Discussion Paper

Pforzheim University
of Applied Sciences

Rainer Willi Maurer[1)] June 2004

Falsification of Theories without Verification of Basic Statements – An Argument for the Possibility of Knowledge Growth

Abstract: *Karl Popper rightly contests the possibility of a verification of basic statements. At the same time he strictly believes in the possibility of growth of empirical knowledge. Knowledge growth, however, is only possible if empirical theories can be falsified. This raises the question, how theories can be falsified, if a verification of those statements that falsify theories – i.e. basic statements – is not possible. This problem is often referred to as the "basic problem" or "problem of the empirical basis". In this paper I show that – from a logical point of view – a falsification of theories is possible without a verification of basic statements. Furthermore I show that knowledge growth in the empirical sciences will be possible if two assumptions are valid. These assumptions can neither be proven nor falsified. However, they have to be postulated by everybody in everyday life.*

[1] Pforzheim University of Applied Sciences, Tiefenbronner Str. 65, D-75175 Pforzheim, Germany, rainer.maurer@fh-pforzheim.de. This paper is a summary of appendix 3 of Rainer Maurer (2004), Zwischen Erkenntnisinteresse und Handlungsbedarf – eine Einführung in die methodologischen Probleme der Wirtschaftswissenschaft, Metropolis-Verlag, Marburg.

1. The rise of the basic problem

Karl Popper contests the possibility of a verification of “basic statements”. “Basic statements” are “singular statements”, i.e. statements that relate an event with a certain spatio-temporal position.[2] An example for such a basic statement is “At the spatio-temporal position (w, x, y, z) a black swan exists”.[3] Popper argues that all such basic statements include abstract terms (“universals”), which include characteristics (“dispositions”) which transcend all observations. He illustrates this argument with the following example:

„Admittedly, if we say ‘All swans are white’, then the whiteness we predicate is an observable property; and to this extent, a singular statement such as ‘This swan here is white’ may be said to be based on observation. Yet it transcends experience – not because of the word ‘white’, but because of the word ‘swan’. For by calling something a ‘swan’, we attribute to it properties which go far beyond mere observation (…). Thus not only the more abstract explanatory theories transcend experience, but even the most ordinary singular statements. For even ordinary singular statements are always *interpretations of ‘the facts’ in the light of theories*. (And the same holds even for ‘the facts’ of the case. They contain *universals*; and universals always entail a *law-like* behaviour.)” [4]

Since at least one basic statement that contradicts at least one empirical hypothesis[5] derived form an empirical theory is necessary to falsify this theory, the

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[2] Synonymous expressions for „basic statement“ are „elementary statements“ (Reininger (1931), Metaphysik der Wirklichkeit, p. 134) and „protocol sentence“ (Neurath (1932), Soziologie, in Erkenntnis 2, p. 393).

[3] In this basic statement the “event” is the “existence of a black swan”.

[4] Popper (1980), The Logic of Scientific Discovery, p. 423. Italics set by Popper.

[5] “Empirical hypotheses” are “strictly universal statements”, i.e. statements that relate an event to an unlimited number of spatio-temporal positions. An example for a strictly universal statement is the statement “All swans are white”, which is equivalent to “No matter what spatio-temporal positions you check, you will never find a swan that is not white”. A Strictly universal statement is falsified by a basic statement which states the existence of an event, that is “forbidden” by the strictly universal statement. For example, if we are sure that the basic statement “At the spatio-temporal position (w, x, y, z) a black swan exists” is true, this will clearly falsify the strictly universal statement “All swans are white”. From the point of view of an empirical science, whose aim it is to evaluate empirical theories, falsifiability is a great advantage of strictly universal statements. Because there exists a law of logic (the so called “modus tollens”: $[[t \Rightarrow h_i] \wedge \bar{h}_j] \Rightarrow \bar{t}$]), which implies that the falseness of a statement always implies the falseness of at least one the axioms from which a statement is logically de-

impossibility of a verification of basic statements *seems* to imply the impossibility of a falsification of an empirical theory. If however a falsification of empirical theories is not possible then by Humes' problem of induction[6] (which excludes the possibility of a verification of empirical theories) an evaluation of empirical theories will not be possible: Without the possibility of either falsification or verification of empirical theories it is not possible to determine whether theory A is better than theory B. Consequently, in this case a substitution of an empirical theory that contains a more falsified empirical hypotheses by an empirical theory that contains less (or no) falsified empirical hypotheses – i.e. a growth of empirical knowledge – is not be possible.

