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Psychogenesis of Gestalt

Our immediate target is a formal phenomenological description of simple aspects of how the visual field comes to be. In the long term, this fits with our interest in psychogenesis *per se*. It is a likely target, because vision is one of the best explored areas of experimental phenomenology. We concentrate on a very simple issue, that of the transitions between approximately uniformly colored patches, conventionally denoted "edges" (Jacobs 1988; Cateura 1995). Simple though an edge might appear, many painters are ready to state that all they do is essentially render edges (Jacobs 1988). Thus the edge may prove as important to experimental phenomenology as the hydrogen atom was to physics. We consider it a key exemplar, perhaps a "*Sésame, ouvre–toi*".

Pictures are planar distributions of scalar *values*, an abstraction from physical fields. They occur at distinct ontological levels, radiance at the cornea, retinal pattern of photon absorptions, cortical neural activation, and light-dark structure in visual awareness.

Physiology, or neuroscience, describes the *visual front-end*. *Psychogenesis* remains scientifically mysterious. Visual awareness is *immediate reality*, even though some deny its existence (Daniel Dennett 1991). Our account is based on Jason Brown (1977), derived from a large corpus of psychiatric observations. It involves a process that applies to physiology and phenomenology alike. In our view, the common ground is geometry, which bridges disparate ontological levels (John Bell 2005).

Geometric entities are *points*, *curves*, and *areas*. Optics deals with planar *scalar fields*, which fail "atomic parts". Physiology deals with "receptive fields" as *atomic units*. We describe the visual field in terms of "perceptive fields" (Lothar Spillmann 2009), although it is a whole, rather than an aggregate of atoms. A uniform patch of blue sky is not composed of parts.

Receptive Fields

Receptive fields are *atoms* (David Hubel & Torsten Wiesel 1968). "Atomic" refers to outputs of neurons. Axons carrying action potentials are the hallmark

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of atomicity. All action potentials *being equal,* neural outputs have no intrinsic meaning. Meaning derives from effect, from connectivity. At the level of the neuron there is none. Values yield no information as to how they were "computed". Physiology describes activity as a function of stimulation. In this, it assumes an outsider's perspective, or "God's Eye View" (Koenderink 2014). The brain itself has no access to stimulation in the way that the outsider has. Activity depends on other cells, and optical stimulation. Does it make a difference to a neuron whether it is stimulated optically, or by another neuron? Not that we know of.

Formal description abstracts from anatomical and physiological details, emulating physics: *Simplify, but not too much*! "Scale-space theory" (Jan Koenderink 1984a; Luc Florack 1997; Bart Romeny 2008) fits the bill. It has proven utility in image processing and has a solid mathematical basis. It is unique in providing an algebra of receptive fields (Koenderink 1990). Thus it provides a rare example of a theory of the functionality of cortices on a formal, not physiological, level.
"Points" involve no relations over finite distances. A point marks an *arbitrary* value independent of all others. In visual awareness "points" do not occur: again, the blue sky is not made up of blue points!

Consider how to *implement* a point (Koenderink 1990). It should be *somewhere*, and output a scalar *value*, representative of the local optical stimulation. "Radiance at a point" is based on radiant flux incident on a finite area. *Size* is an arbitrary property of the machine (Wassily Kandinsky 1959). The value represents average retinal irradiance over its domain, normalized by area. It is a scalar, rendering the machine atomic. According to Euclid (c. 300 BCE), a point is *that which has no parts*, Thus "point" is an apt term. Scale-space formalism considers "point operators" at *any* location and *any* size.

Various formal constraints indicate a unique receptive field profile (Koenderink 1984a), an isotropic Gaussian "bell shaped" function. This leads to a rich theory of the plane that can be implemented to an arbitrarily good approximation (Romeny 2008). Scale-space *embodies* the plane as a machine (Koenderink 1990) with the functional properties of geometry.

The point operator (figure 1) is the simplest receptive field. But this assumes "God's Eye", because points do not broadcast their location and size. Irradiating the retina activates all point operators. The *value* of any *single* point operator is meaningless. Meaning resides only in the context of *all* point operators.

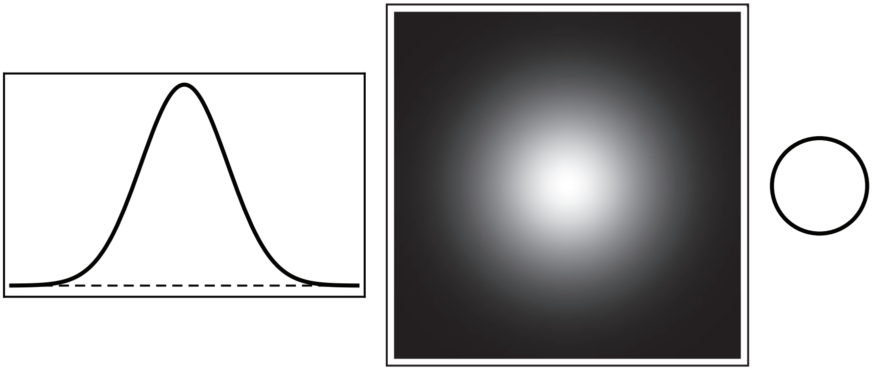

Fig. 1 The "point operator". At left a section of the receptive field profile, at center a density plot showing both dimensions: a point is "somewhere" and has a certain "size". It has no "parts", being a featureless fuzzy blob. At right the symbol that we use to indicate a point. "Size" and "location" could be anything. The formal representation is an algebraic expression. The value "computed" by the point is pooled *image intensity* over the image as "seen through the point's (fuzzy) aperture".

