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SEEING AND THINKING

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According to ratiomorphic theories of perception every visual phenomenon would be the result of unconscious inferences through which the visual system, starting from a set of axioms and premises, reaches certain conclusions (which constitute actually the visual phenomena) by a process analogous to a reasoning process. The author presents some examples from the area of amodal completion which, according to him, hardly support a ratiomorphic theory. Instead they constitute counterexamples that rather support the hypothesis that seeing and thinking function according to different rules.

1. 'Sense data' or 'visual objects'?

I would like to modify slightly the theme that we have been asked to discuss. Seeing and knowing do not in fact seem to me terms which refer to activities that are, in some way, opposite or mutually exclusive. The eyes inform us about the presence of things which are either near or distant and provide different information about them than our other sense organs. From this point of view, seeing is undoubtedly a form of knowledge, an instrument for knowing. Other more evolved forms of knowledge are the operations with which the mind integrates and goes beyond the information that the organism acquires through perception. These are the operations of abstraction, categorization and inference, which we generally call 'thinking'. The problem thus does not seem to lie in the relationship between seeing and knowing, but rather in the relation between *seeing* and *thinking.* With this relationship I will be concerned in the following considerations.

Seeing means 'meeting' or 'confronting' a world segmented into discrete objects of various sizes, forms and colours, either at rest or

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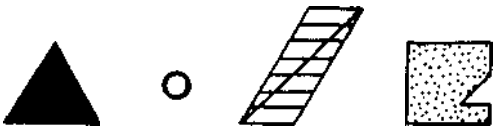


Fig. 1. Patterns easily related to some mental schema, therefore easy to describe.

moving in a three-dimensional space. We may be uncertain about their identity: an object may be partly occluded by another object, or it may be badly illuminated, or have gaps, or may disappear too quickly from sight. In these cases we formulate hypotheses about their identity, we seek further data to confirm these hypotheses, we mentally fill in the gaps, we interpret on the basis of knowledge or context, and so forth. These hypotheses are suggested to us by some feature of what we see and we compare them with an 'internal representation' or 'world knowledge' with which our cognitive system is provided.

However, I can also imagine a situation in which, opening my eyes, 1 find myself surrounded not only by objects that I can recognize, but by things that are unfamiliar. I have never seen them, I do not know what purpose they serve or what they can do. How will I give a meaning to such a scene? Let us imagine that we are carrying out the following experiment, in which two subjects take part. The first subject must describe what he sees in the display of fig. 1 to a second subject who, without seeing the display, must produce a drawing of it. We may suppose that the first subject will say something like this: 'There are four figures. The first, on the left, is an equilateral triangle with sides about 2 cm long...'. On the basis of these indications the second subject will be able to draw, to a good approximation, what his partner sees. We now give the first subject the task of describing the display of

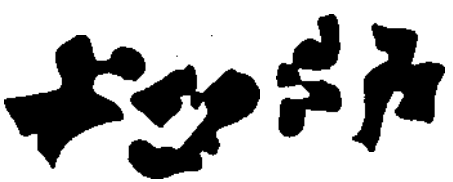


Fig. 2. Patterns unfamiliar and meaningless. However, they are clearly segmented (i.e.. their shape, colour, size and spatial relationships are stable and perfectly visible).

fig. 2. It is most unlikely that in this case the performance of the second subject will be even remotely satisfactory.

Which features differentiate the two situations? In the first case I can describe the visual entities presented to me because I have in mind schemes to which I can assimilate them, namely categories into which I can fit them; often I can give them a name. In the second case I am confronted with unfamiliar visual objects, objects which are irregular and hence difficult to describe. As occurs with Rorschach ink-blots, they may 'remind' me of something; I can try to interpret them. A strong urge for meaning drives me to scrutinize them in the attempt to fit them into a category less generic than that of 'unfamiliar visual objects of irregular form'. But to be honest: notwithstanding my efforts to imbue them with meaning, they actually remain no more than unknown visual entities.

On the other hand - and this should be strongly emphasized - while the second situation differs from the first through being without meaning, *there is no difference between the two situations with regard to the visual aspect as such.* The lack of a definite interpretation does not preclude these visual objects from being what they are: black shapes on a white background, well defined by clear contours. There is no meaning, but there is organization: segmentation, spatial, chromatic, dimensional, topological relationships. All but the 'sense data' dear to Anglo-Saxon philosophers, raw material, disorganized as well as senseless, 'patches of colour' awaiting to be ordered. Which 'schemes' or 'anticipations', which 'internal representations' or 'world knowledge' must be supposed to act in this case to give what I see the actual form it has, stable and precise, unambiguous even though not classifiable with certainty?