Popper proposes a conventionalist solution to this problem: He states that basic statements – even so they cannot be verified – are "inter-subjectively testable". With relation to his example this means: It is not possible to verify that the organism at a certain spatio-temporal position is actually a "swan". However it is possible to test, whether the organism displays certain characteristics, which are typical for the universal called "swan". For example, it is possible to test, whether the organism displays the swan-specific relation between body-length, whether beak and feet display the swan-specific form, whether the organism

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rived. Consequently, if a basic statement falsifies a strictly universal statement that is logically derived from a set of axioms of a certain theory, the theory itself is falsified – since at least one of its axioms must be false. So, in this case, the evaluation of the theory has led to a clear cut result: the theory is false. To show that an empirical theory is false is the only way to evaluate an empirical theory, because Humes' problem of induction (see footnote 6) excludes the possibility to prove that an empirical theory is true (Popper (1980), The Logic of Scientific Discovery, p. 27 f.).

[6] Following Humes' problem of induction, even if a verification of basic statements were possible, it would not be possible to verify an empirical theory (Hume (1992), Treatise of Human Nature, p.90 f. and p. 138 f.). A simple proof of this (i.e. for the impossibility of induction) is given in the following: (1.) Assume an empirical hypothesis H_A derived from theory A is not falsified by empirical observations. (2.) Assume a second theory B, from which two hypotheses, H_{B1} and H_{B2} can be logically derived. (3.) Assume that hypothesis H_{B1} is identical to hypothesis H_A, while hypothesis H_{B2} cannot be derived from theory A. (4.) Furthermore, assume hypothesis that H_{B2} is not falsified by empirical observations (and thereby falsifies theory A). The logical consistency of these four assumptions implies the *impossibility* of a verification of theory A by the fact that hypothesis H_A is not falsified by empirical observations. Since, however, in every *infinite* universe (i.e. a universe that can not be completely described by a finite amount of observations) it is not possible to exclude the possibility that for each theory, whose empirical hypotheses are not falsified by observations at date t, at least one other theory may be found at date t+x, which implies all the empirical hypotheses of the former theory plus additional (new) hypotheses, which are not falsified by observations (and hence imply a falsification of the old theory), it is in general not possible to verify a theory, whose empirical hypotheses are not falsified by observations at a certain point in time t.

posses a plumage and so on. The problem with these kinds of tests, so Popper, is that they can be infinitely continued. For, each of these characteristics (dispositions) can be disaggregated into further characteristics: In order to test, whether the organism possesses a plumage, it is necessary to check for the typical characteristics of plumes. This includes the typical density of a plumage as well as its structure and substance, which e.g. consists of beta keratin. Beta keratin can be analyzed whether it displays the typical chemical composition of beta keratin, which consists e.g. of a share of 25% of cystine in its amino acids. Cystine in turn can be analyzed whether its molecular composition consists of two molecules cysteine. These molecules again can be analyzed concerning their atomic composition etc.

Following Popper it is possible to disaggregate the basic statement “At the spatio-temporal position (w, x, y, z) a black swan exists” in an infinite class of further basic statements. This “infinite regress” is a logical necessity according to Popper. It is what he means with his assertion that all basic statements “transcend” experience.

The only way out of this infinite regress is, according to Popper, “abort of testing”. At what stage of testing the abort has to take place is determined by agreement between the observers: “Basic statements are accepted as the result of a decision or agreement; and to that extent they are conventions.”[7] The “observers” are the members of the scientific community, which is concerned by the “agreement”. Popper writes on the possibility to come to an agreement in such a community (whose function he compares with that of a classical “trial by jury”):

„It is fairly easy to see that we arrive this way at a procedure according to which we stop only at a kind of statement that is especially easy to test. For it means that we are stopping at statements about whose acceptance or rejection the various observers are likely to reach agreement. And if they do not agree, they will simply continue with the tests, or else start them all over again. If this too

[7] Popper, ibid, p. 106.

leads to no result, then we might say that the statements in question were not inter-subjectively testable, or that we were not, after all, dealing with observable events. If some day it should no longer be possible for scientific observers to reach agreement about basic statements this would amount to a failure of language as a means of universal communication. It would amount to a new "Babel of Tongues": scientific discovery would be reduced to absurdity. In this new Babel, the soaring edifice of science would soon lie in ruins."[8]

