B. VAN NORREN

DEPARTMENT OF RURAL SOCIOLOGY
OF THE TROPICS AND THE SUBTROPICS
AGRICULTURAL UNIVERSITY
WAGENINGEN, THE NETHERLANDS

Original and Derived Creativity in Scientific Thinking

BULLETIN Nr.
39

AFDELINGEN VOOR SOCIALE WETENSCHAPPEN AAN DE LANDBOUWHOGESCHOOL
WAGENINGEN
1976

Contents

Preface

The following study is a theoretical elaboration of part of an investigation carried out by the author in 1970 as an undergraduate research assistant in the Department of Extension Education of the Agricultural University, Wageningen. The investigation concerned the influence of social and psychological factors on the results achieved by a team of staff members of the Agricultural University who were assigned the task of drawing up a regional plan for a Southeast Asian country. [1] This "exercise in regional planning" was set up with the object of compiling a handbook for regional planning in the tropics, the achievement of which constantly posed problems for the team.

One of the conclusions to emerge from the investigation was that the team had initially worked from a model of regional planning that, in contrast to the view prevailing among its members at that time, was an agricultural rather than a general model, which meant that it could not serve as the basis for a general handbook.

The author felt justified in pointing out that the team members, in using that model, had tended to overlook the non-agricultural economic sectors in the region while at the same time believing that they were in fact taking account of the entire economic structure; that they had confused their regional planning model with the true situation in the region; that as a result of their psychological approach — which, though in internal harmony, was at variance with reality — they had continued to neglect certain aspects of regional planning; and that at the time of the investigation they had not yet entirely abandoned their original approach in favour of one better suited to their aims.

In the following study of scientific thinking some of the observations made at the time are included by way of illustration in the hope that the problem, which is dealt with in abstract terms will be appreciated more readily. The country, region and town concerned have been given fictitious names.

The author wishes to express his gratitude to Professor R. A. J. van Lier, to whom he owes his appreciation of problems relating to the philosophy of science and who was his principal source of intellectual inspiration in working out and formulating the ideas presented in the following pages. He is also indebted to Professor A. T. M. Meyer for his experienced and tireless assistance aimed at enhancing the philosophical soundness of reasonings and concepts used, and to Dr. Niels G. Röling, whose penetrating comments were of value in clarifying various points in the text.

Introduction

In the course of their professional lives some scientists change their ideas regarding one or more fundamental points, while others progress no further than on-going refinement of familiar data on the basis of the same unchanging models. We have termed the scientific thinking of the former "original creativity", and that of the latter "derived creativity". *

The assumption underlying the ideas presented in this study is that each of these two types of scientific creativity is accompanied by a specific psychological approach on the part of the scientist to his "world of experience", which term we use to indicate everything in his material, cultural and mental world to which he *could* direct his attention.

The scientist's world of experience may be regarded as consisting of five qualitatively different elements, and his capacity for original creative scientific thought may be influenced either positively or negatively by the way in which he relates psychologically to each of those elements.

Proceeding from these basic notions the study opens with an account of the theoretical background of our ideas and of the way in which our principal concepts were formed. Chapter II is devoted to a schema illustrating what we believe to be usual process of scientific perception, thinking, formulation, testing and modification, and to a second schema localising and defining the five elements of the scientist's world of experience and tracing their interrelationship.

The next chapter deals with the concepts of "original creative scientific thinking" and "derived creative scientific thinking" in detail, and Chapter IV introduces four psychological concepts which enable us to show how the scientist relates to each of the five elements of his world of experience. The implications of this for both types of scientific creativity are discussed in Chapter V. The study concludes with a recapitulative typification of original and derived creative scientific thinking and an endeavour to fit our conclusions into a wider psychological context.

* Exact definitions of the concepts of original and derived creative thinking are given on pp. 18, 19 and 20. A similar definition of the world of experience is to be found on p. 15.

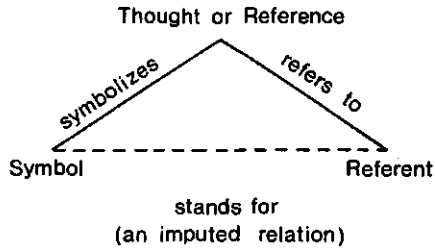
I. The theoretical background of the conceptual framework

As stated in the foregoing, we propose to present a framework of concepts in the form of a schema which we feel to be of value as a guideline for the examination and description of creativity in scientific thinking. In constructing the schema we were inspired primarily by Ogden and Richards' "The Meaning of Meaning" [2] and by Thomas Kuhn's "The Structure of Scientific Revolutions". [3] In the course of the following discussion of the generalisations in both works which were of special interest to us, we shall explain our own terminology.

I.1. *The first theoretical source: Ogden and Richards' symbol-thought-referent triangle*

Ogden and Richards constructed a diagram [4] as a means of analysing the way in which symbols — largely words — influence thought:

DIAGRAM 1



Their point of departure is a special type of thought, viz. thought concerning the external world, or thought referring to something — a material matter, a fact, an event — outside ourselves, which they term "reference". That which the reference indicates is termed "the referent". The thinker expresses his thoughts about the outside world (his references) in symbols, either words or images. Thus the real meaning of a symbol is the thought which the thinker wishes to express by this means. Symbols symbolize, according to Ogden and Richards, *thoughts* and not the referents. They state that the relation between the symbol and referent is an indirect one, consisting of the thinker's opinion on how both are related to each other. Thus the symbol-referent relation is "an imputed relation". [5]

We have adapted to our purposes Ogden and Richards' symbol-thought-referent triangle and incorporated it into our schema of scientific perception, thought, formulation, testing and modification. * As stated in the intro-

duction, our general aim was to create a conceptual framework for a description of the way in which the scientist psychologically relates to everything coming to his attention. The referent in our schema is not simply the phenomenon to which a symbol used by him refers, but all phenomena presenting themselves to his notice as potential field of research; this we have termed "the external world". Comprising all physical, psychological and social phenomena coming to the attention of the scientist, the external world is thus his potential research area in the widest sense of the word and invariably includes the referents of the symbols he uses. **

We, too, have adopted thought concerning the external world — in this case that of the scientist, however — as our psychological point of departure. Following in the footsteps of Carl Steinbuch, who posits that any meaningful definition of thought must take its "model structure" into account, [6] we assume that the scientist thinks of the external world in terms of a model of the structure of that external world which he carries in his head.

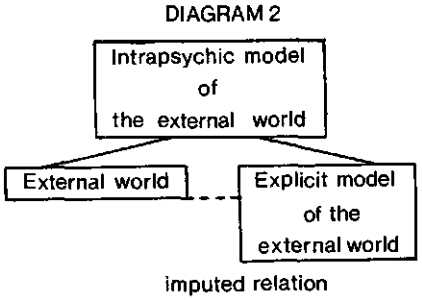
We have termed this model the *intrapsychic model of the external world*, a term which may thus be regarded as a specification, for scientific thinking, of Ogden and Richards' "reference".

The intrapsychic model of the external world consists of actual thinking itself, of a changing arsenal of thoughts and visual impressions of which the aspects formed in the past may vary from forgotten and half forgotten to full recollection, and the nascent aspects from still unaware to pre-awareness and full awareness. The thinker will be able to convert some of these thoughts and impressions into words and images; others will be merely grasped intuitively or only vaguely perceived.

The scientist can express his intrapsychic model, i.e. render it visible or audible to others, in the form of a body of symbols which we have termed his *explicit model of the external world*. This term, too, may be regarded as a specification, for the formulation of scientific ideas, of Ogden and Richards' general term "symbol".

The first part of our model is shown in the following diagram:

DIAGRAM 2



* See pp. 14-16 for further elaboration of this schema.

** The external world should not be confused with the world of experience. As we explain on p. 16, in our terminology the external world is one of five constituent elements of the world of experience.

The term "imputed relation" indicates, as in Ogden and Richards' triangle, that the thinker has formed a certain idea of the nature of the relation between his explicit model and the actual external world.

