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The Role of Gestalt Perception in Animal and Human Behaviour

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The Role of Gestalt Perception in Animal and Human Behaviour

I. Introduction: The Concepts of "Gestalt", "Whole", and "System"

It is the merit of Gestalt psychologists to have introduced the method of correlative analysis to the study of organic systems, at a time when the atomistic way of thinking was holding sway. They showed that the characteristic quality of the whole can be dependent on the universal interaction of literally all its parts, thus proving the naivety of the current atomistic assumption that a part, though isolated experimentally, would behave exactly as it did in the context of the whole.

To a considerable extent the rules laid down by Gestalt psychologists can be applied to the treatment of other organic systems, for the simple reason that the central nervous apparatus, whose function is the perception of Gestalt, is nothing else but one such system. However, it must be borne in mind that this apparatus, so far from being a typically average example of an organic system, is a very special case indeed whose particular qualities and function cannot be attributed to organic systems generally.

One of the most important criteria of Gestalt, and one upon which Ehrenfels laid particular stress, is the fundamental independence from particulate elements. The Gestalt of a melody

is independent of the question in what key and on what instrument it is played. Now it seems a rather silly truism to state that this independence of elements is characteristic of perceptory processes alone, that a spherical conductor cannot be charged with soap solution and that bubbles cannot be blown from electricity. Yet this very same error has been committed again and again by group and social psychologists who, under the influence of the Gestalt theory, totally neglected the particulate element, its structure, and its influence on the whole.

A whole, in our sense of the word, is a system in which every part influences every other part. The soap bubble, the spherical conductor, and the solar system are doubtlessly perfect examples of such a system. But organisms are not! There is not one organic system in existence in which the mutual causal coherence of all parts is as complete as in these examples, because every organic system contains unchangeable structures which, though certainly causally influencing the form and the function of the whole, are not appreciably influenced by it in turn. Skeleton elements, for instance the chitinous cuticle of insects, are, in the definitive state of their development, good examples of such fixated structures.

In analytical research work it is of the utmost importance to know, at an early stage of the investigation, whether a subordinate element stands in a relation of mutual causal influence with all other parts of the system, or whether it is an unchangeable independent structure, influencing the whole by "one-way" causation. Indeed, the mechanistic dogmatic assumption of the latter is far less detrimental to analytical understanding than the procedure of many sociologists who consider exclusively the influence which the whole exerts on its parts and who totally neglect the unchangeable structures existing in the "elements"! One-way causation, acting in the direction from the part to the system is present, at least in some cases. In the opposite direction it is not, and its assumption is a misleading fiction.

The research worker confronted with an organic system is under the methodological obligation to ascertain to what extent and in what regards the object of his investigation is a system of universal interaction and to what extent and in what regards it is a mosaic built up of unchangeable independent structures.

This obligation is particularly stringent for the student of behaviour because there is no other organic system in which universal causal interaction and mosaic-like independent structures alternate and interlock in so utterly incalculable a manner as they do in animal and human behaviour! Jakob von Uexküll, in his drastic way, once said: "When a dog runs, the dog is moving his legs; when a sea urchin runs, the legs are moving the sea urchin". I hold that it is an extremely pertinent question, whether the dog moves the legs or the legs the dog — particularly in social psychology! Where investigation has to deal with universal causal coherence, it must necessarily resort to the slow and painstaking method of correlative analysis. Where the existence of independent, unchangeable structures has been proved, there we may begin with linear causal analysis and with experiments isolating constituent parts. This is exactly why the discovery of an independent structure has, every time, brought our understanding a tremendous step forward. But whether the one or the other procedure is brought into play, is not, or ought not to be, dependent on the question whether the investigator is a "holistic" vitalist or an "atomistic" mechanist, but exclusively *from the nature of the object*! Attributing Gestalt features to a mosaic system of independent structures just as irretrievably falsifies the facts as does the attempt to isolate "elements" in a system of universal interaction. The biologist and particularly the behaviour student must maintain an absolute readiness to use both methods; which of them has to be applied at a given moment is a question that cannot be settled by metaphysical speculation or by the dogmatic misapplication of a slogan, but one that must be answered by patient inductive research, separately for each individual object and at every single step of the investigation.

Among all organic systems hitherto known there is hardly one which conforms to our definition of a whole so completely, as does Gestalt perception. But, though every Gestalt is indubitably a whole, not every whole is a Gestalt. Ehrenfels' criterion of independence of — or interchangeability of — elements is the most essential character of true Gestalt, and it is only to be found in a central nervous process, in which *many* single elementary excitations *converge* into one common effect. This

intrinsic function of *integration* is performed by the apparatus which, out of single and interchangeable sensory data, builds up the unmistakable one-ness of perception. It is a process which is possible only on the afferent side of the central nervous system, a statement which almost amounts to a tautology. These are the reasons why I propose not to use the term Gestalt in so wide and loose a sense as Wolfgang Koehler, but only to describe a much narrower concept, i.e. that of Gestalt perception, exactly as Ehrenfels and Wertheimer originally did.

