Konrad Lorenz 1962

Gestalt Perception as Fundamental to Scientific Knowledge

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-- p. 37, col. 1 --

Is nature great only because it makes you count?
Schiller

I. INTRODUCTION

The problem of this paper is expressed in the above quotation from Friedrich Schiller. We live in an age when it has become all too common to judge the value of every scientific result exclusively by the role which quantification has played in its attainment. In so doing, the very process which is the basis and root of all inductive research, i.e., simple, unassuming observation, is denied all value and scientific legitimacy. This is so much the case that in the eyes of some behavioristic psychologists the term "naturalistic" has assumed a derogatory connotation. Furthermore, the various sciences become ranked in an unjustified scale of values, in which all those concerned with research on structures come to rank at the bottom of the scale, while physics and above all nuclear physics, is admired as the highest and almost unique form of truly "scientific" research. As a consequence of this, some disciplines whose subject matters are integrated systems of complex structures subscribe to the erroneous belief that they can arrive at an understanding of function without examining structure. Actually, the functional laws of a pendulum clock (for example, the law that the long hand moves twelve times faster than the short one) cannot be traced back to the laws of classical mechanics without a morphological examination of the structure of the clockwork.

Along with the lack of insight into the theoretical necessity of research in structures, we find a disregard for those processes of cognition that tell us of the existence of structures. Wolfgang Metzger makes the following witty remark about some scholars: "There are those who are so handicapped by epistemological considerations that they cannot use their senses in the pursuit of scientific knowledge." Paradoxically this remark applies to some otherwise keen investigators, who believe that by banishing their own observations from their methodology as far as possible they proceed "objectively" in the spirit of the natural sciences. The epistemological inconsistency of

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this procedure is even more easily pointed out, than that of the scholars whom Metzger makes fun of. The inconsistency lies in the fact that scientific legitimacy of perception is acknowledged where perception serves in the reading of measuring instrument, but is denied where perception is used for the direct observation of a natural event. Physics is not only forced to the continual use of measuring instruments by the nature of its subject, but is also justified in doing so by the level of its insight into the structure of that which it examines. The attempt to investigate a natural event by measurement alone before one has gained an insight into its structure by, perception, shows a misconception of physics and the mistake of imitating its superficial aspects.

The physicist himself thinks quite differently about the achievement of perception. Max Planck, in a small essay published in 1942 has shown very clearly that the physicists' world picture is arrived at by the same achievements of cognition as those of the naive, pre-scientific man, or even the child. All our knowledge of the laws of external reality is based on the reports of that miraculous (but scientifically examinable) neural apparatus which fashions perceptions out of sense data. Without the perceptual apparatus, above all without the literally objectifying achievement of the so-called constancy mechanisms, we would know nothing about the existence of those natural units of varying duration which we call objects.

These communications of perception (unwittingly accepted as true by those who disdain them most) are based on processes which even though completely inaccessible to introspection or conscious control possess close analogies to the rational process of drawing conclusions, as Helmholtz has pointed out. In the case of those highly differentiated achievements of gestalt perception (especially the perceptual constancies), these analogies extend even further. It is these processes which enable us to comprehend immediately the order in a complex natural event; that is, to extract order from the background of incidental, insignificant information transmitted to us simultaneously

by our sense organs and lower achievements of perception. As I shall try to demonstrate later, the mechanism of gestalt perception accomplishes achievements in this process which are amazingly analogous not only to "unconscious inference," but also to the classical three steps of inductive science: collecting the basis for induction, classifying it systematically, and abstracting lawfulness.

This process is of a physiological nature, or even of the nature of the functioning of a computer. In spite of this the rather mystical concept of "intuition," has been used to cover gestalt perception and the other achievements of the central nervous system that are inaccessible to introspection and rational reconstruction. This may be the reason why many serious scientists are inclined to regard with suspicion anyone who admits frankly that he lets himself be influenced or even guided by gestalt perception in his scientific work.

The more the object of research is a complex systematic whole, the less one can dispense with the help of gestalt perception. There is no system in the whole world that surpasses in complexity of structure and integration the physiological mechanisms which underlie lawfulness of behavior found in man and the higher animals. More for the behavioral physiologist than for any other natural scientist it is an important question how far he can accept as true the reports of his own gestalt perception, in that sense which is expressed etymologically in the German word for perception Wahrnehmung (truth-taking). The necessity of critically evaluating gestalt perception as a source of scientific knowledge thus originates from the needs of my daily work. Therein lies my justification for having made this evaluation my special task in the paper at hand, although I am aware of having little ability to master it.

II. EPISTEMOLOGICAL CONSIDERATIONS

I would like to prevent the misunderstanding that the following points are made solely to support the epistemological position of hypothetical realism. They perhaps accomplish this as a side effect, but their real goal is much more immediately the task outlined in the preceding paragraphs. This section seeks to demonstrate the following: If one assumes a real external world at all, one has to concede that the way in which the simplest forms of space orientation and perception transmit to us, by analogy, knowledge of extra-subjective actuality is basically equivalent to the way in which the highest forms of reason do the same (differing only in the degree of analogy reached). It shall thus be proved that they are equally legitimate sources of knowledge. The

naive realist only looks outward and is not conscious of being a mirror. The idealist only looks into the mirror and with this direction of vision is unable to perceive that the mirror has a non-reflecting back side. When one as a physiologist examines animal and human behavior, one cannot, help assuming some sort of isomorphism between physiological event and experience, and it is heuristically immaterial whether one subscribes to the theory of psychophysical identity or of parallelism. In both cases the conclusion is inevitable that, as a natural scientist and thus as a hypothetical realist, one must credit the physiological mechanisms and functions running parallel with our cognition with the same kind of reality and cognizability as the things of external actuality about which they report to us. From this we arrive at the equally inevitable conclusion that we cannot advance our knowledge about the "back side of the mirror," i.e., about the apparatus taking in our world picture and projecting it into our experience, without simultaneously advancing our knowledge about the "mirrored" givens of extrasubjective actuality with which the apparatus has a real cause-effect relationship. It stands to reason that this sentence is reversible. Therefore for the hypothetical realist the pursuit of epistemology means investigating, as an organic system, the human apparatus for organizing the world picture. I am aware that traditionally the word epistemology has had an essentially different meaning in philosophy and that scholars in the humanities may take offense when I denote as achievements of knowledge the simple partial functions of the apparatus for organizing the world picture (such as spatial orientation and perception, or even their analogues in animals). But I do this as a matter of conviction. The paper at hand has been written to demonstrate that form perception is a basically indispensable partial function of the human achievement of knowledge. The following epistemological considerations serve only this goal, and should perhaps better be called applied epistemology.

As Max Planck says, every scientist would be guilty of an unpardonable inconsistency if he did not want to assume as real that which he endeavors to investigate. The assumption made by all physical scientists that an external world exists independently of the experiencer is taken as a working hypothesis by D. T. Campbell, who therefore calls his epistemological orientation "hypothetical realism."[*] There is more to this conception than is expressed in Planck's statement. To the concept of hypothesis belongs its property of being examinable by confronting it with facts. But it is just this that the Kantian would deny most vigorously. He would state that all knowledge concerning the natural sciences can only refer to the world of

[*] Translation editor's note: approximately the same phrasing is used in Lorenz's 1941 paper "Kant's doctrine of the a priori in the light of present-day biology," see pp. 103-106 of the original and pp. - of the accompanying translation.

phenomena, and that the belief that human knowledge processes can be tested at work and caught in making errors is an admission of naive realism. I believe that this argument is not valid.

I assert rather that modern physics has already done the allegedly impossible. Men like Planck and Einstein have a view of extrasubjective reality to which the denotation "phenomenal world" can no longer be applied. In this world-picture of modern physics one notes very little of those forms which, according to transcendental idealism, are forced upon all human experience by the "glasses" of space, time, causality, substantiality and other categories "necessary for thought." If we do not prefer to discard all laws of logic and mathematics, we must reluctantly take cognizance of the fact that the beautiful and apparently clear phenomenal form which our intuitable three-dimensional and infinite Euclidian space forces upon the objects, only fits the actuality hiding behind the phenomenon "space" in a middle range sphere of measurement, so to speak, and that this reality is not only finite, to our disappointment, but in addition is irregularly and confusingly curved in a never suspected fourth dimension. We have to be told that the statement that two events have occurred simultaneously is likewise only meaningful in the practical narrow consequences of life, but lacks an exact physical meaning. We must believe that causality, as a form of thought apparently so imperative and logically incontestable, only fits things on a crude scale and in a statistical way; that matter and energy are the same in the last analysis, etc., etc.

Every step of knowledge in physics means taking off "a pair of glasses." Not that man could dispense with all "glasses." What physics has brought to light in the way of new discoveries about extrasubjective reality it likewise owes to a priori forms of thought, of course, but to such forms as are applicable to such domains of fact for which the other categories prove to be inadequate. "Discarding" the inadequate categories has occurred in exactly the same way and for the same reasons as putting aside a man-made working hypothesis: because phenomena become known which it can no longer classify. That one then can manage with another working hypothesis does not mean that one considers the new one to be absolutely true, and modern physics likewise need not believe in the absolute validity of the forms of knowledge by means of which it learned to criticize the sphere of application of others.

The biologist is by no means surprised that physics has lost faith in the absolute validity of a priori forms of thought and intuition. As a physiologist of sensory achievements and perception he knows how "narrow-minded" is the organization of peripheral and central receptors, directed toward practical consequences of the survival of the species. He knows how it arbitrarily excerpts

from reality only just that much as is important for these consequences, and what a "slanted" picture of reality it thus produces. A choice example for this process is color perception, which divides the continuum of wave lengths arbitrarily into a discontinuum of "spectral colors." This is for the purpose of establishing complementary switching pairs, in the process forming the color white. (The color white is especially invented for this purpose, a qualitatively-uniform mode of experience to which nothing simple corresponds in reality.) Since the center of the spectrum does not have a complement in the form of one actually-existing wave band which could be used for its compensating extinction, the complementary color "purple" is invented (just as white is) and thus closes the scale of colors as a ring of colors. The species-preserving achievement of this whole apparatus consists in compensating for fluctuations in the color of the illuminating light, and thus to set off as constants the properties of objects as reflectors. This "objectifying" function, which I shall discuss in detail below, aims exclusively at the thing viewed, and not at the light as such. Crudely speaking, it is quite immaterial to the bee what kind of a reality lies behind the phenomenal "light"; what concerns the bee is to recognize a blossom by its constant properties of reflection, independently of its being struck by light containing varying proportions of red and blue. The wide distribution of the mechanism just sketched speaks in favor of its great species-preserving appropriateness: If, as has been proved, such diverse beings as man and bee have a mechanism for color constancy working on the same principles, it can be assumed with certainty that it has developed independently in the evolutionary history of the two, though certainly under the selection-pressure of the same function.