I.2 *The second theoretical source: Kuhn's paradigmatic historicism*

Our second source of scientific inspiration consisted of the principal concepts and themes put forward by Thomas S. Kuhn in the study referred to above, in which he is concerned to trace the regularities underlying all scientific development, as viewed from the angle of the psychology and sociology of thinking. He is of the opinion that two types of science, which he terms "normal science" and "extraordinary science", have continually succeeded each other throughout the history of western science. [7]

"In this essay 'normal science' means research firmly based upon one or more past scientific achievements, achievements that some particular scientific community acknowledges for a time as supplying the foundation for its further practice. Today such achievements are recounted, though seldom in their original form, by science textbooks ... (which) expound the body of accepted theory, illustrate many or all, of its successful applications, and compare these applications with exemplary observations and experiments. Before such books became popular early in the nineteenth century (and until even more recently in the newly matured sciences), many of the famous classics of science fulfilled a similar function. Aristotle's 'Physica' ... Newton's 'Principia' ... and many other works served for a time implicitly to define the legitimate problems and methods of a research field for succeeding generations of practitioners. They were able to do so because they shared two essential characteristics. Their achievement was sufficiently unprecedented to attract an enduring group of adherents away from competing modes of scientific activity. Simultaneously, it was sufficiently open-ended to leave all sorts of problems for the redefined group of practitioners to resolve.

Achievements that share these two characteristics I shall henceforth refer to as 'paradigms', a term that relates closely to 'normal science'. By ... it, I mean to suggest that some accepted examples of actual scientific practice — examples which include law, theory, application and instrumentation altogether — provide models from which spring particular coherent traditions of scientific research. These are the traditions which the historian describes under such rubrics as 'Ptolemaic astronomy' (or 'Copernican'), 'Aristotelian dynamics' (or 'Newtonian'), 'corpuscular optics' (or 'wave optics'), and so on. The study of paradigms, including many that are far more specialized than those named illustratively above, is what prepares the student for membership in the particular scientific community with which he will later practice."

Kuhn states that it is usual for normal science to be practised up to the point where one or more perspicacious scientists begin to realise that a particular observation or group of observations can never be explained within the framework of the existing paradigm. Thus driven by need, they will proceed to the type of research that Kuhn terms "extraordinary science" and that he describes as follows:

First of all, he says, the scientist will push the rules of normal science

harder than ever to see, in the area of difficulty, just where and how far they can be made to work. If this does not succeed, he will pursue one or more of a number of courses. Led by his "intuition", he may begin trying random experiments in the hope that the results will provide him with a new theoretical route to the solution of his problem. And often, since no experiment can be conceived without some sort of theory, he will try to generate speculative theories, which process Kuhn terms "thought experiments": [8]

"... the analytical thought experimentation that bulks so large in the writings of Galileo, Einstein, Bohr, and others is perfectly calculated to expose the old paradigm to existing knowledge in ways that isolate the root of crisis with a clarity unattainable in the laboratory."

The practitioner of extraordinary science is thus constantly preoccupied with thoughts like "What if this or that were the case?". In such periods of crisis scientists will often turn to philisophy with a view to laying bare the philosophical assumptions underlying existing opinions and to replacing them with others wherever possible. If a new way of explaining the anomaly is found, this means that a scientific revolution has taken place and that a new paradigm to serve as the basis for a new series of finely-shaded insights has come into being. [9]

Like Kuhn, we incline to the view that all essentially *new* scientific knowledge is gained through the replacement of certain current assumptions by others which prove to provide a more satisfactory explanation of the phenomena observed. We feel, however, that two aspects of his concise but comprehensive study require further comment.

Kuhn's yardstick for classifying any particular aspect of scientific thought or research as "normal" or "extraordinary" is the paradigm concept, made up of both the scientific assumptions current in any given scientific community and the values and norms prevailing in that community, such as the experimental methods considered appropriate, the lines along which research is expected to be conducted, the requirements to which scientific theory must conform and the views held respecting the social desirability of research. [10] We may conclude from this enumeration that for Kuhn the paradigm concept implies all those views, values and norms shared by a scientific community which stand in some relation to their scientific work and which they tend to accept as self-evident. But because he has incorporated in his concept a medley of theoretically different elements of knowledge, the question whether a piece of scientific work is normal or extraordinary will inevitably be decided in part by the personal preference of the investigator concerned. For if a scientist exchanges a certain assumption — one relating, say, to experiments — for another, while retaining the rest of the assumptions current in his scientific community, what criterion must then be used to determine whether he is practising

normal or extraordinary science?* By defining the term "paradigm" with a certain vagueness, i.e. in such a way that the meaning of the word fluctuates in accordance with how it is used because the various aspects of the research subject indicated by the term change according to the context in which it is used, Kuhn has left himself considerable scope in which to label scientific work as normal or extraordinary. Though this has enabled him to produce a work which is at once easy to read and wide-ranging in its conclusions, the accuracy of his observations and deductions has been adversely affected in the process.

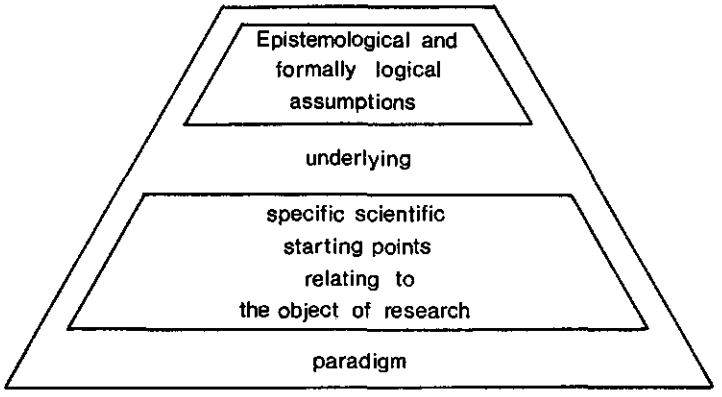
The second point in Kuhn's work requiring comment is this. He tells us that philosophers of science are generally of the opinion that scientific development is cumulative, which is to say that new theories derive logically from their predecessors, and goes on to put forward his own opposing view that the development of science consists of a succession of qualitatively different paradigms, and consequently of paradigms possessing no logical affinity with one another. [11] Leaving aside the question of who is right here, it seems to us that a useful criterion for deciding whether a newly introduced theory represents scientific progress is whether or not it adds to the number of phenomena that may be regarded as being scientifically explained. This being the case, we propose to regard the introduction of a theory shedding new light not only on phenomena that have already been explained but also on a number of hitherto inexplicable phenomena as accumulation of scientific knowledge, irrespective of whether or not that new explanation is based on a scientific viewpoint qualitatively different from its predecessor.

As stated in the introduction, the question at the heart of this study, viz. why it is that some scientists succeed in altering their ideas about essential points at least once in the course of their professional lives while others seem to get no further than a constant refinement of their knowledge deriving from the same unchanging model, is borrowed from Kuhn's analysis. We are thus concerned with the question of why some people prove to be capable of practising "extraordinary science" while others do not move beyond the practice of "normal science". In seeking the answer — necessarily highly incomplete — to this question we have followed Kuhn's example and adopted as a criterion for determining the degree of originality the extent to which scientists manage to free themselves from certain paradigmatic assumptions and to replace them with new assumptions which — and here we deviate from Kuhn's views — make it possible to amend essential points of existing models or to construct entirely new models in such a way that phenomena remaining inexplicable in terms of the old paradigm can henceforth also be explained. So as to be able to define

* Kuhn is aware of this problem himself, for he refers repeatedly to "minor scientific revolutions", by which he means changes of insight whereby the more specialised scientist sheds his low-abstraction-level paradigm. The difficulty remains, however, that his terminology provides no clearly drawn guidelines for the way in which the investigator of scientific practice is to incorporate specific elements of knowledge into the paradigm concerned.

