WARSAW SCHOOL OF ECONOMICS

METHODOLOGY

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FOREWORD

Considerations contained in this part of the course book belong to the area of general methodology of science and philosophy of science. Their intention is to put a bridge between the epistemological considerations included in the first part of the course book and the methodology of economic sciences/detailed methodology of the research work, delivered in the other courses, to precede them with a more general background in the form of universally applied rules of scientific conduct and to introduce fundamental mechanisms of the development of science. Methodological issues and those adequate for the philosophy of science will merge here – both fields complement each other, though they also differ essentially: whereas methodology develops methods of realization of the accepted theory of the scientific knowledge, the philosophy of science subdues this model (and the methods of its accomplishment) to critical reflection based mainly on the epistemological arguments.

The term "method" comes from the Greek word meaning 'a way' (which is to say – the way leading towards the destination of a journey); since the method is – generally speaking – the well-thought-out in advance and consciously applied way of conduct that allows achieving intended aim.

The method should not be equated with *ability*, since each method of conduct can be used either competently or incompetently. The ability is always somebody's skill, whereas the method does not contain this subjective reference, it is impersonal (due to which possible is science about the method – methodology). On the other hand it should not be equated with an *algorithm* of conduct, as the algorithm always allows achieving the assumed effect, whereas the method does not, especially when it regulates an activity of the creative nature, which is characteristic of the cognitive activity.

The *scientific* method is a collection of measures aiming at the most effective realization of cognitive values. These measures include: correct *ways of terms moulding (*logical division, defining), *analysis* (breaking down the problems, situations or objects into some kind of "constituent parts" and studying their mutual relationships), *reduction* (an attempt at the cognitively lossless elimination of some entities for the sake of the others, more fundamental ones), *analogy* (reasoning, on the basis of the partly ascertained similarity of various systems, about further similarities among them), *idealization* (constructing and studying simplified models of certain phenomena or processes), *criticism* (revealing the ulterior assumptions of certain arguments in order to assess their validity, programmatic seeking the weak points in the proposed theories – not excluding one's own – submitting the results of research to the public discussion, etc.

When speaking of a method, we assume implicitly the *rational* conduct is concerned. Let us therefore proceed to the characterization of rationality.

CHAPTER ONE

Rationality

In the preceding booklet we tried to characterize man from the point of view of cognitive activity. We have therefore taken into account from the field of the humana *consciousness* and *intellect* only. The humana is not, however, merely a cognitive tool, it is first of all an organ of action, of practical life. Attaining cognition is not, then, an end in and of itself, though it often has intrinsic value. People engage in cognitive activity in order to achieve their goals, to act effectively. Therefore, once the cognitive interpretation of representations is done, it is next necessary to *weigh* them, i.e. to appraise them in terms of their importance and relevance to one's own goals, particular situation, affirmed values.

Humana has two instances with such a function: the *soul* (a human analogue to anima's vital subsystem[1]) – an organ of spontaneous (as opposed to reflective) and non-sensuous feeling and evaluating, and the *reason* (without any analogue in the animal kingdom) – the ability to freely and deliberately decide on the basis of prior understanding.[2] Due to the ability to perform such understanding-based evaluative acts, their subject, taken along with his/her beliefs, constitutes a *person* – a selfdependent (or autonomous) spiritual being. The notion of a person is not, then, to be understood as the notion equivalent to either a human being, or even to a conscious being. In order to become a person, a self-aware human being must first develop the ability to motivate himself through certain supra-

[1] The main difference between humana and anima in this respect is that whereas anima's vital subsystem weighs representations by referring them to the current state of biological drives, the soul does this by referring to the acknowledged needs and interests, represented by ideas and beliefs which a given individual regards as important/good/beneficial for him and his loved ones. These interests are to be understood broadly as all the perceived/imagined gains, whether relating to material goods, to social status (e.g. prestige, power) or – for those possessing religious beliefs – to the eschatological realm (e.g. salvation or rewards in the next life).

[2] These acts include decision-making, choosing from among known alternatives, setting goals and initiating acts to achieve them.

sensory (= spiritual) ideas – mainly those concerning values. Only by relying on the spiritual can a person free himself from the pressure of animal drives, thus achieving autonomy as a spiritual being.

Expressive phenomena

Let us try to characterize this new, non-cognitive aspect of the humana somewhat more systematically.

Within the framework of spiritual domain two classes of elements should be distinguished: 1. object-directed *ideas* (= cognitive phenomena) and 2. purely subjective *expressions* (= expressive phenomena). Ideas include perceptions, images, concepts, as well as judgments founded on them. Their characteristic feature is that they are not relevant in themselves but only in their function of representing something, or referring to something. In a word, they are all signs and thus have certain meaning (informative contents). Expressive phenomena, on the other hand, such as acts, attitudes, emotions, volitions, etc. do not have the nature of signs, they do not by themselves "stand for" anything – they are just what they are. Well, they also have as a rule some kind of "directedness" – e.g. the feeling of gratitude may be directed at someone who made us happy – but this is due to the fact that expressive phenomena assume prior existence of some ideas and it is only through them that they secondarily acquire their directedness. One cannot, for instance, simply *want*: one must essentially want *something* which has already been present somehow – in thought or imagination – independently of the act of will and before it.[3] With an act of will we do not, after all, bring an object into existence but we simply want it. Expressive phenomena are, therefore, phenomena dependent on cognitive phenomena.[4]

Because expressive phenomena are not signs of some other reality, they have no meaning (i.e. intension), but they may have *sense*.[5] (As we are talking about expressions, we will call this the *expressive* sense, to be distinguished from the *objectual* one, i.e. from an intensional object of appropriate sign). Recall that we have defined sense – conceived as the determination principle of the whole spiritual domain – as a conjectured (by some subject) ontic ground of something accessible ("given") to the subject, which he treats as not selfdependent, i.e. as dependent (in its "being something determinate") on something else. Now, expressive phenomena are just such entities, for we can legitimately ask why they are like they are and no other – e.g. why we *desire*

[3] This "directedness," constitutive for all spiritual acts, is called intentionality.

[4] There is a similar pattern at work the other way round – more about this shortly.

[5] So far, we have linked the category of sense only to signs (via their meaning), i.e. to semiotic situations. It is a more universal category, however, applicable to everything depending on some spiritual phenomena. Utilitarian activities, for instance, such as painting one's flat or sowing seeds, may have sense, although they have no meaning, because activities in general are not signs (unless they are symbolic).

one thing and not another. They, therefore, may have sense, i.e. appropriate hypothetical grounding.