At this point we would like to counter the reproach of metabasis eis allo genos (mixing of categories) often made to the physiologist of perception, because he uses perception, that is, a subjective experience, as an indicator for a physiological event. He not only may do this, but he must do so. As has already been stated, the assumption of some sort of isomorphism between physical and psychic event is the very basic hypothesis of all perceptual physiological research, and it is quite immaterial whether one subscribes to a theory of identity that views physiological and experiential processes only as two incommensurable aspects of the same extrasubjective actuality or to a psychophysical parallelism. In both cases the reproach of metabasis would challenge the term "physiology of perception." If the manner in which physiologists apply experiential terminology to objective events appears somewhat impure to the terminological purist (if von Frisch and his coworkers speak of "bee-purple" as of a color) this is only a concrete shorthand for expressing facts which

very well be represented in objective language and which have been discovered by purely objective research. Finally, confidence in the hypotheses of psychophysical identity or parallelism is strengthened by the fact that as in the case of the mechanism of color constancy) one arrives at the same conclusion whether one chooses one's own subjective experience or the objectively observed learned behavior of the bees as an indicator of the physiological function. Everyone who seriously pursues the physiology of perception is quite aware of constantly riding in two saddles. But the attraction and the value of this branch of knowledge lies just in one's being able to grip one and the same event from both the objective and the subjective aspects. Secretly one chews at the difficult mind-body problem, unable to leave it alone, though knowing very well that “from the cradle to the grave no man is able to digest it,” as Goethe puts it.

The physiology of perception supplies important results which should not be ignored by the epistemologist, with regard to the peculiar transformation taking place between the reception of physical impingements at the peripheral sense organ and the experience of the perceptual phenomenon. The criticism of perception as an achievement of knowledge which is thus provided has significant similarity to that criticism which modern physicists level at the central knowledge processes. The relationship between “outer” and “inner” presents itself with notable similarity to the physiologist and the physicist. A great mind like Goethe could still seriously believe that colors were objective indisputable givens and objects for physics, but not for physiology. Today hypothetical realists are beginning to realize that even the forms of intuition and the categories of knowledge are functions of the organization of the central nervous system, with an equally incomplete analogical relationship to the thing-in-itself as has the color red to the electromagnetic waves within a certain range of wave lengths.

But the one who can least believe in the absolute validity of a priori forms of thought and intuition is he who does comparative research on the evolutionary history of animal and human forms of behavior and their determining physiological mechanisms. For him, the organization of the sense organs and the nervous system whose function reports to us on extrasubjective reality is obviously something that has developed during the course of the evolution of the species in coping with and adapting to these immutable givens, just as is the organization of all other bodily structures, and like them are accessible to the same methods of comparative phylogenetic research. This research shows a smooth transition between the mechanisms of spatial orientation and perception on the one hand and a priori forms of thought and intuition on the other. In spite of the formidable

differences which these lower and higher achievements of cognition show in their complexity and level of integration, they all agree with the Kantian definition of the a priori: They all are given prior to individual experience and have to be so in order that experience may become possible at all.

This evolutionistic view of the a priori forms of human thought and perception produces a judgment about the possibility of knowing extrasubjective actuality which basically diverges from that of transcendental idealism. It is logically consistent to name the thing-in-itself in the singular and to denote it as fundamentally unknowable only so long as one regards the a priori forms of intuition and the categories which are absolutely necessary for thought as givens with an artificial relationship to the world of things, even though they represent the only "glasses" through which we have any chance of seeing things. If one assumes a complete irrelevancy between the a priori schematism and the extrasubjective world, the phenomena world would in no way be a picture of the real world. The relationship between the two, to use an allegory, would be the same existing between experience and the reality behind it as if, let us say, a person without any information about toxology would slightly poison himself with some exotic poison or other: the person experiences something, but the experience has no pictorial relationship, no analogy of the ordinary type, to the reality of that chemical compound. This relationship between experience and the reality hiding behind it changes fundamentally, however, as soon as the one receiving experience possesses information on the respective reality, as when, to remain with our allegory, the poisoned person is a pharmacologist who can by observing his own symptoms "form a picture of" which drug has caused the poisoning.

The organization of our perception, our forms of perception and categories, in short, of our entire apparatus for organizing a world picture, contains more knowledge than this about the real givens, knowledge mediated to us in the form of phenomena. The a priori schematisms of our intuition and thought do not arbitrarily and unrelatedly dictate to extrasubjective reality the form it takes in our phenomenal world. Rather, in the evolutionary perspective, it was the extrasubjective reality which in the eon-long struggle for survival forced the human apparatus for organizing a world picture to take into account its givens. Just as the fin of the fish has not dictated to water its physical properties, just as the eye does not determine the properties of light, so our forms of intuition and thought have not "invented" space, time and causality. Certainly the fin determines in a decisive manner the way in which a fish experiences water, and the eye determines the way in which light paints itself in our phenomenal world; and certainly water and light have other properties

that cannot be transmitted by these organs to their bearers. Certainly the thing-in-itself is never completely knowable. But just as certainly the basically imperfect and coarse reports on the external world which our apparatus for organizing a world picture gives us have their real correspondence in properties belonging to the thing-in-itself. No one thinking along the lines of the natural sciences doubts that our apparatus for organizing a world picture has developed during the course of evolution in coping the pitiless givens of the actual external world. This fact has interesting consequences for the disagreement between idealism and empiricism with regard to the a priori nature of our forms of thought and intuition. Though it does not dissolve the contradiction into a pseudo-problem, it nevertheless makes its resolution appear as a question of quite low epistemological significance. Obviously the thesis "Nihil est in intellectu quod non ante fuerat in sensu" would be pure nonsense if one were to take it literally and interpret it as if the entire central nervous system of the young organism without experience were a completely structureless mass that needs sense experience in order to acquire any structure at all. On the other hand, the phylogenetic process leading to the development of species-preserving meaningful structures is analogous to the learning of the individual in so many points that we need not be particularly surprised when the end results of both are often so similar that one could be exchanged for the other. The gene, the system of chromosomes, contains an incredibly rich treasure of "information" which would fill many, many textbooks of anatomy, physiology, and behavioral science if we were at all capable of reproducing this information in human words. This entire treasure has been accumulated by a process most closely related to the process of learning by trial and error. The arrangement of the genes in the chromosomes, their limited prescribed variability, and their possibility of new combinations by the processes of sexual reproduction, all together form an apparatus which makes careful experiments with the givens of the surrounding world. In these experiments, continuance of the species with all of the already achieved adaptations ("information" about environmental factors) is never put at stake, since only a probabilistically determined percentage of the offspring are involved. We know that this method has been of striking biological success; all animals and plants are offspring of the organisms that originally "made use" of the method, namely the flagellates. Campbell (6) has shown that the method by which the evolutionary genetic variation explores the realities of the surrounding world for new possibilities of life is in all points equivalent to a purely inductive process, rather than a deductive one.

We know of only two ways by which an

organism can gain information about the surrounding world. The first is the genetic-phylogenetic coping of the phylum with its environment just outlined. The second is learning by trial and error in the individual. But it is evident that learning itself is the function of an exceedingly complicated apparatus which has been well constructed down to the smallest detail in the course of evolution, through the coping of the species with its environment. (The third possible assumption that could explain the adaptation between organism and surrounding world is that of a pre-established harmony. Rejecting all mystical assumptions and insisting on a causal explanation, one could conceive of this only through the possibility that functional properties of matter, based on structure, affect the organism in the same manner as they affect its inorganic environment; this seems so unlikely in view of the structural differences in complexity that a more detailed discussion of this thought appears unnecessary to me.)

All animal and human behavior, coping with certain features of the surrounding world in a manner relevant to the survival of the species, owes this adaptation to one of the two cited sources of information, in most cases to both. For the behavioral physiologist, it is important to attribute the adaptation of single behavioral elements to one or the other of these sources; but it is almost immaterial for the epistemologist to which of the two methods of adaptation a certain structure or function of our perception, thought or cognition owes its existence and its special form. In the supra-individual evolutionary sense, the forms of our intuition and thought have developed in a manner just as a posteriori as those of our organs, that is, from that form of empiricism which endless successions of generations have been able to exploit, although the individual cannot.

Certain forms of intuition and thought are “necessary” only inasmuch as some natural laws are so omnipresent that every higher organism must bring into the world with him the ability to cope with them. Almost every higher animal has heredity-bound structures in the organization of its body and its behavior that take into account such inescapable facts as, for example, that no two solid bodies can occupy the same place in space; that light moves approximately in a straight line; or that effect always follows cause in time.

From such organizations of the central nervous system, which have developed in adaptation to the most general and omnipresent natural laws, almost continuous transitions lead to organizations developed in connection with the very special requirements of the human environment and especially of human society. When we, while looking at the facial expression of a fellow man, join in his experience directly and intuitively, and when we, looking out of the window of a railroad carriage at night, correctly interpret the shifting of

a few points of light as movement parallax and perceive directly not only the spatial distribution of the lights, but also the movement of our train itself, these two achievements surely are due to very different physiological processes. The first one most probably, like the reaction of the smiling infants of Spitz, is due to an innate releasing mechanism, the other to one of those most complex processes of reckoning so characteristic of our space and form perception and so similar to conscious reckoning that Helmholtz could name them "unconscious inference." Both processes are, however, achievements of neural structures of organs which during the course of evolution of our species have developed in coping with and adapting to the givens of our environment. The difference between the two is that the first one copes with a very special, specifically human environmental situation, while the second copes with an ubiquitous exigency biologically relevant not only for the species Homo sapiens but also for most organisms which orient themselves optically.

