Shelia Guberman

On Gestalt Theory Principles

In the last 50 years many attempts have been made to advance image recognition. The main tool has been pattern recognition technique, and the images have been restricted to a single object. In most cases, solutions are based mainly on complete enumeration of possibilities plus a number of heuristic restrictions. Even if partial success is achieved it is determined to a great extent by high speed of computers (so a huge number of possibilities could be analyzed) and tremendous size of memory (so a huge number of examples could be stored and used for comparison). Despite numerous attempts by all leading companies in the world, there is no pictorial search (search for images similar to a given one) available on the internet. The main cause of stagnation in this field has been the neglecting of knowledge accumulated in Psychology of Perception in general and in Gestalt Psychology in particular. Too much emphasis has been put on mathematics and engineering and too little on laws of human perception, which must be imitated. History shows that a number of basic AI problems like abstract object detection [Guberman 2008], handwriting recognition [Andreevsky 1996], clustering analysis [Guberman 2002], and image understanding [Guberman 2012], were resolved on the basis of Gestalt Psychology after many years of unsuccessful attempts grounded in formal mathematical approaches. Implementing Gestalt principles in computer programs demanded, on the one hand, formal interpretation of Gestalt principles; and on the other hand, adjusting computers to operate more adequately with objects of a spatial nature.

When computers began to be used to improve decision making in medicine and geology (not formalized branches of science) it demanded not only more precise measurements or definitions but also clearing up some basic notions and formalizing intuitive decisions. Also, in image processing on computers, use of Gestalt principles demanded some shifts in understanding of basic notions and principles. In this article I will show how Gestalt theory appears from an algorithmic point of view. Two main algorithmic concepts will be described, which were developed for adapting Gestalt principles: 1) **Linguistic** interpretation of Gestalt, and 2) Bongard's **imitation principle** [Bongard 1970]. These algorithms were developed in the context of pattern recognition problems, but turn out to be

GESTALT THEORY
© 2015 (ISSN 0170-057 X)
Vol. 37, No.1, 25-44

useful in modeling perception (in complete agreement with wise Wertheimer's prediction: "This applies not only to recognition but to perception in general"). It is important to mention that Gestalt psychology is based on analysis of human-made linear and dotted drawings (Köhler was the first who noticed that Wertheimer's illustrations refer to the grouping of separate dots and lines [Köhler 1975, p.85]. These images are tools for human communication. The second feature of these drawings is their discrete nature: each image could be described as a set of strokes – lines that could be drawn with no stops and no interruptions. These strokes are the elements, the building material, for constructing the Gestalt.

Linguistic Interpretation of Gestalt

Described below is what a typical experiment in Gestalt psychology looks like. A psychologist picks an object in the physical world and shows it to the subject. Then the subject reports what they see. It is assumed that perception creates a Gestalt in the subject's mind and when they are asked to describe what they are seeing, they describe not the visual stimulus but its generalized description: the Gestalt. Köhler stated that seeing something means its occurring in the description of the pattern [Köhler 1975, p. 114].

This point of view was expressed already in Wertheimer's 1923 paper. In that article the word *Gestalt* is used in two ways: as part of a label ("gestalt theory", "gestalt logic") or as a self-contained notion. As a notion it was used only in conjunction with the word "good": "good gestalt". Discussing Fig.1, Wertheimer describes the common perception as an "oblique deltoid within a rectangle" vs. "a hexagon on the left side whose lower right-hand corner is shaded, and another hexagon on the right side whose upper left-hand corner is shaded."

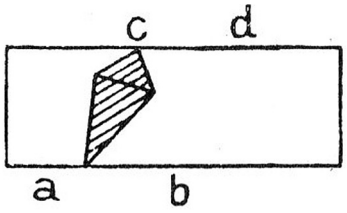

Fig.1

After these two descriptions Wertheimer concluded with a remark: "Once more we observe the influence of a tendency towards the "good" Gestalt, and in the present case it is probably easier than before to grasp the meaning of this expression". Here Wertheimer explicitly shows what a good Gestalt is and what the bad one is: **the short and simple description is a "good" Gestalt, and the long and complex description is a "bad" one.**

Of course, new psychology raised a lot of discussion and objections from the psychological community. One of the strongest points of criticism was the notion of "good Gestalt" – that gestaltists didn't provide a satisfactory explanation of

that term. In his book "Gestalt psychology", Köhler [Köhler 1975] didn't even use the term "good Gestalt" while discussing Gestalt principles of perception. But Metzger explicitly confronts the problem: "In general, one must not form too narrow a concept of the term 'good Gestalt'. It includes such simple forms as **a straight line, a circle, and a square**". So, a **straight line**, or a **circle**, or a **square** are "good Gestalten" of a specific straight line, a specific circle, or a specific square. But now the same words are *descriptions* of particular images, and therefore are generalizations of these particular images, i.e. Gestalten. He shows examples of good and bad Gestalts: "Two intersecting circles" and "a *mantle* in the form of a bread roll and a *core* in the form of an almond". Metzger started to use regularly the term "simple Gestalt". He feels that the term "simple" is much easier to explain and even measure than the term "good", and constantly alternates between these words.

Criticism has continued until now: "Some of their 'laws' of perceptual organization today sound vague and inadequate. What is meant by a 'good' or 'simple' shape, for example?" [Bruce 1996].