To emphasize the narrowness of the concept of Gestalt as I intend to use it here, I would lay stress on a fact which is usually lightly passed over by Gestalt psychologists: Gestalt perception can only exist in the realm of a sense which is able to render a configuration of stimuli. For this reason Gestalt perception is only possible to a sensory organ receiving data which are either spatially or temporally determined. It is useless, therefore, to look for Gestalt phenomena in the sphere of the olfactory and the gustatory sense.

In accordance with this very restricted conception of Gestalt I shall confine myself, in this paper, to the perceptory side of animal and human behaviour. Whenever, for brevity's sake, I use the word Gestalt, it is used for *Gestalt perception!* I shall try to convey some idea of the very complicated manner in which Gestalt perception interlocks and co-operates with other types of perceptory function which, in the literal sense, bear the character of mosaics or sums. I shall try to show how indispensable both regulative "wholes" and mosaic systems are in the life of a higher organism.

II. The Innate Releasing Mechanism

Whenever, without previous experience, an animal responds to a biologically relevant situation with specific behaviour of indubitable survival value, the observer cannot help feeling that the animal "knows" that situation. Indeed the loose and anthropomorphic description that an animal "knows innately" or "recognises instinctively" its prey, its female, or its young, is often used by good ethologists, even in writing. Yet this expression is distinctly misleading, because all real "knowledge" or

recognition" always implies Gestalt perception. The human observer in whose own life learning and Gestalt perception plays a much more obtrusive role than innate responses, is necessarily tempted to assume that an animal which innately reacts as if it "knew" the situation, must possess something like an "inherited memory" that had, in some mysterious way, been previously acquired by the species. C. G. Jung, in his work on the "Archetypus" speaks of "vererbte Erinnerungsbilder" (inherited memory images) and Alverdes, in his paper "Die Wirksamkeit der Archetypen in den Instinkthandlungen der Tiere", expresses the same opinion.

However, a closer experimental study has shown that the perceptory process through which innate responses are released, is very different indeed from Gestalt perception. The effect of acquired responses to Gestalt is always dependent on the perception of a complex quality, into which a great number of sensory data with all their relations and relations between relations are woven to form one unmistakable unit. In striking contrast to this complexity, the perceptory side of innate reaction is invariably dependent on very few and very simple releasing stimuli. The receptory apparatus which, like a lock, keeps innate activities under control until the biologically adequate situation is reached, does not respond to the complex of stimuli characteristic of this situation, but is selectively tuned to respond only to very few among them. Because this central nervous apparatus removes the inhibition under which the higher centres constantly keep instinctive activities, it is called the *Innate Releasing Mechanism* (IRM) by comparative ethologists. Because the few, yet characteristic stimuli to which it responds, represent, metaphorically speaking, a simplified diagram of the adequate situation, I have formerly called it the "Angeborenes auslösendes Schema" (innate releasing diagram), a term which Tinbergen and I later relinquished, because it rather suggests the existence of "innate pictures" in the sense of Jung's "Archetypus". The releasing stimuli, to whose reception an IRM is tuned, have been termed "sign" or "key" stimuli. I prefer the latter term, because the simile of lock and key is really apt for the IRM and the specific stimulation to which it responds.

Wherever the response of an organism is elicited exclusively through an IRM, it invariably is far less selective than any response to acquired Gestalt perception. It is a crude but rather reliable rule that a response which can be elicited by a "dummy", is an innate one, and that one which cannot, is acquired. Yet the selectivity of an IRM must be sufficient to prevent the activity controlled by it from "going off erroneously" in any but the biologically adequate situation, or at least to make this eventuality improbable enough not to impair the survival of the species. This selectivity is attained by an adaptive "choice" of the key stimuli, to which the receptor of the IRM is "tuned". The pike's preying activity responds to the silvery glinting of the minnow's sides, the tick's blood-sucking reaction is released by the stimuli of butyric acid and a temperature of 37° Celsius. Simple though these IRMs are, they suffice to characterise the adequate object unambiguously enough to prevent the responses from ever going astray — unless human subtlety plays tricks on the poor animal.