Simplest relations between points are *dyadic*, and apply to operators that are similar in location and size. Formally one regards "infinitesimal differences" (John Bell 2005). Values of such almost identical operators are mutually correlated, a condition that reveals their adjacency to higher order systems (Koenderink 1984b).

Consider dyadic relations, either two operators at different locations but of the same size, or two operators at the same location but of different size. Higher order machines encode such relations, as "atomic" entities whose values have a novel significance. This bypasses "God's Eye" but complicates matters through the introduction of distinct types of "atom". In elementary scale-space theory (Florack 1997), one considers differences of values of *adjacent* points.

Two adjacent points define a *direction* in the plane. The difference of values, divided by mutual distance, is the retinal irradiance gradient at the scale of the points. The receptive field profile is the directional derivative of the Gaussian bell shape. It is the "simple cell profile" (figure 2), often denoted "edge finder" or "edge detector". (Although we use the term "edge finder", it is an awkward one, because bilocal operators are not necessarily connected with transitional areas ["edges"]. "Edge detector" additionally assumes the existence of edges in the world, and thus is even more awkward. We bow to convention.) Statements can be backed up by mathematical expressions, skipped here (Koenderink 1990).

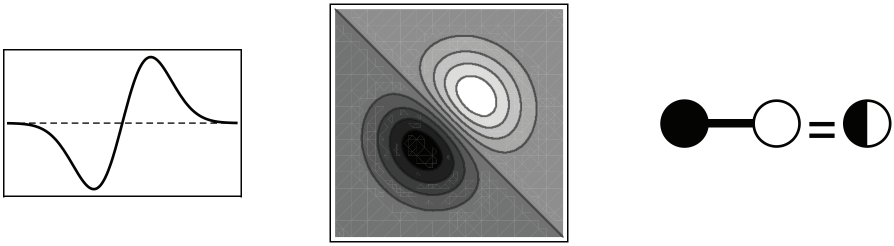

Fig. 2 "Edge finder". At left the cross-section of its receptive field, at center the density plot of an edge finder in the upright direction. At right we show how we symbolize the edge finder as a dyadic atom. The values of two point operators of slightly different locations are subtracted and normalized by their mutual distance. The limit for small distances yields the edge finder. Notice the symbolic representation. "From the outside" the edge finder is atomic.

Two points at the same location but of different sizes define a *local excess* of retinal irradiance. The value is the difference of values normalized by difference in scale. This is the familiar "Mexican hat" profile (figure 3). It is conventionally denoted a DOG ("difference of Gaussians") receptive field profile (Eric Kandel, James Schwartz & Thomas Jessell 2000).

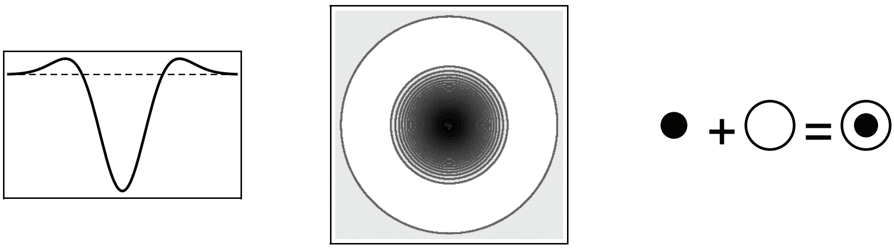

Fig. 3 "Mexican hat" operator. At left a cross-section through the receptive field, at center a contour plot. At right the construction from coinciding point operators of different size. Notice the symbol we use. "From the outside" the operator is atomic.

One also considers *n*-ary relations. Consider a triad of equi-spaced collinear points, defining an orientation in the plane. It yields a 2nd order orientational derivative, a "line finder" (Hubel & Wiesel 1968). This triadic relation of *points* can also be obtained as a dyadic relation of *edge finders* (figure 4). From the output value you cannot decide whether it is a triad or a "dyad of dyadics": such distinctions are functionally void.

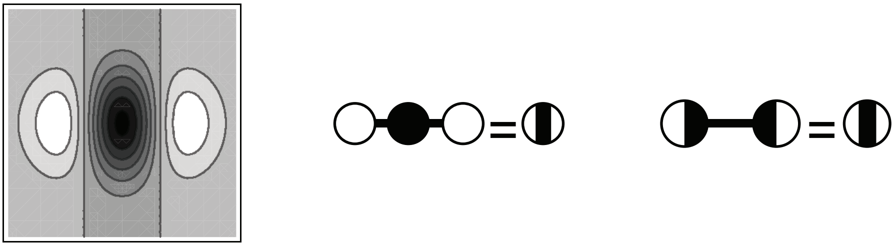

Fig. 4 Line finder. At left a contour plot of the receptive field profile, at center a triadic point configuration. The value is the average of the outermost points, minus the center one. Blind to gradients, it is normalized by dividing by the square of the separation. At right the symbolic representation of a dyadic edge finder configuration. The atom hides internal structure. "From the outside" there is only one type of atom.