Now we have an answer**. "Good Gestalt" is a short and simple description of a visual stimulus. As such, it is a generalization and it presents a set of different visual stimuli with the same Gestalt. When people are asked to report what they see on a given visual stimulus, they use the simplest and shortest description of that stimulus.**

The linguistic approach to Gestalt problems is not a sharp turn from the mainstream of Gestalt theory. The idea that simplicity is a crucial characteristic of Gestalt was acknowledged by von Ehrenfels and attributed to Mach: "By using this term for spatial and tone-Gestalten, Mach had been wishing to affirm their simplicity" [von Ehrenfels 1890]. A. Luchins and E. Luchins testify that Wertheimer in his lectures on productive thinking (at the New School for Social Research) stressed the need for a new logic and new mathematics that would deal with Gestalten. E. Scheere mentioned that in the 1937-1938 seminars Wertheimer dealt with the environment that one imagines and thinks of, as well as with emotions, language and symbols. Koffka recognized that "an ultimate explanation of the problems of thought and imagination will not be possible without a theory of language and other symbolic functions" [Koffka 1935]. It takes time and the involvement of modern theories of language, influenced by mathematics and computer development [Mel'chuk 2010, Guberman 2012].

Bongard's Imitation Principle

Gestalten, i.e. our descriptions of images that we perceive, are descriptions of how those visual stimuli can be created ("two crossing lines") – I call it *Bongard's imitation principle*. I have developed this concept in a number of publications: in

one of them it was shown that the *imitation principle* explains the *continuation principle* and the *closure principle* [Guberman 2007]. Practically, the *continuation principle* means: when following a line and approaching an intersection, one has to continue the line in the same direction (if possible). The words "following" and "approaching" explicitly describe a process of redrawing the given stimulus i.e. imitating the process that creates that image. By describing the process of creating a drawing, which consists of a number of recognizable objects, we reasonably assume that the objects were created consequently, one after another. We don't know which one was drawn first and which one last, but we are sure that nobody draws half a circle then quarter of a square and then returns to finish the circle. And that is the *closure principle*. (Such principles seem not to have been used in the Soviet construction industry: crews would start working on a building, build the foundation and then move to another location and build another foundation before finishing a number of previously started buildings. The reason was that the government would pay contractors more to build the foundation than to put up walls or lay the floors. As a result, in Russia you could see several started buildings with only the foundations in place.) Wertheimer described perception in the same way: "One has a feeling how successive parts should follow one another" [Wertheimer 1923]. And the classic phi phenomenon – the visible "movement of the bar" in Wertheimer's experiment – is a description of what is the simplest way to reproduce a perceived stimulus.

Let me describe the process of perception in other words: we look at an image; the image is composed of reasonable parts – strokes, which have a particular arrangement in space. The number of possible combinations of strokes is very large. Our goal is to combine strokes to form meaningful objects. By creating a model of producing that drawing we arrange all strokes in the time domain. We know that all strokes belonging to a meaningful object are created in sequence (without interruption). One can say that in this case the proximity principle works not in the space domain but in the time domain. Let us remark that the proximity principle is applicable to objects similar in some sense (i.e. size, color, shape). In the process of creating the drawing, the creation of each kind of object (dots, spots, strokes) stays in sequence. The transfer from space domain to time domain establishes a connection between our perception and the real world. It places some restrictions of the physical world on our perception and excludes some ambiguities in the interpretation of visual stimulus.
Metzger was in favor of imitation phenomena. He describes a medical case:

> "A man became mentally blind (visual agnosia) after an occipital head injury in the war. He could no longer immediately recognize visual forms. This man was still capable of following visual lines with movements of his head (although not of his eyes) and thereby recognizes the shape of the lines by the shape of these movements. In this way the agnosic patient could even read written text, as long

> as nobody held his head to prevent it from moving. But besides the fact that his performance was very slow, he experienced peculiar difficulties that are entirely foreign to the normally sighted. If he started to trace a letter at the wrong end, he could not recognize it".

It is worth mentioning that 30 years later computer handwriting recognition programs of leading computer companies – Apple and Microsoft – were based on the above-described phenomena.

Now we have a chain **"brain" – "image" – "movement"**: the **brain** perceives the dead **image**, which tells it about the live **movement** of the pen during creation of that image. But we can take it one step farther. When we see in the image something that we describe as "*a circle*" it is never a circle in the mathematical sense of the word. It is always a "bagel" and very often it is not a closed line at all (like in the handwritten characters "a", "o", "g" and so on). As a matter of fact, when we describe the pattern as a "circle" we describe not what we see, but what we think the author's ***intention*** was. So, now we realize that the ordinary act of perceiving a simple drawing is really a process of establishing connections between the sender and receiver by means of the drawing: the **receiver "reads" the sender's intention** (2.4). It is possible only because we imitate a human person, who possesses the same basic knowledge and similar real-life experiences, and who uses a writing tool with some mass and inertia (that explains the good continuation feature). On the contrary, if that kind of communication were to be developed in the course of the evolution of computer societies, there would be no *good continuation* principle, because monitors draw images line after line, so, while producing the "**V**" shape first to appear will be the top dot on the left wing, then the top dot on the right wing, then the second dot on the left wing and so on.

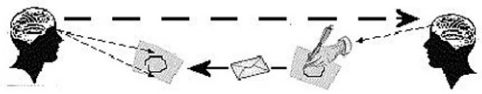

Fig.2

The imitation principle is not only applicable to communication in visual modality, but also in reading handwritten text: the recipient restores the movement of the tool which created the writing – the pen; also in speech perception: the listener restores the movements of the tool, which produces the speech – the vocal tract movements [Andreevsky]. Here is what von Ehrenfels mentioned in his paper on Gestalt qualities: "Each perceived step from note to note caused in us a characteristic sensation (or feeling) belonging not to the sense of sound but to some other sphere (perhaps involving nervous or muscular sensations)".