But if there can be organization without meaning, it follows that even in the case of fig. 1, which exemplifies the normal situation in everyday visual perception, meaning is attributed to a visual reality that is already segmented into distinct and shaped objects. The formation of a visual object as an entity separate from other objects must occur *before* the object can be identified; this is a logical necessity which holds regardless of the fact that the attribution of meaning takes place in such a short time. It is instantaneous in the sense that one cannot observe, within a cognitive act, a phase in which the visual input has not yet been identified.

2. Ratiomorphic theories and perception as problem solving

If coding, recognition and interpretation necessarily presuppose the visual data that are the object of these operations, and if these data already possess an organization of their own, the problem which arises at this point is that of their formation. In other words: how do we form the cues which must be interpreted?

The process of formation of the cues has been called in various ways: primary, precategorial, preattentive, pre-predicative. On the nature of this process the hypothesis which is currently mostly favoured is the 'interpretive' or 'ratiomorphic' hypothesis proposed by Helmholtz and adopted by numerous researchers who more or less explicitly refer to him. According to this hypothesis, the process of forming the cues (the precategorial process) and the process of interpreting them, would not differ substantially in their nature. Both cases would involve reasoning-like procedures analogous to those which are found in their pure form in logical and scientific thinking. Thus the rules of reasoning would dominate perception in all its phases: what we see would not only be *utilized* by inferential processes in the interpretation phase but would also be the *product* of unconscious inferences drawn during the primary process.

This position certainly has a great appeal: it has been widely accepted in the past, and even recently it has been sustained with exceptionally detailed argumentation by Rock in 'The Logic of Perception' (1983). But it is a position which is not all obvious, and which can elicit strong perplexities. It could be maintained that the visual system segments the proximal stimulation into distinct objects with specific shapes, on the basis of probabilistic computation and on the basis of principles of grouping and segregation which the system 'knows'. It can also be said that the objects so constituted exhibit remarkable constancies of colour, size, and shape, because the system 'knows' and applies the laws of optics, prpjective geometry, and vector analysis. However, we may also ask what advantages would be gained from this formulation (which requires among other things the intervention of a homunculus) compared with the view which holds that the visual system does not know or apply any rule but simply functions lawfully according to principles on the basis of which it is programmed.

The nature of these principles must be discovered and not given for granted beforehand, as it is done by ratiomorphic theories, according to which every visual phenomenon would be the result of unconscious

inferences through which the visual system, starting from a set of axioms and premises, reaches certain conclusions (which constitute precisely the visual phenomena) by a process analogous to a reasoning process.

Moreover, a particular class of phenomena is regarded as the result of processes similar to those which occur in standard problem-solving situations. When the proximal stimulation is plurivocal - that is, when it can be 'read' in more than one way - the visual system is obliged to choose from a certain number of possible solutions. The solution eventually chosen would be the most logical, self-consistent, parsimonious and elegant out of those which are theoretically possible. As especially clear examples of 'perceptual problem solving', Arnheim (1969) and Rock (1983) take the phenomenal transparency which occurs when physically opaque surfaces are juxtaposed in particular conditions. Other examples would be anomalous surfaces, and stereokinetic effects. To say that in these cases the visual system 'solves a problem' may be acceptable as a metaphor. Metaphors can of course be useful in sciences as well as in poetry - provided that they remain metaphors and are not mistaken for explanations. To see a problem presupposes, by definition, the awareness of an obstacle which does not allow to reach, a certain goal. Solving the problem consists in the discovery of a way of overcoming the obstacle. Problems do not exist in nature; they exist only when there is a mind which experiences a situation as problematic (see Mosconi and d'Urso 1973). If this were not the case, any result of a natural process could be regarded as the solution of a problem. What would be, however, the advantage of such a position?

