistically define a “fuzzy” line-like entity. We sometimes speak of “fuzzy lines”, and by that will refer to the distribution of successive instantiations of a single bound line.



**Fig. 5.** At left instances of a collinear triple (gray–white–gray), and (directly below it) the average of the instances. It is a perfectly collinear configuration, as all of the instances are. Of course, the exact location of the “midpoint” is fuzzy. At right instances of a three point configuration (gray–white–gray), each point fully intentionally placed, with some unavoidable random deviation. Directly below it we show the average of these instances. It is not a true collinear configuration, as none of its instances are. For the former collinear triple all angles are identically  $180^\circ$ . These are categorically distinct cases..

The model we have set up here is different from perhaps more familiar models in that geometrical relations, such as the incidence of a point and a line, are *exact*, whereas the entities themselves, here the point and the line, may be *fuzzy*. This is possible because the visual field is an *ideal* entity, quite different from the front end activity, which does not readily admit of a geometrical interpretation at all. The front end activity is not intentional, being just an outskirts of the physical world, whereas awareness is. Psychogenesis creates meaning, whereas the world has merely meaningless structure [25]. This can hardly be otherwise, since any meaning must eventually be due to non-contradicted experience of the agent in the world [38,55].

#### 1.2. Geometrical constraints

Geometrical constraints are rather common in intentional geometrical configurations. A simple example is a configuration composed of a collinear triple of points. Such triplets are extremely rare, because a triplet of three random points is truly collinear with probability zero. A triplet of collinear points can occur as an intentional configuration though. Here is how:

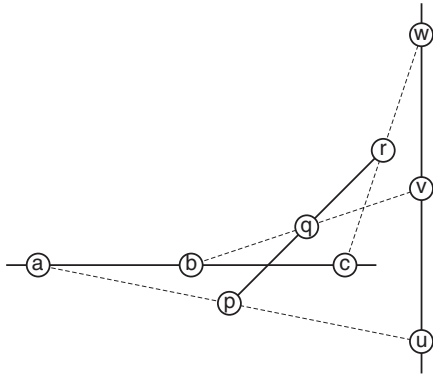
Consider two (distinct) fiducial points  $A$  and  $C$  say, and the bound line  $\ell_{AC}$  that is incident with both. Add a third point  $B$  on that line. The point  $B$  is a fiducial point with only a single degree of freedom, it can only be shifted along the line  $\ell_{AC}$ . The collinear triple is defined as this construction. It is an intentional element with five degrees of freedom, two each for the points  $A, C$ , and one for the point  $B$ . (See Fig. 5.)

The point  $B$  is an example of a constrained element. It is easy enough to find examples of even more strongly constrained points. Consider two lines  $\ell_{KL}$  (through the fiducial points  $K$  and  $L$ ), and  $\ell_{MN}$  (through the fiducial points  $M$  and  $N$ ). The point of intersection ( $P$  say) of the lines  $\ell_{KL}$  and  $\ell_{MN}$  has no freedom at all. It is a “bound point”, in the sense of “amodal”. The point  $P$  invariably lies *exactly* on the intersection of the lines  $\ell_{KL}$  and  $\ell_{MN}$ , despite the fact that the fiducial points  $K, L, M$ , and  $N$  vary with each new instantiation. The point  $P$  is also “fuzzy”, but the geometrical relations remain intact.

##### 1.2.1. Fiducial elements and dependent elements

Geometrical configurations are defined by incidence relations, and instantiated by—intentionally—setting the fiducial elements. The definition is part of the configuration, it is its abstract *shape*. It is an intentional entity of a higher order. Some elements in the configuration will be fiducial to various degrees, perhaps they are partially constrained. Others are bound, like the point of intersection of two intentional lines, each defined by a pair of fiducial points.

The bound elements are *dependent* upon the fiducial ones, *relative* to the shape. Some elements may be of mixed, bound and fiducial, nature. The collinear triplet of points yields a simple example that comprises all these relations. (See Fig. 5.) Such geometry was first studied by Hjelmslev [15].



**Fig. 6.** This is the Hjelmslev configuration. The collinear triples  $a-b-c$  and  $u-v-w$  give rise to the completely bound triple  $p-q-r$ .