The selectivity of acquired responses to Gestalt perception on the multitude of sensory data and relations between them is immensely improbable on mere chance. Therefore, Gestalt is practically "unmistakable". However, as the unmistakable total quality is dependent on all integrated parts, a change in one of these will effect a change of the whole. The Gestalt of a well-known face can be rendered by a crude sketch, but if, in this sketch, one detail, for instance the contour of the nose, is slightly altered, the whole portrait does not become quantitatively "less like" the original, but the likeness is totally destroyed. In this dependence on detail there is a very great difference between Gestalt perception and responses elicited by IRMs. If, in an innately releasing stimulus situation, we remove one key stimulus after the other — an experiment which can easily be done with dummies — the response does not break down suddenly, as any acquired reaction to a Gestalt would do, but only gradually diminishes in intensity.

Alfred Seitz, experimenting on the fighting reaction of the Cichlid fish, *Astatotilapia strigigena*, first ascertained the key stimuli to which the IRM in question responded: the shining blue colour, the black marginal stripe of median fins, the black

gill membrane, and furthermore the movements of spreading fins and gill membrane, moving parallel to the opponent, beating the tail sideways in a peculiar manner, and, last not least, the tactile stimulus of the adversary's bite, were found to be the key stimuli which a model must send out in order to release the fighting activity with maximum intensity. The removal of any one of these stimuli only causes a corresponding quantitative decrease in the intensity of the response, never a change in its quality. Even when only one of the key stimuli was presented, unmistakable fighting activity was released. Its intensity however varied exceedingly in correlation to the stimulus that was chosen: the properties of colour and form, though indubitably effective, proved to be considerably less effective than those of movement. A flattened, rectangular, colourless piece of hard paraffin, attached to a glass rod and moved so as to stand parallel to the subject would elicit a slightly stronger response than a perfect model with spread fins and gill membrane, but presented without movement. A real male fish, anaesthetised with Urethan and presented in a celluloid holder, would release a still weaker reaction, because, though it showed the nuptial colouring, its fins and gill membrane remained folded. An imitation of the tailbeat would instantly increase the valence of any model by a very considerable amount, the tactile stimulus of biting or ramming proved to be the strongest of all and would, quite by itself, release the strongest intensity of the fighting activity, i.e., instant counter-ramming. Seitz then tried to find models which, though combining quite different sets of key stimuli, were equal to each other in their releasing valence. If, for instance, the releasing value of the perfect model with spread fins and gill membrane was increased by the additional stimulus of moving broadside-on, it was approximately equal to the crude paraffin square, executing tailbeats. Seitz built up a number of such "equations" and compared the releasing values which one and the same key stimulus developed in different combinations with others. This value proved, for each key stimulus, to be an absolute constant. In other words, the valence of each model was strictly equal to the sum of all key stimuli emanating from it. This rule was called "Reiz-Summen-Regel" by Seitz, a term which was translated

into English as "law of heterogeneous summation" by Tinbergen. In regard to the effect of and relation between the several key stimuli, the IRM is the very reverse of a Gestalt, being a *mosaic* and literally the sum of its elements!

III. The Releaser Principle

The selective response of an IRM to a biologically adequate object is obviously the achievement of an evolutionary process which has adapted the perceptory apparatus within the central nervous system to "receive" certain characteristic stimuli emanating from the object. Obviously, it is only the "lock", and not the "key" of the response, which can be adaptively altered in the interest of the species. All that the IRM can accomplish in the way of adaptation is to "develop a more perfect enclosure of the adequate object", as Baerends aptly puts it. The pike, to express it very crudely, is not in a position to attach a little red signal flag at the minnow's tail, the better to release preying responses. But this is quite exactly what can be done when the releasing object is an animal of the same species. The jackdaw can, phyletically speaking, attach a bright yellow pad at each corner of the nestling's mouth in order better to release and to guide the parent bird's feeding responses. When the object which is sending out key stimuli, and the subject upon whose IRM they impinge, are animals of one species, not only the "receiving station", the IRM but also all the structures, colours, and movements which send out key stimuli, come within the scope of all those factors which effect the evolutionary development of the species. There is a multitude of organs and movements whose sole function is the sending out of key-stimuli correlated to IRMs of the respective species. The bright colouring of so many young birds' mouths, the peacock's tail, all the striking movements of threatening and courtship display, the scent glands of so many mammals, practically all the sound utterances of higher animals and innumerable other differentiations, down to the queer, arrow-like stimulating organ of snails, serve this same function. All these stimulus-sending organs and movements are termed releasers in comparative Ethology.

Practically all the social co-ordination of animal behaviour is

brought about by the function of releasers and correlated IRMs. Visual releasers in particular often attain a very high level of differentiation. Because of their striking beauty and easy accessibility to the human senses, these stimulus-sending organs and movements have, since the days of Darwin, attracted the naturalist's attention and the greater part of investigations which occupy themselves with IRMs are concerned with those correlated to visual releasers. It is indeed the visual releaser which has taught us the most important physiological facts about the nature of the IRM. All releasers, and particularly the visual ones, are characterised by the simplicity of the key stimuli which they send out. Nevertheless these stimuli are very pregnant and, to a high degree "unmistakable", or, in other words, of a high general improbability. The compromise between simplicity and improbability is reached by that symmetrical regularity which is the mark of all visual releasers.