Now, combining the definition of gestalt as a description and the imitation principle one can say that **Gestalt is the shortest description of the way in which the visual stimulus can be recreated.**

Discussing Gestalt Principles

The fewer basic notions there are in a scientific theory, the higher is its value. Newtonian mechanics has only three. One of the basic weaknesses of soft sciences is an excessive number of variables in the description of natural phenomena. Every day economists explain why the market is going up or down: unemployment grows, real estate prices increase, Greece has financial trouble, and so on. Almost every other day a new variable is named as responsible. The number of variables in oil geology does not grow every day, but because the ratio of empty exploration wells to oil discoveries is 1:5 to 1:10, very often geologists have to explain why their predictions were wrong. And every time new factors appear: pH of the rocks was too high, or the temperature of the rocks in the past was too low, or "the mother bed" of oil is too thin, or the permeability of the bed is zero, etc. etc. Gestalt Psychology has a more solid basis, but the tendency to increase the number of basic principles and notions exists.

As time passed, new principles (suppression, balanced form, unity of structure, good Gestalt, belongingness, order [Metzger 2006], common region, simultaneity, connected elements [Palmer 1999], symmetry, convexity [Todorovich 2008] and some more) were added to the original ones. The latest addition came in 2010: "New Gestalt Principles of Perceptual Organization" by B. Pinna [Pinna 2010]. In solid review on history of Gestalt ideas published in 2012 this problem was mentioned as one of the main issues of criticism: "Gestalt psychology was severely criticized for … adding new "laws" for every factor shown to have an influence on perceptual organization" [Wagemans 2012]. Gestaltists were troubled by that situation and from time to time proposed reducing the number of basic principles. Wertheimer did it first but not explicitly, not declaring it as a goal: "The Factor of similarity can thus be seen as a special instance of The Factor of the Good Gestalt". To my knowledge, Metzger was the first to recognize it as a problem: "The meaning of these laws of Gestalt obviously implies that only a very small number of such laws can be found which are valid in, and can be applied to, all the various kinds of wholes". So, he suggested: "Law of good continuation and the law of closure are special cases of the general law of order or pragnanz… The law of similarity is thus again a special case of the general law of the unity of structure, or of the law of the good Gestalt." [Metzger 2006]. The most radical suggestion was made by Todorovich: "… most Gestalt principles are special instances of the overarching Good Gestalt principle, in the sense that being continuous, closed, similar etc are ways of being maximally good, ordered, simple etc" [Todorovich 2008]. However, although

this idea achieves some explanatory economy and unity, it does so at the cost of clarity and operationalizability. For these reasons, Todorovich's suggestion was unacceptable for computer use. In addition to the above-mentioned natural-philosophical reasons for reducing the number of principles (Occam's razor), it turns out that some principles, when applied to a particular stimulus, lead to different grouping, and rules of preference could not be established.

The growing number of principles was accompanied by a growing number of terms. To characterize bad Gestalten, words like "poor", "arbitrary", "piecemeal", "crooked", "disorderly", and "senseless" were used, and words such as "harmonious", "from one stroke" were used for good Gestalts. None of them had clear definition.

Parallel Analysis of Visual Stimuli

We will analyze the visual stimulus used in works of Wertheimer, Köhler, Metzger and others by applying the imitation principle: **Gestalt is the shortest description of the way in which the visual stimulus can be re-created.**

1. Wertheimer's Figures and Comments *(all figures are copies from* [Wertheimer 1923], *Wertheimer's comments are in Italics)***.**

1.1

Fig. 3

"Normally this row will be seen as ab/cd, not as a/bc/de". The Gestalt, the short description of this image, is "several two-dot groups". The description of a/bc/de will be much more complicated: a) the first and last dots have to be additionally described, b) to pairs of dots bc/ de and so on could not be applied the term group (because the meaning of group is "closer to each other than to the rest") and the description will be much more complicated. If we want to copy that image, we will draw dots from any group, one immediately after another. In other words, the parts belonging to one group will be neighbors in the time domain. It is trivial for that image because the dots are arranged in the same way also in the space domain.

1.2

Fig. 4

"Both similarity and proximity are employed". The shortest description of that arrangement is "four two-dot groups (black and white in each)", which favor proximity. If one tries to combine the objects according to similarity, there is no way to give each group a short description nor to describe the differences in their positions. The only possibility is to indicate positions of each dot, but that doesn't create a generalization of the image, i.e. it **doesn't create a Gestalt.**

1.3

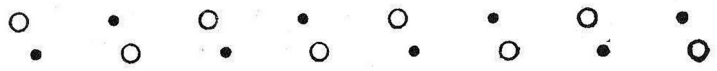

Fig. 5

"*An illustration of opposition in which similarity is victorious despite the preferential status given to proximity*". It could be described as a "number of two-dot groups (black and white in each)" favoring proximity (similar to the previous one). But it is a poor description, which doesn't reflect a lot of organization in the figure. Forming groups according to similarity reveals existing organization inside each group, defines the relative position of groups, and creates a very informative Gestalt: "two nested dotted zigzag lines". It has to be noted that there is no line in 5. But the Gestalt is not a description of the visual stimulus but a description of redrawing the figure and that includes the **movement of the pen along a zigzag line**. For the same reason the Gestalt of the following figure will be: draw a "horizontal dotted line and a perpendicular dropped on the line".