Popper's conventionalist solution of the basic problem has the consequence that the acceptance of basic statements is the decision of a certain scientific community, living in a certain historic situation. Ideally this community draws its decision on the basis of rational arguments. However, it is of course possible that this community practises some kind of dogmatic or biased behaviour. In this case the acceptance of a basic statement (and probably the falsification of a new theory) would be false. Therefore Popper points out that the acceptance of a basic statement does not imply the establishment of an ultimate dogma:

"The basic statements at which we stop, which we decide to accept as satisfactory, and as sufficiently tested, have admittedly the character of dogmas, but only in so far as we may desist from justifying them by further arguments (or by further tests). But this kind of dogmatism is innocuous since, should the need arise, these statements can easily be tested further."[9]

According to Popper, the acceptance of a basic statement by a scientific community has not to be ultimate. In a sense, this "weakens" the problem resulting from dogmatic or biased behaviour of scientific communities. It has however the consequence that theories can never be falsified with certainty: if the acceptance of basic statements is always preliminary, then of course the falsification of theories will be preliminary too. If however a falsification of theories is not possible, then a growth of empirical knowledge will not be possible too. This problem is often referred to as the "basic problem" or the "problem of the empirical basis".

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[8] Popper, ibid, p. 106.

The basic problem arises because Popper assigns universals a kind of autonomous character. Universals like “swan”, “glass” or “water” are “interpretations of ‘the facts’ in the light of theories”[10], but the question, where the theories which interpret the facts come from, is left open by Popper. From a logical point of view this is the reason, why a certain scientific community has to interpret the facts and decide over the acceptance of a basic statement.

2. The disappearance of the basic problem

However, the basic problem will disappear, if we consider the fact that the universal “swan” has to be (either implicitly or explicitly) defined within a theory from which the empirical hypothesis “All swans are white” follows. If it were not possible to find the definition of the universal “swan” within this theory, it would not be clear what the empirical hypothesis “All swans are white” really means. A theory that does not define the universals that are used by the theory cannot be falsified – its empirical content is zero. Therefore, the “burden of definition” has to be carried by the theory itself – and not by a scientific community or a somehow chosen “club of experts”.

However, how is it possible to decide, whether the definitions of universals given by the theory actually refer to something we usually call “reality”? Is it not necessary to have a “club of experts” to draw at least this very important decision? I will argue in the following that it is not necessary. In order to do so, I will decompose the problem into two sub-problems:

- First, how is it possible to prevent the infinite regress which is according to Popper implied by the definition of universals?

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[9] Popper, ibid, p. 105.
[10] Popper, ibid, p. 423.

- Second, which minimal assumptions are necessary and sufficient to make sure that the observations of a human being refer to something that actually exists in reality?

As it will turn out, the answer to the first question can be given on the basis of simple examples. The answer to the second question will show that only two assumptions are necessary to make sure that the observations of a human being refer to something that actually exists. These assumptions can neither be verified nor falsified, but everybody human being has to make these assumptions in his everyday life in order to survive. Furthermore, the alternatives to these assumptions can also neither be verified nor falsified.

2.1. The avoidance of an infinite regress

To the first question: How is it possible to prevent the infinite regress which is according to Popper implied by the definition of universals? An infinite regress will only evolve if universals are not defined by the theories under test. Popper's implicit assumption is that they exist somehow "outside" of theories. In this point Popper is vague, because he nevertheless claims that universals are "interpretations of 'the facts' in the light of theories"[11]. The question is, what theories? If it is not clear by what theories universals are defined by, it seems to be possible to disaggregate them into an endless chain (swan → plumage → beta keratin → cystine → cysteine → …). If however the definition of universals belongs to the theory under test, then each such chain must necessarily come to an end. This point is indeed rather trivial: A well defined theory has always a closed form, i.e. it does not contain infinite chains of definitions for universals.

It is important to see that this does not imply a somehow "arbitrary" interruption of a chain of definitions: Beside the possibility to define universals by disaggregation into "subordinate" universals ("vertical definition"), there exists the possibility to define universals by "interaction" ("horizontal definition"). For example, to define a certain chemical element it is not necessary to disaggregate it into its

[11] Popper, ibid, p. 423.

specific composition of subordinate universals like electron, proton and neutron. In many cases it is possible to identify a chemical element by its interaction with other chemical elements. And indeed, many practised chemical identification procedures are based on this kind “identification by interaction”. The following example shows that such a “horizontal definition” by interaction is unanimously possible from the logical point of view:

Consider a chemical theory which implies the empirical hypothesis that an alloy of substance A, substance B and substance C results in the chemical element “gold”. To be testable, i.e. to contain “empirical content”, the theory must define the universals substance A, substance B, substance C and gold. Let us assume that the theory implies that these substances are the only one in the universe with the following colour reactions: substance A alloyed with substance B results in a substance with the colour blue, substance B alloyed with substance C results in a substance with the colour red, substance A alloyed with substance C results in a substance with the colour green and that gold displays the colour yellow. If the theory implies these colour reactions, then the three substances A, B, C can be unanimously defined by their interactions: If one alloys two substances and the result is a substance with the colour blue, then one of these two substances must be substance A and the other must be substance B. Consequently, if one alloys one of the two substances with another substance (which has not to be identified yet) and a substance with the colour green results, then this one substance must be substance A. By this result the substances B and C are simultaneously identified too.

