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What Are The Limits Of Gestalt Theory?

It has been almost a century since the main Gestalt laws were introduced by Wertheimer (1923). Though several limits of this approach have been highlighted, Gestalt laws are still one of the main points of reference for the understanding of perceptual organization (Elder & Goldberg 2002; Luccio 2011; Wagemans, Elder et al. 2012; Wagemans, Feldman et al. 2012). The principles of grouping have never been called into question by cognitive scientists and several scholars have actually looked for confirming evidence at the neuro-physiological (Roelfsema 2006; Spillmann 2006), computational (Kienker, Sejnowski et al. 1986; Desolneux, Moisan et al. 2003; Grompone von Gioi, Delon et al. 2012) or other levels (Hatfield & Epstein 1985; Luccio 1999; Kubovy & van den Berg 2008; Pomerantz & Portillo 2011).

A limit of Gestalt theory is the lack of a comprehensive view of perceptual organization. This can be seen in the distinction between figure-ground segregation and grouping, as well as in the proliferation of principles of grouping (Wagemans, Feldman et al. 2012,1225). The lack of a comprehensive view has become more apparent in recent decades. Current research on perceptual grouping and figure-ground organization "does not itself form an integrated domain of research, let alone a coherent research program or theoretical framework guided by a limited set of (meta)theoretical principles as their foundations, as was the case in the Berlin school of Gestalt psychology" (Wagemans, Elder et al. 2012,1208).

The analysis I carry out is aimed at making a comparison with Gestalt theory through a psychophysical approach. I do not make any reference to the extensive neurophysiological literature on perception, i.e. to the large body of evidence concerning a variety of aspects, such as the processes triggered by the stimulation of the photoreceptors of the retina (Masland 2012) and the organization of the striate and extrastriate cortex (Prasad & Galetta 2011). However, it should be noted that:

1. Gestalt laws are still an important point of reference for the understanding of perceptual processes, which have yet to be fully explained by the cognitive and neurophysiological approaches – especially with respect to their global aspects

(Levitt & Lund 2002; Elder & Goldberg 2002; Ehrenstein, Spillmann et al. 2003; Craft, Schütze et al. 2007; Shapley 2007).

2. The psychophysical approach is methodologically sound and still used in the study of perception (Fetsch & DeAngelis et al. 2013).

In this paper I will introduce an alternative model to Gestalt theory, with the aim of overcoming the lack of a comprehensive view of perceptual organization, as well as other limits of the classic approach which I will highlight in my argumentation.

1. The Surrounding Contrast of the Structure of the Proximal Stimulus

All the perceptual situations analyzed by gestaltists present an *alternative.* In other words, these situations are such that, based on how we group the elements of the visual field, we can see one thing rather than the other, or we can see in one way rather than in another. For instance, in figure 1 we see two pairs of triangles rather than other possible alternatives.

Fig. 1 Two pairs of black triangles

These situations are apparently useful for assessing the validity of the factors involved in perceptual organization. But what happens if we eliminate three of the four triangles, such as in figure 2? When there seems to be no alternative to the perception of a simple, homogeneous shape – unless we see it as a hole (Nelson & Palmer 2001; Bertamini 2006) – on the basis of which factors do we see the object? A possible reply may be that, since there are no elements to be grouped, the image is not organized on the basis of grouping, but on the basis of one of the factors of figure-ground segregation, i.e. surroundedness. However, as I will argue below, this principle responds to a *slightly* different question. In addition, it does not allow us to highlight the points in common with the concept of grouping.

Fig. 2 A black triangle "without alternatives"

If we ask ourselves which "laws" govern the perception of the black triangle, it does not seem difficult to find an answer. The conditions under which we see a simple figure can easily be derived from the nature of the figure and of the ground, i.e. what they help to define. The perception of a black triangle is conditioned by the

brightness of the background. The bigger the object-foreground difference is, the more vivid our conscious experience will be. Therefore, these conditions imply the division of a field into two homogeneous regions, one internal to the other and the two contrasting with each other (Wertheimer 1923, 348; Todorović 2008). One may say that the conditions under which we see a simple shape on a homogeneous background consist in the *surrounding contrast (SC) of the structure of the proximal stimulus*. There is a SC when a spatially extended region of the proximal stimulus contrasts with the surrounding region. Since the SC of the proximal stimulus concerns the relationship between an internal space and the external surrounding space, it involves the structure of the stimulus in its entirety.

However, the conditions under which we see a simple figure are not as obvious as one may think. Unlike in the Gestalt approach, they lead us to focus on the characteristics of the proximal stimulus, i.e. on the ways in which the external reality is projected on the retina (Heider 1959). In other words, they lead us to adopt a psychophysical approach (Gescheider 1997). Therefore, we can ask ourselves if the factors in the presence of which we perceive a triangle are also involved in the perception of the two pairs of triangles.

Let us now go back to situations in which the stimuli are a bit more complex, as is common in our visual experience. How does a complex perceptual situation differ from a simple perceptual situation? One may say that we see several objects, that an object is made up of several parts, that it combines with other objects to form a Gestalt, that it belongs to a scene and so on. However, if we make reference to the characteristics of the proximal stimulus, we may say that, while in a simple perceptual situation there is only one contrast between internal space and external space, in a complex perceptual situation there is more than one contrast between internal space and external space. In other words, we may say that there are several SCs in the field of the stimulus. This is a counterintuitive view of the structure of the stimulus, because we have to imagine that several SCs of the structure of the stimulus are overlapping.

I will now try to adapt the principle which I have just stated to a more complex situation. If we assume that in contents which are phenomenally more salient there are stronger contrasts between internal and external space, we can hypothesize that the main content which our perceptual processes lead us to choose is correlated with the strongest existing contrast in the structure of the stimulus between internal and external space. In other words, it can be hypothesized that *the perceived content corresponds to the strongest SC of the proximal stimulus.* In this case as well, the relationship involves the internal space and the external space in their entirety. Furthermore, the term SC refers to a region located inside the field, without necessarily identifying it with an object or a figure. As I will demonstrate

below, this region can correspond to the grouping of more elements in a Gestalt. Under conditions in which a SC is significantly stronger than the others, one would expect perceptual salience or pop-out (Derrington 1996). On the other hand, under conditions in which no SC is significantly stronger than the others, it will be more difficult to identify one object. Under conditions in which two SCs are much stronger than the others, we would expect the two corresponding objects to be perceived to the detriment of others and not to prevail over each other at a phenomenal level.

It is worth emphasizing that the use of the term *SC* takes into account the difficulty of describing the actual conditions of stimulation, differentiating them from what we perceive. For instance, it does not seem appropriate to use the term *difference*. In the case of the black triangle on a white background, the term *difference* cannot indicate the relationship between internal space and external space. The term also implies a difference in shape which cannot be considered in the relationship between internal space and external space, because it is precisely the relationship with the external space which defines the shape of the object.