scientific thought unequivocally as normal or extraordinary science, our paradigm incorporates only philosophical and scientific assumptions and takes no account of normative factors and values judgments. This paradigm of exclusively cognitive elements may be set out as follows:

DIAGRAM 3



By "epistemological assumptions" we mean the views of the scientist under investigation concerning the way in which phenomena in the external world ultimately stand in relation to one another, e.g. causal, final, statistically co-variant, etc., in three- or multi-dimensional space and in absolute or relative time.
"Formally logical assumptions" refers to the rules of logic which he follows in arriving at conclusions based on his observation, e.g. syllogisms, truth tables, and so on. *

Together, these two types of assumption constitute the most abstract part of the scientists' paradigm. If we endow his paradigm with elements of knowledge at this level only, we necessarily find ourselves at the level of comparison between three dimensional and multi-dimensional geometrical systems, between Newtonian and Einsteinian physics and between causal and final interpretations in the biological and behavioural sciences. Most scientific thinking, however, is carried out within the confines of certain scientific points of departure as regards the research subject, within a certain scientific trend or "tradition", as Kuhn terms it. Examples of what we mean here are the psycho-analytical, behaviourist and Gestalt starting points in psychology, the social action and social systems concepts in sociology and precisely formulated comparisons such as Newton's Laws and Einstein's explanations of gravitational attractions, used in classic and modern mechanics, respectively, as basic comparisons. These scientific

* The epistemological and formally logical assumptions, as we define them, are derived from the two fields of philosophy usually referred to as "epistemology" (or "the theory of knowledge") and "formal logics".

traditions may in turn contain various schools of thought differing — within the bounds indicated above — one from the other on the more detailed points of departure, for example, the Neo-Freudian schools in psychoanalytic psychiatry.

The scientific starting points and philosophical assumptions incorporated in the paradigm are referred to collectively, where this is deemed necessary, as *postulates*.

Our definition of paradigms makes it possible for the investigator of scientific thinking to determine for himself the level of abstraction forming a dividing line between normal science and extraordinary science, for it leaves him entirely free to endow paradigms with specific, scientific, epistemological and formally logical postulates at his own discretion. [12]

After this brief account of the way in which our terminology stems from two theoretical sources, we can now proceed to a more detailed description of our schema, which is ultimately intended to constitute a guideline for discussion of original and derived creative scientific thought.

II. Formation of the intrapsychic model

The hub of the following discussion is the question of the way in which scientists construct their intrapsychic model of the external world. * If we examine the process of scientific observation, thought, formulation, testing and modification which, in our view, all scientists pass through either wholly or partially in the development of their scientific ideas, we come up against the principal (cognitive and perceptual) sources from which they can derive information for the construction of their intrapsychic models.

II.1 *Schema of scientific observation, thought, formulation, testing and modification*

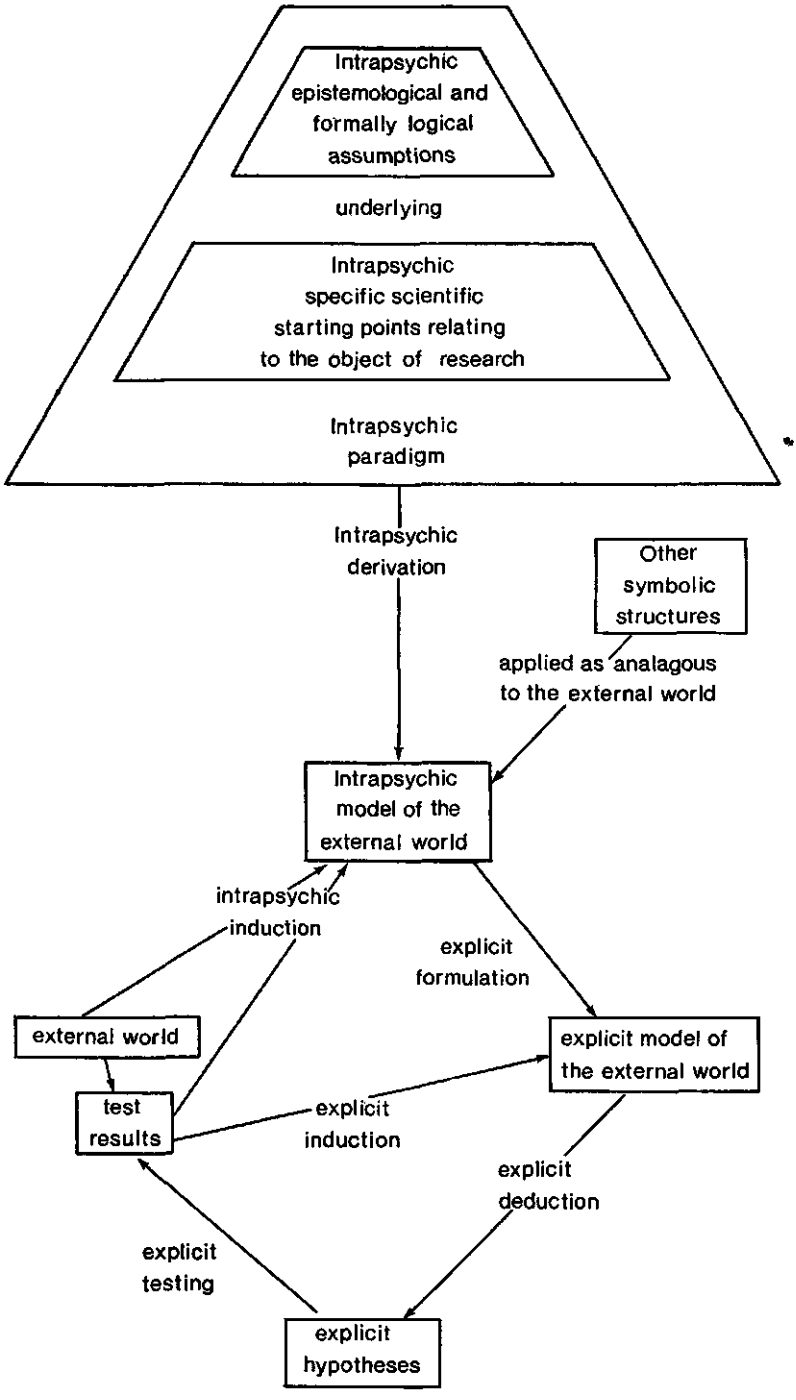
Elucidation

The schema consists of *elements*, or things towards which the scientist can direct his thinking and observation (shown in rectangles) and *stages of thought*, or the deriving of information from the preceding element and the conversion of that information into an aspect of the following element (indicated by arrows). We have termed stages of thought which are not explicitly formulated *intrapsychic*, in contrast to *explicit* stages of thought expressed in words and images. The word *deduction* refers to the inference of a more detailed structure from a less complex element, and *induction* to the building up of an idea or a model on the basis of observed fact. It will scarcely be necessary to add that "intrapsychic" should not be confused with "unconscious", the former referring to inner processes which may be either conscious or unconscious.

As the schema shows, the scientist constructs his intrapsychic model from various sources. There is first and foremost *the external world* ** from which he derives his visual and auditive impressions. From his *intrapsychic paradigm* he derives, consciously, or unconsciously, the epistemological, formally logical and specific scientific postulates on which

* The intrapsychic model may in itself be something to reflect upon.
** Defined on p. 8.

DIAGRAM 4


Intrapsychic epistemological and formally logical assumptions
underlying
Intrapsychic specific scientific starting points relating to the object of research
Intrapsychic paradigm
Intrapsychic derivation
Other symbolic structures
applied as analagous to the external world
Intrapsychic model of the external world
intrapsychic induction
explicit formulation
external world
explicit model of the external world
test results
explicit induction
explicit deduction
explicit testing
explicit hypotheses

he *wishes* to base his substantive knowledge (if he is aware of his presuppositions) or is *constrained* to base it (if he is not aware of his presuppositions). And, finally, he derives certain insights from his *other symbolic* structures (his cultural environment, consisting of scientific theories, works of art, philosophical systems, etc.).

