FORM AND MEANING*

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INTRODUCTION

It seems obvious that we do not perceive Gestalten alone but that we experience them with meanings attached. For instance, when our retinas pick up the form of something big and hairy, we may perceive a black dog. This article is about the relationship between perceptual forms on one hand and their meanings on the other. I will argue that the perception of forms and the attachment of meanings to them are two relatively independent processes and moreover, that both processes follow their own sets of rules. The rules that guide the perception of forms are well known and well explained in the Gestalt literature. Therefore, I will concentrate on the process of attaching meanings to them, particularly, how scientists do this. My claim is that recently mathematicians have developed a model that represents how we attach meanings to forms. Thus, now there is an answer to Abraham and Edith LUCHINS (1965) "challenge to logicians and psychologists to analyze thinking and to devise 'logics' that include the aspects of thinking that are not covered by the existing systems of thought" (p. 252), and a response to their invitation to scholars to develop "new logical concepts, methods, and systems for use in theory and practice" (ibid).

The article begins with a distinction made by KÖHLER between different types of sciences. It continues by discussing WERTHEIMER's view on productive thinking and specifically how he analyzes scientific thinking. Then the article will determine how WERTHEIMER's notions fit into the wider framework of how the sciences have progressed, which has been spelled out by Tadeusz CZEŻOWSKI (2000) in his *Knowledge, Science and Values, A Program for Scientific Philosophy*. It will also discuss how WERTHEIMER's notions on the relationship between forms and meanings were further developed by Rudolf ARNHEIM and Abraham LUCHINS. The article will end with a contemporary view on scientific thinking in general and Gestalt theory in particular.

DIFFERENT TYPES OF SCIENCES

Wolfgang KÖHLER began his (1947) *Gestalt Psychology* with a description of how the world appeared to him while he was working on his book; "A blue lake with

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dark forest around it, a big, grey rock, hard and cool, which I have chosen as a seat, a paper on which I write, a faint noise of the wind which hardly moves the trees and a strong odour characteristic of boats and fishing" (p. 3). The appearances of physical things, however, were not the only ones available to KÖHLER at that particular moment; when he closed his eyes, what came to him was "another lake of a milder blue, at which I found myself, some years ago, looking from its shore in Illinois" (ibid).

In other words, KÖHLER perceived and remembered the world as a scene; in his case, the scene was of landscapes made up of several Gestalten such as lakes, forests and big, grey rocks. Köhler believed that this scene as it appeared to him was the starting point of his knowledge of the real world. He then classified all appearances into two groups, namely appearances that fall under the physical sciences and appearances that are the subject matter of psychology. Here KÖHLER just reiterated the traditional distinction between the physical [*Naturwissenschaften*] and the mental sciences [*Geisteswissenschaften*]. These sciences are different, according to KÖHLER, because their respective research subjects require different approaches. Köhler (1938), in his earlier book *The Place of Value in a World of Facts* stressed that the physical sciences can never reach "data of conation" (p. 67), because these data fall outside the realm of science. In order to study mental phenomena scientifically (for instance, when one is interested in a theory of value) other methods must be employed (see p. 67/68). KÖHLER believed that human beings are biological organisms, but he denied that the research methods practised in biology, or in the physical sciences in general, address all of the interesting questions about humans. Thus, KÖHLER believed that the research practices of the physical sciences do not exhaust the subject matter of the mental sciences.

We can have different theories about things we perceive. One person could explain a landscape, for instance, as God's creation, while someone else could see it as the result of evolutionary forces. Both people view the same scene, but they interpret it differently. We also see that different phenomena can be the subject matter of different sciences. KÖHLER would allocate perception to psychology, but the lake, the trees and the rock to the physical sciences. Sciences, of course, proceed through the thinking effort of scholars and it is about this effort that Max WERTHEIMER wrote a book, *Productive Thinking,* which appeared in 1945, two years after his death. The title indicates that the book is about producing thoughts. Thinking, as his student Rudolf ARNHEIM (1969) remarked, "is necessary concerned with generalities" (p. 98), and producing is a term that designates a process that causes something to happen. WERTHEIMER's book is about creative thinking and developing new ideas and insights that set aside old ones. *Productive Thinking* is a book that gives a Gestalt theoretical point of view of how Gestalten are interpreted. WERTHEIMER presented some mathematical problems and then he focused on how the mind would solve them. Although WERTHEIMER's lead examples were all mathematical problems, he believed that his conclusions were also valid for other areas of human thought.

REFERENCE IS FIXED BUT NOTIONS MAY CHANGE

WERTHEIMER noted that the meaning of elements may change during the productive process; in his words: “meaning changes as thinking advances” (p. 214) and again, “in real thinking processes, items often do not remain rigidly identical; and as a matter of fact, precisely their change, their improvement is required” (ibid). As far as I know, WERTHEIMER did not define the term ‘meaning.’ However, CZEŻOWSKI did shed light on this question when he remarked that people need to communicate with each other. They need to describe what they study. Obviously, this can only be done through a language. If a group of people wants to study stars, they must all focus on those points of light in the night sky. It cannot be, for example, that some talk about stars and others about dogs. If people do not agree upon the basic perceptual characteristics of their study objects, they live, according to CZEŻOWSKI, in different worlds where no intelligible communication exists. In other words, scientists may disagree on the explanation of phenomena, but they must agree on what they wish to explain. Their disagreement should not be about what stars are, but what stars are all about. Thus, any discussion, including a scientific one, demands that the terms of reference are fixed for a language community. I interpret WERTHEIMER’s idea that “meaning changes” as stating that notions about objects might differ but that their perceptual presentations remain the same. For example, radically different views regarding the nature of the stars have existed throughout the ages. That is, people have given stars very different meanings throughout the whole of history. The meaning of stars may differ from age to age, but not their appearance in the night sky. Thus, it is possible for us to change the meaning of an entity while still talking about the identical thing.