The differentiation of the sending-apparatus of key-stimuli in itself betrays certain limitations to the differentiation of the "receiving station" of the IRM. Symmetrical and regular forms are forms whose regularity can be expressed in a comparatively simple mathematical relation, and it is these that, for some unknown reason, evidently lend themselves particularly well to the processes of perception. Even human Gestalt perception, although it is able to extricate extremely complex regularities out of a most intricate maze of sensory data, nevertheless has a distinct preference for mathematical simplicity. What is called a most "pregnant" form in Gestalt psychology is objectively that of the mathematically simplest regularity. There cannot be any doubt that *the perceptory side of the IRM is limited to extremely "pregnant" key stimuli*, in other words, to mathematically simple ones. As I shall explain later on, the single key stimulus can be represented by a relational property, but if so, by one of extreme simplicity that can be described in a few words. "Red below" is a key stimulus for the fighting response of the stickleback, "standing broadside on" for that of Cichlid fishes.

Perfect geometric regularity of form and movement, pure notes and unmixed spectral colours, all the typical qualities of releasers, are certainly "easy to remember" and very simple to

describe, but they can only be attained by superlatively complicated processes in evolution and ontogenesis. If so many higher animals went to these extremes in the differentiation of their releasers, it was certainly because it is impossible to tune the IRM to respond to less pregnant signals. The very existence and omnipresence of releasers in the realm of higher animals constitutes a very strong argument for our assumption that it is in principle impossible for the IRM to respond selectively to complex Gestalt perceptions. Hitherto, all our experimental and observational evidence tends to reinforce this argument.

If, in a zoological book, one reads the description of the colour patterns of male and female of one of these sexually dimorphous species, one is struck by the fact that the description of the female is several times longer than that of the male. To our Gestalt perception, it is just as easy to differentiate between a female mallard and a female gad well, as between the males of both species. My daughter knew the difference at the age of four. But it is next to impossible to convey to anyone the faculty of telling these cryptically-coloured, releaser-less birds apart by verbal description. This description would have to go into such minute details of plumage patterns and proportions that even a listener with an extraordinary power of imagination would find it impossible to form a picture of the bird. As Goethe says: "Das Wort bemüht sich nur umsonst, Gestalten schöpferisch aufzubauen". Unlike acquired Gestalt perception, the IRM conveys to the individual an almost unconnected sum of informatory data, in a way curiously similar to that of a verbal description, and as the form of releasers is dictated by this limitation of the IRM, all releasers are surprisingly easy to describe unambiguously in spoken and written words. If one describes the male mallard as the one with the uniformly green head and a white ring round the neck, and the male gadwell as the grey one with the black posterior half of the body, such descriptions are quite unmistakable.

IV. Interaction of Innate Releasing Mechanism and Gestalt Perception

In some animals the response elicited by IRMs so completely supersedes all acquired reactions to Gestalt perception that when-ever

a conflict between both functions arises the organism seems to be totally blind to Gestalt. A robin redbreast, for instance, is a very intelligent little bird whose faculty for Gestalt perception is highly differentiated: a robin is able to recognise, by their physiognomy, not only other individual robins, but even humans. Yet, by presenting to a male robin a square inch of the russet breast feathers of its species, we can release its fighting activity to the fullest extent, exactly as if the bird were confronted with a real rival. From its actions we have absolutely no right to conclude that the bird perceives any difference between the two situations! If we present the bird with a model complete in every detail, but lacking the red breast feathers, no fighting ensues. Similarly, in the stickleback all fighting responses and all sexual activities are elicited by IRMs and can be released by the crudest of dummies, although the fish indubitably possesses the faculty to recognise its own kind by Gestalt perception; the common reaction of social "schooling" is evidently not dependent on IRMs, but on conditioned responses to an acquired Gestalt.

This type of relation between IRM and Gestalt perception must not, however, be generalised. Even in some fishes, true Gestalt learning, in the form of personal recognition of an individual, is able to inhibit innate responses. In the Cichlid fishes, the mutual care of both parents for their offspring has led to the evolution of complicated instincts, releasers, and IRMs coordinating the activities of the mated pair, in defending their territory against intruders, relieving each other in "incubation", in protecting and guiding the young. Particularly interesting is the personal recognition of the mate, a faculty which was experimentally proved by Noble and Curtiss in the Jewelfish, *Hemichromis bimaculatus*, and by myself in *Herichthys cyanoguttatus*. When both mates attack an intruder, they cannot help seeing each other's threatening display which, if shown by any other fish, would instantly evoke intense fighting activity in any of the two fishes. Particularly if the intruder loses courage and ceases to display and to fly his fighting colours, while both mates continue to do so, it is exceedingly surprising that they do not attack each other — at least to an observer who knows the warp and woof of innate responses! Although the strongest of key

stimuli are indubitably impinging on both fishes, their mutual personal recognition succeeds in inhibiting their fighting responses.

