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The Foundation of Theories in the Complementary Relationship of Explanation and Description

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1. On the Problem

The subject of this article is the foundation of theories (Begründung von Theorien) by means of explanations and descriptions in their reciprocal and conditional relationship[1]. Foundations deliver on the one hand an explanation of scientific theories, and on the other hand however also deliver an explicit development of these same theories out of everyday knowledge. In a didactic sense well founded theories are a suitable means to a self-organised learning process.

The terms *description* and *explanation* are hereby used in the following way: in the narrower sense the term description refers to the everyday empirical world. In contrast to this term is the term explanation. Explanations in this sense make a scientific and theoretical comprehensibility of the relevant object possible. In the following however this differentiation will not be made the underlying basis of the argument for two reasons: firstly this difference suggests a dichotomy between the empirical and the theoretical. The empirical aspect and the theoretical aspect are however regarded in this work as complementary entities. They therefore stand in a reciprocal conditional relationship to one another, that is to say both in the everyday world as well as in science. Secondly the pragmatic context is excluded from such a perspective. This leads to a reduction of the term "explanation" to the terminology of logical derivation, as was originally carried out by POPPER (1973, 59 et seqq.; first published in 1934) and then further developed by HEMPEL and OPPENHEIM (1948).

Description and explanation relate to different areas: descriptions are made by means of terms or systems of terms (theories). These descriptions may as easily belong to the level of the everyday world as to the level of the scientific world. While descriptions relate to questions of the type "What is/was the case?", "What is/was the matter?" explanations on the other hand answer "why" questions: "Why is/was that so?", "Why is/was this and that the case?".

These questions involve the pragmatic context of the explanation, which is characterised by a discrepancy between expectation and observed phenomena. This is because explanations are based on problems whose solutions are tied to the filling of gaps in our knowledge. This takes place in the circumstances of complex analysis-synthesis processes in which knowledge is organised, explained, modified, and also developed, in order to carry out problem solving descriptions. Explanations also condition descriptions and descriptions also lead to situations that necessitate explanations, such as the anomalies which manifest themselves in the course of normal scientific activity.[2]

In the second section the possibilities for an introduction of the fundamental terms of a theory will be discussed. The result it will be seen is that foundation remains the only sensible means of mak-

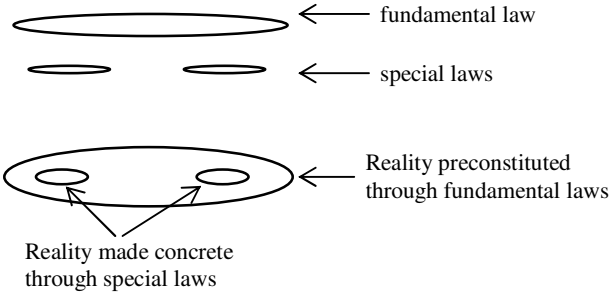
[1] We are grateful to Julia Buchheit (M. A.), Knut Latus and Andreas Susczyk for many improvements in the text.

[2] Normal science is according to KUHN (1978) that phase of a science, in which tasks are carried out with the help of a theory that has already been developed.

ing the said introduction. In the third and fourth sections foundation will be elucidated as a methodico-genetic development. Finally in the fifth section it will be made clearer through an extensive example, that foundation is a complementary relationship of explanation and description.

2. Beyond Defining and Axiomatic Introduction

Theories consist of laws. These can be divided into general laws, the so called fundamental laws, and special laws. The special laws render particular specific areas of the fundamental laws concrete and thereby also the corresponding areas of reality. Laws in turn are conjunctions of terms. The terms of a theory are thus on the one hand determined by the theory, and on the other hand determine the terms in which the theory is couched. The terms used and the theory in which they are used stand in a specific part-to-whole relationship to one another. As a result, one speaks of "systems of terms".



An example of a fundamental law is Newton's Law $F = m \times a$.

Two examples of special laws are the Law of Gravity and Hook's Law.

In normal science the reality preconstituted by the fundamental law is investigated with the help of the same law and more concretely by means of the special laws that have been developed.