This simple example shows that it is logically possible that the three substances unanimously identify themselves by their interactions. However this means that – from a logical point of view – the definition of universals does not necessarily result in an infinite regress.

Based on this identification it is now possible to test the empirical hypothesis that an alloy of substance A, substance B and substance C results in the chemical element “gold”. If the test shows that an alloy of substances A, B and C displays the colour “yellow”, then the theory is (by Humes’ induction problem)

not verified but corroborated. It is important to see that the fact that the theory itself is not verified also implies that the basic statement, namely the description of the result of the experiment ("At a certain spatio-temporal position in laboratory w,x,y at point in time z, an alloy of substance A, B and C yields gold"), is not verified, since substance A, B and C are identified under the assumption that the theory is true. However, from the logical point of view this is no problem, if and only if we do *not* claim that the basic statement verifies the theory.

If the test shows that the resulting alloy is not gold, then the theory is unanimously falsified. In this case it is of course not possible to state that the three identified substances are actually substance A, B and C, because this identification was only possible under the assumption that the theory is true. All we can say is that, if we use the theory to interpret our observations (i.e. identify substances A, B, C on the basis of their interactions), these observations contradict an empirical hypothesis derived from the theory. In other words, the theory "leads to observations that contradict the theory". Consequently, the theory must contain a contradiction. Consequently, the theory must be wrong. This clearly shows that *it is possible to falsify a theory without a verification of basic statements*.

The example shows that in order to falsify a theory it is *not* necessary to have an *unconditional basic statement* of the type "At the spatio-temporal position (w, x, y, z) a black swan exists", but simply a *conditional basic statement* of the following type: "If we interpret our observations at the spatio-temporal position (w, x, y, z) on the basis of theory T_0, we come to the conclusion that a black swan exists there". Consequently, to falsify a theory it is not necessary to verify an *independent basic statement* (which can be verified independently from a theory), but only to verify a conditional basic statement (which can be called "verified" only if the assumption is made that the theory is verified.).

The principle (and the logic behind the principle) to interpret our observations (or "raw data") on the basis of the hypothesis that the theory is true (null hypothesis) and then test the theory on the basis of these observations is the standard approach of classical statistics (as opposed to Bayesian statistics). In

many cases this can imply a bias in favour of the acceptance of the null hypothesis. A point typically criticised by Baysians. But the Baysian proposal to substitute this objective bias by the subjective bias of the researcher is not a serious alternative. *First*, there are many cases where we can falsify the null hypothesis in spite of this bias. *Second*, if we think that a theory is false in spite of the fact that it is not falsified by empirical tests, we can construct a competing theory and test both theories against each other.

2.2. Metaphysical assumptions necessary and sufficient to make empirical theories falsifiable

To the second question: which minimal assumptions are necessary and sufficient to make sure that the observations of human beings refer to something that actually exists in reality?

First we have to assume that a reality which is independent of our conscience does exist (in the following "assumption of an autonomous reality"). This is the basic assumption of realism as opposed to all forms of idealism, which more or less explicitly state the contrary. The assumption of an autonomous reality is a synthetic statement[12] that can neither verified nor falsified. It cannot be verified because by Humes' induction problem, no synthetic statement can be verified. It cannot be falsified, because each falsifying basic statement could be interpreted as an indication for a kind of "higher order" realism.[13] Therefore, the basic assumption of realism has not the status of a scientific hypothesis but of a metaphysical hypothesis.

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[12] In terms of Leibniz, Gottfried Wilhelm (2000); Neue Abhandlungen über den menschlichen Verstand, Digitale Bibliothek Vol. 2: Philosophie, p. 18619 (Concordance: Leibniz-Abh., p. 266), Direktmedia Publishing, Berlin.