There is a rather dastardly experiment which makes it still harder for the fishes' higher brain functions to cope with the fighting drive: a stranger fish, a courageous fighting male for choice, is introduced into the tank of a nesting couple of Jewel-fishes and, when their fighting activities are at their highest, the strange male is suddenly and unobtrusively removed again. In this situation, the "after-discharge" of all fighting activities imperatively urges the fishes to "fight something" and the "temptation" to attack each other becomes overwhelming. And yet the mates refrain from doing so! They may come very near fighting, from unmistakable intentional movements it becomes abundantly clear how strong an urge is driving them to attack, but, at the last moment before they strike, the personal recognition of the partner vanquishes the innate response. This feat of acquired recognition is very remarkable in a fish; if one performs exactly the same experiment with Egyptian Geese (*Alopochen aegyptiacus*) or ruddy sheldrake [*Casarca ferruginea*] a furious marital fight invariably results!

However, the interaction between IRM and learning is not exclusively antagonistic. Every conditioned response is dependent upon an "unconditioned" one, as a basis on which to develop. What Pavlov and his school call an unconditioned reflex is in most cases elicited through the means of a more or less complicated IRM. When a dog learns to react to a little bell as a signal for approaching food, there is hardly any innate connection between the conditioned stimulus and the unconditioned response: the same response could just as well have been conditioned to the lighting of a little red lamp. But when a bee learns that, among different radially symmetric forms, all of which have an innate valence for it, a particular one will yield honey, there is a dual functional relation between the innate response and the specific ability to learn: the IRM directs the learning process to its adequate object, while learning, on its side, complements the IRM by making the response more selective. Thus two physiologically different processes form a distinct functional unit.

This unit plays an important and interesting part in the

ontogenetic development of the behaviour of some birds and insects — whether also in that of Man, is still doubtful. There are IRMs connected with conditioning processes, both of a very special type adapted to supplement each other: the IRMs are particularly "wide" or unselective, while the learning processes directed by them make up for their lack of selectivity by being restricted to an extremely short duration of time, within which it is sufficiently improbable that the response can be conditioned to anything but the adequate object. A good example of this kind of co-operation is to be found in the IRMs and conditioning processes of the newly hatched Greylag gosling. In the first few hours of its life, the tiny bird reacts with its "greeting response" rather indiscriminately to any object which (a) moves, and (b) utters sounds. But, while greeting, the gosling intently scans the releasing object and, after a few repetitions, becomes conditioned to it in a very peculiar way: it is not only the greeting response which is henceforward fixated to the particular object which first released it, but, with it, practically all the other reactions with which a young gosling responds to the parent bird. This kind of conditioning differs in three essential points from all other types of learning: (a) It is confined to a fixed and very limited period in the organism's life, (b) The stimulus situation which will, later on, elicit certain responses, is determined at a time when these responses have not yet matured, (c) Unlike all other types of learning, this process is irreversible. Because of this last mentioned property I termed it "*Imprinting*" (Prägung), when I first described it in 1935. For many years imprinting was only known in birds — with a few doubtful analogies in human psychopathology. It was only a short time ago, that true imprinting was found in insects by Thorpe.

A very curious feature of the Gestalt perceptions which are acquired through imprinting, is their generic character. If in our experiments, we let a young bird become imprinted "erroneously" to another than its own species, we never yet found the subject's responses irreversibly fixated on the individual that had induced the imprinting process, but only on the species of that individual. This is particularly surprising in those cases, in which young birds have been imprinted to the human species

whose individuals show such an extreme breadth of variation. It is, however, an inherent faculty of Gestalt perception to "abstract" from the accidental, variable properties of an object, and to respond exclusively to essentials. But it is still a complete riddle, how the Gestalt perception of such a young bird can "know" what is variable and what is invariable and generically essential in the one human being which induces imprinting!

"Pure" processes of response to an IRM, of imprinting, and of true Gestalt learning, as we describe them for the sake of theoretical clarity, are actually rare. Much more frequently, all three functions co-operate in one organic unit, as in the following example. A Mallard duckling will, immediately after hatching, respond to its mother's call note by means of an IRM. This response directs its imprinting towards its mother or, as I proved experimentally, to any other object emitting that call. The imprintable phase is even shorter than in the Greylag and at an age of five or six hours it is no longer possible to induce the duckling to follow a human being. As yet the duckling responds indiscriminately to any mother mallard, but two days later it has learned to know its mother personally and will have nothing to do with another mallard, even if the latter leads young of the same age. Thus, a "wide" IRM is first made more selective by imprinting, and this selectivity is still further increased by true Gestalt learning later on.