The difference in achievement between these two examples of cognitive mechanisms is not that one reports something more true and correct than the other; but rather in the different breadth of the sphere of application for which they function. A neural computer which is capable of utilizing all occurring movement parallaxes of all possible visible objects to achieve a correct report on their position in space (and in addition on the movement of the viewing eye itself) must, of necessity, possess real analogies to the facts of extra-subjective actuality in a great number of aspects, analogies which it mirrors in our phenomenal world. The experienced phenomenon provided through movement parallax is in a sense more abstract a picture of extrasubjective reality than is our experience of a single quality of feeling transmitted to us as by way of an inborn releasing mechanism when looking at the expressive movements of a fellow man.

It is perhaps not quite correct to state about such diverse forms of cognition that some are more and others less anthropomorphic, as I have done in 1943 (12). They are evidently all equally anthropomorphic in the last analysis. Only those more general preformations of possible experience coined for natural laws operating everywhere can be proved to exist also in other organisms, whereas the most specialized releasing mechanisms are naturally very specifically human. Even the most general forms of experience possible for us (space, time, causality, etc.) have, as modern physics knows, only limited domains of application (different from one to the other), and where they all fail, the most "un-anthropomorphic" of all categories, the one of quantity, helps us along a little further. It was a revolutionary act (entirely illegitimate according to the transcendental-idealistic laws of human reason) to simply put aside the

category of causality where it was of no further help, just as one would do with a humanly-created hypothesis, and to replace it by a probability calculus.

Possibly it is the characteristic of having the greatest generality conceivable that makes quantity appear as the only "nonanthropomorphic," plainly objective category to so many natural scientists. Many frequently cited quotations express the primacy of quantity: e.g., "every natural research contains as much scientific method as there is mathematics in it"; or, "science consists of quantifying what can be quantified and to make quantifiable what is not." What the authors of these clever and false aphorisms forget is the structure of matter. In addition they deny the status of science to psychological research and the status of reality to the multicolored world of qualities. Besides, pronouncing the category of quantity absolute is epistemologically incorrect. It, too, is only a box which plainly and honestly fits the facts of extrasubjective reality to a degree sufficing for the needs of survival of the species. "Two times two equals four is truth: pity that it is easy and empty" says Wilhelm Busch. The counting machine of extensional quantification works like a dredging machine, adding one small shovelful of something to the preceding one. Its work is really without contradiction only as long as it runs empty, counting always only the return of its only shovel, the number one. As soon as we allow this machine to interact with the in-homogeneous matter of extrasubjective actuality, the absolute truth of its statements is immediately lost. The assertion that two rams or two atoms plus two more equal four has only a very crude approximate value, for the simple reason that two actually equal atoms or rams do not even exist, not to mention the eight necessary to make the above assertion absolutely true. The equation two million equal four million, if applied to reality, is much more correct than the statement two times two equals four, for the reason that the individual differences of the counted units equalize themselves statistically in the case of large numbers with a probability bordering on certainty, always assuming that one does not add rams to oxen. Our form of thought of extensional quantification thus is like that of causality in the decisive point that its statements correspond to extrasubjective actuality only with statistical probability and do not contain absolute truths.

As has already been shown, an approximate truth, "a piece of information" on the extrasubjective given is contained within every behavioral adaptation, making possible its successful coping with the environmental factors concerned. In cases where both simpler and more complex mechanisms cope with the same fact, this analogy between behavioral adaptation and cognition of the actual often becomes very clear. The blind and rigid retraction

of Paramecium contains only a single piece of information on the object obstructing its way, namely that an obstacle insurmountable for the locomotional efforts of the ciliatum lies in that spot. The three-dimensional spatial insight transmitted by our optical depth perception registers many more details for the human observer about the object obstructing the path of the little animal, but it confirms the modest information of the Paramecium on the aspect that is essential for it: at that point the little animal can indeed swim no further in the direction hitherto taken.

The mechanism enabling so many animals to develop conditioned reactions is an adaptation to the physical fact of transformation of energy. Responding to a conditioned stimulus which precedes a biologically relevant one makes possible a meaningful species-preserving preparation or evasion only if both stimuli follow each other with reliable regularity, and this is the case only when they are both links in the same chain of causality. From this connection the mechanism of the conditioned reaction contains only the one piece of information that effect follows cause in time—but how immeasurably valuable is this "knowledge" for the survival of the species! Besides, it is correct, for it remains entirely true even when seen from the higher observation tower of causal thought.

A more primitive achievement of cognition thus does not differ from a more highly differentiated one in reporting different facts, but in including fewer details of extrasubjective actuality. The simpler world picture is, compared with the one most highly differentiated, not distorted but only reproduced through an incomparably coarser screen.

If there is anything suited to confirm our belief in the reality of the external world, it is the functional analogies existing between simplest and most differentiated, or between the unconscious and rational, achievements of cognition. They can be understood only on the basis of the assumption that the analogous mechanisms have developed in adaptation to the same structure of extrasubjective actuality. Analogies like the two illustrated above can likewise be found when comparing animal and human achievements, as when comparing lower with higher functions of cognition in man himself. When Egon Brunswik and I still worked in Vienna, he on mechanisms of perception, and I on innate releasing mechanisms, we were again and again surprised in our discussions by the detailed nature of such analogies. Frequently human perception reacts exactly "like an animal" and can be led on to the wrong track by crude dummies; often animal perception accomplishes achievements which are to the highest degree what Brunswik later called "ratiomorphic" (4).

The considerations just discussed, deriving from introducing the evolutionary idea into epistemology,

agree just as much with the basic assumptions of hypothetical realism as do the results of modern physics and of perceptual physiology. It fulfills the demand for a new hypothesis capable of classifying facts not explained by other epistemological orientations, above all, not by transcendental idealism.

One demand which I mentioned at the beginning and which I had already concluded was essential in 1941 (13) through the adoption of hypothetical realism is the postulate that every theory of knowledge must take into consideration all advances in our knowledge of the nature of the cognized, especially where the theory proves to be so obstinate when applied to the a priori forms of thought and intuition as is the case of modern physics. It is possible to make the forms, the empty-running mechanism for the achievement of knowledge, so-to-speak, the subject of investigation; one can pursue "pure" theory of cognition. But one would thereby proceed as if one examined the mechanisms of a camera, let us say, of a Leica, with regard to their inner lawfulness without taking into consideration that the whole apparatus serves the function of photography and has been developed by the Leitz Company in Wetzlar from simpler, earlier models in the service of that function. But in such a procedure one will neither learn about the achievement nor about the limits of achievement of the apparatus limits which must be known if one wants to understand and improve the achievement in order to push beyond those limits.

The essay in which I first presented the most essential parts of this epistemological perspective had just been published when the cited paper by Max Planck appeared, in which he arrives at results agreeing with my conclusions in many points. Niels Bohr (2) has set forth the same principles in an address given to the American Academy of Arts and Sciences in 1957, and P. W. Bridgman (3) said in his summarizing comments on this address: "The object of knowledge and the instrument of knowledge cannot legitimately be separated, but must be taken together as one whole." I mention the priority of my own small essay over the similar statements of the three Nobel Prize winners in physics, only because the agreement of independently formed opinions is significant, and one would sooner believe that I had been influenced by them than the converse. But I shall not conceal that it was by far the proudest moment of my life when I received a letter from Max Planck saying it gave him great satisfaction "that starting from such completely different bases one can arrive at ideas on the relationship between real and phenomenal world which are in such complete agreement."

In terminating this section, the question should be posed as to whether the conjecture made at the beginning of this paper is confirmed. Do arguments in favor of the assumption of

hypothetical realism actually result from the study of the human apparatus of knowing? Theoretically, proving the legitimacy of perception as a source of knowledge, which in my opinion has already been done, is not affected by the answer to this question.

Upon superficial examination of the above deliberations, the suspicion arises that the argument in favor of the assumption of an actuality knowable only partially and through analogy, moves in a vicious circle, like the procedure of Münchhausen who pulls himself out of the swamp by his own pigtails. It may seem as if the knowledge of physical facts, as well as the acknowledgment of their reality, is an assumption used to achieve certain conceptions about the apparatus of knowing likewise assumed as real (the apparatus that projects physical facts as phenomena into our experience, for example, the mechanism of the color circle). Here the didactically simplest form of presentation deceives us about the way in which cognition originally worked. The physicists would never have arrived at the representation of light as a wave form if the mechanism of the color circle had not dissected the spectrum into bands perceived as qualitatively different. As much as the mechanism of color constancy is tailored to its special function; as arbitrarily as in the service of this one function it treats the continuum of wave lengths hidden behind the phenomenon; as deceivingly as it passes off white and purple as ”pure colors”; it nevertheless has helped physics to the one essential discovery that different wave lengths exist at all. It was a further step in knowledge when later the understanding of the wave nature of light stimulated further questions on the nature of the color circle.

It seems to me that this procedure is less like that of the legendary liar Münchhausen than that of an ordinary man who puts forward one foot after the other in walking. That results originating from completely different fields of knowledge and derived from completely different phenomena never contradict one another, but on the contrary augment fields far removed from their origin, is a fact which does not surprise the nonrealistic philosophers enough. It seems to me absurd to look for any other explanation other than that behind all phenomena hides only one extrasubjective actuality. This opinion is admittedly based on the naive but well-tested view that the correctness of all testimony by witnesses becomes more probable with an increasing number of witnesses independently agreeing with one another. If the five persons of a symposium engaged in a discussion agree in the statement that there are five wine glasses on the table at which they sit, I am not able to understand how any rational human being can look for an explanation for this agreement other than the one that whatever may be hiding behind the phenomenon “wine glass” is really present to the extent of five in number.