After thus drawing upon the external world, his own paradigm and other symbolic structures, the scientist moulds suitable aspects of his intrapsychic model into an *explicit model of the external world*, from which he can then deduce certain *explicit hypotheses relating to the external world*. The latter can be assayed against the external world itself, and the *test results* thus obtained used to modify both his intrapsychic model and his explicit model. Such a modified explicit model can stimulate further thought and thus set in motion a new cycle of observation, thought, formulation and testing.

Some remarks

The schema set out above describes scientific thinking in which the paradigmatic postulates are not explicitly formulated by the thinker, a type of scientific thinking which, in our opinion, is frequently encountered. For this reason we have incorporated only the intrapsychic variant of the paradigm followed. Should the thinker set about formulating his postulates explicitly, he could embody those postulates of his intrapsychic paradigm which he is able to perceive into an *explicit paradigm* which, if his reasoning is logical and consistent, should incorporate all the postulates underlying his explicit model.

Though scientists are concerned to render intrapsychic ideas explicit, it should not be concluded from this that the most ideal kind of scientific thought would be one in which all the elements of our schema — with the exception, of course, of the external world — could be explicitly formulated. If this were so, the development of new ideas would be impossible because all creative activity includes a stage in which the ideas concerned are nascent and thus (still) inexpressible.

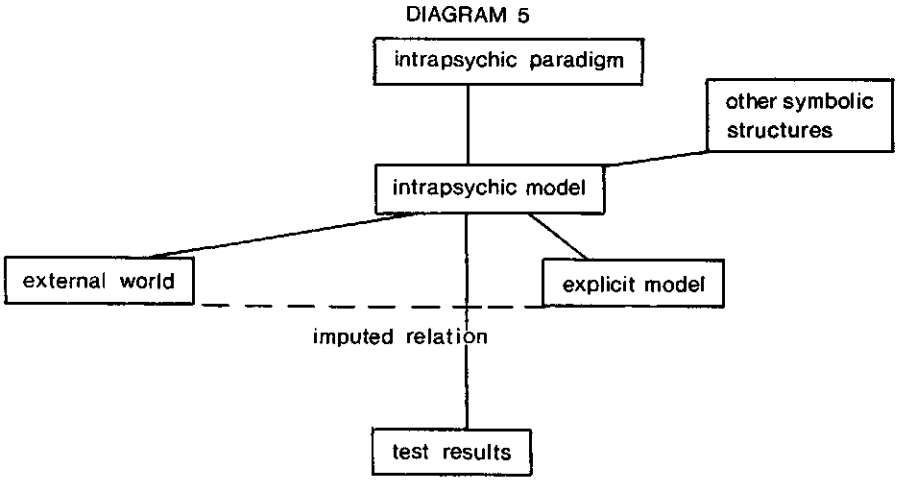
II.2 *The relation pattern of the intrapsychic model and the world of experience*

In our schema the intrapsychic model stands in direct relation to five other elements, if we consider the explicit hypotheses to belong to the explicit model itself. These five elements will be referred to in the following pages under the collective term of the scientist's *world of experience*, for each of these elements contributes something to his intrapsychic model.

Since we propose to analyse scientific thought and observation with the aid of these five relationships, the focal point of the schema is for our purposes the relation pattern of the intrapsychic model and the five

elements making up the world of experience, which may be shown as follows:

DIAGRAM 5



In this instance the lines no longer indicate the deriving and conversion of information, but show the relation established by the thinker/observer between his intrapsychic model and an element in his world of experience or the way in which he interprets that element.

The term "imputed relation" under the interrupted line refers, as before, to the relation established by the thinker/observer between his explicit model and the external world. We shall see that the degree to which he is aware of an essential difference between the two is of influence on his ability to be originally creative as a scientist.

We would emphasize the fact that our schema is built up exclusively of cognitive and perceptual elements of knowledge and consciousness, with the exception, of course, of the "external world" concept. This was decided upon with the object of creating a framework of concepts harmonising as closely as possible with one another, to which end Kuhn's comprehensive but vague conceptual framework was exchanged for one which covers a much smaller area of the subject under investigation but which is more precisely defined. Broadly speaking, our research field consists of the elements of the scientist's world of experience which we surmise to be capable of exercising a certain influence on his capacity for creative scientific thought. Besides cognitive elements, his world of experience may include the code of ethics to which he adheres, his religious and political beliefs, his specific personal and scientific problems, the system of norms and values observed in his environment, and so on. Without wishing to make light of the influence that all such factors may have on the development of scientific thinking, we shall leave them out of consideration for the time being in the interests of the logical consistency of our schema.

The following chapters, III and IV, will be devoted to a further elaboration of our conceptual framework, after which we shall proceed to a discussion of the nature of the relation pattern introduced above as regards both original and derived creative thinking.

III. Some additional concepts

III.1 *Scientific models*

We would define a scientific model as a combination of variables abstracted from the external world or mentally conceived as being pertinent to that external world that proves to be effective as a means of describing or explaining certain phenomena in the external world, while other phenomena prove to be either incompatible with it or irrelevant.

The practice of science is directed, in our view, towards a continuing process involving the creation of new models and the modification of fundamental parts of existing models with a view to describing or explaining as well those phenomena that were previously incompatible with, or irrelevant to, those models.

III.2 *Original and derived creative scientific thinking*

Starting from the above view of what constitutes a scientific model and its development, we now come to a more precise definition of original and derived creativity than that given at the beginning of this study.

Obviously the "originality" of any given scientific idea will depend on the scientific criterion used to assess it. Our schema permits us to select such a criterion at three levels:

— the level of the epistemological and/or formally logical assumptions;
— the level of the specific scientific starting points relating to the object of research;
— the level of the explicit model of the external world (not the level of the intrapsychic model of the external world because here we are seeking a criterion for describing the degree of originality of this intrapsychic model itself which therefore can hardly be used as a criterion).

As a continuation of this line of thought, we give the following *general* definitions of original and derived creative scientific thinking:

Orginal creative scientific thinking

= a mode of thinking about the external world whereby a scientist arrives at a new insight — at a level of abstraction fixed as criterion by someone else — allowing for developing new models of the external world, which are capable of explaining, besides phenomena already accounted for, also phenomena incompatible with models based on his former insights.

Derived creative scientific thinking

= a mode of thinking about the external world whereby scientist proceeds no further than refining existing insights at a level fixed as criterion by someone else.

These defenitions permit us to make a clear distinction between *model-based, paradigmatic, epistemological* and *formally-logical* original creative thinking, and between the corresponding levels of derived creative thinking. For the sake of clarity, the word "paradigmatic" is used here to indicate original and derived creative thinking at the level of specific scientific starting points, a description, it may be added, which is possible only if the investigator of scientific thinking endows "specific scientific starting points" with certain elements of knowledge.

Our "paradigmatic original creative thinking" corresponds to Kuhn's "extraordinary science", and our "paradigmatic derived creative thinking" to his "normal science".

Our conceptual specification of original and derived creativity may be illustrated by means of an example drawn from the development of economic theory. In replacing the classic macro- economics supply model by his macro-economics demand model, Keynes displayed model-based original creativity". However, observing that Keynes followed classic economics by adapting the concept "homo economicus" (= rationally calculating, maximum-profit-oriented man) as his main scientific starting point, we could be obliged to call his thinking "paradigmatic derived".

An economist replacing this model of "homo economicus" by a new model of economic activity better adapted to the reality of man's economic behaviour would then have to be described in terms of "paradigmatic original creativity", while his thinking would remain to fall into the category of "epistemological and formally logical derived creativity". If an economist were to exchange the syllogism as a formal means of arriving at conclusions for something else, his thinking could be characterised as "formally logical original creativity".

If we are to refer unequivocally to original and derived creativity within the framework of our schema, then we, too, must fix a certain level as our criterion. We have therefore settled upon the lowest possible level, that of the explicit model, as being the most suitable. In the interests of clarity, the terms accompanying this level are defined as "model-based original creative scientific thinking" and "model-based derived creative scientific thinking".