The process of change in meaning must be the result of a psychological process that went on in someone’s mind. This change in meaning has not only happened throughout history but also during an individual’s development. A child has an idea of what stars are and so does an astrophysicist. The child and the astrophysicist talk about the same objects but each gives them different meanings. Indeed, the meaning that the astrophysicist now gives to the stars is radically different from the meaning that she gave them when she was a little girl! Note that the perceptual Gestalt remains unchanged when we change its meaning. Perceptually stars appear the same before and after a change in their meaning. Thinking is about Gestalten and the perceptual form of Gestalten is maintained although their meanings may alter.

WERTHEIMER pointed out that a change in meaning often requires a wider change. He believed that meaning couldn’t be apprehended in isolation. The meaning of the term “star” must be understood in a wider context. It depends on broader views regarding nature, gods, space, motion, fire, energy, make up of matter and so forth. A concept, according to WERTHEIMER, cannot be seen in isolation, but must be evaluated in the framework it is placed in. In WERTHEIMER’s own words: meaning must “often be understood in a structural sense” (p. 215). This implies that concepts form a network and that changes to one concept may reverberate throughout the network.

Any model of meaning must be able to explain the obvious fact that thinking can be a highly abstract process and that thinking may arrive at conclusions that go beyond the noticeable relations of phenomena. As we saw, the model must also be able to explain that our perception of the world remains stable while our understanding of it may undergo a sweeping process of transformation.

HOW TO MODEL DYNAMIC THOUGHT PROCESSES?

Now the question arises, what model may help us to analyze and describe this change in meaning? WERTHEIMER claims that logic is not suitable. The LUCHINS (1999) noted that WERTHEIMER "stressed the need for a new logic and a new mathematics that could deal with Gestalten and Gestalt processes" (p. 217). We must take it into consideration that WERTHEIMER's opinion was about logic as it stood in the first half of the 20th century. Obviously, he could not comment on logic as it is practiced nowadays. Until very recently logic was just an independent tool utilized in assessing the soundness of a line of reasoning, and WERTHEIMER knew logic only as such. However, since then logic has become a branch of mathematics and its range of applicability has been broadened considerably.

A classic example of a logical train of thought and one that WERTHEIMER must have known by heart is:

All men are mortal,
Socrates is a man,
Hence, Socrates is mortal.

Let us now, for argument's sake, change the meaning of one of the terms, say Socrates. Instead of giving him the meaning 'man' we give him the meaning 'extra-terrestrial.' The statement now reads:

All men are mortal,
Socrates is an extra-terrestrial,
Hence, Socrates is mortal*.

The conclusion that Socrates is mortal is now clearly wrong. After having changed the meaning of Socrates, we cannot conclude anything about Socrates' mortality because he is no longer a member of the set 'men.' WERTHEIMER, it seems, is right in his assessment that logic "regards it as a very basic rule that the items of discourse – concepts, propositions, and so on – have to remain rigidly identical if repeated" (p. 214). The meaning of terms like "human" and "Socrates" must be fixed so that the conclusion remains valid.

However, "the history of science provides many instances of scientific discoveries based on reasoning which involved restructuring, recentering, and seeing a premise in a different light" (LUCHINS, 1965, p. 261). But "the laws of traditional logic are not concerned with the part played by recentering and restructuring" (ibid). Although traditional logic could not handle a change in meaning, WERTHEIMER believed, according to LUCHINS, that such a change still "may actually be in accordance with certain laws or principles that have not been adequately recognized" (ibid).

CLASSICAL LOGIC AND INCLUSIVE LOGIC

Logic, as WERTHEIMER knew it, was not a model that described how people thought; it was only a tool that helped people differentiate between correct and incorrect conclusions from a couple of statements in which a predicate (e.g. mortal or extra-terrestrial) was linked to a subject (e.g. men or Socrates). Thus, the LUCHINS

(1965) could note that logic "may be extremely useful for the verification of proofs" (p. 260). We saw that conventional logic was only able to do so after the meanings of the predicate and subject terms were fixed. As a consequence, this logic was of no aid when the meanings of the terms were in a state of flux.

I believe that the logic familiar to most of us depicts relationships through sets that may overlap each other by different degrees. Let me illustrate my point with an example of a dog named Boeffie. Boeffie is a dog, dogs are mammals, and mammals are animals. Most of us will depict relationships like these in the form of inclusive sets. Two year-old Kendrik is adamant that Boeffie is a dog but not an animal! We may depict this – factually incorrect, but logical – relationship by partly overlapping sets. Boeffie is an element of the set 'dogs' and the set 'dogs' partly overlaps the set 'animals' but not where Boeffie is situated. We will later see how in this model we may depict the changes that will take place in Kendrik's mind when he begins to understand the kind of relationship that exists between dogs and animals.

ARNHEIM (1969) gave a list of sets to which a cat is a member, namely: "material things, organic things, animals, mammals, felines and so forth" (p. 158) and then he continued by saying that "our cat would also belong among the black things, the furry things, the pets, the subjects of art and poetry, the Egyptian divinities, the customers of the meat and canning industries, the dream symbols, the consumers of oxygen, and so on forever" (ibid). ARNHEIM's remark pointed to another criterion that any model of conceptual thought must answer to; namely, the ability to handle in an elegant manner a seemingly catastrophic onslaught of sets.