### 1.3. Geometrical constructions

Geometrical constructions are operational definitions of shapes. It is important to appreciate that shapes that look the same on first blush may actually be very different because of their diverse origin.

For instance, here is an alternative construction of a collinear triple of points (see Fig. 6): Start by constructing two distinct collinear triples  $ABC$  and  $UVW$  according to the method discussed above. Construct the lines  $\ell_{AU}$ ,  $\ell_{BV}$ , and  $\ell_{CW}$ . Next bisect the line segments  $AU$ ,  $BV$ , and  $CW$ ; call these midpoints  $P$ ,  $Q$ , and  $R$ . Then the triple of points  $PQR$  is collinear, by application of Hjelmslev's theorem [32].

Notice that the collinear triplet  $PQR$  has 10 degrees of freedom, whereas all three points are bound. It is completely different from a triplet like  $ABC$ , or  $UVW$ , which both have five degrees of freedom, namely two fiducial points with two degrees of freedom, and one constrained point with a single degree of freedom. It is crucial to distinguish between such entities.

### 1.4. Structural complexity of geometrical configurations

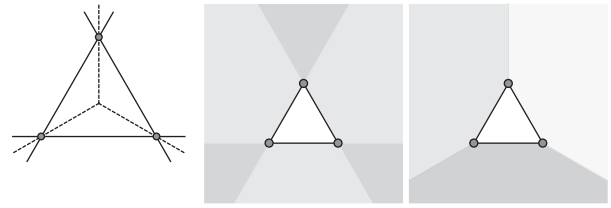
The Hjelmslev configuration described above (see Fig. 6) has 10 degrees of freedom. It is made up of nine points and six lines. This is structurally already more complicated than the psychogenesis bottleneck can handle. We need to take this bottleneck into account.

Geometrical configurations soon become very complicated. Given half a dozen (6) points, one may draw 15 lines, the lines again define 105 points of intersection. This is far beyond the capabilities of psychogenesis. The structural complexity that may be handled by psychogenesis is (roughly speaking) limited by the *magical number seven, plus or minus two* [35].

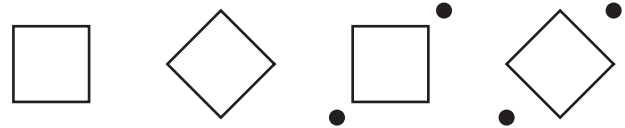
The limit seems to be about half a dozen degrees of freedom, implying a triangle. A triangle (see Fig. 7) is a configuration of three points and three lines, dividing the plane in seven areas. Three medians, and their common intersection, the centroid, are implied. They define the “pointing directions” of the triangle [25,34], and mutually divide the plane into three regions.

A generic quadrangle has eight degrees of freedom, and is already too complicated for psychogenesis to handle. Constraints that lower the complexity bring the quadrangle into the reach of psychogenesis though: you obtain the parallelogram and the rectangle (both six degrees of freedom), and the square (five degrees of freedom). Notice that the square is even simpler than the generic triangle.

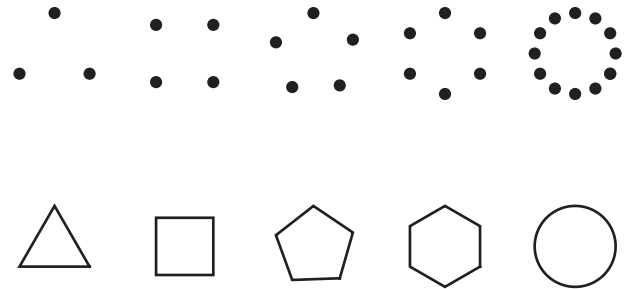
It is of considerable interest that these configurations are not rotationally invariant. Even an isosceles triangle is best appreciated when its axis of bilateral symmetry is vertical [34]. A geometrical square, which has two distinct types of axes of bilateral symmetry, appears as a *square* when one of these is vertical, as a *diamond* when the other one is vertical (see Fig. 8) [31,36]. Here “vertical” applies if the



**Fig. 7.** A triangle induces various segmentations of the space around it. This example of an equilateral triangle is, of course, ambiguous. There are three potential regions that might contain points the “triangle is pointing at”. In this case the “pointing direction” is of course ambiguous, the three directions seeming equally compelling.