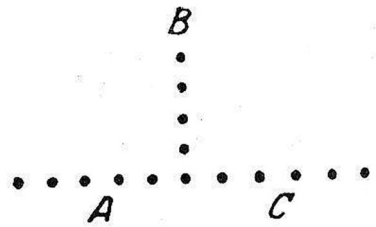

Fig. 6

Wertheimer's comment on this image was "*Taken individually the points in B are in closer proximity to the individual points of A (or C) than the points of A and C are to each other. Nevertheless the perceived grouping is not AB/C or BC/A, but, quite clearly '****a horizontal line and a vertical line****'".* Then Wertheimer shows these two figures side by side and makes no differentiation between them in his interpretation. It shows that he implicitly recognizes that under visible dots exist

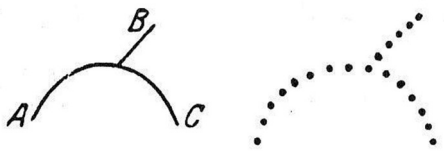

Fig. 7

imaginary lines – tracks of a drawing tool. Accordingly, in the last two dotted images parts of the whole (not pieces!) are not dots but dotted lines.

That means that the proximity principle is not applicable to them. So, there is no contradiction between proximity and good continuation. From that point on, in his article, Wertheimer used only linear images. Some of them obviously support the thesis: from visual stimulus we perceive the Gestalt that is a description of the process of drawing the image. In the case of the following figure it is "*sinusoid curve and crenellated curve*".

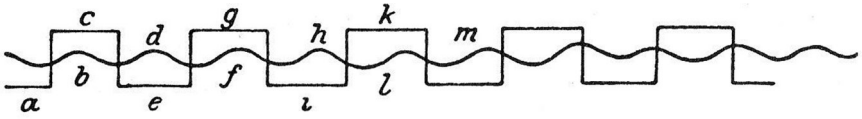

Fig. 8

With the following image Wertheimer demonstrates collision between *good continuation* and *closure principles.* The first one wins but with no reasons. When redrawing the figure everybody draws the stepped part and then the smooth curve, without a doubt!

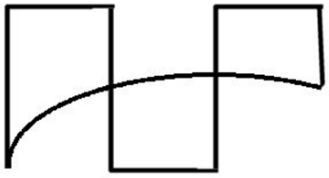

Fig. 9

The last images analyzed in Wertheimer's paper illustrate the phenomenon of perception that sometimes ignores objects physically presented in the stimulus. Let us analyze "Fig.30" (in Werheimer's original notation). In that figure 17 pieces can be picked out.

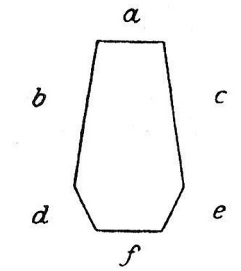

Fig. 29.

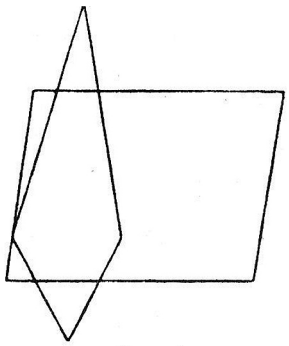

Fig. 30.

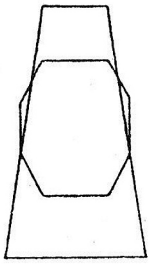

Fig. 31.

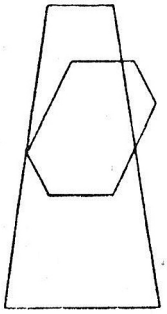

Fig. 32.

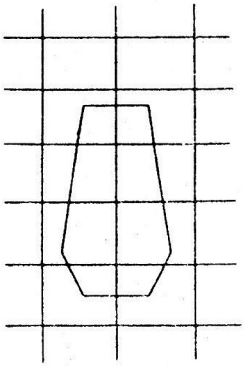

Fig. 33.

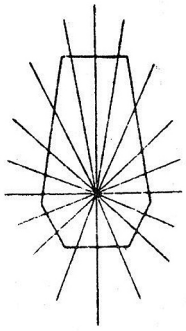

Fig. 34.

Fig. 10

The founding fathers of Gestalt psychology emphasized the difference between "pieces" and "parts": "*individual parts ('elements') are not primary, not pieces to be combined in and-summations, but* ***are parts of wholes***". A piece is any randomly cut part of an image. A part is a part of a whole: if the whole is sensible, each part of a whole must have a sensible interpretation. The 17 pieces on "Fig.30" could

be 17 parts of the whole, if the whole presents, for example, a communication net, which contains 17 communication lines. But as soon as we perceive it as an abstract drawing, and transfer it to the domain of the moving pen, parts of that whole will be elementary movements – strokes, movements without stops (breaks) or interruptions. In that case parts of "Fig.30" are strokes **8+9+1**, **2, 3+4+5, 6+7, 11+17, 13+15, 14+16, 12+10.** From these 8 strokes only 2 quadrangles can be drawn. The hypothesis that it could be a hexagon ("Fig.29") doesn't even arise. On the contrary, in last two figures, all 6 strokes that constitute the hexagon are presented and are drawn in a sequence, which indicates that it is a distinguished object.

2. Köhler's Figures and Comments *(all figures are copies from* [Köhler 1975]**).**

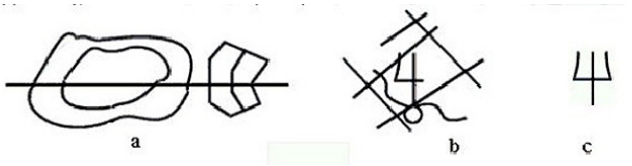

Fig. 11

The question is obvious: why do we perceive "4" in **b** but not in **a?** The answer is trivial: when redrawing figure **a** none of the strokes that constitute the figure are strokes that commonly constitute "4". On the contrary, in Figure 11**b** there are all three strokes which form "4". It is interesting enough to mention that all additional strokes in **b** are well organized: a group of North-East parallel lines, a group of North-West parallel lines, a wave, a circle and the rest, which is "4". There is a proof that parallel lines are organized in groups: in experiments aimed at redrawing that figure, parallel lines were drawn in sequence.