III. THE ACHIEVEMENTS OF CONSTANCY OF PERCEPTION

I cannot imagine a better way of establishing the legitimacy of perception as basic to scientific knowledge than through the proof that form-perception not only achieves what is generally credited to rational thought, but in addition accomplishes it by closely analogous operations (which, however, are inaccessible to introspection). To prove this, I have chosen to discuss two mechanisms which have been known for a long time, but whose mode of operation and utility for the survival of the species have been clarified in recent years, particularly by E. von Holst.

a) Constancy of Color

I see the top of my desk in always the same light brown color, regardless of whether I look at it in the bluish morning light, in the strongly reddish light of the late afternoon or in the yellow light of an electric bulb. Factually the top of the desk reflects very different wave lengths under each of these different circumstances, but my perception reports little or nothing of this. What it reports to me is, in the last analysis, no color at us all, but a property constantly attached to the object, the property of reflecting light of one type of wave length better than that of another. How perception discovers this constant property under changing conditions will be represented first of all in a "ratiomorphic" manner for the sake of easier, though not simpler, understanding. First the mechanism of perception "surveys" the entire field of vision and ascertains the profile of wave lengths reflected in it. If among them those of a certain spectral color are predominant, it supposes that the source of light emits more of this than of other colors. The mechanism thus works on the basis of an assumption which is only probable and by no means certain, namely, that on the average, sets of objects in the field of vision reflect all spectral colors equally well, not giving preference to any particular one. If this hypothesis is wrong, for example, if among the seen objects those that preferably reflect red are predominant, then the constancy mechanism concludes that the illuminating color contains a lot of red and erroneously ascribes to those objects reflecting less red in this instance the general property of reflecting red less than other wave lengths, i.e., of preferentially reflecting these other wave lengths. This is a conclusion which is logically correct, but since it is based on an erroneous premise, is wrong. Apart from such special cases, this constancy mechanism informs us with great reliability of the significant reflective properties of an object, which we perceive immediately as "its color."

What has just been represented in a ratiomorphizing manner is actually achieved by a physiological mechanism which in a considerably simpler way extracts the same information from

the same stimulus data. Its function is based on the well-known principle of complementary colors. The ingenious "trick" which the evolution of this mechanism "has invented" is the reduction of spectral colors to an "arbitrarily" chosen zero point, the color white. (Strangely enough it is not the mixture of wave lengths corresponding exactly to sunlight which we perceive as "white," but rather one which has been slightly shifted toward the short-wave side of the spectrum. We do not know why this is so; it is rather immaterial as far as the function of the constancy of colors is concerned.) The second great invention consists in grouping together certain spheres of wave lengths separated in the spectrum in such a way that they complement each other, thus yielding zero, that is, white. Since the spectrum has a linear arrangement, this system of mutual compensation of two spheres of wave lengths encounters one great difficulty: however the spheres complementary to each other may be situated, one of them must always remain without its complementary partner. This difficulty was overcome by the "fiction" of a non-existing spectral color, purple, which closes the spectral band to a circle by joining the red end with the violet one.

When an area of the retina is struck by light of a certain wave length, the sector of the perceptual apparatus receiving this color registering and relaying it to the center, simultaneously starts to register also the complementary color. Contrary to the primary color registering, the complementary color irradiates other parts of the retina and the afferent parts of the nervous system synapsing with the latter, if these are stimulated by light of any kind. Here we meet a widespread achievement of the apparatus of perception, namely that of a synthetic production of a "perception" which cannot be differentiated from a registering of the same nature coming from the peripheral sense organ. The highly important species-preserving function of these "phantoms" lies in their ability to extinguish messages from the sense organs where a perception of constancy requires it by superimposing the same message with a reverse sign. The green which is synthetically produced when red radiations are received by the eye, combines with the actual red of the same intensity to produce white, just as would "actual" green registered upon the retina. Therefore we still see our writing paper as white under a red lamp.

This registering of green produced synthetically as a perceptual compensation under red radiation does not result from, or at least does not exclusively result from, the process that lowers the perceptual threshold to green light increasing and emphasizing a green which is already there. If one contrasts a red-irradiated semicircle with one whose white is mixed from spectral blue and yellow and thus does not reflect

actually green light, the person sees this white likewise as green. However, whether this green is as intensive as it would be if seen on a white mixed from all the colors has not yet been investigated quantitatively.

Dividing the continuous scale of wave lengths into a number of discontinuous complementary bands with positive and negative signs; introducing the zero-color white; and above all the active production of "phantom" colors; all of these together form an organization of perception which has surely been evolved in the service of constancy of color and thus indirectly in the service of the constancy of objects. Just as so many other so-called sense illusions, the long-known phenomena of color contrast are senseless misachievements of a highly differentiated organic system (though not endangering the survival of the species) whose function paradoxically is that of avoiding sense illusions. Their function is to report to the higher channels of our apparatus for organizing the world picture only such information as actually has its correspondence in extrasubjective reality.

b) Constancy of Direction

The second mechanism of constancy which I shall use as an example of an apparatus of perception working ratiomorphically is the one that prevents us from erroneously interpreting shifts of the image on the retina due to the movement of our own eyes as movement in the environment.

As early as Helmholtz there was appreciation of the importance of the fact that passive movements of the eyeball (such as with a finger or with a suitable mechanical device if the eye is anaesthesized) result in illusory perception of movement of the environment in the opposite direction. Helmholtz therefore concluded correctly that proprioceptive cues could not prevent illusory movement perception in the case of active eyeball movements. An important supplement to Helmholtz's observation is a long-known observation of ophthalmologists: when people with paralysis of the eye muscles try to look in the direction prevented by their paralysis, their surroundings seem to jump in the direction of the intended, but not occurring, eyeball movement.

One can make these two phenomena comprehensible in a ratiomorphizing way as follows: When the eyeball is turned passively, perception does not "experience" this as an eye movement; therefore it must "conclude" that the observed shifting of the image on the retina has been caused by a movement in the external world reverse in direction to the forced turning. On the other hand, in the case of the paralysis, the attempt to turn the eyes creates the expectation of a shift of the image on the retina. The perceptual center does not "know" anything about the paralysis and therefore presumes that the command given from the center has been duly carried out, that is, that the eyeball

has turned to the degree prescribed by the command. On this false premise it must logically conclude that the external world has moved in similar degree, since the image on the retina is on the same spot as before.

The process thus presented ratiomorphically is actually mastered by a mechanism discovered and analyzed by Holst and Mittelstaedt (9). Part of the command directed at the motor system, a “copy” so-to-speak, is led directly to those perceptual centers which will also receive those reports which are to come from the sense organs as a consequence of the command just given. These latter sense reports, the immediate products of the organism's own movement, are called re-afferences. The report directed to perception by the motor command just sent out is called the efferent copy. The achievement of constancy by the entire mechanism is based on the efferent copy actively producing a perception in the higher receptor centers which is exactly the same as the one caused by re-afference, but with the reverse sign, so that both complement each other and combine to give a zero report. Therefore in the case of active, undisturbed movements of the eye, we see our environment as completely quiet, although extensive shifts occur on our retina and are relayed to the center.

It is obvious that the same achievement of constancy could theoretically be accomplished by reporting the actual movement to central perception through proprioceptors, there bringing it into relationship with the re-afference. In fact, such a process has been chosen by evolution in many cases, especially in those cases where more emphasis is placed on accuracy than on rapidity of compensation. The biological advantage of the efferent-copy procedure consists in its anticipating the re-afference, so-to-speak, in arriving simultaneously with it at the perceptual center.

To these examples of mechanisms of constancy, I shall briefly add one more, that of constancy of size. Regarding this, Holst has demonstrated that the motor processes of convergence and accommodation, occurring at the time of closer approach of the visual object, surprisingly create a compensatory “phantom” of reducing size, most probably by means of an efferent copy, without perception of distance playing a part. If somehow both eyes are forced into stronger convergence, accommodation remaining equal, the image seen becomes smaller. The same thing occurs when both eyes are made to adjust to stronger accommodation, convergence and size of image on the retina remaining the same. These two processes have an additive effect which von Holst has investigated quantitatively. This mechanism evidently also reports to the perceptual centers information on the distance of the object. The only surprising thing is that the mechanism does not proceed in a way closer to our ratiomorphizing, i.e.,

through measuring the distance and then determining the constant size from the correlation between distance and the size of the image on the retina (as is assumed in many textbooks). This is the more strange as other mechanisms of size constancy apply this latter method: e.g., the illusion in which objects seen in a fog appear larger is based on the fact that under these conditions the depth criterion of air albedo erroneously reports a larger distance, from which a too-large expansion of the seen object is then calculated.

c) Constancy Achievements in General

In the above I have intentionally chosen as examples constancy achievements which in their causal-physiological origin are very different from one another; I have done this in order to show more clearly the common properties developed in adaptation to similar functions.

They develop their special value for the survival of the species by compensating accidental and fluctuating conditions of perception (the first example coming from the changing color of illumination, the second from the changing position of the sense organ in space) and by reporting directly to perception facts which are attached to the things of extrasubjective actuality.

Both achieve this by actively producing the phantom of perception. This "illusory" perception is, except for a reversed sign, qualitatively and quantitatively exactly like the one the accidental change of the conditions of perception causes, or more exactly, would cause if this report were not completely extinguished by the superimposing of the "phantom." I have put the words "phantom" and "illusory" in quotation marks for the reason that they are really true perceptions. In other words, it is highly probable that the compensating messages in the service of constancy use the same channels on the last stretch of their afferent path and excite the same central channels as do "genuine" perceptions, that is, perceptions caused directly by activation of the sense organs. At least this assumption suggests itself if one considers complete indistinguishability of two forms of experience as an argument in favor of the identity of their physiological correlations. Perceived movement offers a good example for the identity of the central phenomena in spite of the different origin of the reports. When we see a bird flying across the blue sky, elements of the retina are the first to supply information about the movement of the bird, through the temporal succession of their reacting. In the next moment, however, the image on the retina is transferred to the central fovea by "telotactile" mechanisms and there maintained stationary by the eye following the movement. From now on it is only the efferent copies of the commands directed at the eye muscles which report information about direction and speed of the moving object seen in the center of the retinal

world. Our perception of the gliding movement of the bird remains the same during the whole process; we notice nothing of the intermediate stage in which one peripheral reckoning apparatus takes over from the other.

All apparatuses of constancy, just as those discussed in detail are “ratiomorphic” in the strictest sense, for all contain processes analogous to induction and deduction; all contain “hypotheses” whose attunement is not absolute, but only to a high degree probable. All can draw the wrong conclusions if their inductional basis is falsified, conclusions to which they cling, often incorrigibly.