Recall that the relation of grounding is transitive; therefore we can always continue to ask for ever more deep (i.e. more selfdependent) grounding, until we reach something which is the ultimate ground. Generally speaking, the immediate sense of some activity is the *intention* of its subject, the sense of this intention in turn is the *aim* he wants to achieve, and the sense of any aim will be a certain value which he wishes to realize with the help of the achievement of the aim.[6]

Here is a more specific example. Let us say we see someone running. We can observe, therefore, the performance of a certain visible *physical* activity (it is what is "given" to us). To determine this activity more closely, i.e. to understand it as the activity of a *person*, we should put a hypothesis about the person's motivation or intention, for it is that which supposedly led him to move his muscles. Thus, we treat the activity as dependent on something else. It is legitimate, then, to ask about its own sense. Depending on the answer we can interpret the run e.g. as *jogging*, *pursuit* after something or *flight*. That is not all, though, for we may ask why it is this conjectured motivation and not another behind this activity. The answer requires reference to the aim the subject hopes to achieve, for we assume that we are dealing with purposeful activity. (Please note that the aim is not the same as the intention, for it is an imagined or future state, while intentions exist here and now. On the other hand, intentions are inner mental states, while aims are external to the mind). Lastly, we can ask why the subject wants to achieve this supposed aim, i.e. – what the aim's sense (ontic ground) is. And to this question the legitimate answer will, as a rule, refer to some value the agent wishes to realise.

Both objectual and expressive senses are grasped by means of *understanding* – an exclusively spiritual faculty.

It is an attitude to grasp full – i.e. objectual as well as expressive – sense, which distinguishes *hermeneutics* from *semantics*. Hermeneutics is the art of understanding both signs and expressive phenomena that one can find in (or "behind") various "texts." If for example we were to read the line that "dwarves exist in this world," in order to adequately understand the line we would have to realize that the author's intention was to tell a fairy tale. Similarly, when someone tells a joke or makes use of irony, the sense of his words differs from what they designate, since the attitude of the author of the utterance has also to be taken into account – if one treats an ironic or joking utterance exclusively literally, we can say that he did not grasp its sense.

Bearing in mind that each idea is the intension of a certain sign, the relations of ideas may be called *meaningful relations*, whereas relations between

[6] Values can, therefore, be defined as ones which constitute the ultimate ground of expressive phenomena.

expressive phenomena (e.g. between an emotion and an act of will) and relations between an expressive phenomenon and an idea may be called *sense relations*. The meaningful relations are subordinated to – or governed by – *principles of logic*, broadly understood.[7] Contrarily, what enables us to properly link cognitive elements with expressive ones, is just our ability to grasp (or establish) sense relations,[8] governed in turn by *principles of rationality* (having – as we will soon see – the form of "extremum" principles).[9] And just as some combinations of ideas – e.g. "round-square" or "wooden-iron" are not meaningful (and thus illogical), some combinations of ideas and expressions (e.g. striving to construct perpetuum mobile) may be senseless (and thus irrational).

The concept of rationality

The everyday notion of rationality – one linking it to the faculty of reason – is too narrow as it treats emotions, for example, as by definition irrational, whereas fear, joy and the like are themselves neither rational nor irrational. Fear can, in the right circumstances and for the right reasons, be considered completely rational.

The point is that the idea of rationality does not apply to separate items of the spiritual domain, but to *relations* among them.

The Latin "ratio," of which the word "rationality" is a derivative, has many meanings, not all associated with reason (as suggests it's another derivative – rationalism). "Ratio" means also an attitude towards something, a relationship, a proportion. With such proviso, *ratio*nality would require a suitable relation between certain entities to occur – they should be adequate or proportional one to another.

The entities we are talking about are those which may constitute a sense relation, i.e. the cognitive elements on the one hand, and the expressive elements on the other. In other words, the essence of rationality consists in appropriate linkage of cognitive and expressive phenomena within our minds. They should fit. If they do, we get a sense relation. What is at stake in rationality, then, is sense relations. And whether in a particular case such relations of sense obtain

[7] We said "broadly understood" because logic in a "narrow" (or strict) sense 1. concerns not the mental states, but their linguistic expressions, 2. deals with meaningful relations generated by a very limited class of such expressions, namely logical connectives, quantifiers and functors, i.e. by logical *constants* which must always be explicitly specified, whereas names, predicates and sentences appear in logic as unspecified *variables*, which can freely be substituted with any other linguistic expression of the same category. More on this matter later.

[8] These can be connections between premise and conclusion, intention and activity, aim and means, aim and value, as well as diverse hierarchical connections between values.

[9] If, for instance, we *wish* (= expressive phenomenon) to invest a certain sum on the stock market, to do this rationally we should get to *know* (= cognitive phenomenon) relevant information concerning stock indexes, etc.; and principles of rationality suggest then either a safe investment (which will minimize loss), or more risky one (which will maximize gains).

or not, is determined by the principles of rationality mentioned above (to be discussed later, as we do not yet have all the necessary prerequisites to state them).

Only such phenomena can then be qualified as either rational or irrational, wherein two kinds of elements – cognitive and expressive – are linked together, forming a "chemical compound," so to say. This is so in the case of any *goal*, "composed" of some imagined future state (idea) and the will (expressive phenomenon) for this state to occur.[10] Similarly, *beliefs* can be legitimately qualified as either rational or irrational because in any belief one can distinguish some informational content which represents something (a proposition) and the expressive act of its assertion.[11] Both cases are instances of sense relations.

The presence of sense relation is not a sufficient condition of rationality, however, because the category of sense can occur both in rational and irrational set-up. To see this note that the category of sense is, by definition, relativised to some person (a subject of spiritually determined acts) and his/her beliefs; and so are sense relations. And beliefs may be both rational and irrational.

Assuming a given subject's beliefs are coherent, the sum total of sense relations built upon them forms what we once referred to as the *inner cosmos* – an idiomatic virtual reality that we establish – and then occupy – as persons.[12] We are not, however, just persons (subjects of spiritual acts) but also creatures "of flesh and blood," and our Self is the highest instance not only regarding the sphere of thinking and feeling, but of actions as well. We can basically think whatever we wish to, for in this way we constitute a trans-subjective, virtual reality only; our actions, however, require contact with "hard" reality – objective, independent of ourselves. Sense, therefore, is not enough for us as human beings.

Constituting sense and, consequently, grasping sense relations is always hypothetical, since it necessitates an interpretation of available data, which may be interpreted in many different ways. And there is no guarantee that our cognitive interpretations will prove adequate. If they were purely contemplative – as is the case with interpretation of works of art for instance – we need not worry, as their inadequate interpretation would not usually entail any serious straits. The point is, however, that in this very world whose features we try to discover and interpret, we have to live and act. And acting within it, we must take it into account.

[10] Man is not a rational being because of the ability to act purposefully. Quite the contrary – man can act purposefully just because as a spiritual being he/she is rational, i.e. capable of grasping and instituting a sense and sense relations. Purpose should be conceived as a special case of a sense, and the relation end-means by which it is achieved as a special brand of the sense relation.