3. Metzger's Figures and Comments (*all figures are copies from* [Metzger 2006], *Metzger's comments are in Italics).*

First, let us quote Metzger's comment on Köhler's example (Fig. 11): "Why the numeral 4 is not perceived in figure **a**, but is readily perceived in figure **b**, even though the **additions** in the latter are just as unusual as in the former." While drawing, one can add some strokes after drawing "4" as in figure **b**, but one can't add surrounding strokes to "4" and get figure **a:** the connections between strokes composing "4" and approaching strokes will never be smooth, and will show.

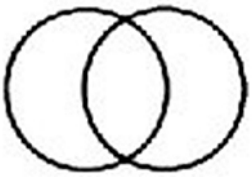

Fig.12a

3.1 Metzger describes this image as "two intersecting circles" but mentions seven more possible descriptions. For example, "'mantle' in the form of a bread roll and a 'core' in the form of an almond". But there is only one way to redraw that figure: to draw two circles.

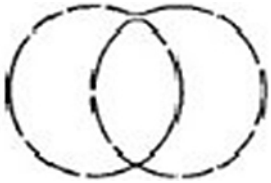

Fig. 12b

3. 2 The image contains a number of small arcs and two intersections of arcs (X-like shape) of an intersection (lower center), two angled V- shapes, and even a cross (lower center), two angled V-pieces touching point-to-point (upper center), and nine irregular arc segments.

The point is that they are not parts but pieces, in the sense that the whole can be separated into any pieces but arbitrary pieces can't be composed into a whole. The right Gestalt is the description of the way fig. 15 can be reproduced: two intersecting circles drawn with regular interruptions.

3.3 Here (Fig. 13) is a variant of the hidden "4" in Köhler's example: why don't we see the figure **a** in figure **b** ? Experiments show that subjects redraw figure 13**b** starting with the outer quadrangle (it is obvious because the quadrangle set the limits for the rest of the lines). It is followed by drawing two parallel oblique lines. The last drawn are the series of stepped lines. These three groups of lines constitute the figure, and there are no strokes that compose figure **a**.

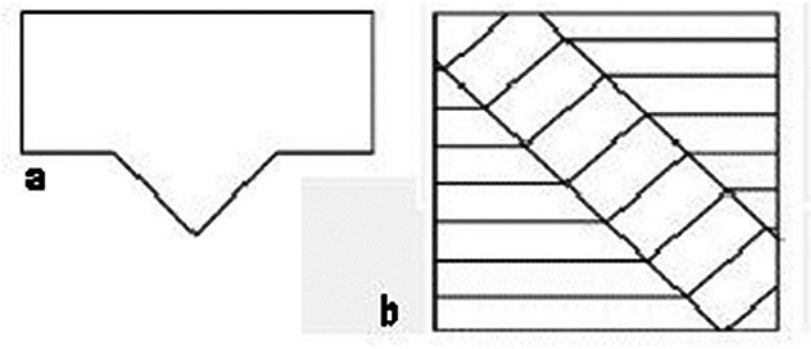

Fig 13

The next figure (Fig. 14) is also Köhler's example: the Maltese cross. Metzger explained our blindness to possible components by describing them as crooked, disorderly, senseless, poor, arbitrary, and piecemeal. By drawing that "cross in

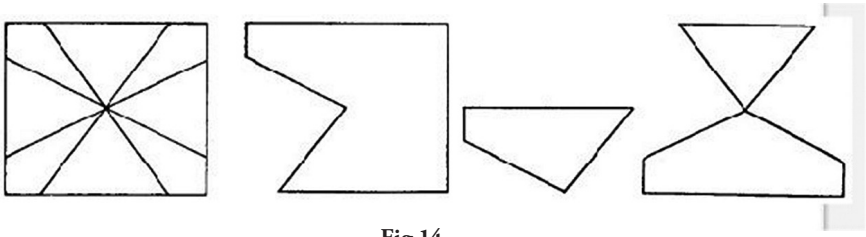

Fig.14

quadrangle" one draws first the quadrangle and then the cross. At no point do other possible figures come to the attention of the viewer, so the viewer has no chance to describe them as ugly, senseless etc.

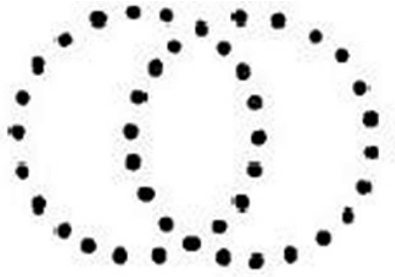

Fig.15

3.4 *"The dotted pair of circles is hardly different from two regular circles. There are not forty-two dots, but rather two circles with dots on them. Gestalt laws work unchanged despite partition and interruption".* It is in complete agreement with that mentioned above: under visible dots exist imaginary lines – tracks of a drawing tool.

3.5 *"What is this? No one recognizes the constellation of the Big Dipper in figure a., although the corner points correspond exactly. The* ***natural*** *bridging lines are replaced in part by arbitrary connections."*

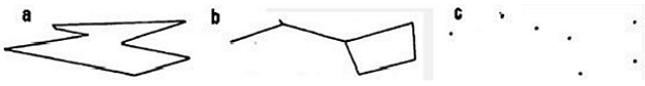

Fig. 16

Now let us redraw the constellation (c): first, you will draw 4 dots along the "handle", then the corner points of the quadrangle (or vice versa). In any case these two objects constitute the constellation, and define the shortest description. No other way of drawing comes to mind. The path of the drawing tool defines the invisible bridges. Metzger used the word **"natural",** which means that **figure b** shows the natural way of drawing that constellation.