Numerous formal relations exist between such machines (figures 5 and 6). Important is that the average output of "line finders" over all directions yields the "Mexican hat" profile. A *triad* of line finders is indistinguishable too! Such distinctions are meaningless, because internal structure is functionally ineffective.

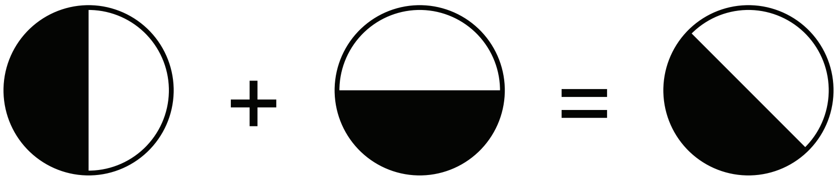

Fig. 5 Edge finders combine like vectors, functionally this is hidden. Top-down processes may construct edge finders of any direction from any distinct pair on the fly.

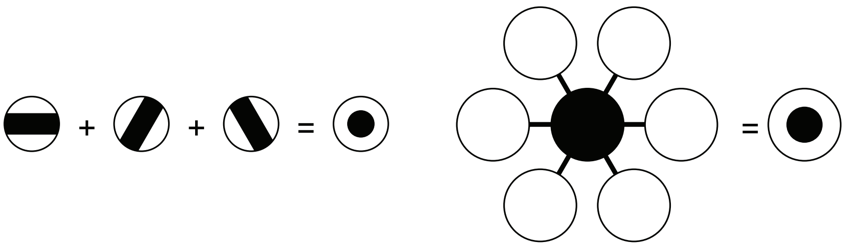

Fig. 6 An average of three line detectors yields a Mexican hat operator. The combination of offset points at right achieves the same. Numerous combinations yield trivial algebraic identities. If such an atom plays a role in a larger whole, it makes no sense to "look inside" it; its function is independent of its "origin". The parts are lost in the whole, like "4" retains no traces of "being" 1+1+1+1, 1+3, or 2+2. Thus "4" is atomic, not an aggregate.

Formally, the "Mexican hat" machine returns the *derivative with respect to scale*. This implies that the average over all such machines exactly equals the retinal irradiance. The logic is that if you slice a sausage, then stacking up the slices gets you the sausage again. According to this formally trivial *representation theorem* the retinal irradiance is “represented” by the set of all Mexican hat operators. All that might be lacking would be the average level, which is ignored by the Mexican hat operators. In practice, this is irrelevant.

The concept of cortical activity “representing” optical stimulation is void. The representation theorem is a *theorem*, but this does not imply that the cortex *represents*. Atoms are individuals and do not compose a coherent nexus. Such coherency must come from elsewhere and is often *imposed*. This is vividly illustrated by cases of *tarachopia*, where observers have perfect visual acuity and contrast detection thresholds, yet fail a coherent visual field (Robert Hess 1982). The atoms are templates that spew out local samples on an individual basis. The visual field is more than a collection of atoms.

Contemporary physiology has no clue when it comes to differentiating these possibilities; it is not the place to learn about psychogenesis. A speculative heuristic is the only option.

Does it have any potential relevance that the retinal irradiance is represented by Mexican hat operators? Yes, for one might pick and choose between the values used in the “reconstruction”. The representation yields room for *creative interpretation*. That is to say, the synthesis might take account of a “beholder’s share” (Ernst Gombrich 1960).

Averaging over orientations of line detectors yields a Mexican hat profile, thus *all line detectors* also represent the retinal illuminance pattern. This yields a different “handle” on synthesis. Might there exist additional handles? Yes, i*nfinitely many*: think of the Fourier representation (Tom Cornsweet 1970). Any image may be *decomposed* in Fourier components, yet is in no way *composed* of such – a common enough misconception.

That psychogenesis must pass the structural complexity bottleneck forces it to be *local*. Scale-space is an exact model of “infinitesimal analysis” (Bell 2005) on a finite scale. Fourier analysis is global, thus *way beyond possibilities* of biological systems. This singles out scale-space formalism as appropriate. “Local” implies “tunnel vision” but this may be hard to spot in practice, for “local” can involve *any size* (Roger Boscovich 1758; Kandinsky 1959).

One may define local machines for any differential invariant (Koenderink 1990), including boundary curvature, corners, and T-junctions. Such machines exist at higher levels of the front-end. Their complexity and size grows and there are fewer of them as one moves higher up in the hierarchy of the peripheral visual system. All are (often nonlinear) atomic units, their outputs meaningless trains of the same action potentials.