DYNAMIC FOUNDATION OF PERCEPTUAL GESTALTEN

WERTHEIMER believed that logic could not handle dynamic processes and so he had to look elsewhere for a more suitable model. The Gestalt psychologists found that model in the workings of electrical fields. KÖHLER introduced the electric field model to psychology. When Köhler was a student in Berlin, he not only took courses in philosophy and experimental psychology under Carl STUMPF, but he also took some courses in physics under Walter H. NERNST (see MURRAY and FARAHMAND 1998). NERNST was a field theorist and he taught KÖHLER the latest ideas concerning force fields and how the diffusion of charged particles may lead to electric currents. KÖHLER's (1924) electro-chemical model of the brain was based on these ideas.

KÖHLER (1924) began his analysis by differentiating between a perceptual field and a somatic field. The perceptual field is the area in the real world from which the perceptual stimuli depart. These stimuli reach our senses, but such stimulation has no Gestalt character according to Köhler. Thus, the form of the outer object is not explicitly present in the pattern of the stimulation reaching the sense organs. In order to detect the outer form, the stimulus must be transformed into a Gestalt pattern and that happens, according to KÖHLER, in the somatic field. The somatic field is part of the brain; it receives stimulation from the perceptual field via the senses. KÖHLER (1924, p. 3–4) presented a simplified model of the workings of the somatic field. He compared the somatic field to a container carrying free floating electrically charged ions. The walls of the container have electrodes. If a receptor cell is activated, it will send an electric current to an electrode and the somatic field gets activated at the location of the electrode. The local electrical stimulation leads to a redistribution of charged particles in the immediate neighbourhood of the electrode. KÖHLER emphasized that the reaction in the stimulated area of the somatic field would depend on the overall distribution of ions and electricity in the whole somatic field. One cannot understand a local reaction at a stimulated point without taking into account the status of the whole system. The flow of ions and electricity at a local point depends not only on the specific electrical stimulation at that particular point but also on the general distribution of ions and electricity in the system.

KÖHLER captured his ideas on the relationship between biological events in the brain and experienced phenomena with the term 'isomorphism.' Isomorphism is an explicit theory relating brain states to conscious states. KÖHLER proposed that a pattern of nervous activity in the brain would result in the perceptual experience of a corresponding image. John SULLIVAN (1968) pointed out that "KÖHLER's notion of isomorphism is fundamentally a physiological account of inexistence" (p. 260). Indeed, KÖHLER taught that Gestalten exist in the brain of the observer and these Gestalten are then the physiological basis of the conscious image of the perceptual objects. Mary HENLE (1984) defined psychophysical isomorphism as "the hypothesis that the structural properties of the processes in the nervous system are the same as the structural properties of the corresponding psychological facts" (p. 317). A few pages later she wrote: "isomorphism is concerned with the relation between perceptual (and other psychological) processes and the corresponding brain processes" (p. 320). This, according to HENLE, must be distinguished from the relationship between physical objects and their subsequent brain processes. According to her, the term isomorphism is used by Köhler to indicate the relationship between brain processes and conscious experiences. Isomorphism, then, would not tell us how external objects influence brain processes. HENLE believed that the latter is a neurological problem, which does not address the question of the relationship between brain and consciousness. In 1987 HENLE gave another definition of isomorphism: "The hypothesis of a sameness of structure between molar physiological processes in the brain and structured phenomenal facts" (p. 16). We see Gestalten – "structured phenomenal facts" – because Gestalten are formed in the brain – "molar physiological processes" – and the structure of the physiological events in the brain are similar to their resulting conscious experience.

ARNHEIM (1954) defined isomorphism as "a correspondence of structure between meaning and tangible pattern" (p. 43) and he explained it in 1969 as follows:

> "According to gestalt psychologists, the cerebral area contains a field of electrical forces. These interact freely, unconstrained by the kind of compartmental division that is found among the retinal receptors. Stimulation at one point of the field is likely to spread to adjoining areas" (p. 6).

ARNHEIM (1969) stressed that there exists solely one field and that it is situated in the brain; no field forces occur at the level of sensory receptors. ARNHEIM wrote only about the visual modality, but he thought that the same kind of analysis would also hold for the other sense modalities. Here follows his description of the visual process:

> "Each of these many small single receptors [rods and cones] or groups of receptors is stimulated independently by one point of the image. Given the isolation of the messages, the retinal receptor is nothing but a transition station at which light is transformed into nerve impulses… Interaction in the field as a whole can be assumed to exist in that part of the brain upon which the optical nerve projects the retinal stimulations" (p. 206).

And a few sentences further he wrote:

> "We [ARNHEIM] picture the visual cortex as a three-dimensional field, in which the stimulations arriving from the retinas are 'let loose.' They are isolated as they arrive [namely, in the receptors in the eye], and in principle they are free to assume any spatial configuration flat or voluminal, frontal or tilted" [after having arrived in the visual cortex] (ibid).

Fiorenza TOCCAFONDI (2002) also stressed that "the isomorphism postulated by KÖHLER concerns the structural similarity between phenomenal *Gestalten* and the underlying physiological processes" (p. 211) and that KÖHLER was "not in the least interested in the correspondence between physiological *Gestalten* and environmental *Gestalten* (that of the outside world, the physical stimuli)." And Ruth KIMCHI (1992) summarized KÖHLER's position as follows: "the perception of distinct organized units is not the product of sensory elements tied up together by associative learning but is, instead, an immediate product of electrical field processes in the brain that respond to the entire pattern of stimulation" (p. 24).