**Fig. 8.** At left square and a diamond, at right they are influenced through context. The “square” can be seen as a “diamond” and vice versa if the context is adjusted appropriately.



**Fig. 9.** The regular polygons that may appear in the visual field. From about six vertices on one sees a circle, rather than a polygon.

drawing board is empty. Other elements (e.g., drawing a “frame” around the figure) may induce a different reference orientation that takes over the role of the vertical [36].

More complicated configurations include the regular polygons. (See Fig. 9.) The hexagons are immediately recognized, the pentagon less so, even when presented in a canonical orientation, that is to say, with a major axis of bilateral symmetry in the vertical. Polygons with seven or more vertices are recognized as sparsely sampled circles. They have no “sides”, but the points are seen to lie on a circle [34]. Similar things happen when a series of points apparently lies on a curved arc. Such arcs may even have inflections. When points are added “outside the arc”, these are indeed seen as extraneous elements.

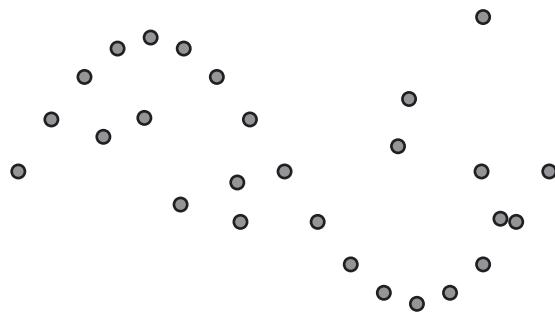
The phenomenological fact that arcs become visible through discrete, non-collinear point-triples, suggests that objects not unlike “splines” may be posed by psychogenesis [9,58]. (See Figs. 10 and 11.)

### 1.5. The atlas structure

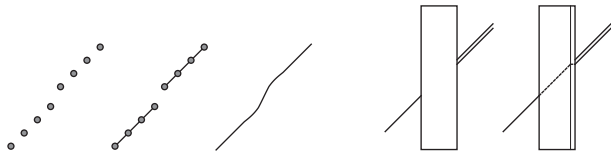
If psychogenesis handles only structural complexity of about half a dozen degrees of freedom, then how can it be that one—as experience seems to teach one—may become aware of rather complex pictures? There are four important properties of vision that make this indeed possible:

**Independent processing** psychogenesis mainly yields relatively precise geometrical descriptions in an area about the fixation point. However, it does so at a fast rate, the beats follow each other up at least a dozen a second. From one beat to the next the fixation may shift. This is handled in a pre-conscious fashion by psychogenesis. In the course of a second or so one





**Fig. 10.** A field of points. Notice that the smooth curve is immediately noticed. Points not upon it are seen as intruders. A point configuration like this on the night sky would probably give rise to a stellar constellation named like “snake”, “winding path”, or “Venus’ girdle”, and so forth, depending upon the culture.



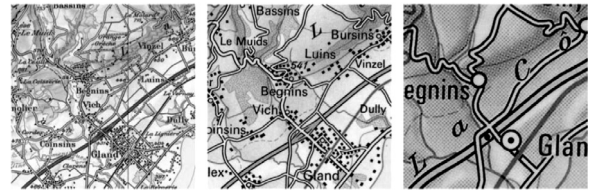
**Fig. 11.** From left to right: a row of points; two collinear rows that are mutually offset; a smooth curve has been interpolated through the points. Notice that it is apparent in the point set at left; At right the well known “Poggendorff illusion” [58]: the upper oblique line at right is collinear with the oblique line at left, although it does not look that way; at far right the offset made explicit. It is like the rectangle had a different width “than it really has”.

collects a number of samples that become integrated in a “good glance”. A good glance is still largely “something that happens to you”. There is no cognitive process implied here. Of course, cognition kicks in soon, and various voluntary fixations are interspersed with the involuntary ones. The transitions between pure awareness, visual cognition, and reflective thought (involving scrutiny) are gradual, and ill understood.