[11] Beliefs are thus double grounded ontically – in their conjectured object (grounding of a cognitive component) and in a certain value (grounding of an expressive component).

[12] There are as many inner cosmoses as there are persons, since everyone has his own individual inner cosmos, corresponding to his beliefs (con-sisting with them).

Therefore, next to the demand for sense, a second normative requirement arises for human activity – that of *realism*, of taking reality into account.[13]

We may meet the requirement only provided we have knowledge of reality that is when our beliefs concerning it are *justified*. Realism thus goes hand in hand with *criticism*,[14] since 1. to attain knowledge we should make use of adequate tools and legitimate cognitive resources, 2. for a belief to qualify as knowledge it should be defended against all actual and possible criticism.

To put it in other words: besides sense, there is a second measure of assessments used by the Self: the need for *objectivity*, that is for supra-individual *validity* of our proposals, as distinguished from personal *weight* one ascribes to that which is important (relevant, significant) to him/her only. It concerns both factual statements and evaluative ones, that is both ideas and expressions.

Now, what is both valid and important is constitutive for the category of *value*. It is therefore the category of value which is a common measure of our spiritual life.[15] The Self assesses cognitive submissions of intellect from the perspective of *cognitive* values, while those of the soul – from a perspective of *personal* values.[16]

Consequently, principles of rationality should be characterized in terms of values.

According to us it is best to treat the principles as instances of the so called *variational principles*, i.e. principles determining which of possible courses of action will be in fact realized. In general, they state that the actual course of action is that which minimize or maximize certain entity.[17] A specific feature of the principles of rationality, one which sets them apart from other similar rules such as Hamilton's principle of least action or Fermat's principle of least time, lies in that entities they warrant to achieve in the extreme are certain *goods*. For example: the rules of rationality dictate that one should choose from among conflicting hypotheses that which makes *least* assumptions, is *best* supported by empirical evidence or has the *best* explanatory power. Similarly, if a certain aim can be achieved in more ways than one, the rules of rationality dictate the "least costly"[18] course of action.

The principles of rationality require us to take into account the need for both sense and realism. Let us state some of them. For a given *aim* to be treated as

[13] Reality is not to be confused with real mode of existence (as distinguished from irreal or ideal ones), but is to be understood as the collection of beings which are independent of any individual subject. More on this topic later.

[14] These are in fact *complementary* requirements: while the requirement of justification concerns already attained beliefs, criticism concerns the way they were acquired.

[15] If values are the basis of evaluations – that is, if our evaluative beliefs are grounded in values – we are dealing with *wisdom*.

[16] "Personal" does not mean here private or concerning this or that individual, but concerning the *category* of persons.

[17] In mathematics, calculus of variations is a discipline that aims at finding extrema (minima or maxima) of functionals, i.e. functions whose arguments are also functions.

[18] In practice, *optimisation* (instead of maximisation) is often enough.

rational it should both realize some value (which furnishes it with sense) and be attainable (realism). For the *means* of achieving an aim to be treated as rational, they should be both effective (realism) and not lead to the negation or destruction of a value higher than that aim (sense). A belief is rational if it allows solving some problem (sense) and at the same time is justified (realism). Consequently, unjustified belief cannot be qualified as rational. And if an unjustified belief is cherished in spite of evidence against it, it qualifies as *irrational.*[19]

Paradigms of rationality

Principles of rationality, some of which we listed above, are – similarly to those of logic – impersonal. In fact, they are *universal*, the same for everyone. They thus can hardly be the only measure of rationality, as they are purely formal,[20] and people make their decisions on the basis of some "material" beliefs. Human activity is therefore determined not only by universal, formal rules of rationality, the same for all persons, but also by ideas and beliefs which make us distinct individuals. From principles of rationality, which are formal in character, we should therefore distinguish *paradigms* of rationality – certain general, coherent strategies, based on certain "material," fundamental statements which are the source of the supposed relations of sense.

Let us outline a simple typology of such paradigms. They will be certain *models* of rationality – i.e. ideal types – and not actual practices, which are often more complex than their idealized models. In accordance with the conclusions we reached earlier, such a typology should take into account the relation between expressive phenomena and ideas on the one hand, and demands for sense and realism on the other.

To be more specific, the following questions should be answered:

1. Recall that only such phenomena can be qualified as either rational or irrational, wherein two kinds of elements – cognitive and expressive – are linked together. In fact, neither of these elements can stand alone, each needs to be complemented by the other.[21] The problem, however, is which of them is prior (determining) and which is determined (which one is being "adapted" to the other).
2. Is the cognitive element based on knowledge or is it merely a belief?

[19] Generally speaking, rationality requires that the weight with which we affirm some belief should be proportional to the weight of evidence for it. One therefore should be ready to abandon one's belief if the sum-total of evidence speaks against it.

[20] Formal is taken here to mean "non material" and not "formalised." The principle stating "choose an action which maximise the desired effect" is formal, while the advice "invest in PKO BP shares" is material.

[21] There can be no expressive phenomena without some preceding ideas – you can only desire, doubt, love or hate something which has already been somehow represented (and then presented to the Self). And the other way round: there can be no cognition without some underlying expressive phenomenon, since cognition is a goal-oriented activity, and thus an expression of the will.

3. How evaluative judgments are qualified? Are they qualified as either true or false, or not?
4. What does one acknowledge as "reality?"

Depending of the answers to the above questions, there may be several different paradigms of rationality. We will distinguish three basic paradigms, which we call *pseudo-rationality*, *semi-rationality* (or *restricted* rationality) and *full rationality*.

1. *Pseudo-rationality*. If personal activity is dominated by the soul (i.e. by expressive phenomena) – which means that the main sense-giving factor is some self-interest – with little attention paid to the demand of realism, we are dealing with pseudo-rationality or "wishful thinking." Questions of adequacy, legitimacy and justification of the cognitive components do not appear here because the agents are so strongly convinced that their beliefs are right/true, that they feel no need to examine or discuss them; they just entrust them. Their beliefs are thus not rational. But because it is the spiritual Self that ultimately sanctions the soul's submissions, something like secondary *rationalisation* of the beliefs and decisions usually follows.[22]

Within this paradigm the spirit and the soul go hand in hand. The spirit serves the soul, acts as its extension which – for lack of a sound cognitive base – supplies manifestations of the soul with an ideological superstructure that is with the framework of ideas and arguments aimed at convincing other people that the manifestations are natural, reasonable and legitimate. It is this paradigm that produces myths, religions and ideologies, which are not discourses but persuasive narratives. Also any kind of dogmatism can serve as an example here, granting itself status of the defender of impartial truth and rightness, and treating its own critics as motivated by some interests, whereas it itself is so motivated. We have therefore a typical example of "false consciousness" here.[23]

If the dynamics of the soul is mitigated (moderated) by the requirement of realism (or, to put it in another word, of objectivity) we deal with *proper rationality*, which however should be further divided into two key varieties, depending on what counts as reality (more on that topic later). If decisions of the spiritual Self are determined by empirical knowledge-based cognitive elements (i.e. by knowledge concerning facts and factual regularities) – with the additional reservation that evaluative statements do not count as knowledge – we have *semi-rationality* or *restricted* rationality. And *full rationality* appears when we 1. take into account not only knowledge of what is actual or phenomenal, but of all modalities (essential possibilities,

[22] Thus, pseudo-rationality may be also qualified as *rationality ex post*.