KÖHLER (1924) believed that electric currents spreading unhindered throughout the brain must underlie perceptual phenomena. KÖHLER's (1924) extrapolations were purely speculative and not based on observations of the brain. He denied the role of synaptic conduction between brain cells and believed that ions and electricity spread unhindered through the brain. Thus, he was convinced that the nerves must be connected at certain points so that all the nerves form one single and unified system in which charged particles and electrical currents can flow freely; that is, until a state of equilibrium is reached whereby no more currents flow. It is now the established opinion among scientists that there is no free flow of charged particles and electricity between nerve cells, but that cells communicate through synaptic conduction. MURRAY (1995) concluded: "Recent developments in sensory neuro-psychology have made the neurological theorizing by KÖHLER and the other Gestalt psychologists obsolete" (p. 5). It is an empirical matter whether the biological process that underlies the perception of Gestalten and their characteristics can or cannot adequately be modeled by an electrical field. The specificities of this model need not concern us, although, I think, it is an established fact that conscious perception involves the workings of the entire brain. What is of importance to us is that KÖHLER related conscious processes to a reaction of the whole brain to sensory stimuli. The total activity in the brain, according to KÖHLER, correlates to conscious experience. That brain state is activated by individual stimuli, but the specific response of the brain is the response of an overall system to a local stimulation. It is unknown how the transformation comes about from brain activity to mental phenomena (and vice versa) but it surely cannot take place in a brain that is simple a relay station between incoming sensory nerves and outgoing motor nerves; arguably the leading view in the first half of the twentieth century.

It is also interesting to note that the LUCHINS (1999) pointed to a difference between KÖHLER's notion of isomorphism and WERTHEIMER's. According to the LUCHINS, WERTHEIMER was not interested in the relation between phenomenal experiences and their underlying brain patterns. Instead, he was "concerned with the relationship between organization of the phenomenal field and that of the geographical field" (LUCHINS 1999, p. 215). He was interested in the relation between the objects 'out there' and how they are perceived; not how dynamics in the brain would lead to the experience of Gestalten.

Let us now return to two year-old Kendrik who is about to figure out that Boeffie is not only a dog but also an animal. The model of an electrical field seems appropriate to depict the process of change in Kendrik's mind. Just as particles move in an electric field, sets of objects move during productive thinking. Productive thinking can be modeled as a rearrangement of objects and their sets to a new equilibrium. Field forces in Kendrik's mind, as it were, exercise pressure on the set of dogs to move completely inwards into the set of animals. Note that the place of an element – Boeffie – is dependent upon the whole picture of the relationships among sets; in this case how the set dogs and the set animals are related.

PRODUCTIVE THINKING, A PHASE IN THE SCIENTIFIC SEQUENCE

WERTHEIMER focused his (1945) analysis on productive thinking, which is only one phase among several in the process of scientific thinking. As CZEŻOWSKI noted, scientists need to make several important assumptions before they can even consider (or reconsider) the meaning of a phenomenon. There are several ways to look at the world and looking at it through scientific glasses is just one among many. Scientific knowledge is one among several kinds of knowledge; we may, for example, also look for beauty or for justice. CZEŻOWSKI believed judgments are in the eye of the beholder and not in the objects of the world. Moreover, not all scientists look for the same underlying structure. A physicist studies physical objects. Physical objects have surfaces and edges; surfaces and edges are proper study material for mathematicians. CZEŻOWSKI identified two steps that one must take before one may engage in productive thinking: (1) having a scientific attitude and (2) focusing on certain aspects of a phenomenon. Before I can discuss more phases in the scientific sequence, we must take a close look at the different kinds of knowledge that scientists may hope to reach, according to CZEŻOWSKI.

He called the first kind of knowledge rational and it is characterized by infallibility. Rationalists proceed by identifying some axioms and then looking for statements that logically follow from the fundamental given axioms. Mathematics is the example *par excellence* of a rational science. Rationalists arrive at abstract truth; that is, truth which is not necessarily applicable to real life phenomena. The truth of a rational statement is based on the premise (not on reality) and the logical validity of the deductions. A rational statement is true because it fits into a logical coherent structure, not because it refers to an outside reality. However, axiomatic theories can model empirical theories. Newton, for instance, described the paths of the heavenly bodies in mathematical terms.

Empirical knowledge, on the other hand, is knowledge about existing phenomena. An empirical statement is true because it corresponds to an outside reality. We would say the statement is 'valid.' Empiricists, according to Czeżowski, do not start with identifying some self-evident truths. Instead, they commence by observing the behavior of real events. Observing and naming go hand in hand; things we observe are named. Naming is a form of categorization and the first categorization of objects is based on the way we perceive them. According to Czeżowski, empiricists continued by describing properties of phenomena. This is done as follows: an individual object is selected as a representative of a set of objects. Next another selection is performed: some features are chosen as distinctive characteristics of that unique object. The scientist, for example, could select a particular flower and study its many parts. He could dissect a flower and identify features such as a stem, pedals and so on. The scientist, however, would consider it to be irrelevant that her particular flower grew in a bed that was situated 3.5 meters south of a 76 year old oak tree. Kurt KOFFKA's (1924) *Growth of the Mind* is a book about developmental psychology. He noted that developmental psychology is not about "'Infant X' or 'Infant Y,' but rather about those features common to all ordinary children" (p. 4). Analysis of a single object leads to identification of characteristics that are assumed to be true for all the members of the set. An analytical description provides a first qualification of elementary terms and it helps to classify and order real life entities. In other words, an analytical description may lead to an overview and ordering of empirical objects, as well as to a list of terms designating objects and their parts. Both CZEŻOWSKI and KOFFKA pointed out that scientists differentiate between incidental and relevant properties. However, there is nothing in the perceptual array that informs the scientist that the stem and the pedal are relevant properties, but that the distance from the oak tree is an incidental property. It follows that scientists are operating with perceptual guidelines even at the exploratory level of observing and categorizing objects.