**Summarizing** psychogenesis often “summarizes” structure, thus rendering it manageable. Of course, much of the available structure is sacrificed, that is to say: simply ignored, in the process. This is a very important ability of psychogenesis, it is genuinely *creative*. What appears to happen is that psychogenesis forces some kind of flexible template, one of many, on the structure, in thoroughly Procrustean manner. Such a procedure is useful when the range of possibilities is limited, and the structure is noisy. Then extreme structural complexity is simply ignored as “noise”. It is a bit like “Greeking” in setting type: whole paragraphs are simply “represented” through a gray silhouette, not a single word is actually set. The creativity involved is similar to “cartooning”, or even “caricaturing”. Psychogenesis somehow reveals the “gist” of a local structure.

**Texturizing** is somewhat similar to summarizing. It is applied to areas of high structural content that has some degree of statistical stationarity. In that sense it is similar to “hatching” in drawing. The statistical complexity of texture can be quite high, though it is hard to express in terms of the number of degrees of freedom involved. One would guess perhaps “the magical number seven plus or minus two” again.

**Scale space hierarchy** As mentioned before, a “point” is a “point” only because its internal structure is intentionally ignored. Psychogenesis is somehow able to focus not only on location, but also on scale, to a limited extent even simultaneously. Thus a configuration may be composed of configurations on a finer scale, and may itself figure as an element in a configuration on coarser scale. It is as if a “point” may contain a summary of what is “in” it. Geometrical relations only exist on a given scale though. It is similar to the geometrical relation



**Fig. 12.** Example of “cartographic generalization”. This is how a single region would be rendered differently on maps of different scales. Here the cutouts have been rescaled to the same size.

between the *Tour Eiffel* and the *Brandenburger Tor*. The geometrical relation between them on the map of Europe is inherited from the relation between *Paris* and *Berlin*. The *Arc de Triomphe* has exactly the same relation to the *Brandenburger Tor* as the *Tour Eiffel* has, although—on the map of *Paris*—they are at distinct spatial locations.

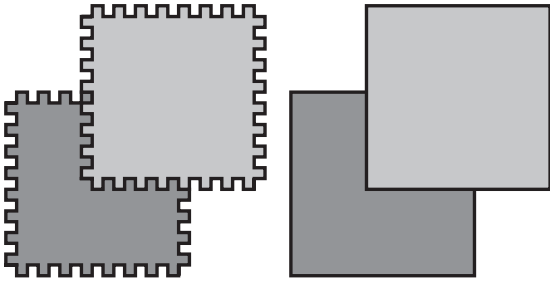
Of course, this causes many complications in the formal description of the visual field. This despite the fact that these abilities greatly simplify the task psychogenesis serves.

In almost all respects, the visual field is very *unlike* a picture. A better analogy, for the moment, at least, would be a data-structure similar to a geographical atlas. Typical atlases indeed implement many of the properties of psychogenesis, and for much the same reasons. These reasons have to do with the bottleneck of structural complexity that psychogenesis deals with. The map-maker has to ensure that a user, handicapped through tunnel-vision and a bird-brain, can actually “read” the map(s) in an efficacious manner. Here are some common map design objectives and the way the map-maker deals with them (see Fig. 12)<sup>2</sup>:

- A map cannot have arbitrary size, or the user will have serious problems to find the relevant area. Thus an atlas is divided into pages, each page being of manageable size. A very coarse map is provided to help locate the relevant page. If necessary this is repeated in hierarchical fashion (world map, continent, country, region, ...). The coarse map is similar to the “gist”, the pages similar to “good looks”. This implements independent processing.
- A map maker uses *generalization* in order to be able to put various entities on the map. For instance, cities below a certain size will be represented through conventional symbols. Small villages will be omitted altogether. This implements summarizing. The disk is like a “point” in that only its location matters, not its shape, color, and so forth.
- A map maker uses conventional color and hatching to indicate areal properties such as sea, ocean, desert, savannah, forest, and so forth. This is the analogue of texturizing. It is very helpful, because it allows one to obtain a rough understanding of the landscape at a glance, at the cost of structural complexity. Many atlases will have several pages of the same region, revealing different areal properties. This is very similar to the various “maps” one encounters in the visual front end. In ancient maps white areas would indicate “mystery”, that is to say, unexplored regions where anything might be. The mystery might be made explicit by printing “here be dragons” (e.g., HC SVNT DRACONES on the Hunt-Lenox globe (ca. 1503–07)<sup>3</sup>), or pictures of mythological creatures like mermins.
- A detailed atlas will be organized like an inclusion hierarchy. If one needs more detail one pages to a map of higher resolution. Of course, such a map will cover a more limited area, though in