Meaning is imposed in addressing atoms. The advantage of atomicity is that no geometry is involved, the disadvantage that values are intrinsically meaningless. Atoms do not “detect” anything, but slavishly “do their thing”. A “top-down” process decides, detects, “sticks its neck out”, and commits errors, whereas atoms are beyond “right or wrong”.

The Case of “Edges”

Edges are mental entities. Conventionally, *edges are what edge detectors detect*, introducing the chicken or egg problem. Layers of edge detectors yield scalar fields of “edginess”, but no “edges”. We use “edges” as a convenient example. Similar analysis would apply to regions, curves, corners and what have you.

Consider all “edge detectors” of a given size. Feed them an “edge”, an image split in the middle, dark at left, light at right, and you get an “edginess” field of very low value almost everywhere, but much larger in a shallow strip along the mid-line. The values suggest “how much edge”. Engineers respond by thresholding edginess in order to define “the” edge. This has led to numerous ingenious and intricate solutions (David Marr & Ellen Hildreth 1980). One picks the “right scale”. Scale and threshold are rarely reported. Choices are determined by where one intuitively estimates the edges “are”. This hardly fits any principled account, yet is established practice, making solid engineering sense.

We submit that edges are not *detected*, but *imposed*, against the grain of mainstream conviction. Imposed edges are *subjective*! The alternative is an imperative filter “EDGE!”. This suits a “zombie”, but is it logically consistent to believe that we are like that? Many authors think so (Dennett 1991). We do not advocate mere “hallucination” as an alternative though. Imposing an edge takes edginess into account, it optimizes your biological fitness (Donald Hoffman 2009).

Here is an instructive anecdote. In the 1960s one author was at the Royal Meteorological Institute of the Netherlands. His task was to draw “weather maps”. At the time one had no access to satellite data. There existed a coarse grid of land stations, and there came scattered reports from ships at sea. Not all of the data were necessarily correct. Scores of clerks entered data, in hand drawn pen and ink, on the basis of radio reports, cables and facsimiles, on huge maps of Europe. These were the input data. He was supposed to draw “fronts” and the like. Fronts are boundaries–edges!–between thermodynamically distinct air masses. A front is a *mental entity that science imposes on nature*, you can’t see it in the sky (Stephen Monmonier 1999). He learned to draw fronts as perfectly sharp curved lines on the map, taking temperature, wind direction, barometric pressure and cloud cover into account. He did the best he could to make them “fit the data”–always allowing for errors by various men at sea, or slips made by the clerks. He would boldly draw the front through regions devoid of data, and skip data that failed to "fit". His fronts fitted theories, as well as data. He could see from maps drawn by friends that his fronts were as much "his" fronts as "the" fronts. They were the result of halluncination constrained by data and theory. But although they were products of creative imagination, they made good sense because they "made sense of" the data. Weather maps drawn by various experts look similar, there is something "objective" about them. The final weather map is the result of a shared subjectivity.

Edges in visual awareness are like that, products of creative imagination that make sense of current optical stimulation. It is what we glean from the awareness of others, especially artistic renderings of scenes. They are "real" in the same sense as meteorological fronts are "real". Remember that the latter were introduced by Vilhelm Bjerknes (1862–1951) in the early 1920s, appropriately named after the WW–I battlefronts. "Edges" may have existed for evolutionary time spans, but that does not change their ontological status.

"Edges" are simple instances, suitable to explain how psychogenesis–at least in its initial stages–proceeds.

The Psychogenesis of Edges

The bottom-up stage of processing being somewhat understood, one easily loses track after the initial cortical areas. This topic is best left to physiologists. We broadly sketch a cartoon-model.

The retinal irradiance pattern is encoded as differential invariants of low order, lowest orders being discarded. One encounters no "point operators" in V1. Orders 2 and 3 are simple cells. Complex cells possibly encode higher order invariants. Orders 4 and higher are too scarce to tile the visual field. (We informally base this on anatomical counts of cell types in V1.) Processing is bottom-up, cells individually adjust their gain. Thus values are significant up to unknown factors. What does the visual cortex preserve or discard, cells not broadcasting gain factors, locations, types, or sizes?

Primary visual areas receive massive top-down input. Speculative accounts of "how vision works" naturally concentrate on the interaction of bottom-up and top-down processes. We return to that topic below.

We propose that the visual cortex is a *volatile buffer*–continually overwritten–of condensed and packaged optical structure in brain readable format, a *proxy for the Umwelt* (Jakob von Uexküll 1920). Cortex is like the receiving room of the meteorological institute, it records and condenses data in standard format on the standard map. It does not tamper with the data, and does not speculate, or interpret. If data is lacunary, dead reckoning or just guessing are alternatives. No doubt it is wise to discard the occasional outlier. But that is the task of a *data interpreter.* A proxy is trustworthy and dumb.

In the case of "edges", the datum is *edginess*. Fields being continuous, there is a non-empty value at any location. Moreover, the datum at a point is *more* than a mere value, because there are edge detectors differing in direction and scale. The value is accompanied by qualities.