After entities are identified and described, empirical scientists may propose explanations of observed regularities. An explanation is a coherent set of sentences, and it can either be true or false. It is the result of productive thinking. Since explanations can be wrong, empirical scientists have to check whether their accounts indeed hold up. In other words, the validity of empirical explanations has to be made sure. That makes these kinds of statements likely to change. CZEŻOWSKI believed that, at this point, empiricists reason as follows: if we understand something, we should be able to predict its behavior under certain conditions. The criteria of how well an explanation fits, is how well it predicts future behavior under new circumstances. Herein lies an important difference with the rationalists who study how well a conclusion follows from statements that are accepted as being true. An empirical explanation, on the other hand, demands that things turn out as foreseen. A prediction takes the following form: if *A* is true, it necessarily follows that *AP* will happen under condition *C*. An empirically inclined scientist can create condition C and determine if *AP* happens or not – if the outcome is not as foretold, one may assume that the proposed explanation is wrong. However, the opposite is not true – if the outcome turns out as predicted, *AP* happens, one cannot claim that the theory is correct. It is possible that the outcome turned out favorable to the theory for reasons not related at all in the theory. Thus, it is always possible that the model will fail in a new situation. As a consequence, empirical theories do not lead to certain knowledge; verified explanations are only justified in the current situation.

CZEŻOWSKI recognized three different types of empirical sciences and each has its own objects of study. The physical sciences are concerned with physical nature, the humanities with cultural products, and psychology with mental events. All three use the methods of observation, classification and description. In addition to these methods, the physical sciences also use descriptive statistics. Descriptive statistics differs from description in that not only one particular object is carefully analyzed but that many objects, all coming from the same set, are examined in order to determine how a few features are distributed. For example, Gregor Johann MENDEL (1822–1884) observed a few characteristics of pea plants like the placement of their flowers or the length of their stem. He crossbred them and examined how the distribution of these characteristics turned out among their offspring. He, then, proposed an explanation of the observed distributions.

The humanities focus on cultural products, and as in every empirical science, their entities are classified. There are, for example, novels, operas, gothic churches and so forth. However, in the humanities an object is not appreciated as the representative of a set, but for its own merits. The study of cultural products differs, according to CZEŻOWSKI, from studying physical products. A novel is evaluated because it is a good novel, not because it could tell us something about novels in general. Cultural products are analyzed for their exceptionality while physical products are analyzed for what they share with other members of their set. Scientific theories are about empirical matters, but as *theories* they are singular ideas and cultural products, and that makes them proper study objects for the humanities. A scientific theory is favorably evaluated because it is a good theory that tells us something about an empirical reality, not because it could tell us something about theories in general.

Note that mathematics is a rational science and WERTHEIMER's conclusions regarding productive thinking were mainly based on solving mathematical problems. He assumed that the way we reach new insights in mathematics must be the same as the way we reach them in an empirical science like chemistry or in a humanistic subject like the history of art. CZEŻOWSKI, it seems, would have disagreed with WERTHEIMER. CZEŻOWSKI seems to have argued that there is no reason to assume that creative processes in the rational sciences are similar to those in the empirical sciences.

CZEŻOWSKI described the scientific process very differently from WERTHEIMER. CZEŻOWSKI wrote about the whole process and highlighted individual decisions at crucial moments. Moreover, there seems to be room for freedom in CZEŻOWSKI's account. WERTHEIMER, on the other hand, limited himself to the productive phase and his depiction seems to leave no room for individual choices. He painted a process in which the individual thinker, the person in whom the process takes place, is noticeably absent. The right field, with the right forces and objects produce – in any one of us – the same insights. A change in meaning, according to WERTHEIMER, is forced upon an entity, just like a particle in an electrical field has no freedom of movement. WERTHEIMER highlighted aspects of the process of problem solving which, he believed, are shared by all problems. CZEŻOWSKI pointed to aspects that are determined (1) by the kind of problem and (2) the kind of knowledge that we aim for. If we encounter a mathematical problem, we look for eternal truth through a rational approach. If we encounter a problem in the theory of psychology, we look for an empirical answer. If we study a novel, we look for what is exceptional and outstanding. CZEŻOWSKI does not depict a uniform process of creative thought; instead he believed that different problems require different approaches.

GESTALTEN AND THEIR IDENTITIES

ARNHEIM viewed perception as a process that leads to the realization of perceptual concepts. ARNHEIM (1969) reflected that: "Identification … presupposes an identifiable pattern' (p. 29). Boeffie then, in order to be identified, needs to have a form that is stable and recognizable:

> "One cannot identify a percept unless it possesses an identity of its own. Any secondary manipulation of perceptual material presupposes the primary shaping of the material in direct perception itself" (ARNHEIM, 1969, p. 80/81).

ARNHEIM (1969) argued that the perceptual process must lead to phenomena that can be grouped into "kinds of things" (p. 28). Fifteen years earlier he had already noted that the whole perceptual pattern must not only be identifiable but also aspects of that pattern.

> "The stimulus configuration seems to enter the perceptual process only in the sense that it evokes in the brain a specific pattern of general sensory categories, which 'stands for' the stimulation in a way similar to that in which, in a scientific description, a network of general concepts is offered as an equivalent of a phenomenon of reality. Just as the very nature of scientific concepts excludes the possibility of their ever seizing the phenomenon 'itself,' either totally or partially. The nearest a scientist can get to an apple is by giving the measurements of its weight, size, shape, location, taste. The nearest a percept can get to the stimulus 'apple' is by representing it through a specific pattern of such general sensory qualities as roundness, heaviness, fruity taste, greenness" (1954, p. 30).