To say that the perception of transparency is the result of an unconscious process of problem solving does not contribute at all to understanding the phenomenon. Our knowledge of the laws determining the phenomenon, of the conditions which facilitate it and of those which hinder or make it impossible, remains as it was before. A metaphor is no substitute for an explanation. Such an 'explanation', moreover, would have the disadvantage of applying only to positive cases. When a phenomenon does not occur, one can always say that the system has not been able to solve the problem, that it has made some error, that it has let itself be deceived, or applied a rule inappropriately. All this is not a very brilliant way of getting around a difficulty.

To conclude: it does not seem to be epistemologically correct to try

to attenuate, to the point of eliminating them altogether, the differences between seeing and thinking by emphasizing their presumed similarities. But the main problem of a theory of this kind, in my opinion, is that of not being able to suggest any advance, because it bears the risk of extinguishing the desire of investigating phenomena for which it has always ready a prefabricated explanation. From this point of view it is preferable to focus on the *differences* between seeing and thinking, because these, by indicating the possibility that the two classes of phenomena obey to different rules, can set us on the road of discovering these rules.

3. Perceptual and mental integration

The phenomena of completion are probably among the best-suited for revealing the analogies and differences between seeing and thinking, and for evaluating when it makes sense to speak of problem solving and when, instead, this way of speaking is only metaphorical. And in this second case one can show how often the metaphor does not hold.

We have already said that in cognitive activity one always 'goes beyond the information given' (Bruner 1957); the sensory cues are identified on the basis of knowledge, and are enriched by inferential operations based on logical principles or probabilistic calculations. Very often these phenomena are genuine cases of solutions to problems, of decisions reached through reasoning, through evaluating the available clues in the light of knowledge and context. This occurs, for example, when we decide that a dark area on a scene is the shadow of an object and not a black spot.

Besides cognitive integrations (which we might call *mental integration)* there exist perceptual interpolations - those for which the integration is directly visible and is experienced as a 'given' really present, not just imagined or thought - (which we shall call *perceptual integration).* The best-known perceptual 'interpolation' phenomena are: the beta-movement, the completion of the area of the blind spot, the tridimensionality achieved with random-dot stereograms, and the formation of anomalous surfaces.

An ubiquitous perceptual integration phenomenon is the amodal continuation of a visual surface behind another surface. When two contiguous regions in the proximal stimulation have a common border,

in visual perception one typically has a partial overlapping of the two surfaces. It might be, and indeed has been claimed, that this overlapping is the result of a reasoning-like process. In everday experience it repeatedly happens that one object covers part of another object: however, it happens only very rarely, that a visual line corresponds to the common border of two juxtaposed objects. It is therefore highly likely that the line separating two regions of the field will correspond to the border of a surface occluding another surface continuing behind it.

But how does the occluded surface continue behind the occluding surface? The completion can be only '*mental*', that is, a result of an interpretation of the cues provided by the part which is directly visible. In this case the completion can take any form, it does not necessarily elicit a unique solution and it is easily modifiable. But the continuation behind the covering surface, although it is *amodal.* that is, without the chromatic attributes of the visual modality, can be a genuinely *peirepliuil presence,* that is, one which imposes itself on the observer and which, unlike a merely imagined or 'thought' phenomenon, is not easily subject to influences from our knowledge, our attitudes and our will. For this reason, the analysis of the way in which amodal completion takes place offers us an ideal opportunity to compare the modes of operation of the two types of integration.

In 'amodal continuation', a situation in which sensory input is absent, the visual system is 'free' to choose the form of the continuation. Hence, if the perceptual result differs from what the mind would be led to produce by logical reasoning, we must draw one of two conclusions: either the visual system did not have to solve any problem, or. instead, it has solved the problem according to a 'logic' different from that followed by thought. The analysis of the conditions which give rise to these different outcomes should enable us to identify this 'logic'.

This opportunity of making a direct comparison between primary and secondary processes has led me to return several times to the phenomenon of amodal completion (Kanizsa 1969. 1970, 1975, 1979; Kanizsa and Gerbino 1982). In these studies various examples are given of situations in which the perceptual result is radically different from that which one would expect logical reasoning to produce; in what follows I will present some further examples of such situations.

4. Is the 'interpretive' thesis falsifiable?

The central pattern of fig. 3 is usually seen as a polygon partially covered by two black squares. Only with difficulty can one see a juxtaposition of two surfaces.

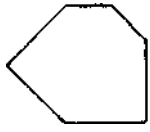
What concerns us here is not the preference for the overlapping interpretation but *how* the polygon continues amodally behind the occluding squares. While the solution most adherent to the logic of the context would be the octagon, the prevalent perceptual solution is that of fig. 4.