V. Gestalt as a "Constancy Effect"

As I have already said, it is a function characteristic of Gestalt perception to "abstract" from the accidental and to extract the prevailing regularity out of the variable sensory data. This performance is, however, by no means confined to true Gestalt perception alone, but is a very general feature of the central nervous organisation which, out of variable sensory data, builds up perceptions. Much attention should be given, in this respect, to the so-called *constancy effects*.

We perceive the colour of any given object as "the same", whether we see it in the blueish morning light, in the more reddish light of the evening, or in the yellowish light of an electric lamp, although, objectively, the object reflects a very different

wave-length under these varied conditions. This subjective constancy of colour is the achievement of a very complicated "calculation" done by an unconsciously working apparatus within our central nervous system. This "calculation" is done in the following way: First, the average colour of the light, as it is reflected by all the objects within the visual field, is drawn into consideration. Then, from this colour, the wave-length prevailing in the in-coming light is "deduced". This colour of the illumination is brought into relation with the colour reflected by the object in question, and this relation turns out to be a constant depending on the reflecting properties of the object. Thus, what we perceive as the colour of the object is nothing else than its inherent property of reflecting wave-lengths in preference to others, and not, by any means, the wave-lengths which it actually reflects at a given moment.

All this "calculation" is based on an "assumption": the central nervous apparatus "assumes" that all objects within the visual field do not, on the average, reflect any wave-length in particular preference to others, so that the mixture of wave-lengths reflected by them adds up to what we perceive as "white" light. Of course, this "assumption" is only based on a rather unreliable probability. It is easy to falsify the premises of the "hypothesis" by filling the visual field with objects all equally reflecting one colour more than others, whereby the central nervous apparatus is misled into the "deduction" that this colour — which is really due to the improbable coincidence of the reflecting properties of objects — is the colour of illumination. If we then put in the visual field one object of reflecting properties different from all the others, our apparatus logically but erroneously deduces that this particular object has the property of reflecting a colour which is complementary to the one that is mistaken for the colour of illumination. What is called simultaneous contrast, is nothing other than the result of this particular mistake of our colour constancy "calculus".

The quotation marks, under which all the terms for logical operations have been put, are meant to indicate that all these processes not only take place unconsciously, but are, in principle, inaccessible to our conscious self-observation. Helmholtz, in his

studies on binocular perception of distance, was the first to take notice of these processes and has called them "unconscious conclusions". There cannot be any doubt that these operations are performed on a central nervous level very different indeed from that of conscious logical inference and that they are, in very many respects, much more akin to the functions of mechanical calculating machines. Modern cybernetics have taught us what surprising performances can be achieved mechanically. Not even the response to "formed stimuli", bearing all the features of Gestalt, such as transposibility and independence from elements, is beyond the scope of contrivances which astonish the biologist by their comparative simplicity. In the study of the constancy effects, if anywhere in biology, the results of cybernetics are directly applicable! The cyberneticist's concept of a computer includes something which certainly is much more than a mere model of those mechanisms of the central nervous system of which we have just described one. If any part of the living organism is a mosaic system, built up of particulate, independent elements, and if any life process shows, by its very limitations, its dependence on a mechanical substratum, it is these parts of the central nervous system and their function of constant perception of objects. And yet, among all life processes, there is none which more distinctly beards the character of a whole!

Other effects of perceptual constancy are contrived in a very similar manner; that of size constancy may serve as one more example. The size, which we perceive any given object to have, is the result of a computation performed on the principle of re-afference studied by E. von Holst. The motor impulses which are sent out to the muscles performing the accommodation or focussing of the eyes, are partly re-conducted to a computer which relates them to the absolute size of the retinal image. From this relation between two variables the constant size of objects is computed. Falsification of the premises results in illusions very characteristic of this process. If the focussing musculature is paralysed, so that the motor impulse to focus on a point near to the eyes takes no effect, the phenomenon known as "micropsy" sets in. All the objects within the visual field suddenly appear quite near before the subject's eye, simultaneously

assuming tiny dimensions. The room in which the subject is standing seems to shrink to a doll's chamber enclosing his head while his chin, like Alice's, threatens to hit the floor. This quaint optical illusion is easily intelligible as a result of a miscalculation of the size constancy computer. From the re-afference of the motor impulse that had been sent out in vain, the computer "believes" that the eyes have been accommodated to a distance of a few inches only, and as the objects of the room, though really yards distant, are still perfectly in focus, the computer logically but erroneously "deduces" that they must be, indeed, at the distance of the intended accommodation, and proceeds to the "conclusion" that they are correspondingly small. A reciprocal illusion can be elicited by poisons which cause a cramp in the accommodating muscles of the eye. If the subject then holds his thumb some inches before his eyes and tries to look into the distance, he perceives a gigantic thumb towering in that distance! Whoever has experienced these illusions himself, has had a very convincing proof of the mechanical character of these functions.