Thus, according to ARNHEIM, perception is not "a reception of the raw material itself" (ibid); instead perception is "a fitting of perceptual characteristics to the structure suggested by the stimulus material" (ibid). And a page further we find: "Perceiving consists in the formation of 'perceptual constructs'" (ARNHEIM 1954, p. 31) whereby perceptual constructs are the overall structural properties of a stimulus that are grasped in perception (see ARNHEIM 1954, p. 133). He also noted that the characteristics of the Gestalt "are applicable not only to the individual case at hand but to an infinite number of other cases as well" (ibid). That is, aspects of a gestalt can be identified under universals.

ARNHEIM thought that we know the 'objective world' only indirectly and by an idealized approximation. However, there is more of interest in ARNHEIM's analysis. I think that he worked out in an interesting manner the Gestalt concept of Prägnanz, often translated in English as 'good form.' The physical processes in the brain are such that the phenomenal experience of objects fit into categories as roundness and motion. Phenomenal objects are stable and recognizable because they have structural properties. These structural properties arise with the Gestalt; indeed they are aspects of the Gestalt. The structural properties can be classified, just like a Gestalt can. That is, the individual characteristics of a specific Gestalt are identified as members of kinds. Thus, when we see a round table, we see an individual object but we also know this particular object to be member of the kind 'table.' Moreover, as ARNHEIM pointed out, we also classify the shape of the table, in this case as belonging to the kind 'roundness.'

Aspects of a perceptual object can be categorized, for instance, its color as red, its weight as heavy and its appearance as untidy. That is, we apply concepts to perceptual objects. However, the use of concepts is not limited to perceptual classification; we use them also autonomously in our thinking. Perception and thinking meet each other in their use of concepts. ARNHEIM's analysis brought together perceptual Gestalten (and their properties), concepts and identities. However, in ARNHEIM's time, the mathematical-logical tools were not yet far enough developed to clarify the relationships that exist between them.

At the beginning of this article, we saw that WERTHEIMER realized that meaning attaches itself to a Gestalt, and that he also noted that meaning might change while the Gestalt remains unaltered. This indicates the workings of two separate processes. One is the creation of a Gestalt or the shaping of perceptual material, and the other is the attachment of meaning or the secondary manipulation of perceptual material. We create meaning by assigning Gestalten to categories and then linking these categories into wholes. Meaning is not a heap of names and categories. Meaning is not honey, flowers and bees. Meaning is a whole network wherein each category has its place. CZEŻOWSKI (2000) said it as follows: "[a] characteristic property of psychic life is the property of joining its elements into wholes rather than considering them separately" (p. 32). Thus, both the process leading up to the establishments of figures and the creation of meaning are holistic processes and both must be able to interact with each other.

I argue that the creation of Gestalten and the attachment of meaning to them are separate processes. Both processes are holistic but that in itself does not imply that both should be modeled in the same way. On the contrary, I claim that they should be modeled differently; one is a biological process and the other one psychological. I also believe that conceptual mathematics is well equipped to model attachment and changes in meaning. I support my argument by pointing to the work of the psychologist John MACNAMARA. The last twenty years of his life he and his friend and collaborator, the mathematician Gonzalo REYES, used conceptual mathematics to model the allocation and re-allocation of meaning (see BOUDEWIJNSE 2002; MACNAMARA and REYES 1994).

CONCEPTUAL MATHEMATICS

Mathematics, as we saw earlier, derives true statements from axiomatic givens. Mathematics is about producing statements that are in themselves true. "Mathematical propositions do not require empirical or experimental evidence for their verification" and they "are empty of factual content and do not refer to matters of fact" (LUCHINS 1965, p. 320). Empirical statements, on the other hand, refer to an outside reality and are only true if they correctly describe that reality. In LUCHINS (1965) words: "Mathematical and logical propositions are often described as logically necessary truths, as unconditional truths, or as absolutely certain, whereas propositions of the empirical sciences are described as logically contingent or as conditional truths"

(p. 320). Empirical explanations model reality and, as we saw, in order to verify the theoretical model we need to come up with predictions. Predictions are true statements only if certain conditions are met. Thus, predictions are true within the theoretical model and that places predictions in the same category as mathematical statements. The difference between a prediction and a mathematical statement is that a prediction follows from a theoretical model that is assumed to describe an external reality, while a mathematical statement does not need to hold up externally. Predictions must be justified while mathematical statements are in themselves true. I believe mathematics is such an ideal language for science because it leads to statements that are in themselves true, and, from another point of view, these statements can be considered predictions ready to be tested for their validity.

Another reason why mathematics is so important for science is the fact that mathematical truths are timeless. They are discovered by individuals and their first formulation takes place in a wider societal framework. However, the wider societal framework does not determine whether a mathematical statement is true or not. The only criterion for a statement to be mathematically true is the logic of its argument. Mathematical truths cannot be reduced to societal constructs.

Logic, as the founding fathers of Gestalt theory knew it, could not be used as a model for explaining how people think. It only provided the basis for validating conclusions based on statements. Immanuel KANT (1800) wrote that logic is not about "how we think, but how we ought to think" (p. 16). Moreover, logical statements have to be predicative; the subject of a sentence (like 'Socrates') must have a predicate (like 'not being a Spartan,' or like 'being mortal'). Mankind already knew for a long time the rules by which conclusions should be evaluated. KANT (1800) noted that: "There are but few sciences that can come into a permanent state beyond which they undergo no further change" (p. 23) and he counted logic among them. However, in the second half of the twentieth century mathematicians revolutionized logic into a scientific tool that describes how people think.