3.6 Metzger introduced a principally new, for Gestalt psychology, visual stimulus: a hexagonal grid, i.e. a plain packed with hexagons. The description is short and simple and presents a good Gestalt.

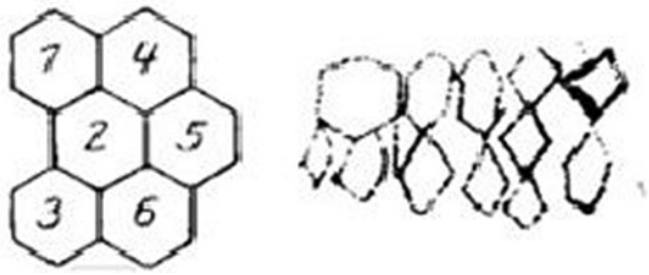

Fig. 17

But there is a trick: if one wants to draw that image according to the description, one has to draw a hexagon, then another one, then many more hexagons close to each other. But surprisingly only the first hexagon (# 1) is a hexagon. To draw the hexagon # 4 one has to draw only 5 sides of a hexagon, and to draw hexagon # 2, 4 sides only, and it varies each time. As a result it is a difficult task for ordinary people. Why is this so? Why is the description so simple but the reproduction so complicated? The imitation principle stated that the description of visual stimuli is not a description of what we see, but a description of how it was created. But most 2-D images which were discussed by gestaltists in the past were drawn with a pen, and consist of one-dimensional objects: strokes. Accordingly, the description – the Gestalt – defines the arrangement of the lines.

On the contrary, the "honeycomb" is described not as a product of pen movement, but as a construction built of 2-D objects (white hexagons) in a special way: by **tessellating** them (like paving the floor with ceramic tiles). The visible lines are only the byproduct of the construction – grout that fills the contacts between tiles (or copper tape between pieces of stained glass). It is remarkable that on the mathematical website Wolfram Mathworld [http://mathworld.wolfram.com/] the difference between the orthogonal and hexagonal grids is described as follows: "Orthogonal grids (such as the square grid) are formed by two sets of **lines** perpendicular to each other. Hexagonal grids are formed by tessellating regular **hexagons** in the plane". It seems that Metzger understands the dilemma.

He shows a "honeycomb" drawing from a mentally retarded student who understood the Gestalt and tried to reproduce it literally. Moreover, Metzger shows that if the stimulus is a rectangular grid (Fig.18, left), i.e. a "plain packed

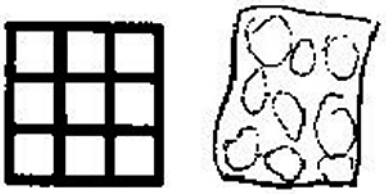

Fig.18

with quadrangles", people have no problems with redrawing it – they draw a set of vertical parallel lines and a set of horizontal parallel lines. But behind the consciousness an idea exists that the whole consists of parts: squares. It becomes apparent when the image is transferred to another modality: a tactile one (Fig. 18, right).

That case shows how deep and extended is the notion of "Gestalt", and how much of human experience and knowledge it contains. Wolfgang Metzger has to be credited for bringing this visual stimulus forward for consideration.

4. Pinna's Figures and Comments *(all figures are copies from* [Pinna 2010], *Pinna's comments are in Italics).*

Pinna's most recent publication piqued our interest because the title of the article is "New Gestalt Principles of Perceptual Organization". Pinna introduced a set of images and a new principle of perception: perceptual meanings.

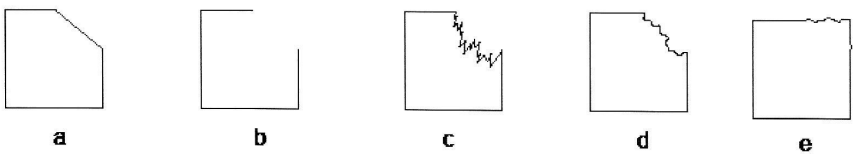

Fig. 19

"In Fig. 19b, neither the gestalt principles nor the form of shape can explain: 'a square perimeter whose top right corner is absent, missing, deleted or cut'. In Fig. 19c, 'the glass square is broken in a corner'. The square appears 'made of glass'. In Fig. 19d, 'a gnawed or nibbled square' is perceived. In Fig. 19e 'the square is deformed by a scorch'". In each case the description tells us how the image was created, so naturally the ***imitation principle*** covers these cases. In addition to all the above-mentioned images in the set of descriptions, the materials were indicated (glass),

as well as transformation processes (broken, gnawed, nibbled, deleted, scorched). As we see the "Gestalt" widens its reflection of reality.

Proximity and Similarity vs. Imitation Principle

Proximity and similarity principles are the most solid and defined principles of Gestalt psychology. In any list of gestalt principles (or gestalt laws) these two are always at the top despite attempts to substitute them with more basic concepts. For example, Metzger wrote: "The law of similarity is thus again a special case of the general law of the *unity of structure,* or of the law of the good Gestalt." [Metzger 2006] As I stated above, a good Gestalt is a *short description.* More precisely, it is a short description of *how the object was created.* How is this definition related to the proximity principle? Let us consider the simplest illustration of the proximity principle: two dot clusters (Fig. 20).