All achievements of perceptual constancy are objectifying in the literal sense of the word. They bring order into the immeasurably polyphonic cacophony of the sense data impinging upon us by abstracting from many individual cases in a truly inductive procedure the lawfulness ruling in them all. They report to us about this lawfulness alone, not about the sense data themselves, nor about the procedure by which they arrived at their abstractions. Most of the well-known illusions of perception are erroneous achievements of mechanisms of constancy “persuaded” by special and generally improbable stimulus situations to produce their compensatory “phantom” where there is nothing to be compensated.

d) Constancy of Form

The most complex and miraculous of all achievements of constancy is that of constancy of form. It is at the basis of the constancy of things, making possible the re-recognition of objects; one need only bear in mind Jacob von Uexküll's definition: “An object is what moves together.” While I regard my pipe which I turn this way and that before my eyes, my perception correctly interprets the manifold changes which the image on the retina experiences as changes in spatial position, not in the shape of the pipe. In this achievement, which in its obviousness hardly stimulates reflection, are contained as its integrating components almost all the previously mentioned constancy achievements plus a large number of such highly complex stereometrical calculations that one would despair of the possibility of exploring the mechanisms by which they are achieved if experience had not taught us that they sometimes work more simply than their rational analogues. The descriptive-geometric achievement of this mechanism is almost undiminished if one removes all cues except the change of contour of the image, (as when looking at the silhouette of an object). The only loss suffered is that the sense of the direction in which the object is turned is no longer present; turning a silhouette, as we know, can be interpreted equally well as to the right or left. The apparatus of perception tells us nothing of this ambiguity, however. It “decides” on the “hypothetical” assumption of a certain direction of turning. As we

know, one interpretation then frequently changes into the other, and this change can be arbitrarily controlled with some practice. One could ascribe a species-preserving usefulness to this sudden perceptual decision in favor of one of two alternative interpretations. Since perception, especially that of processes of movement, serves the purpose of directing an immediate meaningful action, it is no position to use "statistics." It is more purposeful to make an error with a 50 percent probability than to strive for certainty in a meaningless compromise solution. In complex form perceptions of long duration, the situation is quite different, as we shall see below.

In perception of spatial form constancy there are achievements of transposition closely related to those of genuine gestalt perception. The image created by the contour line of the back of a fish on my retina is a line curved several times. This line changes its length, its radii, as well as the direction of its curves depending upon the angle of viewing. It makes a straight line when I see the animal exactly from the front or from behind; when I look at it from above, it stretches to a long line. When my perception achieves a constancy under ordinary conditions of observation, depth criteria and other things may supply information, but when it achieves the same with the silhouette of an object turned this way and that, the sole source of information from which it can derive the constancy of the seen form is the steady relationship between the heights, distances and signs of the peaks and curves which form on the retina. To work the multitude of these very "abstract" constants into a single perceived quality is an achievement which meets all of the classical gestalt criteria.

IV. GESTALT PERCEPTION AS ACHIEVEMENT OF CONSTANCY

I cannot see a basic difference between the mechanisms of optical form constancy just sketched and those of gestalt perception. It is a very continuous chain of simpler and more complex mechanisms which make it possible for us to obtain a picture of the objects around us sufficient for our survival and to recognize them again as "the same" in spite of continuous change of the conditions of perception. It is even misleading to speak of a "chain" since they together form a system in which everything is connected with everything else in a functional cause-and-effect relationship. Constancy of form transposable in size, for example, is contained in the achievement of constancy of size, just as vice versa.

The significant achievement of objectification of all mechanisms of constancy is based, as already stated, on the extraction of a lawfulness ruling in the sense data. This lawfulness can be so complex, especially in the case of constancy form,

that its being set off from the "background" of the accidental seems analogous to genuine rational abstraction. The mechanism accomplishing this special achievement also proves itself capable of mastering a more general one. It shows itself capable of perceiving as constant not only those lawfulnesses which result from the constancy of properties attached to objects, but also those contained in any other stimulus configurations and above all in their temporal succession.

Perception of temporal facts as such is nothing special or new to complex gestalt perception. It certainly also plays a role in the lower achievements of perception, as in constancy of direction of movement, etc. The perception of time is in form closely related to that of space; it is expressible only in the allegory of a movement in space, a fact which is manifest in the double usability of spatial-temporal prepositions, such as vor ("in front of," "before") and nach ("behind," "after") as well as in the image-like etymology of the words future and past, Zukunft, Vergangenheit, etc. But there is also the reverse: the description of the spatial in allegories of events proceeding in time is entirely familiar to us, as when we speak of the "Verlauf" ("course") of a "gewundenen" ("winding") line or the "Ausdehnung" (stretching") of a topic. These mutually exchangeable parallels between the form of intuition of space and of time are certainly significant for more than just the linguistic symbolism of man. They spring from the primary fact that movement has spatial and temporal extension. That central representation of space, which exists in many organisms as a precursor to human form perception, obviously originated in beings that could move freely and were forced to orient their movements in space. Comparative studies show very nicely how the "central space model" has become more and more highly differentiated hand in hand with the increased demands made on the orientational accuracy of movements (17).

In view of these facts it is less surprising (even if still most miraculous) that event perception in space and time, the achievement of transposing space and time through solely spatial gestalten, the offsetting of the transient features of elementary sense data, and above all, the setting off of constant lawfulnesses, occur in almost the same manner. For this reason, in the discussion of the complex functions of gestalt perception most closely related to abstraction, it is almost immaterial whether one chooses examples from the sphere of temporal gestalten (as of melodies), from the sphere of spacio-temporal movement gestalten, or from that of spatial configurations only. (The latter has the advantage of concreteness, although there is no purely static spatial gestalt perception in the strictest sense, or at least only in the special case of the tachistoscopic presentation. In all other cases the eye always wanders over the

seen configuration and thus the mechanisms of constancy and direction, operating in time, come into play.)

Strictly speaking, there is some degree of the memory function in the perception of every temporally extended gestalt, since keeping in mind the beginning links, even if only for a short time, is necessary for surveying its configuration (with the exception of the special case just mentioned). I believe that an achievement of learning and memory, taking place on a different level, plays a decisive role in the realization of the very complex gestalt perception now to be discussed, for the time required is longer by many powers of ten. The constant color and size of a seen thing are instantaneously transmitted in final form, and surveying a short temporal gestalt takes hardly longer. On the other hand, we have to see a really complex gestalt, such as a human face several times, or hear a polyphonic piece of music several times, before the gestalt perceived takes on its final quality. One could say with but slight overstatement that such complex gestalten never reach a really final quality at all, and that at every repetition of perception, at every increase in acquaintance, they change a bit, as newly noticed minor regularities come to stand out from the background of the accidental, allowing an ever deeper penetration into the structure of the whole.

The participation of learning and memory in the realization of complex perception makes “abstracting” the gestalt from the background of chaotic stimulus data possible even when it is completely drowned out by the “noise” of the latter in a one-time presentation. In a process of gathering information which can extend over several years or even decades, gestalt perception in cooperation with memory (in this special achievement a puzzlingly good memory) creates such a broad “basis of induction” that the searched-after regularity seems “statistically based.” The quotation marks here are to express the analogy of the ratiomorphic and the rational achievements. When I once spoke about detailed processes at a symposium, and described how when observing complex animal behavior one can see the same process literally thousands of times without noticing its lawfulness, until suddenly on a further occasion its gestalt sets itself off from the background of the accidental with such convincing clarity that one asks oneself in vain why one has not seen it long before, Grey-Walter summarized my somewhat lengthy speech in one sentence: “Redundancy of information compensates noisiness of channel.”

The clarifying factor of shutting off the accidental, only possible through the contribution of learning and memory, is probably why gestalt perception is an entirely new achievement appearing very late in evolution, and flourishing only in man. The same mechanisms which effect thing constancy and which in the course of phylogenesis surely have

been developed just for this achievement are, as we have seen above, also capable of being generalized to deal with other lawfulnesses, such as short-term temporal gestalten. The same mechanisms, without essentially changing their physiological structure, are also capable of something quite different: from a larger number of configurations which can occur over considerable intervals of time they "abstract" a supra-individual lawfulness ruling them all.

The same mechanisms of perception which enable me to recognize my chow Susi from the front and from behind, from far and near, in red and bluish light, etc., as the same individual, these same mechanisms enable me by a curious change in function to see in this chow, in a great Dane, in a toy terrier, and in a dachshund a common, unmistakable gestalt quality, that of the dog.

It is certain that this highly specialized achievement of gestalt perception precedes the abstraction of genus concepts; most probably it forms the essential precondition of such abstraction. The small child, already capable of denoting all dogs as "wow wow" and all cats as "meow" has surely not abstracted the zoological determining formula of Canis familiaris and Felix ocreata. It also cannot be predicted what content such a quasi-abstraction, made by gestalt perception, covers. The small son of a colleague incorrigibly and stubbornly denoted not only dogs, but also horses, cats, and mice as "wow wows." The consternation of the zoologist parents turned into joy only when it turned out that "wow wow" simply meant "mammal" and was applied without error to all beings of this class, including his newborn sister.

My older daughter at the age of five knew only the moor hen (Gallinula chloropus L.) and the bald coot (Fulica atra L.) from among the order of the ralline birds (Rallidae) which is rich in forms and multi-shaped, but these birds she knew very well. When we tested her on the large collection of birds at the zoo of Schönbrunn, she could tell all the ralline birds kept in the different cages without making a single mistake: the long-legged Sultanshuhn (Porphyrio) kept among the grallatoras, as well as the smaller forms of ralline birds kept together with small gallinaceous birds and in their exterior deceivingly like them, such as the landrail (Crex crex L.). There were some small Turnicidae in the same cage which belong to an ancient group perhaps closely related to the gallinaceous birds; in their exterior they are quail-like birds. When asked about them, she only said doubtfully "there is something of the gallinaceous birds about them," thus stating exactly the opinion of the most authoritative taxonomists.

The existence of a so highly developed "attunement to system" in a five-year-old proves convincingly that this feeling is based upon ratiomorphic, but not rational processes. One is made

very aware of this when one, as an experienced comparative zoologist, attempts to investigate these achievements in oneself. In observing oneself, one may very well discover that the message of the group-abstracting gestalt perception consists of a single, unmistakable quality of experience, but states nothing about the characteristics and combinations of characteristics that are the cues for this whole-quality. I have again and again made this experiment on myself with the family-rich group of the Percoidei. In almost every family of this group there are adaptations to very different ecological niches so that the breadth of difference within one family is far greater than the average, externally visible differences between the families. The marks used by the taxonomists for diagnosis and definition of the families are mostly not visible from the outside. But as early as my school days it struck me that I could identify the members of two families of Cichlidae, already then well-known to me through many representatives, and of the North American Sunfish (Centrarchidae) without fail even when I saw the particular species or genus for the first time. My later efforts to ascertain the configurations of characteristics, which, woven into the integral gestalt perception, determine the unmistakable qualities of the "cichlid-like" and the "centrarchid-like" produced only two negative statements.