[23] Interest (what is viewed by someone as good or beneficial for them) is a degenerate form of value, lacking transcendent sanction or universal validity. While there is no conflict among values, though some of them can be hard to maintain simultaneously, there is always conflict among interests, which are always particular. It is especially dangerous when interests "impersonate" values within a subject's consciousness, thus creating "false consciousness."

necessary relations and oughts included) and 2. when we grant cognitive status to evaluative statements.

2. *Semi-rationality*. To some extent at least, this paradigm is a counter-pole of the first, being just as one-sided. The cognitive dimension outweighs the expressive one which is most visible not only in the programmatic demand to eliminate expressive elements from knowledge (cf. Weber's idea of science free of value judgments) but also from among accepted determinants of cognitive attitudes (in favor of impartiality, neutrality etc.). Cognitive elements are present here in the form of factual knowledge and empirically verified laws, because "reality" is understood within this paradigm as that which transcends consciousness, but which can be verified or falsified by means of inter-subjective checkable facts. Thus, the paradigm depreciates metaphysics (treated as either a form of individual expression or speculation, not considered *knowledge*), proclaims a sharp dichotomy between what "is" and what "ought to be," denies the cognitive status of evaluative judgments and, in so doing, perceives values as subjective.

Intellectual structures within this paradigm include empiricism, phenomenalism, positivism, utilitarianism, nominalism, naive realism, naturalism, reductionism and relativism. Axiologically, these are all in the service of the common good – the maximized form (though with no transcendent sanction, similarly to ulterior motives) of empirically conceived values.

3. *Full* (*balanced*) *rationality*. Within the paradigm of restricted rationality reason operates with a narrowed concept of reality, conceiving it as the domain of what is real, actual or effectively attainable (one could say that *ratio* means *calculate* there); and the answer concerning what is real is furnished by empirically based knowledge (i.e. knowledge of what is "out there"). Now, within the paradigm of full rationality reason makes use of a broader concept of reality, including in it everything that is independent of any subject (essences, oughts and values as well). Knowledge is replaced by wisdom, which gives root to self-knowledge. On the other hand, the paradigm is characterized by striving to attain universally valid solutions, as opposed to any subjectivism, particularism, and relativism, regardless of their scope. A crucial prerequisite is that values are at the source of all sense, being – themselves and within a hierarchy – objective and cognizable, enabling cognitive discourse about them.

This paradigm is not characterized by a one-sided dominance of cognitive elements over expressional ones, because cognizing itself is treated here as a form of expressive being, directed towards realization of *cognitive values*. It is not considered a passive mirror-imaging of objective reality but as active constructing of models of reality, i.e. as generating some virtual reality.

The difference between these two paradigms of proper rationality lies in their distinct claims of validity. While the paradigm of restricted rationality relies on factual knowledge, treating laws as generalized observations which do not need any further justification, the paradigm of full rationality relies on a priori knowledge insight into essences or essential bonds among beings, and on the postulated "first principles" – among them, on values treated as ontic ground of valuations. And justification, after all, consists in referring to some principles.

All adherents of objective, though anti-naturalistic, conceptions of values should be counted among the adherents of this paradigm. The list includes the so-called *idealists* (e.g. Plato, Kant, Rickert and Husserl) as well as the *realists* (e.g. Scheler, Hartmann).

*

Let us ask: Which of the paradigms of rationality outlined above is closest to what is being done in science? Our stance in this regard will be slightly diversified, since the answer will vary accordingly whether it is discussed how the scientists themselves comprehend science (in the sense of typical scientists/ typical convictions), or if it considered in the light of certain more general resolutions.

The answer to the first issue is in our opinion the following: the closest vicinity of scientific rationality is this form of rationality that we have named the semi-rationality. Let us remind that it is characterised by the one-sided domination of cognitive elements (ideas, judgments) over the expressive phenomena (attitudes, aspirations, evaluations). In science it corresponds to the *primacy of the object over the subject*, reflected in the postulate – or even requirement – of *objectivity* constitutive for the scientific attitudes and research. Science should forget, so to speak, about the subject – forget not in the psychological, but in the normative sense, that is by way of methodical elimination – or at least neutralization – of the subjective respects (factors). Scientific conceptualizations and theories are to be formulated in the "third-person" – i.e. de facto impersonal – form. In science there is no room for "I," "You," or "He," persons and their traits are present only *functionally or instrumentally*, they are only the realization factors of cognition, not its determination factors. In the objectively oriented cognition it is not important who cognizes, what really counts is only its content and its relationship with the objective reality. Therefore during the cognitive process we have to neutralize our personal individuality, to keep it under control, due to which knowledge possesses the impersonal character, characterized by inter-subjectivity and cumulativeness of results obtained by various persons. Hence, during the cognition agents are actually interchangeable, differing only in the level of their cognitive abilities.

Such a view of science is supported by the typical epistemological stance of the scientists, which is the attitude of realism. According to this view, science differs from art, religion or metaphysics in that the works of art, religious doctrines or metaphysical concepts are full of metaphors due to which they require appropriate interpretation, whereas the scientific ideas, concepts and theories ought to be understood literally, non-metaphorically. In other words, it is attitude according to which the scientific theorem is true in the classical sense. Or, to put it in terms of denotation/designation distinction, it consists in the identification of *reference* of signs and concepts (resp. cognitive states of mind) with the relation of denotation. What is de facto only designed by the scientific terms (and thereby relativized to the subject, as the relation of designation remains within "the internal cosmos"), by the "typical" scientists is treated as something denoted by them (i.e. as objectively existing).

The aforementioned elimination of the subjective factors goes furthest in logic, particularly in its basic part which is the formal logic (sometimes called also symbolic logic), treated most often as the sound foundation of every science, while in our opinion it is but some kind of "the security service" of scientific thinking.

To see this, let us state briefly the essential ideas of logic.