From the above, it follows that the terms of a theory are not directly derivable from the terms of other theories nor are they directly derivable from the vocabulary used in the everyday world. Terms which sound the same but come from different theories however suggest such a relationship do indeed exist. None the less their connection is not identical – they are from different theories – and thereby the meaning of the terms (the concepts) is also rendered non-identical.

Total reductions of the meanings of terms to the meanings of other terms are known as *explicit definitions.* The terms used within a theory can only be explicitly defined within the context of that same theory by means of the undefinable fundamental terms. The problem therefore consists of developing the fundamental terms of a theory respectively of the foundation of a theory.

There are three distinct possibilities:

(1) Axiomatic introduction.

(2) Explanation of the fundamental terminology through terms taken from other theories[3].

(3) Development of the terms from other already available theories.

In axiomatic introduction the laws of a theory are laid down according to the possibilities available in the formal language of mathematical logic. Thus the syntax and the form are precisely determinable. The problem however lies in the fact that in this manner the empirical dimension of the semantic content cannot be simultaneously determined. In mathematically formulated laws, such as those of physics, through axiomatic introduction we are given only the mathematical content; the empirical content is missing. In order to develop the empirical content we find it necessary to carry

[3] Including terms taken from everyday life: in this contribution the term *theory* is also used for everyday life expressions.

out, at least partially, the same or similar procedures to those mentioned in the third possibility above.

The explanation of terms is carried out by means of available existing theories. They are often based on operational definitions and anticipate empirical laws. They can only determine the meaning of the new terms partially and indirectly.

For the development of a theory a suitable basis and suitable methods must be chosen. For various reasons the everyday knowledge is the obvious choice as a suitable basis. If the development of this theory also involves specific characteristics, then we speak of foundation.

3. On the Term 'Foundation'

Foundations are methodico-genetic developments (constructions), which have their origin in what is taken to be an everyday a priori. They have a triple function:

(1) Explication of the syntax and the semantics of a theory.

(2) Explicit and plausible methodico-genetic development of that theory.

(3) Explication of the relations between the everyday knowledge and the scientific knowledge.

Everyday knowledge is refined in three ways through repercussions on the beginning of the foundation process:

(1) Scientific knowledge no longer simultaneously permeates the everyday world as a natural outgrowth of the process.

(2) Everyday knowledge which is incompatible with the new scientific knowledge is eliminated or adequately transformed.

(3) The relationships between everyday knowledge and scientific knowledge become capable of being more precisely represented[4].

In the following we use the "foundation" term of MITTELSTRASS (1997). MITTELSTRASS developed this term out of the criteria of rationality. At its origin lies the initial idea of scientific rationality that is a rationality unit of research and representation. From this basis MITTELSTRASS demands a "reconstruction model of rationality with which, as in science itself, the constitutive aspect and ensuring validity aspect of the creation of knowledge are methodically connected to one another" (MITTELSTRASS 1997, 272; originally German).

The everyday a priori is determined by MITTELSTRASS through the imperative of reconstruction: "create in your language and scientific construction a connection of constitutions and validity, the foundation of which is always an everyday a priori which is contained in a pragmatic structure" (MITTELSTRASS 1997, 275; originally German).

The everyday a priori involves beside knowledge standardized acts, which are pragmatically independent from the validity of theoretical propositions. These everyday a prioris are conceived as being in principle refutable. The same applies to the genetic development of the theory.

[4] These last two characteristics present themselves for example in the transition from classical to post-classical physics.

4. Methodical Characteristics of Foundation of Theories

Everyday knowledge has the quality of paradigms. In so far as the world of natural science is concerned it has basic characteristics of historical paradigms[5]. Correspondingly the everyday a priori of foundation of a theory consists of one or more paradigms drawn from the everyday world. This a priori is the means through which a methodico-genetic development is initiated.

Fundamental characteristics of the methodico-genetic development are:

(1) The development takes place in the complementarity of discontinuity and continuity. Discontinuities are created through the construction of novelty. These are areas of explanations. They initiate relatively continuous phases, which are the areas of descriptions.