Gestalt judgments are often not about predicative sentences. For example: When we see John and Peter standing side by side we immediately see that John is taller than Peter; and in the same manner we see that Peter is taller than Mark. Note that taller-than is not a predicate of John, Peter or Mark alone, instead it is a relative term. Taller-than does not tell us something about John in the same way as being mortal tells us something about Socrates. Taller-than is about a relation; it is about John and Peter, or Peter and Mark. And because taller-than is a transitive relation, we also know that John is taller than Mark although we have never seen John and Mark side by side.

The above example makes it clear that statements that express a relation justify conclusions, just as predicative sentences do in classical logic. Moreover, relations such as $x > y$ fall under mathematics. In other words, there is a logic that is about relations between elements and that is part of mathematics. Note that logic is not seen anymore as a tool by which to detect flawed thought processes; instead, logic is a branch of mathematics by which we may understand a mental function such as recognizing that John is taller than Mark.

A basic notion of the mathematical logic that, I believe, models mental functioning is: nothing exists on its own. There are no bare particulars. There are no bare particulars because things are characterized and it is the set that characterizes things. For instance, the set 'dog' characterizes a Gestalt differently than the set 'animal.' It is the set that informs us about what is relevant and what is not. The set 'dog' informs us that the hair counts when we talk about a dog but not the mud on its paws and the set 'melody' informs us that the sound of the piano belongs to the melody but not someone's coughing during the concert.

Elements in a set can be related to other elements in the same set or in other sets. In conceptual mathematics these relations between elements are depicted by functions or arrows. Functions tell us how we relate one element in a set to another element (in the same or in a different set). Functions begin at an element in a set, the starting-point, and end at an element in the same or different set, the end-point. These functions are not a given. Nature does not tell us that whales are not fish or that penguins are birds. Science is the endeavor by which we identify the correct functions. For instance, one thousand years ago people believed that there was a function from the set 'woman' to the set 'witch;' some women were grouped into the set 'witch.' Now we know that there is no such function.

A figure might be categorized, for instance, as being an apple, edible or round. It seems reasonable to assume that different categorizations of the same figure might be related and also that categorizations of different figures might be related. In the example of Boeffie: there is the set 'dog' that contains all dogs and therefore also Boeffie. We know that there is a functor from the set 'dog' to the set 'animal.' However, Kendrik has not learned this relation. His mind pictures dogs and animals as unrelated. Productive thinking in Kendrik's mind might be depicted as forming a functor from the set 'dog' to the set 'animal'.

Sciences set criteria for its models; that is, it sets criteria for functions and functors. Functors, for example, cannot be arranged so that self-contradictory statements appear. Thus it cannot be that there is a functor from the set 'whale' to the set 'fish' as well as a functor from the set 'whale' to the set 'mammal' for there is no functor between the set 'fish' and the set 'mammal'. It just cannot be that whales are fish and mammals at the same time, because no fish are mammals.

The network of functions and functors is the subject of study within conceptual mathematics. I believe that the study of conceptual mathematics will help us to model the attachment of meanings to perceptual objects, just like the study of calculus helps physicians in their explanations of physical phenomena. The application of mathematics brought forth breakthroughs in physics and the same could happen with the application of mathematics in psychology.

WORDS AND CONCEPTS

Until now, I have distinguished the mechanism of creating perceptual forms from that of creating their meanings. Although independently functioning, these two systems must somehow connect to each other. Concepts are mapped onto forms, and forms are mapped onto concepts. Concepts, then, influence how we perceive Gestalten and Gestalten influence the ascendance of concepts. One way the mapping between concepts and perceptual forms takes place is through words. (For a well-documented defense of this view, see BLOOM 2000.) One of the functions of words, then, is to bind concepts and forms to one another. When we know the word 'dog,' we know that the sound **dog** – which is in itself a form – links the concept dog to the Gestalt *dog*. Obviously there are many words that do not refer to Gestalten; they bind only to concepts (like 'God,' 'infinity' or 'beauty') or link words to each other ('and,' 'or').

If words link concepts and forms, then concepts and forms should exist prior to and independently of words. Learning words involves relating the right sound (auditory figure) to the right concepts and forms. However, there are other ways of linking concepts and forms, and in the evolutionary timeline many of them must be older than the links between words and concepts. Animals link concepts and actions but obviously not through words. There is empirical evidence (see BLOOM 2000, chapter 10) that concepts exist indeed independently of words. I believe that an important link between concepts, cognition and action is made by emotions. The figure of a snake and the concept snake are linked by fear. Mother's figure and the concept 'mother' are linked by love. Pre-verbal concepts like the 'self' have an emotional link with one's body. Words, it seems, are only one among several possible links between concepts and figures.

There is empirical evidence (see Fei XU 1997) that babies attach rudimentary meanings to perceptual forms. Babies over the age of a couple of months already "know" that objects continue to exist undivided when blocked temporarily from view. According to XU, babies have access to the concept 'thing' and they attach this concept to certain forms. KOFFKA (1924) recognized the importance of the concept 'thing' for developmental psychology. He believed that the concept 'thing' applies to Gestalten that fulfill certain criteria:

> "We can positively say that 'thing' means a definite kind of configuration whose connected membership is much firmer, much more intimately bound together, and the whole much more definitely particularized, than any mere set of external connections would allow. It is also a feature of the thing-concept that its configuration should have a core, or center, to which the members of the configuration adhere in a definite manner; in other words, a thing has attributes" (p. 322).

The concept physical object gives us guidelines on how to interpret particular Gestalten and we must share this concept with other animals. A physical object has a three-dimensional shape and its form remains stable over time. Steven LEHAR (2003) pointed to the importance of a-modal concepts for Gestalt theory (see chapter 9). We only see one side of a perceptual object, like a face, a house or a car. However, we know that the perceptual object has another side as well and the knowledge of the hidden side has to come from non-perceptual sources, namely the concept 'physical object.' The notion of concepts, then, fits into the theory of evolution.