Model-based original creative scientific thinking constitutes a mode of thinking about the external world in which scientists working from a given paradigm reach new insights allowing for the construction of either an entirely new model or the redefinition of the essential variables of an existing model in a way permitting various phenomena that were hitherto incompatible with that model or were considered to be irrelevant also to be described or explained.

Model-based derived creative scientific thinking constitutes a mode of thinking about the external world in which scientists add refinements to the essential structure of their models while anomalies either remain unexplained or can be accounted for only with the aid of ad hoc hypotheses or correction factors.

In defining and describing original creative scientific thinking we have tacitly observed the rule that use of the term "original" at a particular level implies that the person concerned continues to think in a derived creative manner at the level immediately above. The creativity of the model-based original creative thinker remains paradigmatically-derived, while the creativity of the paradigmatically original creative thinker remains epistemologically and formal-logically derived.

In the interests of a simpler method of communication we shall loosen the reins of terminological precision by employing the term "original", in accordance with our choice of the explicit model as the criterion level, in the sense of all elements of knowledge displaying a logical incompatibility with the explicit model used by the thinker (and which at the same time seem to facilitate the development of ideas of a greater explanatory value). The question of the level to which this originality reaches — the paradigmatic or even the epistomological level — will not be discussed here. Where it is necessary to use the term without the risk of ambiguity, we shall do so with the aid of the terminology introduced in this section.

III.3 *Two types of intrapsychic model*

On the basis of what we have just stated regarding the use of the term "original", we can now distinguish between two types of intrapsychic model which may be found among scientists at a given moment: one from which an original creative conversion of the explicit model is possible, and one from which only derived creative refinement can stem.

The original intrapsychic model

= an intrapsychic model which differs in such a way from the explicit model, that it enables the scientist to perceive in his world of experience as well aspects which are logically consistent with his explicit model as ones which are logically inconsistent with it.

The derived intrapsychic model

= an intrapsychic model which is identical with the explicit model and which enables the scientist to perceive in his world of experience only those aspects which are logically consistent with his explicit model.

IV. Four mental mechanisms at variance with original creativity

We believe that a number of mental mechanisms may be found in the five relations between the intrapsychic model and the world of experience which imply derived creative thinking. They are derived assimilation, derived perceptivity, totalization and reification.

IV.1 *Derived assimilation*

On the analogy of Piaget, we have defined "assimilation" [13] as:
— interpretation by the scientist of aspects of his world of experience in a way permitting them to be fitted into his intrapsychic model.

As we have taken it as axiomatic that scientists always interpret in terms of an intrapsychic model, it follows from this definition of assimilation that all scientific interpretation is a form of assimilation. In accordance with our distinction between original and derived creative scientific thinking, two types of assimilation may be distinguished:

Original assimilation

= assimilation occurring on the basis of an original intrapsychic model.

Derived assimilation

= assimilation occurring on the basis of a derived intrapsychic model.

Derived assimilation may be directed as much towards aspects of the world of experience that are logically compatible with the explicit model — in which case the perceiver can assimilate them without difficulty — as towards those that are not logically compatible with the explicit model. These conflicting aspects can be dealt with by the scientist in various ways, as Abelson has described. [14] He can simply deny their existence, or regard them as inexplicable exceptions or as phenomena that can only be explained by means of other scientific theories. If the conflicting aspects belong to the external world, he can try to fit them into his explicit model with the aid of ad hoc hypotheses, correction factors, and so on. What these non-objective approaches have in common, however, is that the basic structure of an, as to the external world, inadequate model, remains unchanged.

IV.2 *Derived perceptivity*

The assimilation of impressions is preceded by observation. In view of the fact that the word "observation" is generally used only in connection with physical objects, while we are dealing with the scientist's world of experience — which contains both material and non-material elements —we have substituted "perception' for "observation".

In accordance with our concepts of original and derived assimilation, a simple type of perceptivity may be defined as a tendency on the part of the scientist to perceive aspects of his world of experience which are logically compatible with his intrapsychic model and to ignore others.

Original perceptivity

= perceptivity for aspects of the world of experience, regardless of whether they are logically compatible or incompatible with the explicit model, based on an original intrapsychic model.

Derived perceptivity

= perceptivity for only those aspects of the world of experience which are logically compatible with the explicit model, based on a derived intrapsychic model.

Derived perceptivity is accompanied by

Derived inattention

= inattention for aspects of the world of experience which are logically incompatible with the explit model, based on a derived intrapsychic model.

By the same token, original perceptivity is accompanied by *original inattention* in that the original creative thinker also tends not to perceive aspects that are inconsistent with his intrapsychic model. If, as we shall later consider, the thinker possesses the capacity to subject his intrapsychic model to a critical scrutiny, he is bound to notice certain aspects of that inattention at a certain moment. Because of the terminological confusion to which it could give rise, however, no further reference will be made to original inattention.

Field of perceptivity

In our model perceptivity is focused on the world of experience, divided into five elements. The three following terms enable us to refer with greater

clarity to what the scientist tends to perceive in his world of experience and what he tends to overlook.

Field of vision

= all aspects of an element of the scientist's world of experience which present themselves to his attention.

Field of perceptivity

= those aspects of an element of the scientist's world of experience, which he tends to actually perceive, when they present themselves to his attention.

Field of inattention

= those aspects of an element which the scientist tends to disregard; that is to say, those aspects which he can easily overlook when they present themselves to his attention.

The fields of perceptivity and inattention together constitute the field of vision, as is clear from the definitions.

It could be argued that all observation, being human, shares certain basic characteristics which are governed by certain laws imposed on all observers by the sheer fact of their being human [15]. It could further be argued that, precisely because these basic characteristics are common to all mankind, we are entirely or almost entirely unaware of them, with the consequence that they are undetectable by scientific research. That being the case, the term "field of perceptivity" could be said to be too comprehensive for the reason that, although it is intended to indicate what some people perceive and what others fail to perceive in their world of experience, there is little point in using it to draw attention to that which is common to all perception and which furthermore lends itself with the utmost difficulty to scientific study and precise definition. To reduce this problem to manageable proportions for the research worker, Van Lier [16] has worked out the following typology of human perception:

Subject-determined perception

= all aspects of perception determined by the perceiver as a human being.

Van Lier gives an ideal-typical description of subject-determined perception, characterising it as consisting of two layers, one evading scientific investi-

as an aspect of the other (All human interaction is communication), and so on.

In our model reification may also concern the aspects of other symbolic structures symbolising the external world. Regarding the percepts (visual impressions) in the intrapsychic model and the aspects of paradigms relating tot the external world, such as the presumptions of time, three-dimensional space and causality, as really existing in the external world may be classified equally well as reification.

The problem of reification is an extremely difficult one because even though we may become aware of a specific act of reification, we are still left with the problem of reification of a more general nature as it is expressed in concepts like "thing", "existence", and so on. We then find ourselves dealing with problems of a philosophical nature which fall outside the scope of the present study.

IV.5 *Interference between the mechanisms*

Our four mental mechanisms may operate in groups of two or more, thus strengthening the scientist's distorted image of some particular aspect of his world of experience. We do not propose to apply all the possible combinations of mechanisms to each of the five relations in the model, but shall restrict our attention (in the form of an example) to the joint occurrence of the four mechanisms where an aspect of the external world is perceived on the basis of a given explicit model.

Let us assume that a sociologist analyses village communities with the aid of the well-known sociological model of "Gemeinschaft".

- Derived assimilation will occur if he interprets all the phenomena he perceives in a community studied in such a way that they can be fitted into the "Gemeinschaft" model.
- This will imply derived perceptivity for the phenomena which are compatible with the "Gemeinschaft" model and derived inattention for some of the phenomena which are incompatible with the model; the remaining phenomena of the latter type will be adapted to fit the model by means of mechanisms which we have not expressly defined as such.
- Totalization will occur if he believes that all aspects of the village community are represented in the "Gemeinschaft" model.
- Reification will occur if he thinks the village communities he is studying are indeed "Gemeinschaften", that is to say, if he thinks the concepts of "village community" and "community" do not indicate, but actually are, identical elements existing in the external world.