This is just an example (and it could be easy to provide many more) showing that the visual and the cognitive systems can produce different solutions to the same 'problem'. This fact supports the hypothesis that the two systems function according to different rules. In the case presented here, the visual system seems constrained to carry out the completion in a way which respects locally the *continuity of direction,* without being influenced by the demands of regularity or contextual adequacy which seem to guide the operation of problem solving at the thinking level.

In fig. 5 we see a white cross superimposed on a white square. This perceptual outcome is peculiar since in fact the white zone of the figure is completely homogeneous; its division into two visual objects is therefore a first fact to explain. The second fact to explain is the order of stratification. Fetter (1965) has given an interpretation of the phenomenon based on a 'minimum-principle'. Such a principle has not necessarily to do with any rational process; it is not difficult, however, to devise an explanation requiring 'reasoning-like' processes.

But how would one apply such an explanation to the cases shown in fig. 6? What 'reasoning' could cause the preference of the interweaving solution in these cases? In another study (Kanizsa 1969) various situations were shown in which the Fetter effect was put in conflict with past

Fig. 3. The figure can *be* seen as an octagon covered by two squares. Amodal completion gives as result the polygon represented in fig. 4.



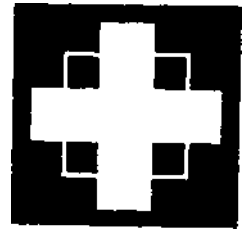
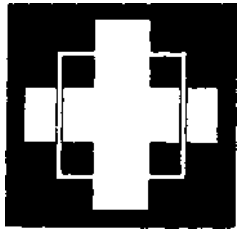


Fig. 4. Main perceptual result for fig. 3.

Fig. 5. In absence of a demarcating line, the white area is perceived as **a cross and a square, with** n univocal structure, the cross being perceived in front.

experience. In all those examples, the perceptual result was such as to convince me that the visual system resolves its 'problems' without regard to logic, expectations, and knowledge. In these cases the existence of a real conflict between the two systems is revealed by the impression of absurdity and amused incredulity which the figures elicil in the observer.

Another example which shows the strength and independence of the primary process with respect to the demands of logic and knowledge is given in fig. 7, which shows a situation in which a particular arrangement of perfectly straight lines produces a marked effect of phenomenal curvature. This perceptual outcome too can be 'explained away' by an obvious ratiomorphic empirist explanation: 'We have often seen woven patterns of this kind ... etc.' That this explanation is inadequate can be verified by looking at fig. 8, which was suggested to me by a painting of Magritte. Here too, as in fig. 7, the amodal completion of the stumps of the motor car brings about a paradoxical forward curvature of the part of the landscape visible between the tree-trunks. In this case the



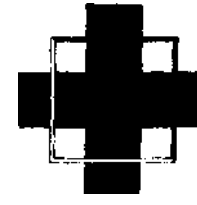


Fig. 6. Three examples of perceptual stratification in presence **of cues** favouring the perceptual allocation of the square in front of the cross. The square **surrounds the** cross.

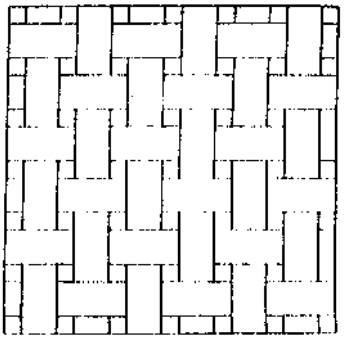


Fig. 7. Phenomenal 'undulation' produced by aiiKidal completion. (Massironi anil Samhin 19X4.)

perceptual outcome is produced in a compelling manner exactly against everything we know from past experience and against all common-sense logic.