Another rudimentary concept could be 'stuff' which become linked to entities like water or sand (see David NICOLAS 2002). XU believes that rudimentary concepts develop into fully-fledged concepts. Thus the rudimentary concept 'thing' develops into concepts like 'chair' and 'cat,' while the rudimentary concept 'stuff' develops into concepts like 'play-do' and 'milk.'

However, from the beginning the development of the perception of Gestalten takes place according to different laws than the development of the network of meanings.

The development of meaning could be considered as follows. First the infant places Gestalten as elements in rudimentary concepts. Thus, mama, the cat, the doll and so forth are all linked to the concept 'thing,' and the bath water is linked to the concept 'stuff.' Then the infant starts to produce its own concepts, for instance, chair, spoon, comb and so forth. It could well be that at this stage perceptual forms also receive an emotional significance. Now the infant is ready to create more connections between elements and concepts, like between the self and an object, for instance: this is *my* pacifier or I am a boy. Finally the child can abstract concepts from Gestalten like color, speed, turn (as in: it is my turn on the swing), furniture, living things and so forth. Other examples of concepts belonging to the immediate sphere are: self, wife, sister, job, house, dog, daughter and son, as well as abstract concepts like 'good' and 'help.' All these concepts are often impregnated with emotions.

Concepts can be grouped into different categories. KOFFKA (1924), for instance, divided concepts in two categories. Functional concepts apply to general observable phenomenon and KOFFKA gave 'memory' as an example of a functional concept. He noted that many of these concepts can be studied mathematically; that is, with the help of "measure and number" (see, p. 11). Other examples of functional or explanatory concepts are: atom, evolution and force. These concepts are often less laden with emotions; they cannot be directly perceived and have a hypothetical character. Science is the human attempt to develop a network of concepts that explains reality. Descriptive concepts, on the other hand, apply to our inner experiences and thus to phenomena that are not generally observable except by inner perception. KOFFKA gave 'feeling fresh' as an example of a descriptive concept. Measurement and number do not seem to apply to a concept like 'feeling fresh.' However, that does not mean that no branch of mathematics is applicable to such concepts.

SCIENTIFIC MODELLING

Concepts are pre-verbal and they are linked through several mechanisms with abstract and non-abstract realities. A special way of linking concepts and realities is through mathematics. Science has made much progress since it began to relate concepts and realities mathematically. For instance, a line came to stand for the side of an object, a mathematical point for a star and so on. The mathematical way of notation facilitated making predictions. Predictions in turn, are a phase in the course of evaluating the validity of statements. The mathematical notation also removed emotions from the scientific discourse. Words and emotions are more closely linked to each other than mathematics and emotions. Words can evoke emotions and emotions can evoke words. However, a mathematical statement arouses an emotion only rarely if at all; and I do not know of even one example where someone's emotion was formulated into mathematical terms. Thus, when we model reality mathematically we automatically take therewith a more objective look at reality. During scientific thinking the emotional content is abstracted from the Gestalten and concepts. That is perhaps a result of abstracting the individual components from the object of study. Anyway, it seems to me that scientific reasoning is unemotional, and that it therefore differs from everyday thinking.

On top of the general criteria, individual outlooks like Gestalt theory have their own set of rules. Inspired by the German Gestalt theorist and psychotherapist Hans Jürgen WALTER (1995, p. 20–21) one could venture the following characteristics for Gestalt theory: the theory is (1) empirically oriented, (2) phenomenological, (3) a dynamic theory and (4) a psychophysical theory.

1.) Gestalt theory is about the real world. It should explain real events. Gestalt theory should be experimentally supported. Obviously the theory has to be adjusted if events turn out different from the theoretical predictions.

2.) Explanations should fit with phenomenological data. For example, often solutions pop up suddenly in consciousness. The question is: can conceptual mathematics explain this phenomenological fact. I believe it can. It is important to differentiate between the global level and the particular functors of the network. A small change in the arrangement of one particular functor may lead to an important change at the global level. This change is consciously experienced as a new insight that suddenly occurred.

3.) Events in the world are dynamic and the models that scientists use must be able to account for the flux of events. Clearly, the model of the electric field was helpful to explore dynamic events. However, I do not believe that models for physical phenomena can go a long way to explain mental phenomena. Still, it is interesting to note that important elements of the model presented here were already formulated by Gestaltists like WERTHEIMER and ARNHEIM.

4.) Gestalt theory relates consciousness with brain events. TOCCAFONDI (2002, see page 210) believed that the driving vision behind this psychophysical stance was a desire to overcome the differences between the sciences and unify them. I believe that today we are far from this ideal and that we have no choice but to acknowledge the differences between the explanations of perceiving forms and assigning meanings to them.

Summary

This paper first discusses WERTHEIMER's notion on the relationships between meaning and form and then how ARNHEIM and LUCHINS further developed WERTHEIMER's notions. Next, the paper explains CZEŻOWSKI's framework how science progresses. It concludes by examining the role conceptual mathematics could play in psychology and how well this role would correspond with WERTHEIMER's and LUCHIN's original proposals.

Zusammenfassung

Dieser Beitrag diskutiert zunächst WERTHEIMERs Theorie zur Beziehung zwischen Form und Inhalt und deren Weiterentwicklung durch ARNHEIM und LUCHINS. Anschließend wird CZEŻOWSKIs Theorie über den Fortschritt von Wissenschaft erklärt. Die Arbeit schließt mit der Untersuchung der Rolle, die die begriffliche Mathematik in der Psychologie spielen könnte und wie gut diese Rolle mit den ursprünglichen Vorschlägen WERTHEIMERs und LUCHINS' übereinstimmen würde.

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