<sup>2</sup> <http://openstreetmap.us/~miguiski/streets-and-routes/>

<sup>3</sup> The Hunt–Lenox Globe or Lenox Globe, dating from ca. 1510, is the second or third oldest known terrestrial globe, after the Erdapfel of 1492. It is housed by the Rare Book Division of the New York Public Library.



**Fig. 13.** The light gray “serrated square” is in front of the dark gray one, despite the “wrong” relation of outlines (they do not define proper “T-junctions”). However, the serrations are not visible on the scale of the squares, thus the relation is really between their summaries. There is no ambiguity in the relation between the summaries at all.

greater detail. Two such finely detailed maps can only be mutually related by way of a coarser map that contains summaries of both. This is the scale space hierarchy [22]. Notice that the scale space hierarchy is only useful because of the summarizing that goes on at all levels. It is the summarizing that provides the “glue”, making the atlas into a unitary structure, rather than a mere collection of mutually unrelated pages.

The atlas analogy is a very apt one. It may be the best way to understand the structure of the visual field. (But see below for complications.) For all the map-maker’s devices one finds obvious analogs in the visual field. Notice that this structure is fundamentally different from a “picture”.

If there is anything like a picture at all, it would be the *gist*. Features in the visual field are “meaningful” because they are part of larger structures. The larger structure is like a context, that bestows meaning on its elements. The gist itself is not part of anything though. It has no context, it simply is. Psychogenesis apparently generates “gist” from global, meaningless structure, probably through a selection from a limited number of templates. Indeed, it would seem that the gist is one of the few visual elements that is largely protopathic.

#### 1.5.1. Summaries

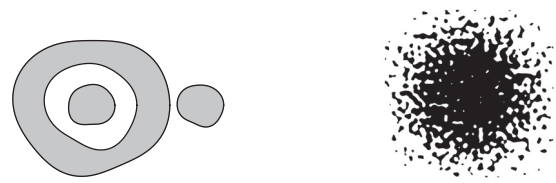
The nature of the “summaries” is important in the understanding of the structure of the visual field. One expects summarizing to be similar to cartographic “generalization”. Summaries are tricky entities [41–45], much more complicated than the simply blurred versions one has in regular scale space theory.

For instance, any configuration may collapse to a “point”, or may vanish in thin air. A number of configurations may together be summarized as an arc, and so forth. In order to keep the map legible, it is often necessary to displace configurations from their actual location. (See Fig. 13.) Various distortions may be used to keep the relations between adjacent summarized configurations clear. All these, very common, properties of cartographic generalization have analogons in visual perception, and—especially—in the art of drawing [46].

#### 1.5.2. General position

The notion of “general position” may also be called “genericity”. Two points are “in general position” if their locations differ. Three points are in general position if they are not mutually collinear, and all three locations are different.

Genericity depends upon the context. For instance, in a generic square opposite sides are parallel, and all sides are of the same length. For a generic quadrangle none of these relations obtains. A square is



**Fig. 14.** A region may have a complicated topology, and still appear as a single region. Notice that—perhaps paradoxically—the region at right looks even more like a “single” region than the one at left, although it is evidently the more disperse one.

a quadrangle, but not a generic quadrangle. Thus genericity depends upon the constraints one accepts as “given”. In the visual field “given” amounts to “posed by psychogenesis”.

It makes sense, for psychogenesis, to accept “general position” as a prior hypothesis. This is likely to increase biological fitness on the average. The mainstream has adopted this as the “Bayesian model” [17,37]. We would not follow the mainstream there. The Bayesian priors refer to the statistical structure of the physical environment. It seems unlikely that psychogenesis would entertain such priors, although it evidently uses recurring regularities. However, such regularities pertain between entities in awareness, rather than entities “in the world”.