The conclusion that can he drawn from these demonstrations is that

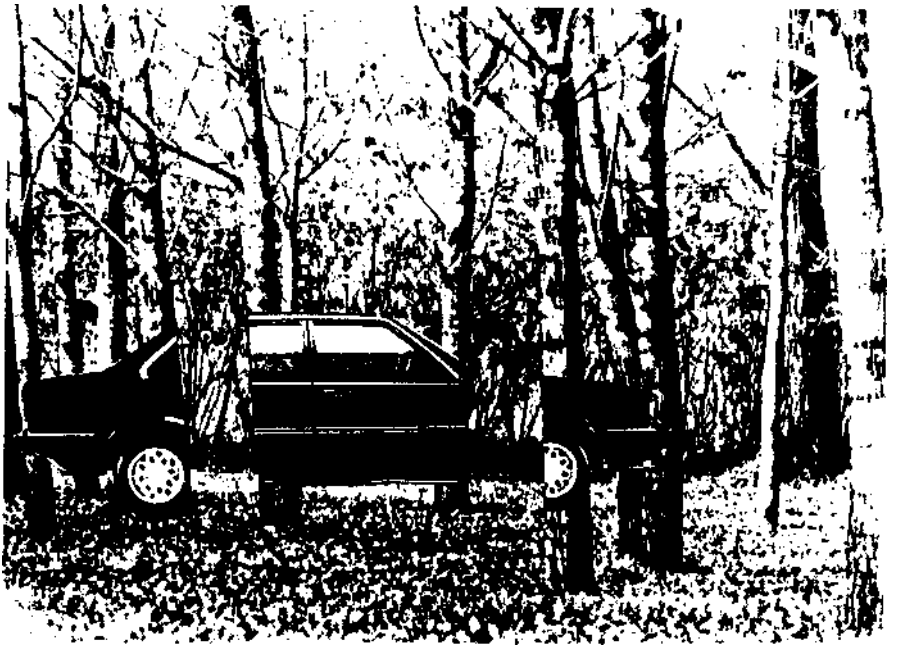


Fig. 8. The amodal completion has functional results: the part of the landscape 'behind' which the car is completed is perceived in front.

the visual system, in the cases in which it is free to do so, does noi always choose the solution that is most coherent with the context, as normal reasoning would require. This means that seeing follows a different logic - or, still better, that it does not perform any reasoning at all but simply works according to autonomous principles of organization which are not the same principles which regulate thinking.

The counter-examples I have cited (a small sample of those which could be produced) seem to me to represent a clear falsification of the ratiomorphic thesis. I am sure that they will not be found equalh convincing by those who support this thesis. Nevertheless 1 think thai even if they are not accepted as valid refutations, such situations pose serious questions to the theorist. It would be unwise to set aside such questions by 'explaining them away' or by regarding them as more or less amusing curiosities. Although I am convinced that to trace and emphasize the analogies and similarities between natural facts is an important goal of scientific research, I am equally convinced thai scientific research is not benefited by ignoring or minimizing the differences.

References

Arnheim, R.. 1969. Visual thinking. Berkeley. CA: University of California Press.

Bruner. J., 1957.. 'Going beyond the information given'. In: J. Bruner (ed.). Contemporary approaches to cognition. Cambridge, MA: Harvard University Press,

llelmholtz, H.. 1867. Handbuch der physiologischen Optik. Leipzig: Voss.

Kanizsa, G., 1969. Perception, past experience and the impossible experiment. Acta Psychologic;) 31,66-96.

Kanizsa, G., 1970. Amodale Ergiinzungen und Hrwartungsfehler des Gestaltpsychologen. Psycho logische Forschung 33, 325-344.

Kanizsa, G., 1975. 'The role of regularity in perceptual organization'. In: G.B. Flores d'Arcais (ed.). Studies in perception. Firenze: Martello-Giunti Ed.

Kanizsa, G., 1979. Organization in vision. New York: Praeger.

Kanizsa, G. and W. Gerbino. 19X2. 'Amodal completion: seeing or thinking?' In: J. Beck (ed.). Organization and representation in perception. Hillsdale. NJ: L. Erlbaum.

Massironi, M. and M. Sambin, 1984. 'Ondulazione fenomenica: un altro effetto del completamento amodale'. In: G. Kanizsa (ed.), Fenomenologia sperimentale della visione. Milano: F. Angeli Editore.

Mosconi, G. and V. d'Urso. 1973. 'II farsi e il disfarsi del problema'. In: G. Mosconi and V. d'Urso (eds.). La soluzione di problem!. Firenze: Giunti-Barbera.

Pelter, G.. 1965. Nuove ricerche sperimentali sulla totalizzazione percettivu. Rivista di Psicologia 50. 213-227.

Rock, L, 1983. The logic of perception. Cambridge. MA: MIT Press.