The sequence in which the various mechanisms interfere is of little interest since the effect is the same in all cases, namely that our sociologist will henceforth associate all villages with "Gemeinschaft", and that will be that.

It should be noted in this context that observing a village — which

includes people in interaction with one another, houses, plots of land and a host of other things — in terms of the concept of "village community" may in itself constitute an instance of derived assimilation followed by totalization and reification.

V. The five relations of the intrapsychic model-world of experience relation pattern

As a general introductory remark, it may be stated that original creativity seems to be possible only if the intrapsychic model is an open one, i.e. if the scientist is capable of abstracting aspects of the five elements of his world of experience and incorporating them as qualitatively new aspects in his intrapsychic model so as to effect fundamental changes in the explicit model or to formulate a new one.

Derived creative scientific thinking seems to be inevitable if the intrapsychic model is a closed one, i.e. if the scientist is not capable of incorporating qualitatively new aspects derived from the elements of his world of experience into his intrapsychic model.

The above two statements foreshadow the logical structure of the following pages. In discussing the relation of the intrapsychic model with the world of experience, we shall endeavour to indicate the factors which seem to constitute a necessary, but not sufficient, condition for original creative thinking (thereby employing the term "seem to make possible"), and the factors which seem to constitute a sufficient, but not necessary, condition for derived creative thinking (thereby employing the term "seem to imply").

V.1 *The intrapsychic model — explicit model relation*

The way in which the scientist relates to his explicit model (which we postulate throughout this study as being already in existence) is of essential importance.

He will possess the capacity for original creative scientific thinking if he is capable of perceiving his own explicit model as a separate element of his world of experience differing from his intrapsychic model in that the latter contains a number of conscious or halfconscious aspects that are qualitatively at variance with the fundamental variables of the explicit model and can be formulated explicitly.

Derived creative scientific thinking seems likely if the scientist does not perceive his explicit model as something objective, with basic characteristics admitting of argument, but as being identical to what he sees as a number of natural and self-evident stages of thought. In such cases there is no longer any difference between his present thinking and the effects of his former thinking. The explicit model and the intrapsychic model have become identical, which can only result in the carrying out of deductive refinements within the explicit model.

Logically speaking, this means that the intrapsychic model has become

just as closed as the explicit model, and this we have termed a "thought circuit".

A thought circuit

= an intrapsychic model consisting of a closed system of constantly repeated thoughts identical to the explicit model deployed, outside of which the thinker does not move in his thinking about the external world and which he does not subject to critical scrutiny.

There are a number of circumstances in which flexible thinking may rigidify and become a thought circuit.

a. *Memorising models which are difficult to understand*

Models, as theoretical structures, are not always easy to understand, and many people never succeed in grasping the full value of the models they use. Through their repeated attempts to understand them, however, they manage to incorporate the internal logic of the models as a matter of habit into their line of reasoning. Most of us undergo this process in the study of mathematics. Though we may never master the essentials of limits and integrals, if we use these concepts long enough, the stages of thought involved nevertheless fix themselves in our minds, even if only as a habit. We may even be able to explain them to others, while not understanding them ourselves.

b. *Force of habit*

But even though the scientist may understand the model he is working with he may still slip into a kind of thought automatism. Everything in the model is logical and explicable, and after a time he is thoroughly familiar with it. If he does not realise that he is slipping into a habit of thought it will not be long before he is caught up in a thought circuit.

c. *Irrational attachment to a model*

Scientists may cling stubbornly to certain modes of thought for all manner of non-scientific reasons, such as faith in a great scientist, the wish to justify their social position by means of a model or the unconscious desire to rationalise suppressed emotions.

The major difficulty with thought circuits is, in our opinion, that the person concerned is often not aware of the fact that he is thinking in this way. If a scientist who is trying to solve a scientific problem continually reaches a deadlock at the same point and makes no effort to analyse his habits of thought in the belief that his thinking is untrammelled, his thought processes will remain confined to the same channels and he will never discover what it is that he is doing. The problem thus remains insoluble.

We shall now consider how the mental mechanisms in the relation between the intrapsychic model and the explicit model can affect the creativity of thought.

a. *Derived perceptivity and the explicit model*

Perceptivity for the explicit model may be more readily understood if considered together with the relation between the intrapsychic model and other symbolic structures. It should be borne in mind that there is a difference between a scientific model as it is used by the average scientist and a model as it can be formulated in extenso.

An explicit model in the narrow sense

= the formulation of a model of the external world in which the variables are simply defined and described in their interrelationship.

An explicit model in the broader sense

= the formulation of a model of the external world in which the variables are extensively defined and described in their interrelationship and in which the assumptions underlying the model are formulated up to the fundamental axiomatic level.

It will often be the case that the explicit model in the broader sense is to a large extent part of the "other symbolic structures" element of the scientist's world of experience. Proceeding from that model in its entirety he borrows the aspects that are suitable for research of a comparatively low level of abstraction, which aspects will correspond with the explicit model in the narrow sense. The scientist's explicit model will then be consistent with his field of perceptivity as regards the "other symbolic structures" element. This means that precisely those aspects of the model that could indicate its problematical nature, viz. the assumptions on which it is based, remain in his field of inattention, which thus consists (in "other symbolic structures") of the very elements of knowledge that he could use, if he were aware of them, for an originally creative conversion of his model.

It follows logically from the above that the next step for the scientist is to incorporate this explicit model in the narrow sense as a thought circuit in his intrapsychic model. For he has not perceived the problematical aspects of the model, which thus seems to him to constitute a self-evident structure for describing the external world.

b. *Totalization of the explicit model*

This heading is in reality a compressed description of a mental process in which two stages may be distinguished. For in accordance with our definition of totalization, the scientist first embodies the explicit model in its

entirety in his intrapsychic model and then proceeds to the tolalization of the latter. For convenience's sake, however, we shall continue to refer to the totalization of explicit models.

An example of this process is the economist who thinks that the "homo economicus" is the definitive model of man, or the psycho-analyst who thinks that all human behaviour can be explained in terms of Freud's model of the human psyche. This kind of mistaken belief can impede an original creative approach to research, for the scientist who totalizes an explicit model of the external world thinks that with the aid of this model he is devoting attention to all important aspects of the external world, while in fact he subjects only a few of them to examination. If the disregarded aspects are of essential importance for gaining real insight into the subject under investigation, he will never succeed in doing so without changing his avenue of approach. Acting in the belief that he is investigating the whole of the subject, he is unaware of the fact that he is consistently overlooking something and consequently feels no need to consult others from time to time.

The occurrence of totalization in scientific discussions amounts to a group instance of such a delusion. Certain aspects of the external world are left out of consideration without the speakers themselves being aware of it, and they can talk indefinitely without ever managing to surmount the barrier barring their way.

An example of the totalization of an explicit model

Before the Agricultural University team referred to in the preface could begin their exercise in regional planning, a suitable region in the tropics had to be found. Two members went on a reconnaissance mission to the country named Tangan and in a report compiled they warmly recommended the Eastern Region with its capital of Tempat, containing 25 per cent of the population, as a suitable area for the projected regional planning. The report stated:

> "Agriculture is the principal means of subsistence but there is sufficient diversification to make regional planning worthwhile. Some of the problems to be expected will be outlined in the following pages."

Of the six problems listed in the report, five were of a specifically agricultural nature, while the sixth was no more than a general reference to employment and investment calculations per economic sector.