It would also be inappropriate to make reference to a condition linked solely to the characteristics of the object, such as homogeneity (Kanizsa 1980, 70). The salience of a foreground can be caused by contrast with the external space, without the internal space being inherently homogeneous, e.g. an inhomogeneous internal space surrounded by a homogeneous external space, or an inhomogeneous internal space surrounded by a differently inhomogeneous external space, such as in the case of a colored foreground with a black-and-white background. On the other hand, homogeneity without contrast with the external space does not bring about perceptual salience. On the contrary, it prevents us from seeing anything. We perceive objects *solely* because the region corresponding to them contrasts with the external region.

A lot of the concepts used in the Gestalt approach pose a similar problem. The difficulty of using common terms such as similarity, proximity and continuity to describe the conditions of stimulation is due to the fact that they are used to indicate the relationship between objects or between object parts. In other words, these terms do not refer to the conditions of stimulation, but to something which derives from these conditions and which already belongs to the domain of visual experience. On the contrary, contrast between an internal region and an external region is an objective characteristic of the structure of the stimulus, which is different and – to a certain extent – independent from the subjective perception of an object on a given background.

2. The Surrounding Contrast Unifies the Main Gestalt Laws

I will now try to illustrate with some examples that the simple rule stating that, given a visual field, the perceived object corresponds to the strongest SC of the proximal stimulus accounts for several aspects of perceptual organization, thus unifying Gestalt laws. According to Gestalt laws, in figure 3 we see a broken line because of factors such as proximity and similarity, which group together the dashes to form a line.

Fig. 3 A broken line

If instead we consider the contrast with the external space, the broken line is perceptually *primary*, because, despite the discontinuity of the parts which make it up, it has the strongest SC in the field. The region corresponding to the broken line is the one which in the figure features the strongest contrast with the external space. Also the internal spaces corresponding to the individual dashes have a certain degree of contrast with the external space, but, because of the presence of the other dashes in the external space, their contrast is not as strong as the one of the broken line.

Fig. 4 Two pairs of dashes

If we move the outer dashes closer so as to form two pairs, we obtain an image which is traditionally used to illustrate the law of proximity (figure 4). However, what happens between the objects cannot be separated from what happens between object and ground. Two objects cannot get closer to each other in the perceptual space with the surrounding space remaining unchanged. The perception of proximity between two objects necessarily depends on the relationship between the spatial extent of the objects, the space between the objects and the space surrounding the objects. The space corresponding to the two lateral pairs of dashes has an overall contrast with the external space that is stronger than the one corresponding to the central pair: the white space, which characterizes most of the external space and contrasts with the black space occupied by the dashes, is larger in the region between the two lateral pairs and smaller in the area separating the elements of each lateral pair. With all other factors being equal, moving two objects which contrast with the external space closer to each other increases the SC of the space corresponding to them.

Similarity can also be considered a factor which increases the contrast of an internal space with the corresponding external space. Similarity is the expression of a relationship between shapes which form in their turn through their relationship with the external space. The similarity of two figures forming a pair brings about an increased homogeneity of the space corresponding to the pair and, as a consequence – with all other factors being equal – an increased contrast between that space and the surrounding space. In other words, the SC of two similar figures is stronger than the one of two different figures. In figure 5 we tend to see rows rather than columns because they have a stronger SC than columns.
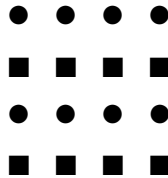

Fig. 5 Alternating rows of circles and squares

The role of the SC is even more evident when similarity occurs in the form of color or brightness of the objects. In figure 6 we see horizontal rows of white circles and of black circles because these internal regions contrast with the external space more strongly than the internal regions formed by the black and white columns.
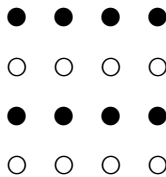

Fig. 6 Alternating rows of black circles and white circles

If the relationship between the two sets involves the internal space and the external space in their entirety, the degree of internality of one space in another plays a role in defining the entity of the SC. When located centrally in the visual field, a figure has a stronger SC than when it is located in the periphery, because the contrast affects all the regions of an external space in a uniform way. Similarly, when a figure is symmetric, its contrast with the external space increases, because the contrast affects the regions of the internal space in a uniform way.

The involvement of the whole perceptual field helps resolve the apparent contradiction between global factors and local factors which arises when our

attention is captured by a detail. Gestaltists are right when they argue that conscious perception is a global process. However, the global dimension does not concern the object or the overall Gestalt, but the relationships between object and ground. The fact that we see the eyes of a person rather than their face, or that our attention is captured by a very small detail of a complex scene because of the salience of these elements is not a local event, but a global one, because, *considering the whole perceptual field*, that is the internal space which contrasts the most with the external space. This interpretation allows us to overcome the difficulty arising when considering these aspects as solely local and, as a result, potentially conflicting with Gestalt laws.

What is the behavior of a line if we not only consider it in itself, but if we consider also the relationship between internal space and external space? First of all, a perceived line behaves like a space, which can be both internal and external to other spaces. Therefore, depending on its form, we must analyze its relationships with the nearby spaces. What is the behavior of a straight line, of a curved line, or of a broken line? From this point of view, different lines produce completely different effects.

A straight - or smoothly curved - line behaves like an internal space and it is in relation to an external space which encloses it on both sides. This relationship is characterized by a very strong contrast, which is at the root of the phenomena described by the principle of good continuation.

A curved line tends to generate an external space on its convex side – hence the role of convex margins – and an internal space on its concave side. If the line tends to close or is completely closed, the internal space and the external space will appear even more clearly – hence the role of closure. In the initial example of the isolated triangle, I used a shape and not a contoured figure, because the latter is more complex than the former in terms of relationships between internal spaces and external spaces. In a contoured circle, the contrast between an internal space and an external space which do not differ from each other is created through the interposition of the curved line.

The space-like behavior of a line is confirmed by the fact that the nature of the relationship seems to depend on the thickness of the line and, as a result, on the width of the space corresponding to it. We probably see a contoured circle because the line is not thick enough to appear as an internal space. As soon as the line becomes thicker, as in the case of a ring, this line tends to become an internal space and the space enclosed by the line becomes an external space acting as ground.

A broken line generates an abrupt change in the external space which forms around a straight line and it tends to divide the field into incomplete content-

ground subfields. As a result, the SC of a broken line is not as strong as the one of a straight line. The incomplete content-ground subfields are perceived as the *parts* of which an object is made up, such as the sides of a square.