First, it is not the striking, coarse characteristics, such as shape of body, number and type of fins, etc., which determine the quality. When I saw the tiny pigmy centrarchid Elassoma evergladei for the first time, which does not look at all perch-like on account of its roundish body shape and the invisibility of the spines of the dorsal fins, I took him for a tooth carp (Cyprinodontidae) for a few seconds and then immediately experienced the highly significant discomfort, well-known to every person trained in gestalt psychology, which is caused by disturbed gestalt perception. Then the well-known gestalt of the centrarchid leaped forward from the background of the accidental cyprinodont-like characteristics with a practically audible "meshing of gears" and a truly relieving "aha-experience."

Secondly, it is not certain that the impressive characteristics which exist in all observed individual gestalten are necessarily quality-determining in the quasi-abstraction of the higher level gestalten. Both ralline birds known to my little daughter were web-footed birds similar to a duck in their exterior body shape. That this mark was missing in the unknown ralline genus which she met for the first time did not distract her from recognizing the quality of "ralline-like." All cichlids known to me until now have a body with the sides strongly pressed together and a high back. When I saw for the first time a type from the rapids of the Congo, flattened ventrally and dorsally to adapt to living at the bottom of the water, I

instantly recognized them as cichlids; the completely changed body shape did not detract from the unmistakable quality of the "cichlid-like."

In such an achievement, which pieces of information inform the gestalt perception that a coarse, striking characteristic, present in all known cases, is only "incidental" in that particular configuration? The functional comparison between the ratiomorphic and the rational mastering of the same task permits certain conjectures as to the direction in which to look for the solution to this problem in information theory. Every zoological taxonomist who would have attempted to abstract inductively a "diagnosis" of the group in question on the basis of what my daughter knew about ralline birds and I about cichlids would certainly have used the web-footedness of the rallines and the high-bodiedness of the cichlids. To be prevented from making this mistake he would have to have much more information. When, for example, zoological taxonomy classifies snakes as quadrupeds, even though the four legs (determining the naming of this large group) are missing in them, he does this with a good reason. Every naïve person knowing the particular animal group, perceives that snakes "according to their essential being" are quadrupeds and that their missing legs are only something "accidental." This conviction corresponds to the phylogenetic conclusion that the lack of legs of snakes could be designated a primary characteristic only by assuming that all the other characteristics which a snake shares withquadrupeds, and particularly with reptiles, have come about accidentally. This latter assumption has an improbability whose calculable mathematical expression requires astronomical figures.

Many decades ago the ornithologist Gadow (8) made the highly interesting experiment of comparing the degree of accuracy of intuitive classificatory feeling with that of rational considerations undertaken on the basis of a known number of characteristics. He came to the undoubtedly correct conclusion that gestalt perception is able to take into consideration an extraordinarily large number of characteristics without the perceiving person being aware of it. How large this number must be is revealed from the fact that from the comparison of very few (in the above examples only two) types, enough information can be obtained to make possible the gestalt-like "diagnosis" of the group.

V. THE WEAKNESSES AND STRENGTHS OF GESTALT PERCEPTION

If anywhere in the physiology of the central nervous system the knowledge of modern computers provides more than a most sketchy model of thought, it is in the mechanisms which extract perceptual information from sense data. Far from

giving the impression of being basically unexplorable, and from misleading one into mystical-vitalistic interpretations, the achievements — and even more the revealing misachievements — of gestalt perception bear the characteristics of the mechanical or physical so much that they are more suitable than any other similarly complex phenomena of life to strengthen our research optimism. Paradoxically it is the misachievements that strengthen our conviction that the apparatus is something actual that relates to extrasubjective reality and that it tells us something true about this cause and effect relationship, even if only approximately (but even the most general and least "anthropomorphic" forms of possible experience can do no more, neither the category of causality nor that of quantity).

One has to vigilantly keep in mind the specific functional properties of gestalt perception in order to avoid their becoming sources of scientific error. Gestalt perception is only one part of the systematic whole of our cognitive functions, a part specialized for a particular function. The special species-preserving achievement whose pressure of selection has caused this specialization is that of discovering lawfulnesses.

Certain other properties have been sacrificed to the sensitivity of this "detector" and from this derives the possibility of misachievement. This possibility is most important for the critical evaluation of gestalt perception, and for this reason will be discussed first. Analogously to many sense achievements, the sensitivity of registering of complex gestalt perception has been increased to nearly that limit beyond which the danger arises that, through self-excitation, reports are generated to which no external stimulus corresponds. The same limit exists in technology. One can for example increase the sensitivity of a microphone only to the level of its internally generated noise.

This inherent noise corresponds to the phenomenon in gestalt perception which has been denoted as "gestalt pressure," "pregnance tendency," the "tendency to gestalt," etc. The phenomenon consists in perception falsifying sense data which almost but not quite conform to a lawfulness, in such a manner that they now seem to confirm it. Obviously the same mechanism also can work so that equivocal sense data are interpreted always in terms of the simpler, "more pregnant," of two possible regularities even when the more complex interpretation is the correct one, and even when a "retouching" of sense data becomes necessary for maintaining the simpler.

When the information contained in the sense data can be used equally well for the support of two perhaps opposite interpretations, our perception does not report this ambiguity but rather "decides" in favor of one interpretation and reports this to us as "true." The choice, however, can fluctuate, with sudden changes occurring. These changes can be intentionally furthered by a trained

person, as in the well-known case of the direction of turning of silhouettes. I observed in myself an analogous case on the level of complex, learning-based gestalt perceptions when recognizing intermediate hybrids of two kinds of animals well-known to me. When I for the first time, unexpectedly saw a hybrid between a domestic goose and a mute swan, I "recognized" it at first as a swan, in the next second doubted my sanity that I could take a domestic goose for a mute swan, and only after several changes of gestalt perception back and forth it became clear to me what I really saw at this point. Then I could let the gestalt of the bird change arbitrarily with some eye blinking, and alternately see it as a goose or a swan, just as one can make the direction of turning of the silhouette of a rotating object change.

Greater scope is given to the "imagination" of this process under perceptual conditions reducing the acuteness of sensory input. As Sander has shown in his experiments with tachistoscopic presentation of incomplete geometrical figures, under these conditions gestalt perception exaggerates the regularity and pregnance of what is perceived. One can often observe sculptors and painters first stepping back and looking at their work through almost entirely closed lids, and then looking at it very pointedly the next moment. Through intentionally making the picture blurred, the pregnance tendency is used to produce the desired regularity, in order to ascertain the discrepancy between the sought gestalt and what is actually present. The portrait photographer uses the same characteristic by intentionally focusing not quite sharply, just as fashion allows a woman's face to be seen through a veil so as to appear more regular than it actually is, etc.

A well-known experiment demonstrates the over-all effect of the misachievements of the "pregnance tendency" just discussed. One makes an outline model of a cube from thin black wire (so thin that the plasticity of the cylindrical wire disappears) and lets it rotate around a diagonal which is held perpendicularly. One looks at it with one eye in front of a mirror in such a way that the mirrored image falls exactly inside the picture of the wire cube and the turning axes are superimposed. Then the mirrored image seems to leap forward into the wire cube, so that both seem to rotate around the same axis; at the same time the perceived direction of turning of the mirrored cube is reversed, so that one now sees both cubes, one inside the other, turning in the same direction around the same axis. This change in the perception of the mirrored cube, both in location and in direction of turning, is accompanied by two easily understood, but very interesting, phenomena. First, the cube seems to become considerably smaller, which is understandable since it is now perceived much closer to the eye than the plane of the virtual image would be. Secondly,

it seems to perform a peculiar belly-dance in which its turning axis, like a flexible shaft, constantly curves in the tempo of rotation in such a way as to turn its concave side to the viewer. The closer one gets the eye to the cube, the more pronounced the phenomenon becomes. The illusion is made possible by the fact that changing perception can reinterpret the image of the wire cube on the retina. This image consists only of black, bodiless lines and is therefore ambiguous with regard to back and front. Perception reports the parts of the mirrored cube actually turned away from the eye as lying in front and vice versa. The parts lying in back in the virtual picture, but reported by perception as lying in front undergo a double diminution. First, there is the one which the image on the retina actually undergoes through the increase of the distance. Second, there is the diminution created by the mechanism of size constancy which for a given retinal magnitude, infers a smaller object in correspondence to a greater proximity.

If one ratiomorphizes the misachievement of perception just discussed, it is like a caricature of the process which takes place on the rational level, in the case of a hasty and uncritical formulation of an hypothesis. An extremely simple and elegant hypothesis is formed without hesitation, which “parsimoniously” manages to assume only one axis and one turning direction. The data which this hypothesis is unable to classify are made compliant by an extraordinarily improbable and forcible “additional hypothesis” which consists in the assumption that the inner cube has become flexible and compressible like rubber. The false report is taken “for true” just as is every perception, and is retained rigidly, just as is the wrong assumption of someone who forms the wrong hypothesis.

Thus we come to the second functional property of gestalt perception, which next to the pregnance tendency is the most dangerous as a source of mistakes, namely its basic uneducability. The mechanism which has been created to discover lawfulnesses ruling in the sense data seemingly receives its information almost exclusively from the periphery. The cases in which one can at will make perception change back and forth between two equally good “hypotheses” form the sole proven examples known to me in which mechanism of perception is influenced by the higher centers of the central nervous system. The false reports of the complex and highly ratiomorphic gestalt perceptions are held on to as incorrigibly as those of the simplest constancy mechanisms. While the perceiver may become aware of the deception, in the case of the highest achievements of gestalt perception its ratiomorphism induces him to make pseudo-rationalizations and to believe he had arrived at the particular result not at all through unconscious processes of perception, but rather by rational means.

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The information theorist and social psychologist Bavelas (1) has reported on an impressive case of this type, occurring in a situation intentionally lacking in any regularity in the data, in order to demonstrate the system-generated “noise.” Bavelas made several persons participating in the experiment press a number of keys in any sequence they chose, and accompanied them by sounding a signal in completely irregular time intervals. Instructions were to find out the regularities in the sequence of the keys pressed which caused the signal. The majority of the persons in the experiment believed they were perceiving such a regularity, and formed rather complicated hypotheses. The subsequent enlightenment that there had been no regularity at all met with strong resistance; one person came to see Bavelas some time after the experiment had been concluded and tried to convince him by means of notes taken during the experiment that the apparatus which took care of the random distribution of the signals had not functioned properly and that the perceived regularity had actually crept into the arrangement of the experiment, without the person in charge of the experiment noticing it.