CHAPTER TWO

Logic

Let us begin with stating that the research domain of logic is not thinking as such, i.e. certain mental processes (these are investigated by psychology, cognitive science, or philosophy of mind), but their linguistic expression. In other words logic does not study the thinking itself, but its idealized, linguistic representation. Thinking is a process that takes place in someone's mind and due to that it is entangled in a network of various relationships with other mental phenomena, such as memory, imagination or emotions, resulting in a more multidimensional and complex form than the verbal attire which it eventually arrays itself in, be it the spoken, or the written form. Now logic filters all such subjective components of the linguistic expressions out, disregarding anything that in the utterance does not serve the characteristics of its object, and leaves only its objective (that is referring to some object) content. In other words, it takes into consideration only the informative and argumentative function of linguistic expressions, is interested in their *cognitive* content and value. It means that it is interested only in such utterances that state something about the world and therefore can be true or false.[24] Such objectified expression of the thought – propositions, arguments and theories – stands in various relationships with propositions that the author of a given thought has never thought of, nor has uttered, and which despite that can be the object of the study.[25] Therefore logic in its investigations can disregard actual processes and states of mind of individual people.

[24] The truth and falseness are in logic called *logical values*.

[25] For instance, it can be studied if a statement uttered by someone is compatible with the current state of knowledge.

Logical (syntactic) categories

Logic divides the universe of linguistic expressions into several general classes called *syntactic categories*. Each category consists of expressions which in any syntactically correct compound phrase (which is determined by grammar) can be exchanged with each other, still obtaining the phrase that is correctly constructed (NB it is not the same as meaningful). For example, it will be so in the situation, when in the sentence "Warsaw is a capital" instead of the word "capital" we use the word "city" or "cake;" although "Warsaw is a cake" is a nonsensical sentence, yet, from the grammar point of view it is constructed correctly. However, if we replaced the word "capital" or "cake" by the word "runs," we would obtain a phrase that is incorrectly constructed ("Warsaw is runs"). Hence, "capital," "city" and "cake" belong to the same syntactical category, whereas "capital" and "runs" belong to the different ones.

Logic distinguishes four syntactic categories: names, predicates, functors and sentences.

Names or – more broadly – nominal phrases are expressions that can function as the subject of a sentence. These can be proper names (e.g. "Warsaw"), general names (e.g. "city"), or so called descriptions (e.g. "the capital of the country between the Oder River and the Bug River"). It should be also remembered that the logical subject of the sentence may be different from its grammatical subject – the logical subject of the sentence does not need to be in the nominative case. For example, if someone utters a sentence "Mary is liked by me," then the logical subject of the sentence – which is this part about which the sentence states something – actually is not this Mary, as the grammarians would claim, but the author of the utterance, since the sentence de facto is about him not about her.

Names have *intension* and *extension*. The intension of a name is its *meaning* (the way it is understood, the information content), whereas its extension is the collection of objects *denoted/designed* by this name.[26] For example: the intension of the name "square" is being a quadrilateral with all the sides and angles that are equal, whereas its extension is the collection of objects that are squares. Note, that names can have different intension, and nevertheless have the same extension (e.g. *woman* and *daughter*). Names that have the same meaning are *synonymous*, whereas the ones that have the same extension – *equivalent*.

To the second category belong *predicates* – expressions that, when added to a name, form a sentence. Example: if we add "runs" to the name "hare" we will obtain sentence, hence "runs" is a predicate. However, it would also be the expressions "runs like mad," "is the herbivorous animal," etc. In other words, predicate is the expression that attributes certain property to referents of a name.

[26] The object denoted by name is otherwise called its referent; the set of all the referents of its name are called *denotation*. So the extension of the name is its denotation.

The third – from the logical point of view the most important – syntactic category are *functors* or *logical constants*, which include *quantifiers* and *logical connectives*.[27] The quantifiers are symbols for expressions of the "quantitative" type such as "certain," "some," "there is" (*existential* quantifier, usually symbolized by the sign "$\exists$") and "all" or "for everyone" (*universal* quantifier, symbolized by "$\forall$"), that allow for the more detailed analysis of sentences through the introduction of variables running the set of names, or the set of predicates.[28]

Logical connectives are the expressions by means of which simple sentences can form the compound sentences. In theory there are twenty of such connectives – the number is related to the *bivalence* assumption that is made by the classical logic – but in practice only few of them are used, the ones corresponding to the expressions occurring in the colloquial language, since all the others can be defined with their help. These are the functors of *negation* ("no" or "it is not true that," symbolized by "$\sim$"), *disjunction* ("or," symbolized by "$\vee$"), *conjunction* ("and," symbolized by "$\wedge$"), *implication* ("if... then," symbolized by "$\rightarrow$"; the clause after "if" is called the *antecedent*, whereas the clause after "then" – the *consequent* of the implication) and *equivalence* ("if and only if," symbolized by "$\equiv$" or "$\Leftrightarrow$").

Although the connectives are expressions that occur in the colloquial speech, in logic they have precise, explicit meaning. Definition of the connectives consists in that it determines the logical value of the compound sentence (formed with help of a given connective) for every possible set of logical values of the simple sentences. It means that connectives are treated as extensional functors (sometimes called also truth-*functional* functors).[29] For example: the conjunction (i.e. the compound sentence formed by means of the conjunction functor) is true only when both clauses of the sentence are true, whereas the implication $p \rightarrow q$ is true always when it is not so, that p is true and q is false.

The fourth category are *sentences*, by which in logic are meant the utterances the logical value can be attributed to. The sentences can be simple or complex, but the classical logic is concerned only with the subclass of the latter, namely with *compound* sentences which are built by independent clauses only. Classical logic makes the additional assumption that the logical value of the compound sentence depends solely on the logical value of the simple sentences constituting it (the so called *extensionality assumption*) not of their meaning (content).[30]

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[27] In the so called non-classic logic there are also distinguished other functors, e.g. *modal* ones (*it is possible /necessary/ that*...), and the deontic (e.g*. it is permitted that*...)

[28] For example: the sentence "Warsaw is a capital city of Poland" can be expressed in the following way "There is such x (where x-es go through the set of cities) that x is Warsaw and x is a capital city of Poland." In the symbolic notation: $\exists$ x [P(x) $\wedge$ Q(x)], where P and Q are the predicates. Whereas the sentence "The flow of current through the conductor generates the magnetic field," can be treated as the more precise expressing of the more general sentence form containing variables, with the form $\forall$ x [P(x) $\rightarrow$ Q(x)].

[29] A connective is truth-functional if logical value of the appropriate compound sentence (i.e., whether it is true or false) is determined solely by the logical value of its components.

[30] It is not so in case of a complex – but not compound – sentence "I think it is Thursday today,"

Logical form and logical implication

The logical analysis of some linguistic expression consists – in case it is a simple sentence – in identifying its logical subject (= the part about which the sentence claims something), the predicate(s) and possibly the quantifiers, whereas in reference to the compound sentences, the simple sentences need to be identified for that purpose, the connectives that join them and possibly the quantifiers. As the result of that kind of analysis *the logical form* of a given expression is determined. The logical form of the expression is constituted by the kind of syntactic categories occurring in the given expression and the way they are interconnected with each other. The formal logic studies thoughts expressed in the language precisely from the point of view of their logical form.