3. Other Perceptual Situations

In the case of amodal completion, we perceive the figure, or rather the figures, which, given the existing conditions of stimulation and considering the whole field, correspond to the strongest contrast between internal space and external space. It should be taken into account that:

- amodal completion occurs in the framework of a relatively complex perceptual organization;

- this perceptual organization entails the coexistence of at least two main objects, the occluding object and the occluded object, which do not clearly prevail over each other;

- amodal completion depends on the behavior of the occluded object, both as internal space towards its background and as external space towards the occluding object. At a perceptual level, the occluded object acts as object and ground at the same time.

In figure 7 the perception of a black hexagon behind the white rectangles – traditionally attributed to the law of closure – is linked to two different relationships between internal space and external space at the same time. We see a series of hexagons because, considering the whole field, they are at the same time the objects which contrast the most with the ground and the part of ground which contrasts the most with the rectangles placed in front.
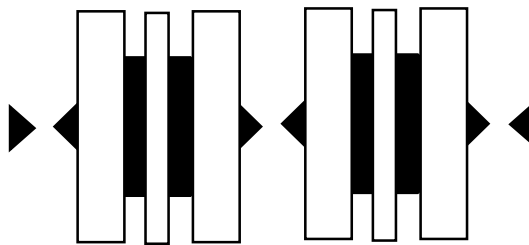
**Fig. 7** A classic example of amodal completion

Similarly, the SC principle accounts for the cases in which the perception of an object is determined by the inhomogeneity of the external space. There may be a ground containing objects, such as a sky dotted with clouds, or a succession

of concentric grounds, or an alternation of objects and ground at the boundary with the internal space – an example of the latter being the Kanizsa triangle.

Apart from the additional effect of amodal completion, we see the white triangle primarily because the internal space corresponding to it is the one which in the field differs the most from the surrounding space. In particular, the fully homogeneous internal space contrasts with an external space which, being made up of the white space and of objects such as the circle segments and the angled lines, is inhomogeneous. Amodal completion in the disks and in the underlying triangle strengthens the contrast, producing the well-known effect of the triangle without contours being perceived as brighter than the background and placed above the other parts of the field. Kanizsa himself gave some examples in which we see a white figure – even if without the typical effect of an illusory figure – corresponding to a homogeneous internal space surrounded by an inhomogeneous external space (Kanizsa 1979, 203). In any case, the relationships involved in this example do not differ from the ones which lead us to see a shape on a background which is made inhomogeneous by the presence of clouds.

The SC principle highlights a problem: Gestalt laws focus on a part of the visual field. Indeed, gestaltists analyze what occurs within a frame, or within a portion of the existing space. The limit of these conditions is all the more evident if we do not analyze the relationships between contents, but the relationships between internal spaces and external spaces which involve the whole visual field. From this point of view, it becomes evident that we can analyze what we perceive within the frame only as long as the external background does not significantly influence the relationships existing within the frame. In order for this to occur, the object perceived within the frame must correspond to the internal space with the strongest SC even when we look at it from a broader perspective.
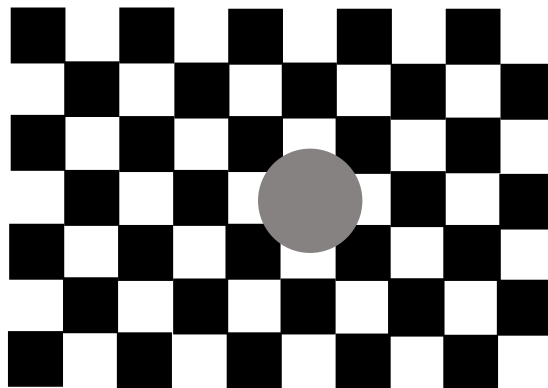
Fig. 8 The gestaltist's error: the black square required by the global structure is not perceptually present behind the disk

These conditions are present in the figures examined so far. However, figure 8 is an example in which these conditions are absent. According to Kanizsa (1979, 84), seeing a white cross behind the gray disk contradicts gestaltist's expectations, because the local conditions prevail over the global structure of the field, which coincides with the checkerboard. In other words, the image seems to demonstrate one of the limits of Gestalt theory. However, there is a theoretical contradiction only if we remain within the gestaltist "field". If we also consider the background surrounding the image in its entirety, there is only a contradiction which is due to the conditions of stimulation, which entail an alternation between a narrow perspective – internal to the image – and a broader perspective including also the background. In the broader perspective, in which we see the checkerboard with a gray circle placed on top in a central position, it is the space corresponding to the whole image which features the strongest SC. As a consequence, in order to ensure as strong a contrast as possible, we expect the checkerboard to be complete behind the gray circle. However, when we focus our attention on what we see behind the gray circle, we inevitably end up looking at the image from the narrower perspective. In this case, it is the space corresponding to the gray circle which features the strongest contrast between internal space and external space. As a consequence, the white cross is the object which best acts as a background to the gray circle.

4. Figure-Ground Segregation

Besides the laws of grouping, we must consider the factors of perceptual segregation or figure-ground segregation, which were first defined by Rubin (1915, 1921). The segregation of figure from ground is one of the most fundamental operations of human vision (Neri & Levi 2007). The factors accounting for perceptual segregation are convexity, symmetry, size, surroundedness, parallelism, orientation and meaning. These factors lead us to see an area of the visual field as figure rather than as ground. In a way, perceptual segregation is close to the approach illustrated in this paper. Unlike Gestalt laws, which are based on the analysis of the relationships existing between contents or between content parts, figure-ground segregation is based on the analysis of the relationship between two areas of the field which potentially form the content and the ground. However, there are important differences between the model of figure-ground segregation and the one illustrated in this paper.

Firstly, when we ask ourselves under which conditions a region of the field is more likely than the others to act as figure (Kanizsa 1980, 41), we assume that these regions are visible – or detected in some way – and that characteristics such as convexity and symmetry lead us to see one of them as figure. In other words, even Rubin does not analyze the conditions of stimulation, i.e. what is at

the source of conscious perception. As a result, the role of the contrast with the ground ends up being neglected, even if it influences the salience of a figure and even if it is essential for its perception (Ehrenstein, Spillmann et al. 2003, 437). In any case, contrast with the ground is not taken into consideration *together* with other factors (Palmer 1999).

Secondly, no common factor is identified, even if many of the factors which contribute to figure-ground segregation imply a spatial relationship between two areas which can essentially be equated to surroundedness. This relationship does not necessarily involve the whole perceptual field. On the contrary, the SC of the field entails at the same time:

1. a contrast between two areas – either direct or mediated by a contour;
2. the surroundedness of the two areas, i.e. the relationship between an internal space and an external space;
3. a relationship which *always* involves the whole perceptual field.

In this way, most of the factors identified in perceptual segregation can be explained through the contrast between internal space and external space. For instance, convexity and smaller size are nothing but situations in which an area tends to acquire a condition of being internal to another. Internality can thus be considered a common factor: in a field divided into two contrasting regions, we see as object the region which tends to place itself inside the other.