The third great weakness of gestalt perception does not lead to actually false messages but nevertheless considerably diminishes the general scientific usability of gestalt perception. This weakness lies in the great individual differences in the talent. Those who are especially gifted in gestalt perception are inclined to be contemptuous of persons unable to perceive what they themselves perceive as obvious, persons who therefore — quite rightly — demand its rational verification. Thinkers who are rationally and analytically gifted (and who rarely possess equally outstanding abilities for the perception of complex gestalten) regard the person who is gifted in gestalt perception as loose tongued because he cannot re-enact the way in which he arrives at his results. In addition, they take him to be uncritical because he does not consider important the verification of what he has perceived. Even if this difficulty of mutual understanding can be overcome with some insight into the nature of gestalt perception, the fact of individual differences in the gift for perceiving gestalten remains an obstacle to its scientific usability, if only because it cannot be taught and can hardly be improved through learning and practice.

A fourth and interesting weakness of gestalt perception is its sensitivity to introspection. As soon as one directs one's attention to its function, the function becomes considerably disturbed. One of my own experiences may illustrate this. In my home district there are only carrion crows during the summer and no rooks. The first rook I saw flying at the beginning of the autumn migration always came to my attention instantly. I never confused the flying view of the carrion crow and

rook (which are different from each other only in the minutest details of proportion). The diagnosis always proved right when the bird came closer and other characteristics became visible. On the other hand, a conscious attempt on my part to differentiate the silhouettes resulted in purely random distribution of guesses. Paying attention rationally to perceived details seemingly interferes with the equilibrium that is required between them if they are to form an integral gestalt. This unfortunately detracts considerably from scientific usability of gestalt perception.

Gestalt perception is decidedly inferior to the functionally analogous rational achievements in the respects just discussed, that is, in regard to its tendency toward exaggeration of pregnance, its incorrigibility, its unpredictable individual differences and the fact that it cannot be taught. It is superior to the rational achievements in two essential points.

First, gestalt perception is able to discover unsuspected regularities missed by rational abstraction. Apart from a few ultramodern computers capable of extracting from the superposition of a large number of curves a lawfulness contained in all of them, we do not possess any means, above all, no rational process of the central nervous system, capable of discovering order. It is always necessary to inquire about, that is, to suspect, a regularity before it becomes possible to prove it.

Secondly, gestalt perception, as has been shown, is able to incorporate more individual data and more relationships between data into its calculations than can any rational process. Even correlational research built upon the broadest statistics cannot approach it. Only the computers evaluating complex curves approximate the mechanism of gestalt perception, and this only in the narrow sphere to which they are applicable. Goethe's statement “It is vain to attempt to create gestalten by building them up of words” is correct for the reason that a rational survey of those data that are transmitted linearly in a temporal succession of words is impossible. Above all, such a survey would never suffice to comprehend the relationships running crosswise between the individual data. The obstacle most probably is failure of memory. If one, for example, reads the description of a bird in a zoological textbook, one cannot form a “picture” because one has already forgotten where, perhaps, a brown stripe was described when one is reading an account of the neighboring region of the body. It is proved that by phototelegraphy and television that it is in principal possible to build up a gestalt from the temporal succession of individual data, although in the case of television the transmission has to follow so rapidly that the positive afterimage can take on the task which is too great for our memory in the case of verbal communication.

Memory refuses to retain individual data and

therefore cannot make it possible for us to rationally relate them to one another, but strangely enough is capable of retaining the mutual relationship, or the "configuration" of a great deal of data very accurately and over long periods of time, provided that memory was informed of these relationships by perception. In this respect it accomplishes really miraculous achievements for which only one example shall be cited. This example will be conversant to every person in the medical profession. One has seen a complex of symptoms just once, perhaps many years ago, frequently without perceiving a particular gestalt quality at this first encounter. If one now sees the same complex for a second time, it may happen that very suddenly from the depth of the subconscious, gestalt perception emerges with the message that cannot be doubted: "You have seen exactly this syndrome before somewhere at some time."

It is also a surprising achievement of memory to retain those gestalten which enable gestalt perception to accumulate such a tremendous treasure of factual material in the course of the years. In a number of retained facts, it surpasses by far the rational knowledge a research scholar is able to consciously hold at his disposal. But at the same time, the extent of this unconscious knowledge influences the probability of the correctness of the perception in the same way as the breadth of the inductional basis influences the reliability of every rationally obtained result. In both cases the probability of correctness is directly proportional to the breadth of the factual basis.

The accumulation of facts stretching across long periods of time which represents the analogy of the inductional basis for the ratiomorphic perceptional achievement, offers an explanation of the fact that great discoveries by the same scientist dealing with the same subject are often several decades apart. For example, Karl von Frisch published his first work on bees in 1913; in 1920 he wrote for the first time on their ability of communication by dances; in 1940 he discovered the mechanisms of orientation according to the position of the sun, which presumes an "inner chronometer," as well as a means of indicating direction in the hive. (This operates through transposing the direction of the sun by "symbolizing" it in the dances by the vertical direction.) In 1940 he discovered the amazing "computer" which can ascertain the position of the sun by the polarization plane of the light from the blue sky. However much diligent experimenting and conscientious verifying is contained in these great discoveries of a great scientist, it is not accidental that they took place during the scientist's vacation and were made with his own beehives in his summer home. For one of the most pleasant properties of gestalt perception is that it is most active in gathering information when the perceiver, absorbed in the

beauty of his object, imagines himself to be enjoying the most profound spiritual peace.

VI. THE CRITICAL USE OF GESTALT PERCEPTION

In my opinion every discovery of a complex regularity comes into being through the function of gestalt perception. This is not only valid for all natural sciences but also for mathematics, as is readily conceded by mathematicians. Even though, as already stated, ratiomorphic and rational achievements of cognition often have high-grade analogous functions and are therefore in many cases capable of taking one another's place, I consider gestalt perception to be completely irreplaceable in this achievement. But just for this reason it seems most important to me that every scientist should know the functional properties of his own gestalt perception well enough to compensate its weaknesses with rational achievements and to make full use of its strong points.

The misachievements arising from the tendency toward pregnance overshooting its goal are most dangerous for just those scientists who are most gifted in the perception of complex gestalten. Nevertheless, this danger can largely be avoided by either “feeding” more and more information into one's own perceptual apparatus or by giving perception opportunity to gather data from another “point of view.” (For example, one destroys the perceptional deception of the rotating wire cube by opening the other eye.) In both cases it is perception itself which drops its own “too hastily formed hypothesis” by means of an expanded “induction basis.” Second, one should obviously never forget that having perceived a lawfulness, however convincing an effect it may have, does not signify a scientific truth until the entire arsenal of higher rational achievements of cognition has either mastered the difficult task of “proving” what has been discovered by perception or, what is an even more difficult achievement, has investigated and re-enacted the procedure by which perception arrived at its result. Third, and above all, one always has to bear in mind that gestalt perception is only a discovery apparatus, and that in cases where its results contradict those of rational achievements, one is obliged to believe in the latter, and that in verification, quantification has the last word.

The second weakness of all perception, its stubborn uneducability makes it particularly difficult to satisfy this last demand. It is capable of plunging the scientist into serious inner conflicts. The third weakness of gestalt perception, the fact of individual differences in talent, can be overcome to a large extent by increasing the “information,” that is, by increasing simple observation. What an observer is unable to perceive in an object for the first twenty times, he can finally see when

looking for the two-hundredth time. And often a disadvantage turns into an advantage, as when a person gifted in perceiving details and in analytical thinking, doubts the perceptions of a person who sees things in their wholeness, and who then verifies rationally what the other never would have verified.

The fourth great weakness of gestalt perception, the circumstance that it goes on strike when reason tries to interfere, calls for a very special technique which one has to learn like a Yoga practice, so to speak. To make this procedure comprehensible, I would like to try to describe phenomenologically the genesis of a rather long-winded gestalt formation stretching over several years. The first symptom that gestalt perception has "scented" a lawfulness in events just observed consists in its "pulling at the leash" in that particular direction, like a good hunting dog. It manages to do this by means of its ability to give an attractive and interesting quality to certain stimulus combinations. This total quality, quite diffuse to begin with, can remain an unorganized experience for years. But at the same time, it affects one's entire emotional life so strongly that one cannot detach oneself from that particular object of observation. Thus more and more information is forcibly squeezed into the computer of complex gestalt perception, and it then leads step by step to the perceiving of the relevant links to the sought gestalt. In these cases of complex perceptual achievement it is not correct that the whole is given prior to its parts, at least not for me. One knows at first which partial complexes are the ones out of which the wholeness will emerge, but one does not know the configuration in which they will join together to form their gestalt. This is very well expressed in the description which Max Wertheimer (17) gives of the cognitive steps which led Einstein to the formulation of the theory of relativity.

This is just the phase during which one should not try to force the synthesis of the gestalt by conscious experimenting with the links recognized as essential. Everyone inclined toward introspection knows, for example, that when solving an anagram one must never attempt to find the desired sequence by permutation. One gets stuck immediately in one or several combinations of syllables and cannot get away from it. Rather one has to keep an eye on all links in the same manner, with a floating accent so to speak and then make an effort in a very special manner which is difficult to describe. The hinted-at "art of Yoga" consists in consciously applying pressure to gestalt perception only in this way without gliding off into the conscious reflection which will certainly prevent finding the solution. Anyone who is convinced that all psychic processes have their neurophysiological aspect should really not be surprised that gestalt perception needs an

energy supply to accomplish its highest achievements.

The decisive step resulting is the sudden “leaping out” of the solution. It mostly comes unexpectedly and almost never when one is occupied with the problem. It is literally as if a messenger whom one had sent out with a certain order of investigation reports back with the message of success. C. F. von Weizsäcker has described this very concretely at an informal gathering of cybernetically interested biologists, in the decisive moment one knows with certainty only that one has the solution, but not yet what it looks like. The experience is as if that messenger handed over the expected report of success in a sealed letter.