From this and other points we have concluded that the writers of the report worked from an explicit model of regional planning consisting largely of plans and policy measures for the agricultural sector, a model which they themselves regarded, however, as a general regional planning model. Thus they totalized their explicit model of agricultural planning for the

Eastern Region into planning as such for the Eastern Region and called it regional planning.

c. *Reification of the explicit model*

In the practice of science reification does not always seem to occur in the extreme form in which we have defined it as a concept, i.e. regarding symbolic structures of the external world as really existing in the external world. It is more likely to be a constant jumbling up of the explicit model and the external world in the scientist's thoughts and in his expression of those thoughts. In referring to his model he shifts his ground imperceptibly to the external world, and in referring to the latter he tends to formulate exclusively within the framework of his explicit model. There is nothing wrong with this, provided he is fully aware of the fact that he is no longer referring to the external world alone.

An example of the reification of an explicit model

The problem of the jumbling up of the model and the external world for which the model was constructed emerges clearly from the following extract from an interview with a member of the team.

Team member:

"I feel that we made the region consistent with the nature of the team and simply eliminated everything that didn't fit. We made a model region, as it were... the team existed before we found a region, which of course didn't match the model. ... so then various things that couldn't be brought into line with the model were eliminated altogether."

Interviewer:

"What things do you mean?"

Team member:

"Well, the role of the town, Tempat. What is in fact of the greatest importance in the region was simply ignored for quite a long time by a considerable part of the team... they talked on and on about agricultural problems ... but the capital, Tempat, was given no attention at all because the team was not prepared to deal with it."

So in the opinion of this member of the team, the region was exchanged for the model and the team went ahead in the belief that they were observing the region.

V.2 *The intrapsychic model - external world relation*

The mentality from which the scientist perceives the external world is one of the factors determining the degree of original creativity he will develop in his thinking. If he is capable of perceiving aspects of the external world

which are at variance with his model or which present the latter in a new light and of making the intrapsychic induction required to convert those aspects into qualitatively new aspects of his explicit model, this will promote original creativity. Original creativity is impeded if the scientist perceives the external world on the basis of his explicit model and thus in effect perceives only those aspects which are compatible with his model, either ignoring the others or interpreting them as unimportant or atypical. In psycho-analytical terms, his perception is based on projection.

Scientific observation aimed at the construction of explicit models of the external world rests largely on abstraction. The scientist extracts certain aspects of the external world and studies them in their interrelationship. This abstraction is deliberate, for it leaves him free to become absorbed in a particular conceptual framework within which he can build up a thought system undisturbed by anything else coming to his attention. The price he pays, however, is that it is subsequently impossible for him to extend his knowledge of the external world beyond those boundaries. Through his constant preoccupation with just a few aspects abstracted from the external world he tends to concentrate his observation of the external world on those particular aspects and to disregard the others.

Pursuing this train of thought to its logical conclusion, we may thus assume that the scientist will tend to concentrate his attention on those aspects of the external world which form part of his own discipline, which means that his field of perceptivity tends to be consistent with his own branch of science. We may also assume that he will be less keen in his observation of that part of the external world which is not connected with his own field of activity. His field of inattention will thus tend to correspond to those branches of science which are not his own.

This phenomenon of selective scientific perception has important implications for scientific discussion which may be summed up in the following thesis: scientific discussion of the external world will not move beyond the shared field of perceptivity of the participants.

An example of derived perceptivity for the external world

In a letter written prior to their report the two team members sent out on reconnaissance made the following references to the suitability of the Eastern Region [italics supplied by author]:

"Acting partly on local advice, we soon focused our attention on the Eastern Region. This area, which is readily accessible, *surrounds Tempat*, the administrative centre, and the data available for it are much more numerous than for any other area".

"It presents interesting problems from the points of view of sociology, land tenure and agronomics, and land development and soil science. The main problem is the switching over from the "ladang" method to permanent cultivation and the question of land rights."

"In a number of discussions held at the weekend we came to the

conclusion that the area *surrounding Tempat*, the Eastern Region, would probably meet the team's exacting requirements better than any other."

From the words italized we have concluded that the writers in all likelihood perceived the Eastern Region as the-area-around-Tempat, or in other words as a geographical area with a hole in the middle. As the second extract shows, they were preoccupied with the agricultural aspects of the project. We feel that this, together with the first example, justifies the conclusion that the members of the mission worked from a derived intrapsychic model of (agricultural) regional planning, from which they perceived the region in a derived manner involving the rural areas as their field of perceptivity and the urban area, the town, as their field of inattention.

The statement that "the area surrounding Tempat would probably meet the team's exacting requirements better than any other" supports our thesis that scientific discussion will not go beyond the bounds of the shared field of perceptivity of the participants.

V.3 *The intrapsychic model - intrapsychic paradigm relation*

To discuss original and derived creative science at the level of paradigms we are obliged to refer once again to the distinction made in Chapter III.2 between model-based, paradigmatic, epistemological and formally logical original and derived creative thought.

Paradigmatic original creative science can be practised if the scientist knows on what paradigmatic — i.e. specific scientific — points of departure his intrapsychic model is based, and is capable of working out other starting points for modifying his model or replacing it by another.

Paradigmatic derived creative science becomes likely when the scientist is unable to develop specific scientific starting points other than those he already uses.

The same applies in respect of original and derived creative science at the epistemological and formally logical level.

It may be posited that the fewer the postulates included in the paradigm by the investigator of scientific thinking, i.e. the more abstract the formulation of the paradigm, the greater will be the originality of the scientist who replaces one or more of those postulates by others with a wider explanatory range. True scientific "revolutionaries", in Kuhn's terminology, are people like Gauss, the mathematican who upset the postulate of three dimensionality in geometry and replaced it by another, and Einstein, who did the same in physics with the postulate of the continuous time scale.

The way in which the scientist whose thinking is of the paradigmatic derived creative kind relates to his own postulates may vary considerably. He may be unaware of them, believing that the essential variables of his model are based on "natural" thinking which requires no further investigation; or he may be aware of them and accept them as dogma established by

an eminent philosopher or scientist, to be used indiscriminately as a basis for all scientific thinking about the external world. It will frequently be the case that he is more or less aware of them, but lacks the insight required to change or modify them.

V.4 *The intrapsychic model — test results relation*

Test results actually are not a *separate* element of the world of experience, being in fact nothing more than an answer to the question of how certain points of the explicit model relate to the external world.

They enable the scientist to trace with greater precision the imputed relation between the explicit model and the external world.

Kuhn [17] points out that the way the scientist interprets the results of his tests is closely connected with his mental preoccupations. In the absence of a better model the practitioners of "normal science" are strongly inclined, he says, to interpret all research findings in terms of the existing model. When they encounter anomalies they will either try to „explain" them with the aid of ad hoc hypotheses or correction factors or will regard them as irrelevant and explicable solely within the context of some other branch of science, or as exceptional cases, and so on. The practitioners of "extraordinary science", on the other hand, are capable of evaluating the merits of anomalies and of constructing models which help to explain them.

So test results that are inconsistent with the expectations of the practitioner of normal science are very often assimilated in a derived creative way, while original assimilation is the exception rather than the rule.

Kuhn states in his analysis of the history of Western physics and chemistry that the scientific community often believed that anomalies had been fully explained with the aid of ad hoc hypotheses or correction factors before an originally creative scientist introduced a qualitatively different model showing that they were wrong.

A derived creative approach to test results will consequently quite often result in a refined model from which both the scientist concerned and others conclude that the problem has been solved.

V.5 *The intrapsychic model — other symbolic structures relation*

Donald Schon [18] has stated that new models of the external world come into being in the following way. The scientist first approaches the field of study with a model that is already known but has never been used in this way before, thus projecting an existing framework of concepts and relations on a part of the external world in an original way and thereby saying in effect, "Let's look at it from this angle". He is now in a position to view the situation in a new light. The model reveals hitherto unsuspected aspects of the situation and armed with his new knowledge the scientist is in a

position to view the model, too. in a new light. The model's unsuspected possibilities open up the way, for instance, for redefinition of the variables. After a time the scientist will be able to modify the model in such a way that it can incorporate new basic variables, and a new piece of knowledge comes into being.

In his argument based primarily on the premise that all new ideas are necessarily rooted in reinterpretation of ideas already in existence, Schon points to the importance of metaphor in all conceptual change, by which he means applying to a new situation a word with a meaning that is considered by the thinker to be applicable in some way to the new situation. The light wave indicating the nature of the movement of light is a metaphor of this kind.