Finally, figure-ground segregation does not provide an explanation of Gestalt laws. If instead we apply the SC principle, object formation and grouping of objects are nothing but two particular cases of the same phenomenon, both governed by the same law. A visual object, such as a tree, a face, a house or a stone, has a given form and it generally has a continuous contour which helps differentiate it from the background. At the same time, it is never fully homogeneous in its interior (Todorović 2011, 7). Unlike a simple shape, it contains details, it has surface characteristics, a weave, it is organized in parts which, even if united in the spatial extent of the object, differ from each other. Like in the phenomena attributed to perceptual grouping, we will see the object when the space of the object coincides with the internal space which features the strongest contrast with the corresponding external space.
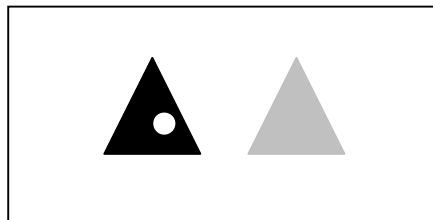
5. The Multiple Hierarchical Segregation of the Stimulus

Figure-ground segregation does not make reference solely to figural areas, as grouping does. However, the difference between asking ourselves under which conditions we see a region of the field as figure and asking ourselves under which conditions we see a simple figure is greater than it may seem at first sight. While

surroundedness entails the detection of two adjacent areas, the SC occurs at the source of visual perception. Unlike the factors involved in figure-ground segregation and in grouping, the SC is a condition of perceptibility, rather than a rule for the organization of perceptual scenes (Todorović 2008). At the same time, the SC gradient of the structure of the stimulus can be considered a unifying factor of perceptual organization, both with reference to classic principles – which I have analyzed above – and with reference to a broader view of the visual scene – which I will analyze in this section.

What I have stated so far only highlights part of what the correlation between SC of the proximal stimulus and conscious perception can account for. I have made a comparison with the gestaltist approach focusing on the main object, because this is what the laws of perceptual organization focus on. If, as gestaltists say, what we perceive is the expression of a process of organization, the outcome of this process should be something which manifests itself in the combination of the phenomenal qualities of the parts which compose it. The comparison between stimulus and visual experience – with a conception of visual experience that is closer to reality – allows us to take into consideration not only the object, but also all the elements which form it and the secondary elements in the field. This possibility is implicit in what was stated above.

If, instead of analyzing only the correlations between proximal stimulus and main object, we consider the phenomenal field in its internal organization, an important aspect comes to light. The prevalence of one object over the other is correlated with differences between internal space and external space which concern the phenomenal field in its entirety. In figure 9 the SC of the white circle is clearly smaller than the one of the black triangle only if we consider the whole field. This means that the SCs of the black triangle, of the gray triangle and of the white circle concern the relationship between the region corresponding to these objects and the rest of the field. Therefore, the many SCs of the field of the stimulus overlap each other, even in a much more complex way than in this simple example.

Fig. 9 A simple example of Multiple Hierarchical Segregation

This does not occur at a phenomenal level. In fact, it seems to occur only for the main object, to which we have referred so far. The strongest SC corresponding to the main object not only causes it to phenomenally prevail over the other elements, but it also brings about a subdivision of the field into two asymmetric areas which we perceive as figure and ground. Unlike the main segregation, the other segregations which derive from the smaller SCs do not seem to affect the field in its entirety, but the areas which formed as a result of the first segregation. We see the gray triangle *in the region which acts as a background* to the black triangle, i.e. inside a space which does not include the whole framed area, but only the white space surrounding the black triangle, and we see the small white circle *inside* the black triangle.

While the main segregation corresponds to a contrast which affects the whole field, the segregation of the white circle only involves the triangle to which it belongs and its contrast with the global external space is phenomenally only potential. As argued by Kanizsa (1988, 19), it can be imagined, but it cannot be perceived. But it may be the main segregation, caused by the strongest contrast, which prevents the secondary segregation from affecting the whole field. This would corroborate the hypothesis of a process which transforms the structure of the proximal stimulus into something else, as the difference between the SC of the proximal stimulus and the visual experience of an object on a background seems to suggest.

Furthermore, every segregation entails an asymmetric subdivision of the field. The ensuing segregations acquire different meanings depending on whether they occur in the figure or in the ground formed by the first segmentation. Both the white circle and the gray triangle are located in one of the spaces created by the main subdivision. However, the former is located in the part corresponding to the figure and the latter in the part corresponding to the ground. The fact that the white circle and the gray triangle belong to different parts causes them to acquire the nature of detail and of secondary object respectively. It is worth underlining that the common way to explain that an object is more salient than another – such as the black triangle being more salient than the gray one – is that the salient object contrasts more strongly than the other with a common background. However, this kind of explanation does not take into consideration the aspects of perceptual space organization which salience entails. As a fact, we see the gray triangle against the background of the black triangle.

Similarly, a face segregates from the background and it is in its turn affected by a process of segregation. This process does not affect the whole field, but only the object, i.e. the face which acts as a "background" to the eyes, nose and mouth. The pair of eyes segregates from the face; in turn, each eye segregates from the region occupied by the pair of eyes. This process appears as the most appropriate

explanation of what occurs when we perceive objects such as a house, a tree or a wardrobe, which are internally complex and which are perceived in a context which is in turn internally complex.

As in the pair of eyes, the progressive segregation of the field occurs not only when an object is located inside another. The term SC refers to a region located inside the field, without necessarily identifying it with a continuously contoured figure, and it can correspond to the grouping of several objects into a Gestalt. Going back to the initial example, the broken line perceptually appears as primary because, despite the discontinuity of the parts which form it, the line corresponds to the strongest SC of the structure of the stimulus. Its phenomenal prevalence and the involvement of the whole field cause it to be perceived as the main object. The SC corresponding to the individual dashes is smaller due to the presence of the other dashes in the external space, while the individual dashes have more or less an equivalent SC. As a consequence, the region corresponding to the line is secondarily subdivided into the four dashes and we see a broken line, i.e. *a line made up of dashes*. Just as the white circle belongs to the black triangle, so too do the dashes belong to the line – and not to the whole image. Each dash, despite not prevailing over the others, is seen "against the background" of a region which includes the other dashes.

In short, there is no grouping of the perceived dashes on the basis of their similarity and proximity, as stated in Gestalt laws. Instead, there is a progressive segregation of the structure of the stimulus, i.e. a process of Multiple Hierarchical Segregation (MHS). MHS, in which the organization of the global aspects precedes the organization of the local aspects, seems to be correlated with the SC gradient of the proximal stimulus. Since the segregations occur at the same time, the term progressive should not be interpreted in a temporal sense, but in a hierarchical sense. The segregation which determines the perception of the line is hierarchically superior, while the segregations which determine the perception of the dashes are subordinate to it.