Any square you draw will necessarily be imperfect as a physical realization. However, the square in visual awareness is a perfect square. The ideal nature of this square is purely intentional, it has nothing to do with the physical realization. It is an entity like Meinong’s “round square”, which is indeed every bit as round, as it is square [33]. This is a crucial notion that is sorely lacking from pure “bottom up” accounts of the structure of the visual field.

#### 1.6. Basic elements

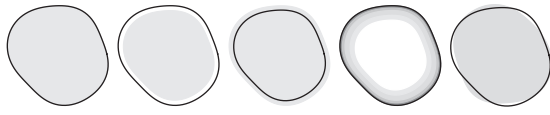
So far we have illustrated various important issues using points as the basic elements. However, points are by no means the only basic elements. As a first, rough categorization one may distinguish (notice that we regard the static case: taking time into account would make the list grow appreciably):

- *Points* that are structureless entities with two degrees of freedom (their location);
- *Curves* (often called “lines” in the visual arts) that are extended entities, such that points may be placed upon them with a single degree of freedom;
- *Regions* (often called “areas” or “patches”) that are extended entities, such that points may be placed upon them with two degrees of freedom.

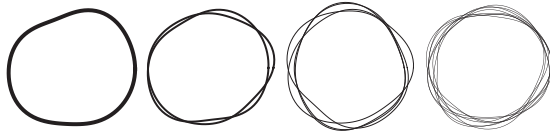
All these entities may have various additional qualities. For instance, a “line” may have a *direction*, not just an orientation, it may be *one-sided*, the boundary of a region, it may have well or ill defined *end-points*, it may have a *shape*, curvature and so forth, it may be *textured*, say stippled or dashed, and so forth. An area may have a *shape*, which includes topological properties like connectedness; see Fig. 14), a *boundary quality*, sharp, fuzzy, serrated, . . . , a *texture*, hatching, stippling, . . . , and so forth.

There are numerous possible relations between entities of the same nature (coincident points, parallel lines, overlapping areas, . . . ), as well as between entities of different nature. In many cases this involves “bound elements”. For instance, a placed area with a sharp boundary (a “blob”) induces a line (its boundary). The line has no freedom, it is a bound element. But, of course, the interior might break away from the boundary (see Figs. 15 and 16).

The variety of possible relations is gigantic, as we will illustrate below.



**Fig. 15.** A blobby shape is colored by neatly filling in (first from the left), by staying away from the boundary (second, notice that the tint becomes lighter), by coloring over the boundary (third, notice that the tint becomes darker), by coloring only a narrow ribbon inside the boundary (fourth, notice that some tint spreads into the interior, like on ancient, hand-colored maps), and, finally by paying little attention to the precise location of the boundary (fifth). In the latter case the outline gains a “dynamic” character, a property routinely exploited in the visual arts.



**Fig. 16.** A blobby shape is outlined through multiple, slightly different lines. Multiple “outlines” tend to appear as a single somewhat fuzzy outline—essentially a single line—giving the region a dynamic, less rigid character. For such reasons one sees such structures frequently used in artistic drawings.

## 2. Pictures and the visual field

For our purposes part of what is a “picture”, in a technical sense, to be outlined below, is a flat substrate, called “picture plane”, of finite size, called “picture frame”, covered with colors in a certain arrangement. We will consider only rectangular frames with aspect ratios not too far from unity. With “colors” we indicate any physico-chemical causes of retinal spectral irradiance. Examples are pencil marks (graphite), touches of paint (for instance, mineral compounds in an oily medium), pre-digital photographs (silver grains in a gelatin carrier), and so forth.

But these are conventional properties of minor importance. Most importantly, a picture is a *physical object seen in a particular mode*. Apart from seeing the picture as a manipulable object, viewers can look “into” a picture so as to become aware of a pictorial world. The physical object, *in the context of such a viewing*, is what we mean with a “picture” in the technical sense [14,23,25]. Thus pictures have a rather involved ontological structure.