Susanne Langer [19] refers to the importance of non-verbal symbolic forms in man's interpretation of the external world, such as the Gestalt principles through which perception derives its structure.

We believe that it may be concluded from the arguments presented by Schon and Langer that the scientist could effect no essential changes in his model if he lacked a certain verbal, visual and, possibly, auditive "power of imagination" which enables him to apply existing verbal, visual and auditive symbolic structures as analogies to situations in the external world for which he is seeking an explanation. The cultural areas in which verbal, visual and auditive symbols are very much in evidence as analogical means of giving expression to personal experience are poetry, the visual arts and music.

Thus the capacity to apply symbolic structures as analogies to an object of research is in a certain sense an artistic capacity, which implies that original scientific creativity may be regarded as a form of artistic creative capacity.

VI. Recapitulative typification of original and derived creative scientific thinking

The original creative scientist has the capacity to develop ideas about the external world independently of his explicit model and to objectify those ideas in subsequent reflection. This leaves him free to note aspects of his world of experience which are at variance on essential points with his explicit model. He is aware of the separate existence of the five elements of his world of experience, tends slightly towards totalization and reification and is capable of building up analogies. These mental qualities enable him to construct new models to help explain aspects of the external world which are inconsistent with the old model.

The scientist whose creativity is of the derived type has converted his explicit model in its entirety into an intrapsychic model, thus excluding all possibility of reflection. His thinking is confined to a thought circuit, which makes it difficult for him to note aspects of his world of experience which are inconsistent with that model. Being only vaguely aware of the separate existense of the five elements of his world of experience, he tends towards totalization and reification. His capacity for building up analogies is small. These mental qualities largely restrict his scientific creative capacity to adding deductive refinements to his model.

The above typification permits us, we feel, to draw the following conclusions regarding the similarities and dissimilarities to be found in certain personality traits of the two types of scientist.

The original creative thinker has a mind in which there is room for logical contradictions, such as those between the intrapsychic model and the explicit model, between the intrapsychic model and thought arising from reflection on it, the explicit model and what he perceives of the structure of the external world, and the intrapsychic model and his test results. We must also assume that he is capable of perceiving the elements of his world of experience on the basis of more than just the intrapsychic models which he has developed for each of those elements. For lack of a better, that "more than" will have to be described as "intuition". This entire constellation of contents of thought relating to a given research object will only be brought into ultimate balance if these contents can be harmonized one with the other in accordance with the precepts of logic and scientific proof.

The derived creative thinker is much more intolerant for harbouring such internally conflicting psychic constellations during a lenghty period of time and he brings them prematurely into balance with the aid of mental mechanisms which are inconsistent with the precepts of logic and scientific evidence. Milton J. Rosenberg, [20] who investigated this phenomenon of longer-term intolerance for logical inconsistencies in connection with attitudinal constellations in general, comes to the conclusion that

people differ in their "threshold of intolerance for inconsistency" in those attitudinal aspects that are *psychologically* incompatible. [21]

Our conclusions may be regarded as supporting his psychologically *general* thesis in the more limited area of *logical* consistency and inconsistency.

Footnotes

1. B. van Norren, *Aspekten van interdisciplinair teamwork in het algemeen en met betrekking tot de tropen. Kommunikatieve en sociaal-psychologische veronderstellingen aan de hand van een case-study* (General Aspects of Interdisciplinary Teamwork in the Tropics. Communicative and Social-Psychological Assumptions Based on a Case Study). Department of Extension Education, Agricultural University, Wageningen, 1971. Stencil. See Section 1:2, "Denkaspekten" (Aspects of Thinking), pp. 15-24.
2. C. K. Ogden and I. A. Richards, *The Meaning of Meaning. A Study of the Influence of Language upon Thought and the Science of Symbolism.* Routledge and Keagan Paul, Ltd., London. Tenth edition, 1969. First published in 1923.
3. Thomas S. Kuhn, *The Structure of Scientific Revolutions.* The University of Chicago Press, Chicago. Third impression. First published in 1962. Second edition, enlarged, in 1970.
4. C. K. Ogden and I. A. Richards, op. cit., p. 11.
5. Idem, Chapter 1, "Thoughts, Words and Things", pp. 8-12.
6. Karl Steinbuch, *Menselijk en Machinaal Denken,* Aula series, Het Spectrum, Utrecht, 1964. Original title, *Automat und Mensch,* Springer Verlag, Berlin, 1961.
7. Kuhn, op. cit., pp. 10-11.
8. Idem, p. 88.
9. Idem, pp. 86-90.
10. Idem, pp. 181-186.
11. Idem, pp. 95-103.
12. In the second edition of his book published in 1970, Kuhn further elaborates the concept of "paradigm" in a "Postscript", replacing it by the new term "disciplinary matrix" which has the same meaning and which covers the scientific principles, system of values and certain standard examples for seeking solutions to scientific problems ("exemplars" as Kuhn calls them), to which all members of a scientific community actually adhere.

    He subdivides scientific principles into "symbolic generalizations" by which, roughly speaking, he means the formulas on which the members of a scientific community base their research (e.g. the principles laid down by Newton and Einstein), and "metaphysical parts of paradigms", embracing even more fundamental scientific principles. As examples of the latter he gives" Heat is the kinetic energy of the constituent parts of bodies" and "All perceptible phenomena are due to the interaction of qualitatively neutral atoms in the void". (Kuhn, op. cit., pp. 182-187).

    Together, Kuhn's "symbolic generalizations" and "metaphysical parts of paradigms" seem to us to correspond more or less to the element which we have termed "scientific starting points relating to the research object". Remarkably enough, Kuhn does not include purely philosophical assumptions in the cognitive part of his disciplinary matrix, and we consequently incline to the view that our definition of cognitive paradigms makes it possible to give a more complete description of a given person's scientific assumptions than his definition.
13. Neil Bolton, *The Psychology of Thinking.* T. & A. Constable, Ltd., Edinburgh, 1972, p. 43.
14. Robert P. Abelson, "Psychological Implication" in *Theories of Cognitive Consistency, a Source Book,* Robert P. Abelson *et al,* Rand McNally and Company, Chicago, 1968. pp. 112-139.

15. This was the view taken by Immanuel Kant, who presented this thesis, in a way comprehensible for non-philosophers also, in his *Prolegomena zu einer jeden künftigen Metaphysik,* published in 1783. Verlag von Felix Meiner, Hamburg, 1969.
16. Communicated orally to the author by Professor R. A. J. van Lier, Department of Rural Sociology of the tropics and subtropics, Agricultural University, Wageningen.
17. Kuhn, op. cit., Chapter 8, "The Response to Crisis", pp. 77-91.
18. Donald Schon, *Displacement of Concepts.* Tavistock Publications, London, 1963. See Chapter IV, "A Close Look at the Displacement of Concepts", pp. 53-108.
19. Susanne K. Langer, *Philosophy in a New Key. A Study in the Symbolism of Reason, Rite and Art.* The New American Library of World Literature, Inc., New York. A Mentor Book. First published in 1942. Seventh impression 1955. See Chapter 4, "Discursive and Presentational Forms", pp. 63-83.
20. For an explication of Rosenberg's theories see, M. J. Rosenberg and A. P Abelson, "An Analysis of Cognitive Balancing" in M. J. Rosenberg *et al, Attitude Organization and Change.* New Haven, Yale University Press, 1960. pp. 112-163. See also Chester A. Insko, *Theories of Attitude Change.* New York, Meredith Publishing Company, 1967. Especially Chapter 9, "Rosenberg and Abelson's Affective-Cognitive Consistency Theory", pp. 177-197.
21. For details of the concept of "threshold of intolerance for inconsistency" see Milton J. Rosenberg, "Hedonism, Inauthenticity and Other Goads" in Robert P. Abelson, op cit., pp. 73-111, and particularly pp. 89-101.