One of the consequences of the strongest contrast causing a segregation of the figure which affects the whole field, and of this segregation generating further subdivisions, is that the secondary objects can only be perceived in the areas defined by the segregation. In other words, it is possible to distinguish between contents which can be perceived as secondary and others which the conditions of stimulation do not allow us to perceive. In figure 5 the rows of circles and squares phenomenally prevail over the individual figures. At the same time, we see alternating rows of circles and of squares rather than columns of circles and squares, because the first combinations have a stronger SC. Therefore, there is a difference between the two occurrences. The individual circles and squares are perceived spontaneously – even if as subordinate contents – whereas the columns

of circles and squares are not perceived spontaneously. This is due to the fact that the former are subdivisions of the subfield which formed following the main subdivision, whereas the latter are incompatible with the main segregation. Like a river allows the formation of tributaries, but not of other rivers crossing the steepest slope in the valley, the visual field defines certain lines of segmentation and, as a result, segmentations are only possible inside these lines. To see other sets, we should subdivide the field in a different way.

So the multiple segregation process starts from the global aspects of the field and its effects become gradually more local. However, it must be clarified that, in referring to the two surrounding regions in which the field is divided, the meaning of the adjectives *global* and *local* is not the common one which normally refers to the contents. The main segregation can also involve what is usually considered a detail – such as the eyes of the subject – in case it corresponds to the strongest SC of the structure of the stimulus. The secondary segregation, which leads us to see the whole face, thus involves a part of the field – the background – which was formed by the main segregation. At a phenomenal level, the face is seen *against the background* of the eyes which have grabbed our attention.

6. What are the Limits of Gestalt Theory?

The main limit of Gestalt theory is that it is difficult to distinguish between what provides an explanation and what must be explained. When explaining why dashes group together to form a Gestalt, i.e. a broken line, gestaltists explain the phenomenon through the phenomenon itself. My proposal overcomes this limit through the correlation between the visual scene and the characteristics of the proximal stimulus. If what we perceive is compared with what is at the source of the visual experience, a consequence is that the change concerns not only the elements which can help find an explanation, but also what must be explained.

From section 1 to section 4 I analyzed the relationship between the strongest SC of the proximal stimulus and the perceived object. Through the main segregation of the field, this correlation accounts for several known aspects of perceptual organization, thus unifying Gestalt laws (grouping and figure-ground segregation). In section 5 I analyzed the relationship between the SC gradient of the structure of the proximal stimulus and a broader view of the visual scene. Through Multiple Hierarchical Segregation, this correlation can also account for new aspects of perceptual organization.

The correlation between the strongest SC of the proximal stimulus and the perceived object highlights that the limits of Gestalt theory derive from the terms of reference used to explain perceptual organization. Gestalt laws of grouping are based on the correlation between the perceived object, i.e. the part

of the field which phenomenally prevails over the others, and the relationships between the elements of which it is composed. According to Pinna (2011), dot elements on which grouping acts must be already segregated as a figure from the background, otherwise the visual system would not know which elements to group. Nevertheless, the same elements do not possess the figure properties of organized and segregated holistic figures; rather, they appear as elementary components necessary to create boundaries. In any case, there is no doubt that gestaltists do not focus on the conditions of stimulation. The element which is united with other elements by similarity or proximity is perceived consciously, so it can be stated that gestaltists analyze how perceived elements are grouped to form a Gestalt. In other words, the analysis they carry out is *internal* to the phenomenal datum.

The gestaltists' position probably originates from the belief that analyzing what is at the source of visual experience causes an arbitrary fragmentation of the phenomenal datum (Kanizsa 1988, 20). On the contrary, we have seen that considering what is at the source of conscious perception does not necessarily lead to the fragmentation feared by gestaltists. The fragmentation of the field of the stimulus is not a condition for conscious perception. The SC of the proximal stimulus is not an elementary characteristic of the sensory datum. On the contrary, it is the expression of a relationship which involves the whole field of the stimulus.

According to Searle (2004), there are two aspects to the Gestalt structure of consciousness: 1) the capacity of the brain to organize perceptions into coherent wholes; and 2) the capacity of the brain to discriminate figures from backgrounds. If we correlate the strongest SC of the proximal stimulus with the perceived object, these two aspects can be unified. In short, in the classic model, perceptual organization occurs both through grouping, which can take place in different ways, and through figure-ground segregation. The model I have illustrated in this paper is simpler, as perceptual organization, which includes the phenomena attributed to perceptual grouping and figure-ground segregation, occurs through a progressive segregation internal to the field.

It is evident that the perceptual situations selected by gestaltists for their analyses favor the possibility of "seeing" groupings of elements instead of the progressive segregation internal to the field, as is the case when observing the most common perceptual situations. However, the progressive segregation internal to the field can be "seen" also in the perceptual situations analyzed by gestaltists.

In this perspective, what gestaltists call grouping by proximity and by similarity can be considered a sort of atypical MHS. A broken line is a sort of incomplete segregation, like the letter "C", because it includes both what we attribute to matter and what we attribute to space. Nonetheless, this region tends to segregate

anyway in the presence of a sufficient SC of the stimulus. Grouping is atypical in that an incomplete segregation such as the one of the broken line, deriving from a stronger SC of the stimulus, prevails over the complete segregations of the individual dashes.

It must also be underlined that the classic concept of segregation and the distinction between segregation and grouping lead to a number of inconsistencies. Is it only the Gestalt which segregates, or only the individual elements? Or do both types of segregation take place? In the latter case, according to Pinna (2011), segregations would have a different nature, even if it is not clear to which extent they influence each other and which background is determined by each of them. For instance, which is the background when a detail segregates? Moreover, the Gestalt would be at the same time the outcome of a process of grouping and of segregation. This leads us to wonder what role the process of grouping can have in the presence of an already completed process of segregation, it being reasonable to consider that figure-ground segregation must operate before grouping (Palmer 1999).

The correlation between the SC gradient of the structure of the proximal stimulus and a broader view of the visual scene highlights that the inability of gestaltists to focus on what is at the source of the visual experience is only one side of the problem. The other side of the problem concerns the phenomenal datum itself. When explaining why dashes group together to form a Gestalt, i.e. a broken line, Gestalt theory not only fails to take into account what is at the source of perception, but it also fails to explain what we actually see and what gestaltists themselves describe when they speak of a *broken* line (i.e. a line made up of dashes), or of an illusory triangle (i.e. a white triangle without contours overlapping three black disks and a white triangle with black contours). It is true that in figure 5 we see rows rather than columns. But it is also true that we see alternating rows of circles and of squares and that they form a square-shaped set.

My argument is that Gestalt theory confuses what provides an explanation with what must be explained. A visual scene is made up not only of objects and Gestalts, but also of backgrounds, of secondary objects, of details, of simple elements, of parts, of internal relations and of its perceived unity. When gestaltists compare the line – considered as the outcome of a process of grouping – with the dashes which form it – considered as the elements which, thanks to their proximity, make this process possible – they explain the phenomenon through the phenomenon itself. The individual dashes are part of the phenomenon which must be explained and they are the result – not the origin – of the process which determines the phenomenon.