The logical form of a compound sentence which remains true in every possible valuation – i.e. in all substitutions of concrete simple sentences for sentential variables – is called *tautology* or *law of logic*. Here are a few exemplary tautologies (in the parenthesis we present their customary names; the letters p, q symbolize simple sentences, i.e. are sentential variables): $\sim (p \wedge \sim p)$ (the law of non-contradiction), $p \vee \sim p$ (the law of the excluded middle), $[(p \rightarrow q) \wedge p] \rightarrow q$ (modus ponens), $[(p \rightarrow q) \wedge \sim q] \rightarrow \sim p$ (modus tollens).

With the concept of the logical form one may define the important notion of the *logical implication* (or: the *relation of consequence*), i.e. the situation in which some sentence logically follows the others. Namely, a sentence W logically implies sentence Z, if the implication $W \rightarrow Z$ is a tautology.[31] In such a situation the sentence W is called *the reason* of Z, whereas the sentence Z is its *consequence*.

Reasonings

In logic the symbol of an arrow can symbolize either the implication (i.e. the formula "if… then"), or the relation of logical implication, or – additionally – *the direction of reasoning* (or: of inference). Reasoning is a mental process in which on the basis of the sentences that we accept as true (in this context called *premises*) we accept some other sentence (the *conclusion*) as true. The inference should not be confused with logical implication: while the former is something that occurs in time, the latter is non-temporal relation between some propositions.

The conclusion of reasoning may be logically implied by the premises, but it does not have to. If it does, then the reasoning is called a *deductive* reasoning.

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as the truth of the whole sentence does not depend on the truth of the embedded simple sentence ("It is Thursday today"), but on whether I really think so.

[31] We use here different symbols from p, q, because frequently in this context the sentences concerned are compound.

In other words, deduction is a mental process in which direction of reasoning is the same as direction of logical implication. Example: Mr. Smith informs us that if he wins the lottery, he will buy a car (a premise 1). On the other day we ask him if he has bought a car and we hear that he has not (the premise 2). Therefore we conclude he has not won the lottery (the conclusion). Deduction is a *valid* (*infallible*) kind of reasoning, i.e. provided its premises are true it guarantees the truth of the logical implication.

If the logical implication heads at the direction opposite to the direction of reasoning, this kind of reasoning is called *reductive* (or: *abductive*). Example: The premise 1: if electricity is cut off, then all the electrical appliances stop working. The premise 2: we noticed that the refrigerator had stopped working. The conclusion: there must have been the disruption of the electricity supply. This kind of reasoning is most often used when we try to explain something or to propose a theory of something. Contrary to the former, reductive reasoning is not infallible.

A particular case of the reductive reasoning is the *inductive* reasoning, whose premises are statements concerning some individual cases, and the conclusion has a general character. Example: We saw five Japanese and all five were black-haired. So we conclude that all the Japanese are black-haired. Inductive reasoning do not warrant veridicality of then conclusion – the premises of inductive reasoning may *support* the conclusion but do not *entail* it.[32]

Let us call by *an argument* a coherent series of statements leading from a premise (or premises) to a conclusion. Then a deductive argument asserts that the truth of the conclusion is a logical consequence of the premises, and an inductive argument asserts that the truth of the conclusion is supported by the premises.

Arguments may be valid or invalid, and sound or not sound. An argument is valid if and only if the truth of the conclusion is a logical consequence of the premises. A sound argument is a valid argument with true premises.

Classical logic assumes that an argument is valid or invalid purely in virtue of its form, and not in virtue of the sense of statements used in it. The assumption is a source of many paradoxical features of classical logic.

Paradoxes of implication

We stated earlier that in its abstracting from the subject of mental acts, formal logic goes very far. Actually, we can even state, that – at least from the point of view of methodology – it goes *too* far, since understood in this way it has (almost) nothing important to offer to the working scientists. Let us see why

[32] There are also varieties of reasoning, where there is no logical implication in either way. The reasoning *by analogy* and by *statistical reasoning* has this kind of character, for instance. Neither of them is infallible, thus they should be used carefully.

this is so.

What scientists would expect from logic is that it should provide conditions or measures of the validity of arguments – to tell what relation must hold between premises and conclusion to be correct to say that the premises entail the conclusion (or that the conclusion *follows* from the premises, or that the inference from premises to conclusion is *valid*). All these depends on the sense of the functor of implication which figures in most reasonings.

Classical logic defines the implication $p \rightarrow q$ as equivalent to the sentence: "it is not the case that p is true and q is false."[33] At the first sight it sounds sensible, for it seems to capture the intuitions concerned with implication. However, when probing deeper, the result become quite surprising, since then we have to accept as valid each implication whose antecedent is false, regardless of what the consequent states (e.g. "If gold is lighter than water, then gold is cheaper than water"), and also implications where both clauses have no relationship whatsoever – if only they both are true (e.g. "If Sunday is the day off work, then the Moon is the satellite of the Earth") or both are false (e.g. "If wolves feed on hay, then Columbus discovered Madagascar"). All such cases differ considerably from what in everyday practice is treated as logical, and if anyone seriously applied such kind of reasonings we would consider him to be plainly illogical or at least counterintuitive.

The aforementioned definition of the implication functor has an immediate impact on the concept of logical implication which is defined by it and therefore does not also depend on the meaning of simple sentences involved in appropriate law of logic, depending only on their logical values. Now, consider the law $[(p \rightarrow q) \wedge p] \rightarrow q$ (modus ponens) whose consequent q logically follows from the antecedent figuring in square brackets, and substitute for p the sentence "It is raining," and for q – "Poland is a republic." Then we should acknowledge that the fact that Poland is a republic is logically implied by the fact that it is raining. Is there any logic here, one would ask?

The source of this apparent illogicality is that the definition of implication is purely extensional, i.e. disregards contents of both the antecedent and consequent. In other words, the formal logic is counterintuitive since it allows the antecedents to be irrelevant to the consequents (to be on completely different topics).

Somebody who in his thinking would like to follow only the formal (syntactic, extensive) conditions would not go too far. Not only his thinking would be insightful; it would not be thinking at all, but a kind of mechanical calculation similar to those that take place in computers.[34]

[33] To be precise, this form of implication is called a *material* implication, to be distinguished from *strict* implication defined in a modal way: it *cannot be* the case that p and not q.