(2) Every stage of development contains law-like methodical and metatheoretical principles. The (general and special) law-like principles give them their ascendancy over the methods used[6]. Because these principles define primarily what can be investigated and also how in principle this has to be carried out or can be carried out. This may as well involve methods which transcend the individual phases. The law-like methodical and metatheoretical principles develop simultaneously relating to each other.

(3) Every continuous and discontinuous step in the development process defines on the one hand the reality constituent role of the new terminology, which is largely determined by the metatheoretical principles. On the other hand each step in the development process opens up concrete possibilities for further development. The success of the explanations and descriptions offers the proof of their validity.

(4) Novelty is an integration of already available elements of knowledge in a new configuration. This is the form taken by most of the new knowledge which finds immediate employment in the following section. New knowledge represents, relative to previous knowledge, a discontinuity.

(5) New knowledge is produced, by means of the everyday life a priori, as the means for developing an explanation. In this sense new knowledge is an object of metatheoretical consideration. In the process of ensuring that the emergence of new knowledge is adequate for the task, the new knowledge functions as a means of explanation. In the further development the relationship between object and means of the new knowledge changed. It is primarily a means and secondarily, in the reflection of the means of its own concretisation, an object[7].

The methodico-genetic development begins with the construction of new knowledge, which then emerges to become a means for further process of development. It goes from being abstract to being concrete. New knowledge finds its legitimation in the first developmental step that it is involved in, in that it successfully explains a phenomenon or a factual state of affairs. New methods and metatheoretical principles are at least implicitly involved. Metatheory is particularly involved in the comparison of knowledge of the everyday world with new knowledge. This is particularly true of

[5] For the justification of this point of view see KROPE and WOLZE (2005).

[6] This definition satisfies the demand of the primacy of the paradigm (or better still the theory itself) over the methods used which is made by scientific theory. It is also compatible with the principle of methodical order of Methodic Constructivism, that is to say it is a generalisation of this principle.

[7] In relation to this differentiation HEINZ VON FOERSTER (1969) in a review of the work of SPENCER BROWN (1969) underlines this connection between means and object in that he conceives their difference as being that of both operator and also operand at the same time.

the elimination and transformation of elements of the a priori of everyday life. Neither transformation nor new knowledge are arbitrarily determinable, but nor are they well-defined. Explanations for one and the same phenomenon, taken from everyday life and from science, co-exist.

The predication method is a fundamental method of Methodical Constructivism[8] for the construction and foundation of a scientific language. It has in its fundamental structure strong similarities with the Distinction Theory as it was conceived by SPENCER BROWN. There is not enough room here to allow the discussion of the similarities and differences between the two theories. In the discussion that follows we will refer to both methods; however we will pursue a direction different from both. Our goal is to avoid the drawbacks of both of them. These are to be seen on the one hand in reduction and on the other in an insufficiently explicit operative dimension of the predicates which are introduced.

Predication, the assignment of predicators, is connected with distinction. Fundamentally distinction is primary. SPENCER BROWN (1969)[9] uses the expression "to draw a distinction". Distinction separates something from the rest of the world; it has an interior ("marked state") and an exterior ("unmarked state"). For the interior an expression is then introduced ("law of calling") (SPENCER BROWN 1969).

The method of predication makes use of counter-examples as well as examples. The counter-examples can be completely marking-off. They can however also be linked to another explicit predicator. In the first case the distinction will be more explicit, and thus the first predicator will thereby become more concrete. In the second case in addition a new marked state is introduced to the unmarked state of the first predicator.

Predications can also refer to the marked state of a predication which has already been made. They can do this in that on the one hand they exclusively explain still further the marked state and on the other hand in that they overlap the marked and the unmarked state. Through predications of this type relationships come into existence between predicators. A fundamental relationship is the relationship "…is more general than …" another is "…is complementary to…" which for instance refers to the relationship between the general and the specific or the part and the whole.