At any given scale there are many edge detectors. Their effective dimensionality is only 1, the single parameter is direction. It suffices to specify just 2 numbers. This indicates a serious problem for the notion of receptive fields as "atoms". The "receptive field" notion is awkward when the "datum" is carried by (at least) *two* atoms. Are there higher order *truly atomic* units? If so, then one of them might be "edginess" proper, that is magnitude, as one has in popular applications like Photoshop (2014). Similar issues arise with many geometrical invariants which are of a vectorial or tensorial nature.

It has often been suggested (Marr & Hildreth 1980) that the bottom-up process generates "cartoon renderings", similar to thresholded edginess. But, as we *experience* it, edginess has little to do with our awareness.

Suppose there are atoms reporting edginess proper, like a Photoshop (2014) edge map. This is a God's-Eye View, for all there are mutually independent atoms. It is an external, physiologist's view. *Hence we have to switch to phenomenology.*

In Brown's (1977) account, awareness emerges from ancient parts of the brain. This is the *opposite* of the mainstream conviction that consciousness derives from recent overgrowth. "Top-down" is a misnomer, when the "top" is at the deepest recesses of the brain! Brown's account makes solid biological sense.

Psychogenesis *creates reality*, starting with dreamlike states that articulate, diversify and compete, many not surviving, in a competition like Darwinian evolution. "Fitness" derives from the degree to which a "hallucination" fits the "facts" in the front-end. The ones that finally make it fit the activity at the primary cortical areas. As they become incapable of further development they surface in awareness until replaced by the next generation. It is a legato style systolic process that renews about a dozen times a second (Brown 1977). Each moment is novel, although likely to resemble the previous one. Sudden changes occur. At a slower rate, visual experience is of an enduring "world". This achievement, one's "reality", is commonly taken as the cause of itself. It is a major delusion (Brown 1977).

We use the term "legato" to indicate that the moments of awareness are in themselves epochal, that is to say past and future are part of the moment, but that the process of psychogenesis arises from processes at slower time scales. Thus the "moments" are overlapping in their genesis, although not in awareness.

How does this work out in the case of "edges"? In awareness edges have a polarity, one color at one side, another at the opposite side. Edges are not experienced as lines of a cartoon drawing. Edges are not "atomic" in the sense of points arranged along a curve, but are like meteorological fronts that extend over hundreds of miles on the map, although based on a collection of sparse local observations. "Atomic perceptive units" remain in proto-awareness. We refer to such elements of proto-edge as "perceptive fields" (Lothar Spillmann 2009).

An edge-like perceptive field would be like a short stretch of edge, at least having a local direction and polarity. It would look like the receptive field of an edge detector. The psychogenetic process "places" them at locations of locally high edginess. Psychogenesis treats perceptive fields as the "touches" of a painter, and applies them according to the values in the edginess map. Formally this is a "convolution" (Romeny 2008), it is much like the "brush" in programs like Photoshop (2014). Thus the edge detector profile appears in two complementary ways, as *operator* in the front-end *analysis*, and as *brush* in the psychogenetic *synthesis*. This is a new insight we present here.

This puts the "homunculus" problem topsy-turvy. There is no little demon "looking at the screen". There is no screen, only a file of raw data. Visual awareness is constructed. But there is no "painter" either. In constructing the awareness the mind constructs (at least part of) itself. Both mind and awareness are momentary achievements. Psychogenesis is a natural process, not "someone's doing".

Formally the local "perception" would be an edge detector profile–the *receptive* field–painted with a similar profile, the *perceptive* field. Such combination has a line detector profile, for in scale-space convolution of an edge detector with itself yields a line detector at slightly coarser scale (Romeny 2008). Adding these all up formally reproduces the retinal illuminance. This is the *perceptual representation theorem*. Psychogenesis, combined with front-end machinery, captures the optical stimulation. In principle that is. It is another novel insight we present here.

This occurs at the level of *awareness*. Whereas the front-end produces a point by point edginess activity that hardly deserves the title "representation", psychogenesis produces a *presentation*, made up of quality and meaning. In the former case the representation theorem is purely *formal*, in the latter it is descriptive of *reality*. The edges "painted" in awareness are like Baingio Pinna's (2012) "water color illusion", curves with ribbons of different colors on either side.

Formally such a process is "veridical" if the data is complete. This *never applies*, because psychogenesis picks and chooses what fits its current situational awareness. Some edginess is ignored, and psychogenesis may present edges where evidence is lacking (Gaetano Kanizsa1977). Front-end *analysis* cannot go beyond the data, but psychogenetic *synthesis* routinely does.

Psychogenesis

The origin of psychogenesis lies hidden. It is likely to take the immediate past into account, because each next moment likely resembles the previous one. "Hallucinations" cannot be far off the mark, except in cases of sudden change. But situational awareness, drives, and so forth will play a role (von Uexküll's 1909, *Suchbild*). Protopathic inputs force resets. Abstracted and summarized "gists" (Aude Oliva & Antonio Torralba 2006) from all layers of the mind modulate the generation of hallucinations. The aim is optimization of biological fitness in the short term (Hoffman 2009).