In looking *at*, and *into* a picture, which may be summarized as “viewing a picture” where “picture” is properly understood, the observer’s perception contains two distinct spaces. One is the space the observer and the picture as an object share, often called “the visual world” of the observer. The other is the “pictorial space” of the observer for the particular picture. These spaces are distinct, and usually do not have much of a mutual relation.<sup>4</sup>

Typically, neither the eye, nor the picture plane, are in pictorial space. Special cases may be set up—these are essentially “laboratory gimmicks”—where certain relations do obtain. The more common ones are related to “linear perspective”, and “virtual reality”. The picture may appear like a “window”, where the space you are presently in, the space seen through the window, and the window frame, are somehow amalgamated. Here the coupling between the spaces is set up by having the pictorial content “require” a physical viewpoint. This is tricky, both practically and conceptually, and sometimes even fails with an actual window. We do not deal with such singular cases here.

There is no direct causal relation between the picture, and the visual awareness of the pictorial world. The relation is indirect, through psychogenesis. Thus the relation may well be different from one occasion to the next, and is likely to be different for different observers.

The experimental phenomenology of the visual field is most conveniently pursued through the use of pictures. Most of our understanding of vision proper derives from such studies. This makes sense because the study of the vision of the scene in which the observer moves involves numerous non-optical factors. It is necessarily enactive [11]. The “visual field” is by definition due to purely optical factors. This is an important phenomenological distinction, first explicitly formulated by Adolf von [14]. Hildebrand differentiated between the *Nahbild*, perhaps to be translated as “enactive image”, and the *Fernbild*, which might be translated as “iconic image”. The iconic image is purely due to optical factors, whereas the enactive image involves opto-mechanical interactions, such as walking around an object, manipulating an object, using binocular vision, and others. That is why we concentrate on pictures, and picture making in this paper.

## 3. The art of depiction

Picture making implies an understanding of generic psychogenesis in one’s own species, the main instance involving *Homo Sapiens*. The artist aims at evoking certain aspects of visual awareness in prospective observers. The major way to achieve this is self-observation, or introspection, during and after the making of the work [14]. This involves a blind reliance on the homogeneity of the species [39].

We discuss a few examples in this section. We will focus mainly on drawing, with a few excursions into painting. The difference between drawing and painting is that the geometrical elements in drawing are predominantly lines (“strokes”) and points (“dots”, “stipple”), in painting mainly areas (“*taches*”, “*touches*”). The difference is by no means absolute though. Hatching (“*hachure*”) uses lines to stand for area, and certain touches may double for lines or points. In something like hatching the twofold intentional nature of pictures is crucial.

### 3.1. The picture plane

Strictly speaking, there is nothing similar to the picture plane in visual awareness. The visual field is never a pure “flatland” [23], despite numerous efforts of artists to force it to be that way. Looking at an X-glyph (like this: ✕) one usually sees the *black* stroke as being “in front”. On the other hand, looking at an X-glyph (like this: ✕) one usually sees the *gray* stroke as being “in front”. When looking at an ambiguous X-glyph (like this: ✕) one usually sees one stroke “in front”, although which one depends upon the particular moment. The order appears to toggle randomly, and more or less beyond one’s control. The intersection of the strokes has a curious split nature, for *it lies on both strokes*. The intersection is a superposition of two mutually “parallel” points.<sup>5</sup> Such parallel points occur in isotropic geometries [48–51,56].

Likewise, any pictorial object lies in front of its background. As is well known, the object-ground relationships in a drawing may spontaneously change from one beat of psychogenesis to the next. Then parts of the visual field are permuted “in depth”.

This type of “depth” is not more than a partial order for a relation “in front of”, that pertains to elements that are at the same location, either crossing (like in the ✕ example), or abutting, like the lower left corner of the gray square and the neighboring part of the interior of the black square in this figure: ■. A global depth order need not exist (see Fig. 17), nor does it occur in awareness, except in singular, trivial cases. When noticed, this tends to be in reflective thought.

The part that “lies behind” still exists “amodally”, in that it is somehow completed in psychogenesis. For instance it has a “shape”. (See Figs. 18 and 19.) Thus the circular disk “occluded by the triangle” is

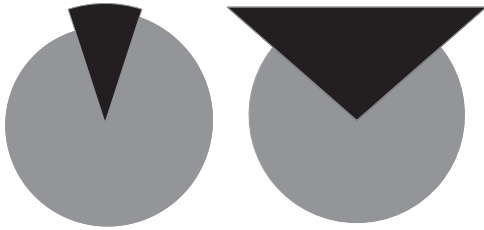
<sup>4</sup> The picture plane does not separate them, for such a separation would be a connection [25]. Exceptions tend to be of an artificial nature, and are usually considered “in bad taste” in the visual arts (see below).