According to experimental phenomenology, "phenomenal facts have to be explained only with other phenomenal facts" (Vicario 1993, 209). However, the comparison could be made, for instance, between two successive perceptual

experiences. In an "instantaneous" experience, in which we deal with the same phenomenal "fact", it is not possible to discriminate between elements which must be explained and elements which concur to an explanation – not even on the basis of their hierarchical position.

Conversely, by entailing a different relationship between what must be explained and what may deserve an explanation, the MHS model overcomes this limit and it can predict these phenomena. What perceptual organization processes should predict does not concern an individual aspect of the field, but something broader, i.e. the visual experience as a whole. We should not consider only one object, however important it may be, but the whole scene, with the elements which form it and the relationships existing between them. This possibility emerges from the process of MHS described in the previous section.

The result of the processes of perceptual organization is thus something broader than what is predicted by the previous approaches. The phenomenon to be explained is not the line, but the line made of dashes as we see it. In Gestalt theory the dash is an intermediate stage in the process of perceptual organization, not the final result. From this point of view, the Gestalt conception presents some inconsistencies.

Firstly, according to Wagemans, Elder et al., (2012, 1175), "Wertheimer claimed that functional relations determine what will appear as the whole and what will appear as parts (i.e., reciprocal dependency). Often the whole is grasped even before the individual parts enter consciousness". However, this is contradicted by Gestalt principles. In grouping there is only a one-sided dependency between parts and wholes. The wholes depend on the parts, but the parts do not depend on the whole. The whole is determined by the relationships existing between the elements, such as proximity and similarity. Instead, in my theory the whole is determined by the main segregation of the field.

Secondly, reciprocal dependency between parts and wholes is the *phenomenal datum*. As such, it is what processes of perceptual organization should explain. In the statement "the whole determines the appearance of its parts" (Wagemans, Feldman et al. 2012, 1240), the distinction between what explains and what must be explained is not entirely clear. It is more correct to say that the whole *appears to determine* its parts, and that we must explain this appearance. A possible explanation is that, by hierarchically organizing the global and local aspects of the field, the progressive segregation of the field determines the dependency of the parts on the whole which we perceive. In this way, MHS accounts for what may be called the phenomenal relatedness between parts and wholes. This relationship is not causal, since both the whole-in-relationship-with-the-parts and the parts-in-relationship-with-the-whole are determined by something else.

The need to refer to the whole visual experience concerns both the relationships existing in the framework of a gestalt and much more common relationships, such as the one between object and detail. We perceive the detail as such because it is part of a hierarchical structure. The detail is not a detail if it is not *perceived* as something that is contained inside the object. Therein lies the phenomenal dependency of the part on the whole. These relationships have been underestimated by gestaltists, maybe because they considered them so simple and trivial not to deserve an explanation.

However, first of all, Gestalt theory does not explain why we perceive the detail of an object as such. The detail of an object must be actively derived from the stimulus and it cannot be guaranteed only by the fact that the object is topologically contained inside that region. The classic model of perceptual organization seems to imply that figure-ground segregation alone can determine the "location" of the other contents. However, the involvement of only one segregation appears insufficient for a number of reasons. For instance, the many cases of ambiguity about the role of a figure of one region rather than another – such as in the case of an object lying on a small table – seem to suggest that both segregations play an active role. I have demonstrated that the perception of a detail inside the main object is actively derived from the stimulus through the MHS process. In other words, detail segregates within the subfield of the object.

More generally, all the components of the field which we see are phenomenally such because they are in relationship with the other components. The phenomenal relatedness emerging from the characteristics of the components of the perceptual field cannot be ignored, nor can it be used as an explanation. The relatedness of the components of the visual scene is what perceptual organization should explain. The principle of MHS helps highlight this aspect and, at the same time, it helps provide a comprehensive explanation of the relationships existing between the components of the field.

7. Frameworks and Perceptual Belongingness

Gilchrist et al. (1999) propose to define a framework in term of the Gestalt grouping principles. A framework is a group of surfaces that belong to each other. The largest framework consists of the entire visual field and is called the *global framework*. Subordinate frameworks are called *local frameworks*. Local frameworks are defined by local grouping factors, not by distance. The idea of a hierarchical structure of global and local frameworks which determine lightness perception (Agostini, Galmonte 1999) is somewhat similar to the idea of MHS. However, there are some important differences.

One of them is that the framework is a descriptive concept, whereas MHS

is involved in the formation of frameworks. Consequently, the progressive segregation internal to the field helps us understand how the various frameworks are hierarchically related. When the main segregation occurs at the strongest SC, MHS concerns the global framework of the field. As the field internally segregates at the weaker SCs, MHS begins to concern more and more local frameworks. For example, the reversed-contrast Necker cube to the left (figure 10) segregates as a whole from the white background. Given that this main segregation – like all other segregations – is based on the SC, a key role is played by corners. Subordinately, gray broken lines segregate from black corners and, still subordinately, gray dashes segregate from broken lines.
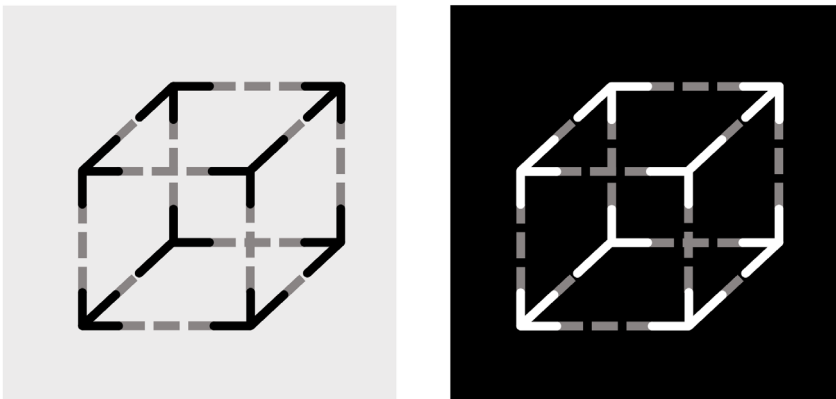
Fig. 10 Agostini and Galmonte's (2002) reversed-contrast Necker cube