A major constraint is the structural complexity bottleneck (Fred Attneave 1954; George Miller 1956; Benjamin Balas, Linda Nakano & Ruth Rosenholtz 2009; Jeremy Freeman & Eero Simoncelli 2011). Novelty comes in limited structural complexity, chunked at various scales. Much of current awareness is "default", based on earlier moments. You'll never notice! Complexity grows over time, which–in the case of visual awareness–is like a "good look", that is about a second, or a dozen moments. Longer periods involve cognition and short-term memory, and can not be considered truly "iconic" (Adolf von Hildebrand 1893).

Psychogenesis is controlled hallucination. *Hallucination* imposes quality, meaning, and value. *Control* ensures "fit" to the *Umwelt* (von Uexküll 1909, 1920). Psychogenesis is like the game of "twenty questions", where players repeatedly guess a random word in fewer than twenty questions (Whitman Richards & Aaron Bobick 1988). Players develop techniques to "zoom in" fast, invariably involving "chunking", the hierarchical structuring of concepts. One imagines psychogenesis to function like that. "Control" starts with dreamlike states confronting structure encountered high up in the front-end, gradually moving to more articulate structure in the early front-end, up to area V1. "Fitting" is like an evolutionary algorithm (Zong Geem, Joong Kim & Gobichettipalayam Loganathan 2001). Diversification and pruning of swarms of hallucinations is like the poking with the cane by a blind person. Psychogenesis probes for answers to its questions in the front-end, a proxy for the outside physical environment. Meaning is in questions, not answers. Questioning imposes meaning on structure.

Notice that the front-end cannot be said to "cause" awareness in a similar sense that the mere presence of fingerprints and discarded cigarette butts could hardly "cause" a criminal investigator to come up with "the" (or rather "a") solution to a crime. Such facts only constrain the articulation of "plots" currently followed up by the investigator. The front-end likewise constrains, or sculpts, dreamlike states or imagery of psychogenesis. In rare cases a protopathic sensation may trigger trains of awarenesses, like sudden discoveries may open up long forgotten criminal cases. But these are beyond normal practice.

Consider Erwin Schrödinger's (1944) psychophysical correspondence principle (Davida Teller 1984): *sparks of awareness correspond to resistance encountered by explorative actions*. No such principle can be *proven*. But if not in conflict with science it is a valid heuristic device. Visual awareness results from fitting hallucinations ("questions", "poking") to front-end activity. This heuristic is the appropriate tool for experimental phenomenology (Liliana Albertazzi 2013).

Early stages of psychogenesis implement a "ratiomorphic engine" that operates independently of the rational mind. It provides the basic material for the latter. This is what perceptual Gestalt research addresses. It structures immediate visual awareness, like language structures discursive thought, but is more "primitive". Honed by long periods of vertebrate evolution, it might well be more reliable than reflective thought (Rupert Riedl 1975).

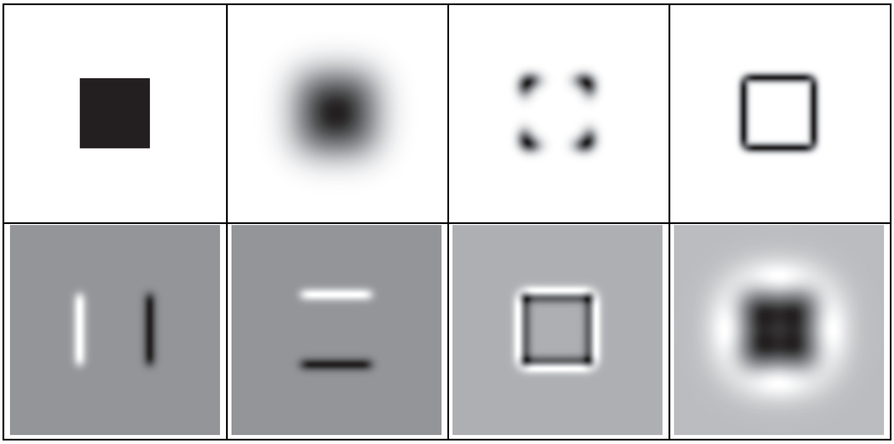

Fig. 7 Stages in the psychogenesis of "black square". At top left the optical stimulation, a physical field of retinal irradiation. At top 2nd from left a coarse Mexican hat response: there is something at some location! At top 3rd from left there is an indication of structure: 4 possible "corners" at a finer scale. At top right the edginess image, at a still finer scale: the corners may be meaningful, because connected! At bottom left and 2nd two edge finder activities. These select directions, and retain polarity. At 3rd position the edginess image as "painted" by a "brush" (perceptive field). The edges are painted as in Pinna's (2012) "water color illusion". A black square? At bottom right the scale is coarsened. Now the painting shows a black square, albeit fuzzily.