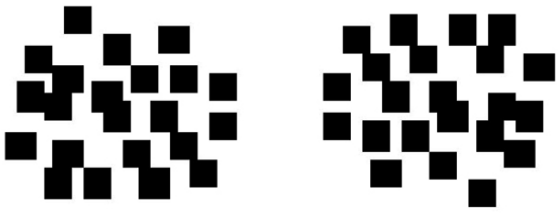

Fig. 20

The imitation principle demands reconstruction of the process of creating the visual stimuli. As a result, discreet elements of the image (in this case dots) become arranged in time and all elements belonging to one object have to be drawn in sequence. Common sense and simple experiments show that people first draw all dots belonging to one cluster and then draw all dots of the second one. It is obvious that in this simple example the proximity principle doesn't contradict all other Gestalt principles and thus gives the only possible interpretation. So, the imitation principle does not help in the interpretation of this stimulus, but it is important to underline that it gives the same solution.

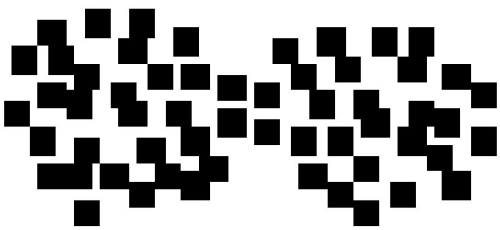

Fig.21

Now let us look at next figure (Fig. 21). Everybody will describe it as two clusters despite the fact that the proximity principle doesn't work properly. The imitation principle still works properly: dots of each cluster were drawn in a sequence without interruption, and the image will be described as "two connected clusters". One can say that in this case the proximity principle is applicable not in the space domain but in the time domain.

Fig.22

In Fig.22 everyone perceives two dashed lines, but neither the proximity principle nor the similarity principle works, despite both principles being applicable. The imitation principle gives the correct answer – two parallel stroke-dashed lines. First one line was drawn, and then the second one. The same happens in a real image of low quality fingerprints (Fig.23).

Fig. 23

It doesn't mean that we neglect the good continuation principle – it is transferred from the Euclidian plain of the visual stimuli to the domain of the imaginable process of creating the stimuli and hidden in the term *stroke.* It doesn't mean that we neglect the closure principle – it too is transferred to the domain of the imaginable process of creating the stimuli and reflects the natural hypothesis that every object is drawn without being interrupted to draw another object.

Important Argument Added After Original Submission

While working on the response to reviewers of this article, I was searching the classical works of Wertheimer, Köhler, and Metzger. My attention was drawn to the notion of **Prägnanz.** Wertheimer at the very beginning (1923) introduced the law of Prägnanz in order to integrate the Gestalt laws of grouping. Köhler, Metzger, and many other gestaltists supported the idea, but none defined it clearly. The translator of Wertheimer's 1923 paper noted that there is no adequate translation of the term. The most popular "definition" today is "tendency to a good Gestalt".

So, I decided to learn what it means in German, and went to Wikipedia. I found the meaning of the word, the antonym, and an example of use. Here they are:

Ein Ausdruck ist **prägnant**, wenn dieser trotz Kürze einen hohen Bedeutungsgehalt aufweist.
Das Gegenteil der **Prägnanz** findet sich in Ausdrücken wie Umständlichkeit, Weitschweifigkeit oder Ungenauigkeit.
Die **prägnante** Schilderung einer Situation verzichtet also auf Füllwörter und inhaltsleere Floskeln und kommt sofort zum wesentlichen Kern.
Der Referent stellte die wirtschaftliche Lage des Unternehmens mit außerordentlicher **Prägnanz** dar. Dies bedeutet, dass die Situation des Unternehmens kurz und treffend dargestellt wurde, der Vortrag also auf das Wesentliche beschränkt war.

Prägnanz is a characteristic of an *expression*, i.e. a *linguistic unit*, which is short and saturated with meaning. And that is precisely what my definition of "good Gestalt" is: "good Gestalt" is a description of what we see. The description is an expression, and the meaning is a generalization, which contains packed-in information about an entire class of stimuli. Now we can understand why the translator put a footnote to the word **Prägnanz:** "the term '*Prägnanz*' cannot be translated" – the regular meaning of the word doesn't fit the model of perception generally accepted at that time (1938).

It turns out that at the very beginning Wertheimer not only raised the problem of reduction of the number of basic Gestalt principles to a single one, but gave us the solution.

Conclusion

From the very beginning of Gestalt theory, Wertheimer was concerned with reducing the number of basic principles. He introduced the law of Prägnanz, as the only Gestalt law of grouping, but didn't find a definite description of the term. To characterize the meaning of Prägnanz Wertheimer used such words as *strong, distinctive, good, inner necessity, inner coherence.* As time went on, new characteristics were used, like *tendency toward maximal simplicity and balance*, or *tendency to the good Gestalt,* but again, none was well defined.

In this article I have presented the "linguistic interpretation" principle that transfers the notion of Gestalt from a visual modality to a linguistic one, from **forms** of visual percept to **descriptions** of visual percept. In that modality the definition of Gestalt is **"description of what we see"** and the definition of "good" Gestalt is **"short"**. I then presented the second principle – the "imitation principle": **"a description initiated by a given visual communication stimulus is a description of how that visual stimulus can be recreated"**. Combining both principles we have: **"good Gestalt is the shortest description of how what**

we see can be recreated".

Based on these definitions it was shown that:

1. The basic principle is a sufficient explanation of Gestalt perception of a wide spectrum of visual stimuli discussed in Gestalt psychology.
2. Gestalt is a generalization of the visual stimuli.
3. The description of the stimuli is really a description of the way the visual stimuli were created or can be reproduced (imitation principle).
4. As a matter of fact, it describes not what was really drawn by the creator of visual stimuli but the **intention** of the creator – the ideal pattern.
5. These concepts are in agreement with Wertheimer's, Köhler's and Metzger's ideas.
6. During its 100-year history, Gestalt psychology has been focused on the leading role of perception of movement in communication between people, and at last mirror neurons were discovered 20 years ago.