The two mechanisms of colour and size constancy suffice to emphasise some features which these two comparatively simple functions have in common with the much more complicated types of Gestalt perception:

- (a) The computer invariably integrates many sensory data into one single report.
- (b) The process of this integration is functionally analogous to a logical conclusion, often even to a mathematical operation, as in the case of the complicated trigonometrical computation performed by binocular perception of distance.
- (c) The process by which the computer arrives at its conclusions is inaccessible to conscious self-observation and is, for this reason, uncontrollable by higher mental functions and incorrigible by insight. We cannot change our perceptions in the least, even if we are perfectly aware of the deception and all its causes. The computer's report bears the character of evident truth — the German word for perception — "Wahrnehmung" — means, in literal translation, "taking as true"!
- (d) The constant regularity which the computer generates from the multitude of variable sensory data is always due to a

permanent property of the object. The primary survival value of these computers lies in the function of making objects of the organism's environment recognisable irrespective of the conditions under which they are perceived.

What appears as an object in our phenomenal world is the result of these constitutive functions of our perception. All of them are objectivising in the literal sense of the word. Of the true Gestalt perception this is true in even a higher sense than of the more primitive constancy computers of colour and size. In its simplest and, without doubt, phylogenetically most primitive form, Gestalt perception is nothing else than the function of another constancy computer which enables us to perceive the shape of an object as one of its permanent properties. It is as well to remind English-speaking readers that the original, non-scientific meaning of the word "Gestalt" is equivalent to that of "shape" or "form". In ordinary German, one cannot speak of the Gestalt of a melody or a movement, but only of that belonging to an object of constant spatial shape. The original survival value of Gestalt perception indubitably lies in perceiving constant shape as the supremely important property of individual objects.

If I turn the pipe which I am smoking while writing these lines to and fro between my fingers, its image assumes an immense numbers of different contours, yet its shape, as I perceive it, remains perfectly constant. This faculty is so familiar to us that we fail to realise what a tremendous feat it is on the side of the computer to "deduce" the permanent form from the innumerable combinations of sensory data which represent the ever changing contours of the moving pipe as it is depicted on the retina. The process, by which the changes in the retinal image are correctly "understood" or "interpreted" as movements of the whole object in space and not as changes in its shape, must involve computations fully equivalent to complicated operations of projective geometry. Yet the perception of distance evidently does not take an important part in this performance, as we can just as well interpret that movements of a solid body by watching its shadow. It is only the direction of turning movements which, in this case, becomes ambiguous. The extreme exactitude and high sensitivity of this interpretation becomes particularly impressive

when we are watching an object which, at the same time, moves in space and changes its shape. Let us suppose, for example, that we are watching a duck swimming on the water, turning this way and that and, simultaneously, ruffling and depressing its plumage. The bird's contours become changed by perspective foreshortening and, in a very similar manner, by the movements of its body and plumage. Yet our perception will never on any account mistake one of these causes for changes in the bird's contours for the other, even if they take effect simultaneously and appear superimposed upon each other.

VI. The "Abstracting" Function in Gestalt Perception, and Intuition

The computer which enables us to perceive the shape of objects as constant, though immeasurably more complicated, is functionally akin to that of colour and of size constancy in that it originally evolved in the service of the same function of recognising individual objects. But, in the course of evolution, any organ may change its function — and a central nervous computer is nothing else than an organ. Organs have a queer knack of suddenly developing unsuspected applicabilities and can be turned to tasks entirely different from those in whose service they originally evolved. Two such changes of function have taken a decisive part in the evolution of Man. One was that of the prehensile hand and of the central representation of space correlated with its function. The other was that of Gestalt perception.