[34] This state of affairs was once ironically described by the great Polish philosopher Roman Ingarden: *...logic is to be a tool guaranteeing the truth of results that are obtained automatically, without thinking, by anyone, preferably by some machine. That is the highest ideal that the logicians*

Recalling what we have said about the validity of reasonings, we then face the fairly unpleasant alternative: either our reasoning is worthwhile (i.e. we arrive with its help at nontrivial truths), but the results obtained in this way are fallible, or they are infallible, but they do not broaden in the essential way our knowledge, since what follows logically from premises is trivial in relation to them.

Is this, however, inevitable alternative? Do we have to care of the *logical* – i.e. formal – implication? Not at all, since in generating new statements – as well as in arguing – what guides us is their *content* and what we find out about the world thanks to them, not their formal relations. On the other hand, thinking is not only thinking *about* something, but also *for* something – it concerns something but it also aims at something. And all these are perfectly absent in logical account of thought which completely disregards mental states of the subject of thought.

Towards relevant logic

The corollary from the above considerations is as follows. If logic is to be of considerable assistance to the cognitive practice of actual scientists, it should not be based on the formal (syntactic) relationships only, but on the meaningful relationships of all logical categories, i.e. names, predicates and sentences, and not only on the logical constants (functors). Consequently, these constants – especially the key functor of implication – ought to be defined without the assumption of extensionality (i.e. not as truth-functional).

It is worthwhile then that formal logic should become *intensional* logic.

The minimal requirement which has to be met by such remodeled logic is that a valid implication must tie the antecedent and consequent together by some notion of relevance – the antecedent and consequent of implications should be related, have something in common. In a word: in a valid argument, the premises must be *relevant* to the conclusion.

To achieve this, definitions of logical connectives should involve reference to the subject of reasoning.

To demonstrate how it can be done, let us define implication as the state of affairs which holds if and only if acceptance of the antecedent as true requires acceptance that consequent is also true. Thus, if somebody accepts the truth of the antecedent and the same time does not accept the truth of the consequent, then he/she thinks (acts) illogically; or: he/she does not understand the phrase "if… then." The logicality perceived in such a way is not an attribute of propositions or theories, but a qualification of the way their author thinks.[35]

and methodologists of the 20th century are overwhelmed with admiration by. A person and his reason – have become obsolete! (Ingarden 1972, p. 202).

[35] Because what is inter-subjectively accessible is not the author's mental states but their linguistic expressions, somebody's logicality can be decided only by means of the analysis of his utterances, provided additionally that we understand words used by him in the same way.

It should be noticed that in the above definition of implication we spoke about the *acceptance* of truth, not the actual truth itself. And these are different matters, as some proposition can be accepted as true, despite not being true. Note also that the act of accepting something as true does not belong to the domain of ideas, but is expressive phenomenon. In this way logic ties the knot with rationality – which we have defined generally as an art of legitimate joining cognitive and expressive elements – since the act of acceptance is the expressive phenomenon determined by the will to achieve some cognitive value.

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The qualification of science, outlined at the end of chapter one, as the closest to the paradigm of semi-rationality, characterized by the one-sided domination of the field of ideas (cognitive contents) over the expressive phenomena, should be therefore modified, since the neutralization of expressive states necessary for achieving the cognitive attitude, is itself the expressive phenomenon, as it is done in favor of achieving some cognitive values. This modification consists in a certain shift of science towards the paradigm of full rationality, due to the fact that cognitive activity is oriented toward realization of certain values, constituting the ontic ground of appropriate expressive phenomena – attitudes and aspirations. It is in favor of these values that the subject reduces itself to some kind of a mirror of what objectively exists, thereby neutralizing its individuality.

What determines the difference between such modified paradigm of semi-rationality and the full rationality paradigm is then not the freedom from the evaluation in general, but the fact that in science the dominating role is played by cognitive values.[36]

We will end our short trip into the domain of logic with some remarks concerning the art of making definitions and (logical) divisions.

Definitions

Most often definitions serve as a tool to explicitly fix the meaning of some term – to state exactly what the word means. Speaking more generally, function of the definition may be facilitating identification of an object denoted by the defined name, specifying the meaning of some unclear term, replacing expression incomprehensible to some people by the equivalent phrase containing the terms comprehensible to them, and precise summary of information about a certain object (in this case we say that we have at our disposal the *concept* of this object).

[36] It does not have to mean that cognitive values thereby are treated as the highest in the hierarchy, since what matters here is methodology, not axiology.

Definitions may be either *real* or *nominal*. Real definition is a characterization of referents of some term (e.g. *mammal* is any vertebrate nourished with milk secreted by mammary glands of the mother), whereas nominal one establishes meaning of the very term ("*mammal"* means…).

The *analytic* definitions serve to acquaint someone with existing (established) usage of a given term (it is for example the case when the professional terminology in some field is not known by an outsider), whereas the *synthetic* definitions concern either establishing meaning of the newly introduced terms (e.g. "mobile phone," "gadget"), or the modification of already existent ones (e.g. the case of the word "sex," originally meaning *gender*).

The *normal* definition is the definition where the term that is being defined (called *definiendum*) does not occur in the defining part (*definiens*). The c*lassical* (*genus-differentia*) definition is the kind of normal definition in which the referent of the definiendum is defined stepwise by first indication of its *closest genus*, and then the *species difference,* e.g. "the square is a rectangle (= the closest kind) that is equilateral" (= the species difference between the square and the rectangle as such).

The next two definitions – *axiomatic* (*implicit*) and *ostensive* – are applied in the situations when the use of the normal definition is impossible. The first one consists in formulating the provisions the referents of the defined terms must fulfill (e.g. the arithmetic operation of *addition* /"+"/ is characterized as *commutative* (a + b = b + a), *associative* (/a + b/ + c = a + /b + c/), and having number zero as its *identity element* (a + 0 = a), whereas the second one consists in indicating an object possessing the defined property (in this way somebody can be acquainted, for example, with the meaning of the word "sweet" or "red").

A good definition should enable a reader or listener to "pick out" instances of the word or concept with no outside help.

The formal condition of correctness of definition is *equality of extensions* of definiendum and definiens – otherwise, the definition is either *too broad*, i.e. it applies to things that are not part of the extension of the word defined (e.g. "a soldier is a man who can use the weapons"), or *too narrow* ("a soldier is a male who serves in the army"). The other mistakes made while defining are following: *idem per idem* occurring when the defined term appears in the definiens; *ignotum per ignotum* (a term with unknown meaning is defined by another unknown term); *a vicious circle* in defining (term A is defined by means of term B, and B by A).

Logical division

When we speak about the division simpliciter, we have in mind the division of a set of certain individuals into subsets whose elements have some feature in common. These subsets are called *parts* of division. Since the individuals typically possess a number of characteristic features, therefore each set of individuals can be divided in various ways. (The set of people can be divided, for example, according to gender, nationality, education, wealth, age, etc.). In order to make the division, we have to establish the set we want to divide (in this context called the *universe* of division) as well as the *division criterion*, i.e. the feature that will be the basis of division due to its possession. From the point of view of logic, it consists in the division of the extension of some name, while doing such a division we are guided by the knowledge of a given name intension.