The presented **imitation principle** of grouping and classical Gestalt principles are applicable only to the area of communicative signs. How the linguistic interpretation of Gestalt works on the infinite number of objects in the world presented by gray and color images one can see in my 2012 paper published in *Gestalt Theory* [Guberman 2012].

Summary

This paper presents the definition of "good Gestalt" based on the "linguistic interpretation" principle: "Good Gestalt is a shortest description of what we see", and the "imitation principle": "Good Gestalt is the shortest description of how the visual stimulus was created". It is shown that **all Gestalt laws of grouping can be derived from these principles,** by testing the statements on examples used in the works of Wertheimer, Koffka, Köhler, and Metzger. Use of these principles allows us to avoid ambiguities which appear when classical Gestalt principles are applied. The presented "imitation principle" of grouping is applicable only to the area of communicative signs.

Keywords: Gestalt theory, Artificial intelligence, principles, linguistics, imitation.

Zusammenfassung

Der Beitrag legt die Definition der „guten Gestalt", basierend auf dem Prinzip der „linguistischen Interpretation", dar: „Gute Gestalt ist eine kürzeste Beschreibung dessen, was wir sehen", und das „Nachahmungsprinzip": „Gute Gestalt ist die kürzeste Beschreibung, wie der visuelle Reiz erzeugt wurde". Indem diese Aussagen an Beispielen aus den Werken von Wertheimer, Koffka, Köhler und Metzger überprüft werden wird gezeigt, dass **alle Gestaltgesetze der Gruppenbildungen von diesen Grundsätzen abgeleitet werden können**. Die Verwendung dieser Grundsätze ermöglicht es uns, Doppeldeutigkeiten, die bei der Anwendung der klassischen Gestaltgesetze auftreten, zu vermeiden. Das dargelegte „Nachahmungsprinzip" der Gruppierung ist nur im Bereich der kommunikativen Zeichen anwendbar.

Schlüsselwörter: Gestalttheorie, künstliche Intelligenz, Gesetzmäßigkeiten, Linguistik,

Nachahmung.

Acknowledgment

I would like to express my gratitude to Dr. Gerhard Stemberger, who for many years has guided me in Gestaltland, and helped to formulate these ideas and the way they are presented to the readers of this journal.

References

Andreevsky, E. & Guberman, S. (1996): From Language Pathology to Automatic Language Processing… and Return. *Cybernetics and Human Knowing,* vol. 3, No. 4, 41 – 53.

Bongard, M. (1970): *Pattern Recognition*, New York: Spartan Books.

Bruce, V., Green, P. & Georgeson, M. (1996): *Visual perception: Physiology, psychology and ecology (3rd ed),* LEA.

Ehrenfels, von, C. (1890): Über Gestaltqualitäten, *Vierteljahresschrift für wissenschaftliche Philosophie, 14,* 249-292.

Guberman, S. & Woitkowski, W. (2002): Clustering Analysis as a Gestalt Problem. *Gestalt Theory*, vol. 24, No. 2, 143 – 158.

Guberman S. (2007): Algorithmic Analysis of "Good Continuation" Principle. *Gestalt Theory, 29(2),* 148-167.

Guberman S., & Minati G. (2008): *Dialogue about Systems,* Milano: Polimetrica.

Guberman S., Maximov V. & Pashintsev A. (2012): Gestalt and Image Understanding, *Gestalt Theory, vol.34, No. 2,* 143-166.

Koffka, K. (1935): *Principles of Gestalt Psychology*. New York: Harcourt, Brace.

Köhler, W. (1975*)*: *Gestalt Psychology. A Mentor Book*, New York and Scarborough: Ontario.

Mel'chuk, I. (2010): *Dependency Syntax: Theory and Practice,* State University of New York Press.

Metzger, W. (2006): *Laws of Seeing*, MIT Press.

Palmer, S. (1999): *Vision Science.* MIT Press, Cambridge (USA).

Pinna, B. (2010): New Gestalt Principles of Perceptual Organization. *Gestalt Theory, vol.32, No. 1,* 11-78.

Scheerer, M. (1954): Cognitive Theory. In G. Lyndzey (Ed.), *Handbook of Social Psychology*, vol. I, 91 – 142.

Todorovic, D. (2008): Gestalt principles, *Scholarpedia 3(12).*
http://www.scholarpedia.org/ article/Gestalt_principles#Closure_principle

Wagemans J., Elder J., Kubovy M., at al. (2012). A Century of Gestalt Psychology in Visual Perception I. *Psychol Bull.,138(6).*

Wertheimer, M. (1923): Untersuchungen zur Lehre von der Gestalt II, in *Psycologische Forschung,* 4, 301 – 350. English translation: http://psychclassics.yorku.ca/ Wertheimer/forms/forms.htm.

Shelia Guberman, (b. 1930), M.D. in mathematics, M.D. in electronics, Ph.D. in nuclear physics, Ph.D in Artificial Intelligence. Head of Division at Institute of Applied Mathematics of the Russian Academy of Sciences (1966-1991). Chair Professorship at Moscow Open University (1989-1992). Author of first applied pattern recognition program (1962), D-waves theory of Earth seismicity (1975), algorithms of gestalt-perception (1980), technology of giant oil and gas fields exploration (1985). Worked in Artificial Intelligence from 1962 implementing principles of Gestalt perception in computer programs for geological data analysis, handwriting recognition, speech compression, medical imaging, oil and gas exploration. From 1992 he has lived in the US. Author of core technologies for five US companies. At the present time he is focused on investigating principles of Gestalt psychology.
Address: PO Box 2411, Cupertino, CA, USA
E-mail: guboil@hotmail.com