All effects of constancy, including that of Gestalt, are based on the single function of extricating the essential constant factor by abstracting from the inessential variable sensory data. The differentiation of this function attains an amazing development in the service of shape constancy and it needs only to be driven one little step further to make possible an absolutely new operation miraculously analogous to the formation of abstract, generic concepts. Not only small children, but also higher birds and mammals, are able to perceive a supra-individual, generic Gestalt in all the individual objects of the same kind. The same faculties which enable these organisms to recognise one individual dog in all shades of light, at all distances and from all angles, need only carry their abstraction from the inessential one step

further to render possible the momentous feat of perceiving one common Gestalt in all dogs of all races, different though they may be. A monkey, a cat, a raven, or a young child is certainly not able consciously to abstract the zoological diagnosis of *Canis familiaris Linnaeus*, indubitably it is the performance of the Gestalt computers which enables them to see "the" dog "in" all the different representatives of the species. Very probably this function of generic recognition achieved by Gestalt perception is not only the phylogenetical precursor of conscious abstraction. We know by much observational and experimental evidence that the human capacity of Gestalt perception by far exceeds that of all animals. In my opinion, the great change of function just described is one of the indispensable conditions which had to be fulfilled in order to make possible conceptual thought and speech.

I hold that Gestalt perception of this type is identical with that mysterious function which is generally called "Intuition", and which indubitably is one of the most important cognitive faculties of Man. When the scientist, confronted with a multitude of irregular and apparently irreconcilable facts, suddenly "sees" the general regularity ruling them all, when the explanation of the hitherto inexplicable all at once "jumps out" at him with the suddenness of a revelation, the experience of this happening is fundamentally similar to that other when the hidden Gestalt in a puzzle-picture surprisingly starts out from the confusing background of irrelevant detail. The German expression: "in die Augen springen", is very descriptive of this process.

Intuition is generally regarded as the prerogative of artists and poets. I would assert that it plays an indispensable role in all human recognition, even in the most disciplined forms of inductive research. Though in the latter the important part taken by intuition is very frequently overlooked, no important scientific fact has ever been "proved" that had not previously been simply and immediately seen by intuitive Gestalt perception. Intuition it was when Kepler first perceived, in the complicated epicycles of the planets' apparent movements, the simple regularity of their real orbits, or when Darwin first saw, in the intricate tangle of living and extinct forms of life, the convincingly clear Gestalt of the genealogical tree. Without intuition, the world would present

to us nothing but an impenetrable and chaotic tangle of unconnected facts. It would be quite impossible to us to find the laws and regularities prevailing in this apparent chaos, if the mathematical and statistical operations of our conscious mind were all that we had at our disposal. It is here that the unconsciously working computer of our Gestalt perception is distinctly superior to all consciously performed computations.

This superiority is due to the fact that intuition, like other highly differentiated types of Gestalt perception, is able to draw into simultaneous consideration *a far greater number of premises* than any of our conscious conclusions. It is the practically unlimited capacity for taking in relevant details and leaving out the irrelevant ones which makes the computer of this highest form of Gestalt perception so immensely sensitive an organ.

The most important advantage of intuition is that it is "seeing" in the deepest sense of the word. Like other kinds of Gestalt perception and unlike inductive research, it does not only find what is expected, but totally unexpected as well. Thus intuition is forever guiding inductive research. Though he may be quite unconscious of it, even the most exact and "inartistic" or research workers is invariably guided by intuition in the choice of his object, in the choice of the direction in which to look for important results.

On the other hand, intuition shares all the typical weakness of Gestalt and other perception. True to its character of a "Wahr-Nehmung" intuition is *very easily deceived*. Though its computers work with the utmost logical exactitude, it is easily led astray by its "uncritical" acceptance of false premises, and its correspondingly erroneous "conclusions" are passed on to our consciousness as an utterly convincing "revelation" whose absolute truth is incorrigibly maintained in the face of all better knowledge and indeed very often puts better knowledge in the wrong. This is also why men excellently endowed with faculties of Gestalt perception very often prove the most obstinate fools, once they have succumbed to this type of perceptory delusion. Next to its incorrigibility, the greatest weakness of intuition lies in its incontrollability. Just as all other processes of perception, intuition arrives at its conclusions by a way which is totally inaccessible

to our self-observation. The correctness of the result cannot, therefore, be checked by consciously repeating that way step by step. If I said, a short while back, that intuition shows inductive research which way to look for results, I have to add here that it does very little more: it only indicates the goal, but not the way by which to arrive at it!

I am fully aware that many readers and especially many psychologists will reject my hypothesis that intuition is nothing but the function of a central nervous "computer" which works rather like a blind mechanism and is, at least in principle, explicable on a physiological basis. "Intuition", just like "instinct", still is regarded by many as something miraculous infallible, something which not only cannot, but ought not to be explained in terms of physiology. Yet I dare to assert that its evident affinities to other and simpler perceptory processes, about whose physiological nature no sensible doubt can be raised, justify our explanatory optimism. The inductive research worker does not believe in miracles and this disbelief does not diminish the reverential awe in which he holds all nature. His maxim is that of Rudyard Kipling's Purun Bhagat, of whom the poet says: "Nothing was farther from his mind than miracles. He believed that all things were one big miracle, and once a man has got to know that, he has got something to go upon."