[13] Each attempt to construct an example to prove the falsifiabilty of the basic assumption of realism regularly fails: One can for example argue that the hypothesis is falsified, if one makes the observation that reality changes according to our conscience. One such example could be a tree becoming a house if our conscience imagines the tree to be a house. However in this case one could defend the basic assumption of realism by claiming that in real reality there is no real difference between a tree and a house and so on. Popper (1972), Objective Knowledge, footnote 7, presents a similar example from the Austrian writer Marie von Eber-Eschenbach. Another, somewhat more sophisticated way to defend the basic assumption of realism against each trial of falsification, is the hint to the fact that our observation of reality can change, if we use another theory to interpret our senses data. So our observation of reality can change even in the case that reality has not changed.

Second we have to assume that our senses apparatus is able to observe some appearances that really exist in this autonomous reality (version 1). Since this seems to be a far reaching assumption, it is important to note that it is equivalent with the assumption that the autonomous reality is not a "foolproof paradise" (version 2). If an autonomous reality exists and has *not* the character of a foolproof paradise human beings (as well as other organisms) *could not survive* in this reality without their senses apparatus providing them at least a certain minimum degree of reliable information about reality.

Of course, the second assumption too (no matter what version) can neither be verified nor falsified. It cannot be verified because by Humes' induction problem, no synthetic statement can be verified. It cannot be falsified, because any falsifying basic statement would discredit the reliability of our senses apparatus and hence the reliability of the basic statement itself. Therefore this assumption too has not the status of a scientific hypothesis but of a metaphysical hypothesis.

It is also important to see that the second assumption does not mean that our senses apparatus is able to recognize the "true" or "absolute" reality "itself" or the like essentialist pretensions.[14] As the above example of a falsifiable chemical theory shows, it must only be able to correctly distinguish *differences* between appearances in reality.

In order to correctly distinguish *differences* between appearances in reality, our senses apparatus must have built-in theories about reality: To distinguish between different colours, it must have a built-in theory about certain aspects of the frequency spectrum of light; to distinguish between different levels of noise, it must have a built-in theory about certain aspects of the frequency spectrum of sonic waves and so on. These theories are built-in our "hardware" (e.g. the eyes and ears) and our "software" (i.e. the neural network that forms our conscience).

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[14] This is an important differentiation: It is logically possible that our senses apparatus correctly detects certain aspects of reality without detecting the "absolute" or "true" nature of reality. This important differentiation is completely ignored by fashionable varieties of idealism as Luhmann (1995), Social Systems, or Rorty (1999), Truth and Progress.

They have *not* to be “true” in the sense that they must correctly explain the “true nature” of light or sonic waves or whatever. However they must possess a degree of empirical corroboration high enough to correctly detect certain differences that exist between these appearances – at least on an ordinal scale.[15] If our built-in theories had not this minimum degree of empirical corroboration, we could not survive in an autonomous reality, which is not a foolproof paradise.

How do these built-in theories relate to the theories, which (like the above chemical theory) we invent and whose empirical hypotheses we test by our observations? It is clear that only those hypotheses are testable that relate to appearances in reality which the built-in theories of our senses apparatus are able to distinguish. This sounds more complicated than it is: For example in order to test the above chemical theory by our observations, we must be able to derive from this theory definitions of its universals, which make these universals observable. A theory from which we cannot derive observable definitions of its universals can not be empirically tested.

This does however not necessarily imply that we can only test an empirical theory, which relates to appearances of reality *directly* observable by our senses apparatus. It is sufficient that it is possible to derive from the theory construction plans for devices that transfer events in spheres of reality *not directly* observable (e.g. the spheres of particle physics or cosmology) to spheres of reality observable by our senses apparatus (typically our visual sense). Examples for such devices are particle accelerators (particle physics) and x-ray telescopes (cosmology).

The two minimal assumptions, which are necessary and sufficient to make sure that human observations refer to something that actually exists in reality, can both neither be verified nor falsified. Consequently, it is logically possible to assume the contrary. This assumption is made by the various variants of the idealist doctrine. However it is important to recognize that this assumption too can neither be verified nor falsified.

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[15] The emergence of organisms with well corroborated built-in theories can be explained by

Despite of this logical “standoff” there is a pragmatic argument in favour of the realist position: In everyday life everybody – even an idealist – acts as if he holds both realist assumptions to be true. Stated in another way: it would be very dangerous to cross a busy street based on the idealist doctrine. Therefore, crossing a busy street most idealists behave like realists. This explains also, why *consequent* idealists are so hard to find: they typically grow not very old. In this sense, a realist can practise his believe, while for an idealist it is suicidal to practise his believe.

Darwinian evolutionary theory.