The distinction or the predication is a fundamental operation with which, according to both theories, the world becomes accessible. This world is however a world that has already been discovered and which is explained through the operations carried out. The question which must be posed here is: what is the basic intended concept of reality? Here we support a constitutional approach which goes beyond realism and idealism. On the foundation of predication theory it can be sketched out as follows: the subjective or social system is distinct from its object, and that is to say they exist as complementary opposites, which mutually determine one another. The unit is the whole system composed of the object and the subjective or social system as partial systems. Knowledge should be seen as an emerging property of this whole system. This knowledge cannot be explained as an additive composition of social or subjective characteristics on one side and characteristics of the object on the other side[10].

[8] The Methodical Constructivism is a scientific and theoretical position elaborated by WILHELM KAMLAH and PAUL LORENZEN in the 1970's. It's beginnings have their roots with EDMUND HUSSERL. "Logische Propädeutik. Vorschule des vernünftigen Redens" is usually taken as its modern starting point. A complete overview of further developments is given by the four volumes of "Enzyklopädie Philosophie und Wissenschaftstheorie", by JÜRGEN MITTELSTRASS published between 1980 and 1996.

[9] See also HEINZ VON FOERSTER'S review (1969) of SPENCER BROWN (1969).

[10] See also KROPE and WOLZE (2005) for a comparison.

5. From the Everyday Paradigm to the Scientific Paradigm of Physics

Using the example of the qualitative basis of the physical paradigm of classical particle mechanics we will now sketch out how the foundation of a theory consists in the complementarity of explanation and description[11]. To this end we will first sketch a few broad outlines of the everyday world a priori. In this case we are dealing with the everyday world paradigm of the material movement procedures. This paradigm is drawn from an analysis of international and of own empirical investigations.

5.1 Characteristics of the Everyday A Priori

Dynamic Terminology

Force is a general cause of effecting change (causa efficiens). Bodies may possess force, exercise force, be subject to force, dissipate force, and transmit force. Energy, impulse and force are not differentiated, but rather seen as different manifestations of the causa efficiens. The particular force entities can be categorically differentiated. Force is seen as a property (potential), as a relationship and as a sort of substance, which can be transferred, stored, and dissipated.

Definitions

K is an active body if and only if K possesses force.

K is a passive body if and only if K is not an active body.

Principles of Motion

Active-passive Principle: An active body possesses the potential to exercise a force on other bodies. A passive body possesses the potential to oppose resistance against other bodies.

Principle of Movement: A body moves if and only if the force exercised upon it is greater than the opposed resistance against the body. The direction of movement is the same as the direction of the resulting force. The resulting force is a sum of the external and internal (stored) forces.

Principle of Dissipation (two versions):

a) A stored force is dissipated through the process of overcoming resistance.

b) A stored force is dissipated through the transference of force.

Principle of Storage: A body in motion possesses force which is proportional to its mass and its velocity.

General Principles of Contextualisation

Principle of Causality: Every change has a cause.

Goal-cause Principle: Motion possesses a (human or technical) cause and a goal.

Because of the reference of knowledge in the everyday world to the subject (systematisation with respect to the subject as opposed to the systematisation in science which is with respect to the object) this context is a synthesis composed of causal relationships and goal/aim oriented action. This turns to a meaning constitutive unit, which can be transferred to other contexts, for example technical ones. This is illustrated by the following example.

[11] This sketch is based on the detailed presentation in KROPE and WOLZE (2005).

A cyclist is travelling over a mountain. The cyclist (muscle) possesses force (force in this case is a property), and can exercise it on the bicycle, and through the bicycle on the road on which it rests (in this case force is a relation). Headwind and gravity offer resistance, and hinder the realisation of the goal. Tailwind is a force. Going downhill, gravity is a force, the bicycle and cyclist store force with gathering speed which are dissipated in travelling over flat and uphill stretches of road (in this case force is a sort of substance). System descriptions of this sort contain at least implicit contradictions, for instance anomalies, which in principle can result in the development of new knowledge.