As a result, the effects occurring in the local frameworks, which also depend on the SC gradient, must be distinguished from the ones due to local factors such as lateral inhibition. The former and the latter can interact with each other in various ways. As expected, MHS overcomes the contrast of the gray broken line with the white background (Agostini, Galmonte 2002). In the Wertheimer-Benary illusion (figure 11), lateral inhibition predicts veridical lightness perception, while in the standard simultaneous contrast effect, the contrast due to lateral inhibition should add up to the one due to MHS. Such combined effect can explain why the Benary effect is weaker than the standard simultaneous contrast effect. In this perspective, the role of spatial articulation on the size of the simultaneous contrast effect (Agostini & Galmonte 1999) should depend on the existing specific spatial relationships.
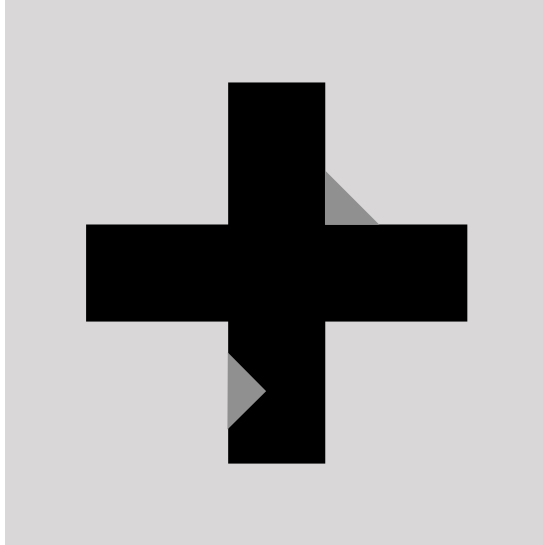
Fig. 11 The Wertheimer-Benary illusion

Another difference between frameworks and MHS concerns perceptual belongingness. Phenomena such as the Wertheimer-Benary illusion and the reversed-contrast Necker cube are explained through the notion of perceptual belongingness. However, perceptual belongingness is a form of relatedness which – like all other phenomenal data – must be explained. As stated above, the perception of a detail, secondary object or element of a Gestalt is an aspect of their perceptual belongingness to that figure, background or Gestalt. Similarly, perceiving a triangle as lighter than another triangle in the Wertheimer-Benary illusion is an aspect of their respective perceptual belongingness to the figure and to the background.

According to my model, perceptual belongingness is caused by the segregation of a perceptual subfield, which is in its turn the result of the segregation of a larger field. In this regard, it should be taken into account that the larger field is the one that involves a larger area of the stimulus, going beyond the figure dimensions. Subordinately to the segregation of the cross from the background, the triangle at the bottom of the Wertheimer-Benary illusion segregates from the cross, while the one at the top segregates from the background. In other words, belongingness is nothing but the perceptual result of a subordinate segregation.

The problem is similar to the one found in grouping. In the case of grouping, what researchers try to explain concerns the main object, while in these cases it concerns a specific chromatic effect. In both cases, researchers try to explain a single aspect

of the field through other perceived aspects and this leads them to identify more and more principles. If instead we consider the correlation between the visual experience as a whole and the SC gradient of the structure of the stimulus, these phenomena – like the others analyzed in this paper – can be explained through MHS. By involving multiple hierarchically organized frameworks, MHS can also explain why in some cases attributed to belongingness there is a contrast and in others an assimilation. The various phenomena of lightness induction associated with perceptual belongingness will be examined in more detail elsewhere (Forti, in preparation). Here I will only make some preliminary considerations.

A contrast is perceived when the contrast existing within the perceptual subfield facilitates – or at least does not hinder – the main segregation. This occurs more easily when the secondary contrast tends to be included in the main one, such as in the standard simultaneous contrast or in the reversed-contrast Necker cube. On the other hand, assimilation occurs when the accentuation of differences may hinder the segregation of the main object, such as in White's illusion. In this case, the need to ensure the visibility related to the hierarchically superordinate segregation causes an attenuation of differences in the secondary segregation.
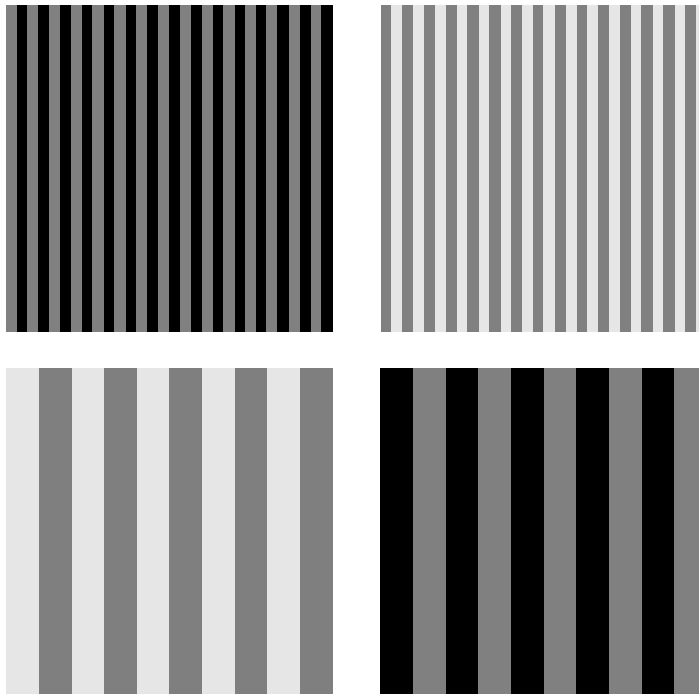
Fig. 12 From assimilation to contrast (Helson 1964)

Something different occurs in the black and white bars alternating with gray ones (figure 12). By increasing the size of the elements, perception changes from assimilation to contrast (Helson 1964). When the bars are narrow, assimilation is the result of the main segregation occurring in the whole frame. As a consequence, an excessive contrast between the bars, which create the texture, would negatively influence the visibility of the frame. If the bar size increases, the main segregation does not concern the frame, but the contours of the bars, so that they are perceived as figures and there is a perceived contrast.

8. Discussion and Conclusions

What I have stated so far entails an identification of what should be explained by the processes of perceptual organization in the visual experience, including all the components perceived in their hierarchical relationships. This idea differs from the prevalent conception, both from a phenomenal and from a functional point of view.

From a phenomenal point of view, the tendency is to identify the perceptual experience in the perception of the main object and to neglect its relationships. The difficulty of conceptualizing vague and fading parts – the so-called fringe components – has almost invariably limited what we consider as perceptual experience in the scientific sense of the term to the perceptually prevalent part. However, in this way we ignore that between the focus and the fringe components there are parts which we perceive clearly enough – including backgrounds – and with which the focused content is in relationship.

What I propose is closer to the reality of visual experience. While it is true that we see less well as we move back from the object we are focusing on, we cannot say that we see a single element *only*. This would entail a simplistic conception of our experience. Failure to perceive the secondary elements would alter the perception of the main content as well or even make it impossible. This is especially evident in illusory figures. Indeed, we would not be able to perceive Kanizsa's illusory triangle if it did not overlap three black disks and a white triangle with black contours, which are in their turn surrounded by a white background. But this is also true in much more common perceptual situations. We cannot see a broken line without seeing the dashes which form it, nor can we see an occluded object without seeing the occluding object.