Consider the detective story leading to the "awareness of a black square" (figure 7). A hallucination that there is "nothing", is falsified at a very coarse level, "local point" (Mexican hat operator) activity. There is something at a certain (rough) location of a certain (rough) size. Does the object have structure? A mere featureless blob is falsified at a finer scale, by the presence of four corners (corner detectors are nonlinear atoms). The plot thickens! Psychogenesis dreams up edges near the corners, moving to a finer scale. Initial hallucinations involve edges of any direction, but this is falsified too. Are there continuous edges, are they connected, do they stand in relation to the corners, to each other? Questions to be asked, and probed against the front-end evidence, thus focussing the investigation. Now evidence in favor of a "black square" becomes overwhelming. Precise "fits" can be attempted, pointed questions asked. It is like a detective story. Psychogenesis collects singularities and unlikely coincidences, the fastest way to falsify unfit "plots". The plot that survives as momentary "solution" is backed up by a folder of striking–because unlikely–pieces of evidence that should convince a judge. The process can be fast because it ignores most of the–irrelevant–front-end structure. It is robust because not bothered by mutilated, or even lacking, data (figure 8). It always leads to "clean" results, although not necessarily "right".

An investigator's "open-and-shut" case (like: *it's a square*!) is a Gestalt. Notice that Gestalts have properties that render them "atomic", albeit on another level than that of the atoms figuring in our formalism. This atomicity is due to their holistic character. An open-and-shut case is not a mere aggregate of facts, but is like a house of cards from which no "part" can be removed, everything hanging together. Addition or removal of a small part endangers the whole.

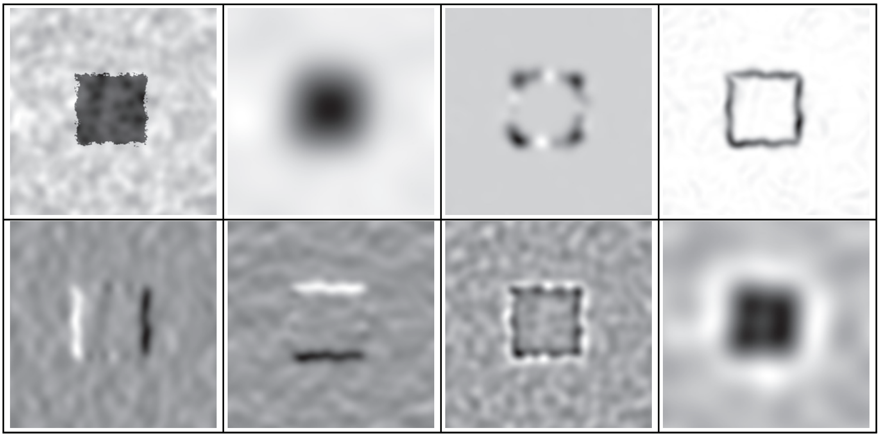

Fig. 8 As figure 7, but optical structure mutilated. This black square in awareness is beyond reasonable doubt, despite noisy brain activity. Evidence need not be complete to be compelling. Perfection is not to be had in real life. Seen squares are intentionally non-existent, they cannot be "computed from data", but have to be *imposed*. There is no doubt that this is "a black square". "True" black squares exist in the same sense as the square circle. They are Meinong's (1899) "subsistent" objects.

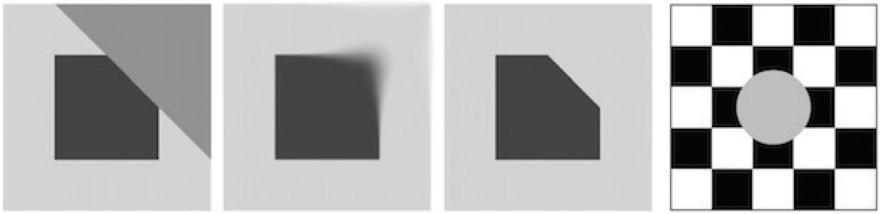

Fig. 9 Three doubtful cases of "black square", and a missing white square.

"Right", technically "veridical", is irrelevant to psychogenesis. It plays a possible role in the interaction with the world in a broader sense. Visual awareness often contains objects that are obviously "non-veridical", or even "impossible" to reflective thought (Wolfgang Metzger 1936).

In figure 9 the first image is a black square *tout court*. The missing corner is "accounted for". Square and occluder testify for each other. The second image is a square missing a corner. The evidence is incomplete, but compelling. This shady character is a black square. The third image shows a bevelled square. There is no explanation for a missing corner, and positive evidence for two corners that testify against squarehood. "Black square" would hardly stand up in court. The image at right shows the "case of the missing white square". Only *local* evidence counts. Psychogenesis cannot avoid the structural information bottleneck. Reflective thought can, and wonders about the black cross, but the perceptual case is closed.

The black square in visual awareness carries its complete forensic history, including occasional false leads, with it. They remain part of the visual object. This defines what can be done to the optical input before the square stops being a square and what the potential meanings of it are. It depends upon the mind. No two black squares are the same!

A black square from a distance might appear as a point, that is isotropic. Somewhat nearer there may occur hints of cornerness and the visual object may become a squarish round thing. The squarish round thing remains an essential element of the black square as "seen clearly".

Formally, one might quantify the evidence by computing the odds, the *Prägnanz,* for competing interpretations. This involves understanding the domain, von Uexküll's *Merkwelt*, and what counts as evidence. This renders the study of perceptual Gestalts "human ethology".