5.2 The Construction of New Knowledge

5.2.1 On explanatory phenomena

The explicit differentiation of the causal principle and the goal-cause principle reveals an anomaly:

- There are various different incompatible terms for force or predications present,
- the terms (predicators) *force* and *resistance* are used in a manner specific to the situation,
- it is not clear in the various different contexts what the cause is. Which is the cause, the property of possessing force or the relationship of exercising force?
- the term *effect* is not explicit.

Explication of the everyday world a priori:

- The situation specific use of the terms *force* and *resistance* (changing the everyday world systematisation with respect to the subject to the systematisation usual in science which is with respect to the object),
- retention of the relational term *force*, the causal principle, and the goal-cause principle,
- elimination of other expressions for force and thereby the principles of movement, dissipation, and storage, as well as the active-passive principle,
- further explication in context including the repercussions of the development of the scientific paradigm (if any).

5.2.2 First Step in Development: The Construction of Novelty

Novelty is a preconstitution of a new reality. To the extent that it is a preconstitution, new knowledge produces a distinction, which however is from an empirical point of view still open. As an integration of available elements, novelty is a more complex idea, which recalls the terms *distinction* and *context* as they are used by GREGORY BATESON (1982). The performance of a distinction implies for BATESON the construction of a distinction[12]. This takes place with the new integration of the available elements. In this case we obtain with both available predicates (elements):

(1) Body K_1 exercises a force on body K_2 over a time τ. Abbreviation: F (K_1, K_2; τ),

(2) The motion of K_2 changes during time τ. Abbreviation: VM (K_2, τ) (variation of motion)

New interpretation: F (K_1, K_2; τ) $\leftrightarrow$ VM (K_2, τ).

[12] Compare also KROHN and KÜPPERS (1989, 52 et seqq.)

With the new integration of the available predicates "…exercises force on …over…" and "…changes the motion of during…" the meaning of these predicates changes however. The new elementary fundamental laws thus acquired reveals an essential constitutive moment in the formation of knowledge, although this knowledge still remains at this stage extremely abstract. Its concretisation begins with the completion of the explanation of the anomaly, with which the construction of novelty began. The meanings of both predicates develop themselves thereby in the context of their dependence on one another. This is a moment of validity in the formation of knowledge. Independent predications using "F (K_1, K_2; τ)" and "VM (K_2, τ)" are therefore not possible.

5.2.3 Second Step in Development: Description of Old Applications

The construction of knowledge in the context of explanation determines possibilities of descriptions through the application of the fundamental law. For their further development and the precision-bringing feedback which refers to knowledge derived from the everyday world, the description of older applications is available (for example: collision processes, mountain biking). The difference between older and newer descriptions also produces moments of enlightenment with respect to their reality status.

Result of the descriptions:

- Resistances create changes in motion, they are according to the fundamental law forces; in the everyday world they manifest themselves as resistance-forces (compare causal principle, goal-cause principal);
- If K_1 exercises a force to K_2 over a time τ, then the inverse also exercises, since K_1 too experiences a change in motion: F (K_1, K_2; τ) $\leftrightarrow$ F (K_2, K_1; τ);
- Changes in the motion are the increase and decrease of velocity as well as changes in directions (otherwise an inconsistency arises);
- Anomaly: The exercise of the same force by K_1 on various different bodies K_n (for example collision) creates changes in motion of different magnitudes, which is a contradiction of the causal principle (same cause same effect).

With this last result a new context for explanation reveals itself with a concretising reality constituting moment. The closing of the gap in knowledge leads to the term *mass*. Here too the explanatory phase conditions once again a descriptive phase with a moment of validity in the formation of knowledge.

6. Conclusion

The preceding treatments of the way in which scientific theories may be constructed are based on the fundamental ideas of the Methodical Constructivism. According to this paradigm science is, like all thinking "a highly stylised version of what one already does in practical life" (LORENZEN 1974, 26; originally German). Scientific theories do not organise and explain the facts of the everyday world, but they organise and explain rather scientific experience. Therefore an analysis of this scientific experience is necessary. A beginning to this analysis has been made by the present contribution.

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