From a functional point of view, it is important to underline an apparently obvious thing: what we see – which takes shape in the visual experience as a whole – is the result of perceptual processes. It may be stated that the whole-in-relationship-with-the-parts and the parts-in-relationship-with-the-whole are pieces of information which the processes of perceptual organization derive from the stimulus. However, the idea that the output of perceptual processes, however

complex they may be, is – almost exclusively – made up of a single element is traditionally well-rooted. Even considering the field of the stimulus in its entirety, the processes concerning the stimulus are generally processes of selection – such as in the case of attention – or of synthesis – such as in the case of grouping. As a consequence, the output is a single element, normally the most important one.

According to the predominant approach, the perceptual processes would consist in extracting from the stimulus what is most important or the priority, to then process it in the following stages. It is certainly true that perceptual processes lead us to identify what is most important at a given time. The main object of my theory corresponds to the figure of Gestalt theory and to the focus of attentive processes. But processing an element – albeit important – isolated from its context is not enough to address the complexity and the variability of relationships – above all the spatial ones – that are present instant by instant in the interaction between the individual and the environment.

In many cases, the problem of perceptual organization is not so much to identify which is the main figure, but above all to organize, according to the right hierarchical relationships, a series of elements fitting one inside the other like Chinese boxes. In most images it does not make sense to identify only the main object. What the visual scene seems to tell us is that the main element must necessarily be associated with a context, which includes the background, secondary elements and even the parts which form it. This is what we see as a result of perceptual processes and the scene we see as being adaptively relevant must play a functional role in the further elaboration of data. In short, this broader conception of what must be explained by the processes of perceptual organization can be considered 1) compatible with the principle of MHS; 2) closer to the reality of visual experience; 3) more effective in addressing the complexity of the interaction between the individual and the environment. The implications of this conception cannot be addressed in this paper. Furthermore, the idea of the perceptual experience as a series of hierarchical relationships between perceived elements forces us to reconsider some aspects:

- What is the nature of the relationships existing in the phenomenal perceptual field?

- How can these relationships ensure the unity of the perceptual experience?

- What is the whole?

- What is the role of the various perceived spaces which form in addition to the main background through the progressive segregation of the field?

- To what extent does the progressive segregation of the field entail an overlapping of field parts which we must take into consideration?

I think it is useful to analyze these issues in the broader context of the issue of consciousness (Forti, in preparation). Even if the complexity of the phenomenal datum is well known, also most of the perspectives on consciousness identify what we are conscious of with something we tend to trace back to a single element: quale, conscious content, focused consciousness, conscious representation, what it is like – as Nagel (1974) argues, "an organism has conscious mental states if and only if there is *something* it is like to be that organism".

The classic separation between issues concerning perceptual organization and issues concerning consciousness has probably prevented scholars from seeing how closely related these issues actually are (Hochstein & Ahissar 2002; van Leeuwen 2007). In this perspective, going beyond the factors involved in the perception of the main content not only implies that we must better take the actual conditions of the perceptual field into consideration, but also that we must focus on the issue of consciousness.

Summary

Gestalt laws are still an important point of reference for the understanding of perceptual processes. However, the distinction between figure-ground segregation and grouping, as well as the proliferation of principles of grouping have made it impossible to achieve a comprehensive view of perceptual organization. This paper shows the existence of a correlation between the characteristics of the proximal stimulus and what we see. These characteristics consist in the surrounding contrast (SC) of the structure of the stimulus, which occurs when a spatially extended region of the proximal stimulus contrasts with the whole surrounding region. The principle according to which the perceived object corresponds to the strongest SC of the stimulus can provide an explanation for several aspects of perceptual organization, thus unifying Gestalt laws.

Another limit of Gestalt theory is that, being internal to the phenomenal datum, the correlation between the perceived object and the relationships between the elements which form it does not explain what we actually see and what gestaltists describe. The Multiple Hierarchical Segregation (MHS) model overcomes this limit and takes into consideration not only the main object, but also the elements which form it, as well as the secondary elements of the field. According to the MHS principle, perception does not occur through grouping mechanisms based on the relationships existing between the perceived elements, but through a progressive segregation internal to the field. This segregation, in which the organization of the global aspects precedes the organization of the local aspects, seems to be correlated with the SC gradient of the proximal stimulus. **Keywords:** Gestalt theory, perceptual organization, grouping principles, figure-ground segregation, proximal stimulus.

Zusammenfassung

Die Gesetze der Gestalttheorie bieten noch immer einen wichtigen Bezugsrahmen für das Verständnis von Wahrnehmungsprozessen. Die Unterscheidung zwischen der Absonderung Figur/Hintergrund und der Gruppierung sowie die Vervielfältigung

der Gruppierungsprinzipien ermöglichen jedoch keine einheitliche Perspektive der Wahrnehmungsorganisation. Dieser Artikel beschreibt eine Korrelation zwischen den Merkmalen des proximalen Reizes und dem, was wir sehen. Diese Merkmale bestehen im Umgebungskontrast (SC "surrounding contrast") der Reizstruktur, der dann besteht, wenn eine räumlich ausgedehnte Region gegenüber der gesamten umgebenden Region Unterschiede aufweist. Das Prinzip, nach dem das wahrgenommene Objekt dem größeren SC des Reizes entspricht, kann verschiedene Aspekte der Wahrnehmungsorganisation rechtfertigen und die gestalttheoretischen Gesetze vereinheitlichen.

Eine weitere Einschränkung der Gestalttheorie besteht darin, dass die Korrelation zwischen dem wahrgenommenen Gegenstand und den Beziehungen seiner Bestandteile untereinander, da sie dem Phänomen selbst innewohnt, keine Erklärung dessen bietet, was wir tatsächlich sehen und was die Gestalttheoretiker selbst beschreiben. Das Modell der multihierarchischen Absonderung (MHS "Multiple Hierarchical Segregation") ermöglicht die Überwindung dieser Beschränkung und die Beachtung nicht nur des Hauptgegenstands, sondern auch seiner Bestandteile und der sekundären Inhalte des Feldes. Nach dem Prinzip der MHS findet keine Gruppierung aufgrund der Beziehungen zwischen den wahrgenommenen Bestandteilen statt, sondern vielmehr eine fortschreitende Absonderung des Feldes in seinem Innern. Diese Absonderung, bei der die Organisation der globalen Aspekte der Organisation der lokalen Aspekte vorausgeht, scheint mit dem SC-Gradienten des proximalen Reizes zu korrelieren.

Schlüsselwörter: Gestalttheorie, Wahrnehmungsorganisation, Gruppierungsprinzipien, Absonderung Figur/Hintergrund, proximaler Reiz.

Acknowledgments

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