Very remarkable experiences take place when gestalt perception has arrived at the formation of two irreconcilable “hypotheses,” as happens occasionally. As already reported, when I unexpectedly saw that mixture of a goose and swan and perceived it alternately as a goose and a swan, I had this feeling with an intensity bordering on nausea. The same quality of experience occurs not only when, as in that case, two equally clear gestalts contradict each other, but even when a smaller minority of stored-up information does not comply with a “hypothesis” which is capable of classifying an overwhelming majority of data with corrupting elegance. One does not feel “quite comfortable” with this interpretation and a feeling of doubt arises which is the ratiomorphic analogy to the rational achievement of doubting. There are also convincing examples for this in Wertheimer’s report on the discussion with Einstein. Most important in the “Yoga art” of the critical use of gestalt perception belongs the principle which I now mention last: One has to learn to sharpen one's ear to the utmost for that warning conveyed by the feeling of displeasure just described. The temptingly elegant reports which the perceptual mechanism sends to us about a complex regularity occasionally can be entirely wrong. But when it makes us suspicious of its own reports through that specific feeling, there is <u>always</u> something wrong with them.

VII. THE ROLE OF GESTALT PERCEPTION IN THE FUNCTIONAL UNITY OF THE ACHIEVEMENT OF HUMAN KNOWLEDGE

Apart from cultural and intellectual-historical factors, the extreme discrepancy of opinions on the value and even on the scientific legitimacy of gestalt perception is certainly to a large extent due to those typological differences in scientists which makes one turn to this and another to that discipline. The zoological and botanical phylogeneticist, the medical clinician, and the European-type psychologist oriented toward the humanities are probably the ones who are most conscious of this value and who use it systematically. At the

other extreme are the behaviorists who deny to gestalt perception (and thus to observation of organisms in their natural habitat) all value and scientific status. A very amusing compromise between the two extremes if formed by those scientists who unconsciously allow themselves to be guided by their own gestalt perception but who "repress" this in the psychoanalytic sense, and deny it indignantly.

Both extremes lead to wrong epistemological attitudes, the first one frequently, the second one always. The worshipers of their own intuition are inclined to underestimate the value of rational inductive achievements, and to be of the opinion that "nature, secretive in broad daylight, does not let itself be divested of its veil, and what it does not wish to reveal to your mind, you cannot wrench from it with levers and with screws." Thus that greatest of all gestalt perceivers, judged the scientist, striving for the broadening of the inductional basis and for rational verification, to be the "poorest of all the sons of this earth" who "all the time sticks to dull stuff, who digs with a greedy hand for treasures and is glad when he finds earthworms." The poet completely overlooked the fact that the person whom he disdained remarkably enough is interested in earthworms and not in treasures, and that he frequently leaves the latter heedlessly to others for exploitation if he unearths them as a by-product of his digging-While one can only reproach as one-sided the exaggerated esteem which Goethe had for the intuitive "revelations," which he judged the achievements of his own gestalt perception to be, the opposite opinion that all messages of gestalt perception are "only subjective" and without any scientific value can also be reproached as having unacceptable epistemological inconsistencies. Quite obviously not only is that which gestalt perception reports to us subjective, but so also is all cognition as such. This suffices to expose the naiveté of the opinion that perception reports something "objective" only when it is used for the reading of a measuring instrument.

It would be necessary to know more about the function of rational achievements than I do in order to represent correctly the role which gestalt perception plays in the framework of the whole system of cognitive achievements. I can therefore only try to describe the distribution of roles of ratiomorphic and rational achievements in rather broad outlines, and I am aware that the sharp division of these two types of processes is already a somewhat artificial simplification of actuality. Most certainly such a simplification occurred when I represented the coordination of the different cognitive achievements as if a regular temporal succession existed between the discovery of a lawfulness by ratiomorphic processes and its subsequent verification by rational processes.

Probably every scientific discovery starts

with gestalt perception drawing attention to the existence of that which is to be discovered, in the diffuse manner described. But it is by no means certain that it is perception alone that leads to extracting a gestalt. It is possible that the data are so complicated and rich in irregularities superimposed upon a lawfulness that it becomes impossible for perception to extract the gestalt. Often a rational, quantifying, statistical, sifting, preparatory job may be necessary to make that possible. How often has a scientist "seen" the suspected regularity only in his curves and diagrams, nay even in his equations; how often has someone found a law other than the first suspected one in these results of rational achievements!

A particularly close and direct functional relationship seems to exist between the achievement of extensional quantification and gestalt perception. If the dredging machine of our computer permits us to make meaningful statements about concrete objects of the real external world, the unavoidable presupposition is that the counted units are equal to one another. But the category of quantity alone is unable to ascertain this—all quantification is thus dependent on the objectifying achievements of the constancy mechanisms of gestalt perception. This is equally valid for an apple-counting school child who directly perceives the equivalence of the counted objects, and for the physicist perceiving the constancy of the measuring instrument which helps him to count every shovel of his computer as indicating the same quantity of the concrete thing to be measured. In his evolutionary development and in the developmental history of culture man has through the millenia counted natural units whose approximate equality perception reported to him, long before he made the happy discovery of the measuring stick, which enabled him to divide a continuum into a number of equal objects. It is not surprising that the lower and phylogenetically older function of perception is presupposed by, and even contained in, the newer and higher one of quantification, since this relationship between lower—older and younger—higher achievements of the central nervous system can be found everywhere. But it is surprising that this fact is not generally considered as legitimizing gestalt perception as a scientific process.

Within the long series of very different processes which lead from a vague idea of a lawfulness discovered by gestalt perception to a clear formulation of scientific knowledge, the mechanisms taking part are being used in a very irregular sequence, frequently simultaneously. Gestalt perception may enter at the most varied stations in order to ascertain an orderly relationship between other rational links of the total event. As we know, one sees true gestalten in figures or in equations. In other places, rational categories may be used in complexes whose natural unity has only been ascertained by gestalt perception and not yet verified

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by any rational achievement (as for example, in the case of counting perceived objects discussed above, or when we ask ourselves whether a certain perceived, but not yet analyzed, complex of symptoms has a causal relationship to another of the same nature, etc.). How very different the coordinated effort of the different achievements of perception, thought, and intuition can be also becomes apparent from the diversity of the paths which can lead to the same cognition.

But the end of this path, just as its beginning, seems to me to be determined by the mechanisms of gestalt perception. Two arguments speak in favor of this. They cannot claim to be conclusive evidences, but they are nevertheless indicators that should not be overlooked. First, in that moment in which one finds the solution to a complicated and "purely rational" problem one has the same unmistakable qualitative experience which also occurs when spatial disorientation is removed by the unconscious operation of space perception: There is an "audible meshing of gears." Buhler significantly called it the "aha-experience."

Secondly, the process of finding the solution is inaccessible to introspection, as is characteristically so for the ratiomorphic achievements of perception. The solution always comes as a surprise, an enlightenment, which seems to come to our rational thinking from elsewhere, from outside, which is expressed, as we know, in many nonscientific terms. If one does not want to believe in the extranatural origin of such "inspiration,"

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the most plausible assumption is that it is the result of the most highly developed achievement of our central nervous system, the one most analogous to rational thinking, namely, gestalt perception.

I come to the conclusion that the perception of complex gestalten is an indispensable partial function in the systematic whole of all achievements from whose coordination our always incomplete picture of extrasubjective actuality is constructed. It is thus equally legitimate as a source of scientific knowledge as is any other achievement in this system. It is even the beginning and the end, the alpha and the omega, in the series of steps leading to knowledge. It is this, however, only in the strictly literal sense, because between these two letters lies the entire alphabet of the other a priori forms of thought and intuition, in whose code phenomena must be written if we are to read them as experiences.

SUMMARY

The aim of this paper is to show that among the functions participating at the total performance of human cognition, none, not even quantification, possesses primacy as the

source of scientific knowledge. In the systematic unity of all cognitive achievements, the perception of complex gestalten plays a scientifically legitimate and completely indispensable part.

REFERENCES

1. BAVELAS, A. Group Size, Interaction and Structural Environment. Group Processes, Transactions of the Fourth Conference, 1957, The Josiah Macy, Jr. Foundation, New York. 2. BOHR, N. On Atoms and Human Knowledge, Daedalus (American Academy of Arts and Sciences), Spring, 1958.

3. BRIDGMAN, P. W. Remarks on Niels Bohr's Talk, ebenda.

4. BRUNSWIK, E. Scope and Aspects of the Cognitive Problem. In J. S. Bruner et al., Contemporary Approaches to Cognition. Cambridge: Harvard Univer. Press, 1957.

5. BÜHLER, K. Hanbuch der Psychologie, 1. Teil, Die Struktur der Wahrnehmungen, Fischer, Jena 1922.

6. CAMPBELL, D. T. Methodological Suggestions from a Comparative Psychology of Knowledge Processes. Inquiry, 1959, 2, 152-182.

7. FRISCH, K. von. Erinnerungen eines Biologen, Springer Verlag, Berlin, Heidelberg, 1958.

8. GADOW, H. Bronns Klassen und Ordnungen des Tierreiches, Vögel. Bd. 6, IV, Abt., Leipzig, 1891.

9. GREY-WALTER, G. The Living Brain, Norton, New York, 1953.

10. HOLST, E. von, und MITTELSTÄDT, H. Das Reafferenzprinzip, Die Naturw., 1950, 37, 20, S. 464-476.

11. HOLST, E. von. Aktive Leistungen Menschlicher Gesichtswahrnehmung, Studium Generale, 10, 4, 1957, S. 231-243.

12. LORENZ, K. Die angeborenen Formen möglicher Erfahrung, Z. Tierpsychol., 5, 1943, 235-409.

13. -. Kants Lehre vom Apriorischen im Lichte gegenwärtiger Biologie, Blätter f. Dt. Philosophie, 15, 1941.

14. -. Psychologie und Stammesgeschichte, in G. Heberer, Die Evolution der Organismen, G. Fischer, Jena, II. Auflage.

13. PLANCK, M. Die exakten Naturwissenschaften, Die Naturw., 1942.

16. SANDER, F. Optische Täuschungen und Psychologie, NPsSt 1, 1926.

17. -. Experimentelle Ergebnisse der Gestaltpsychologie, Be. 10. KgexpPs, Bonn 1927 (Jena 1928).