"Black square" means having it in awareness as an intentional object (Franz von Brentano 1874; Alexius Meinong 1899), not as a result of calculation on optical structure, although it has an intimate relation to that structure. Perceptive fields descriptive of the square, like edges and corners, are constantly tested against the front-end activity. The black square in awareness will survive lacking data, perturbations, and noise. It has "deep" structure (edges, corners, being located, having size, being colored…) that is co-present in subsidiary awareness, and may "surface" at any time (Pinna 2010; Pinna & Albertazzi 2011; Pinna & Deiana 2015).

Such notions fit artistic conceptions well. Consider Ted Seth Jacobs' account of "edges":

> "… think of edges in terms of field effects between tonalities. …, they occur not only between verbally constituted entities, but everywhere. In the strictest sense, optical edges do not exist. The whole visual field is an indivisible continuum of interpenetrating light effects. We can treat optical edges as varying in their degree of sharpness while realizing that none are absolutely sharp. … the "medium edge", or meeting of two patches of paint, if left completely untreated, will look more like paint than an optically perceived effect of light. … there is a desire to make the picture surface come alive … otherwise it is difficult to see any difference between the paint on the palette and on the canvas." (Jacobs 1988, 96.)

Jacobs does not think of "edges" in the way of image processing. Edges are everywhere, and occur at any scale. His paintings are composed of edges, not "pixels". Consider Linda Cateura:

> "… each beginning has a crisp edge. When the light hits a form, it has a crisp or hard edge. As the form starts to turn away from the light into shadow, there's a soft edge, or transition, between the light and shadow, then the form ends with a crisp and a hard edge; a new light begins and the sequence is repeated." (Cateura 1995, 33)

Thus edges come in wavetrains of alternating scale. "Hard" and "soft" are crucial attributes. The painter needs to get edges right, or he will produce cartoons. Visual artists intuit and respect our "edge representation theorem".

Conclusion

We explored a speculative heuristic for psychogenesis, presenting the mathematical basis in an intuitive fashion. It accounts for the phenomenology of visual awareness, and explains its relation to optical stimulation. It is a *heuristic*, since causal relations between awareness and physics/physiology cannot exist.

Awareness originates as resistance met by explorative, intentional action. Probing puts a question to the world, resistance is the answer. Meaning is in the question, which *defines what counts as an answer*. This notion is due to Schrödinger (1944). The function of the front-end is not to "compute awareness". It is a proxy to "the world" in brain-readable form. It enables "fitting" hallucinations to neural activity.

Scale-space assigns unique functional meanings to atoms. It is *implementable* formal geometry. Atoms are directional derivatives of various orders, and combinations, the differential invariants (Koenderink 1990). This does away with "feature detectors". Conventional terms like "edge finder" are misnomers. Such units occur in fitting edges, but equally occur in numerous other relations. Their value does not stand for "edge" at all. "Edginess" is a continuous gradient field.

The theory poses problems to physiology. Fitting hallucinations to front-end activity presumes probing to "know" where and what to address, and how to interpret what it finds. It requires *location*, Hermann Lotze's (1852, Koenderink 1984b) "local sign". It needs to know *what atoms represent*. It needs to know their *gain*. Yet other properties, of a topological nature, are needed. Addressing edge detectors brings up the need for *links to neighboring units*, that are mutually collinear along a possible edge. The mechanism suggested by Platt (1960), based on the effect of eye movements, might be expected to play a role here.

Visual awareness is intentionally non-existent (Brentano 1874). It contains subsisting objects (Meinong 1899). It cannot be perturbed by "noise", as would results from data processing. Apparent "noise" is also intentional. There is nothing in awareness that is not *created* by psychogenesis. This is the difference between a painting and a photograph. In a painting every touch is a painter's achievement, whereas a photograph may well contain details not experienced by the photographer at the moment of exposure (Michelangelo Antonioni 1966).

Summary

Psychogenesis of visual awareness is "controlled hallucination". The hallucination is intentional, the control seeks to fit front-end neural activity. The visual front-end appears as a proxy of the Umwelt in "brain readable form". This heuristic fits phenomenology well, and can be founded on well-developed mathematical "scale-space" formalism. We illustrate this through the example of "edges".

Keywords: Psychogenesis, edges, good Gestalt, receptive and perceptive fields.

Zusammenfassung

Die Psychogenese des visuellen Bewußtseins ist „kontrollierte Halluzination". Solche Bilder sind intentional, die Kontrolle versucht die periphere Gehirnaktivität anzupassen. Die Grosshirnrinde tritt als ein Stellvertreter für die Umwelt in "Nervensprache" auf. Diese Heuristik erklärt die Phänomenologie, und kann in einem gut entwickelten mathematischen „Skalierungsraum"-Formalismus begründet werden. Wir veranschaulichen das anhand des Beispiels der „Kanten".

Schlüsselwörter: Psychogenese, Kanten, Prägnanz, rezeptive und perceptive Felder**.**

Author's Note
This work was supported by the Methusalem program by the Flemish Government (METH/08/02), awarded to Johan Wagemans, and by a visiting scientist grant from the University of Sassari.

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