<sup>5</sup> “Parallel” means: at the same location, yet distinct; this is analogous to the notion of parallel lines, which have the same orientation, yet are distinct.





**Fig. 17.** Notice that this ribbon is both “in front of”, as well as “behind” itself, thus showing that a global depth order cannot be expected in the visual field. Indeed, phenomenologically depth order is a local property, where “local” has to be understood in a sufficiently fuzzy way.



**Fig. 18.** Consider the shape of the gray areas. At left one sees a “deformed circular disk” with a smooth outline, at right a circular disk with a flattened top.



**Fig. 19.** Here two abutting, gray, circular disks (center) are “occluded” by a black rectangle (left). One tends to see the gray area as a dumbbell.

evidently flattened on the (invisible) upper part, although there is enough space to complete the circle. The gray shape that is “partly occluded” by the black rectangle has a smooth boundary, and so forth.

### 3.1.1. Multiple structure

Even in slightly complicated configurations one often notices sequences of different presentations. Each single glimpse yields a certain well defined visual awareness, but continued looking, even a good look of a few seconds, may well reveal a number of qualitatively different awarenesses. It is likely that psychogenesis comes up with numerous ways to account for the optical structure incident upon the retina, and that now this, now that hallucination “wins”, and determines the presentation in awareness. This is a natural consequence of the fact that vision without imagination is impossible. Without its creative nature, the visual system could only sustain the enactive vision of a zombie. Although important enough—probably most of the visual processes in the brain deal with that—this cannot lead to *qualities* and *meaning* in the sense of “good horse sense”, or “gut feeling”. In experimental phenomenology one needs to be able to deal with this intrinsic creativity.

## 4. Conclusions

The “visual field” is a mental entity, the geometrical aspect of visual awareness. Although “geometrical” indicates that one ignores meanings and qualities, this is not really possible. The geometrical elements are not “given”, but *constructed* by psychogenesis. Thus the visual field is not a pre-existing frame, or a blank canvas, ready to be colored in by psychogenesis. That implies it is quality and meaning through and through. Qualities and meanings may be ignored in our discursive models of our visual awareness, but not in experimental phenomenology [1].

One might say that elements of the visual field are objectified emotions, that is to say, emotions ascribed to objects other than the self. This explains that we experience “dynamic lines”, “pointing triangles”, “aggressive forms”, and so forth [13,25]. The “geometry of the visual field” is closer related to the structure of musical compositions than to Euclid’s formal system [2,25]. It may be considered a language of vision, if “language” is understood as a way to express and communicate reality, a notion first forcefully developed by Fiedler [10]. It was developed in the early 20th century in various directions, the experimental psychology of the Gestalt Schools, and the work on *Einfühlung* (empathy) in aesthetics [27,28,47,53,54].

The notion of modes of expression<sup>6</sup> of reality as a way of coming to grips with psychogenesis led to the powerful concept of “symbolic forms” [5–7,25]. In recent times this led to the work of [40] and [24] in psychology.

There also exists parallel threads in biology, perhaps starting with the ideas of von Uexküll [55], that led to the ethology of [30] and [52]. (See also [38]). Von Uexküll’s notion of “functional tone”, is really Gibson’s idea [12] of “affordance”, but where Gibson locates the affordance in a physical object, for [55] it is like the releasers of ecology, a mental construct that is much like a “symbol” as understood by [5–7], or [24].

An understanding of the visual field is the understanding of the language of vision on a number of different levels. These include ecology—von Uexküll’s *Umwelt*—and ethology, namely the releasers and fixed action patterns, in biology, the symbolic forms of Gestalt, Carnap and Lakoff in psychology, and the study of empathy in aesthetics.

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<sup>6</sup> Language has been the major paradigm in science, but already [10] generalized the notion to visual, musical, and other “languages”.



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