The simplest kind of division is a *dichotomous* division, i.e. division into two subsets on the basis of possession of some feature or its negation (e.g. the division of the numbers into negative and non-negative ones). Another kind of division is the division according to the *variant* of a certain feature (e.g. the Christians can be divided into Catholics, Protestants and the followers of the Russian-Orthodox Church). When the feature selected as the criterion of the division is gradable (e.g. affluence, education), the division is called *typology*. The division into literary genres such as epics, lyrics and drama is an example of typology.

The division can be single or multiple (branched). People can be, for example, divided into believers and non-believers, next the believers can be further divided according to their religion, and the non-believers into atheists and agnostics. Such a multiple, branched division is called *classification*. An example of such an extended classification is the biological taxonomy dividing the kingdom of plants and animals into classes, orders, families, kinds and species.

Finally, the divisions can be *crossed* by superposing several independent divisions. For example, mature citizens of Poland can be, on the one hand, divided into poor and rich (provided we first determined appropriate income criteria) and on the other hand into educated and uneducated ones. Next we apply these criteria jointly, obtaining four parts of division: rich and educated, rich and uneducated, poor and educated, poor and uneducated.

The logical division is correct if it is *complete* (the extension of the name constituting the divided universe should be equal to the sum of extensions of the obtained parts of division) and *disjoint* (no part of division can have common element with the others). In other words, the division is correct if each referent of the name belongs to some subclass, and none of them belongs to two (or more) subclasses.

CHAPTER THREE

The structure of scientific theories – empirical sciences

In this and next chapter we shall discuss issues related to the construction of scientific theories, understood both as methods of conduct leading to their formation and as the characteristics of their internal structure ensuring scientific justification of their statements. First we will deal with theories in the empirical sciences and then in formal sciences. We shall also compare briefly methods of forming and accepting statements in these two groups of sciences.

Commencing lecture concerning the structure of scientific theories, the intention of which is to trace steps leading to their construction, one should start with prior definition of science as such. However, since the definition of science is not a simple matter and will be discussed separately in the chapter 5, let us assume here the implicit understanding of what science is and deal with characteristics of their main types and their methods of conduct leading to constructing correct theories.

The overall body of science can be diversified according to various criteria. The fundamental, dichotomous division results in distinguishing *formal* and *empirical* sciences. The division is determined by the kind of *propositions* which can serve as justification of theorems adopted in particular sciences. The additional factor that differentiates sciences is kind of *reasoning* acceptable in them when justifying their theorems. In empirical sciences, such justifying propositions are observational judgments; in formal sciences – axioms. In forming secondary theorems based on the previously accepted ones, in the empirical sciences deductive as well as inductive reasoning is used, whereas in formal sciences – only deductive (infallible) one. That is why the empirical sciences are frequently called *inductive*, whereas the formal – *deductive*. Finally, taking into consideration the ultimate premises adopted by the particular science, the empirical sciences are being named *a posteriori*, since their theorems are made on basis of experience, whereas the formal – *a priori*, since experience is not necessary there.

Observational propositions

In the inductive sciences two kinds of propositions are distinguished: *questionable*, which are formed on the basis of the fallible reasonings, and *unquestionable* ones. In empirical sciences, the unquestionable and primitive propositions (i.e. ones that are accepted without justification) are theorems of logic and mathematics assumed by these sciences, and synthetic definitional sentences accepted without empirical evidence, just by means of convention. They may be cancelled only when we change the meaning of terms which occur in them, i.e. their conceptual apparatus. Of the primitive character are also *observational* propositions which form the empirical base of these sciences.[37]

The observational propositions are formulated either by way of *observation* – a perception guided by some cognitive task, but with the intention of not interrupting the natural course of events – or by way of *experiment* – a deliberate and controlled disturbance of natural course of action in order to observe the outcomes of the intervention.

The observational propositions are ones that are:

- preceded (explicitly or implicitly) by an existential quantifier,
- directly based on sensory experience and formulated in an observational language; in other words, they should include in their predicative observational terms denoting features observable with senses – e.g. colour, shape, scent,
- accepted without participation of other propositions, i.e. regardless of the prior knowledge of a person that formulates them,
- unquestionable, also by means of other experience, because they always concern past events.

Typical observational propositions (e.g. propositions of the type "I see that p") that meet all the above conditions, are accepted tentatively as the statements of science, despite the fact that they express subjective impressions of some observer. As we said earlier, science requires third-person language, that is sentences of the type "*it is so that p.*" However, formulating such sentences directly on the basis of sensual impressions is not possible. Therefore, methodology proposes, as the equivalent substitute, their inter-subjective confirmation, which requires some inductive reasoning and use of generalizations. But this means that observational propositions are not of purely empirical origin, because reasonings

[37] A more comprehensive account can be found in – see: e.g. Ajdukiewicz 1974, p. 218.

and generalizations are not sensory acts, but intellectual operations which presume some prior – e.g. methodological – knowledge. This plainly violates the third above condition and opens possibility of rejecting sensory reports when they are not inter-subjectively confirmed. It shows that the above four requirements for the observational propositions collide with each other, for they cannot be satisfied at the same time.

It is not the only deficiency of methodology of science that is noticed but which is disregarded in practice. Thus, such postulates have to be treated as regulative ideas rather than as necessary requirements.

The intention of inter-subjective confirmation of the observational reports is repetition of observations/experiments by several independent agents, provided that the other accompanying circumstances are the same (so called *ceteris paribus* condition, meaning "all other things being equal") to check if the same results will be achieved in all cases. If the result of such checking is positive, a generalization – a statement with the universal quantifier encompassing all the examined cases and stating that all of them were essentially the same – can be formulated. Thus, to achieve generalization, the inductive reasoning is being applied. The number of the examined cases and the choice of accompanying conditions of the reasoning are not regulated by any general methodological rule – they rather belong to the area of the scientific customs. Generally speaking, it is recommended to carry out observations on the reasonably numerous and diversified sample with participation of a possibly high number of observers.

Scientific laws

The sets of observational propositions confirmed in the way described above constitute the empirical base for formulating the laws of science. It is implicitly assumed that inter-subjective verifiability of generalizations in practice warrants the objective character of the observational reports involved, and that the noted steady occurrence of certain features of objects or events can be extended beyond the observed set.

The laws of science are the propositions written down in the form of general sentences preceded by universal quantifier covering not only all the examined cases, but all the possible cases of the domain (universe) of a given discourse. In other words, the law is a theorem whose pattern is following:

"for each x (belonging to the established universe), if F(x), then G(x)"

which means that each object "x" possesses certain property that necessarily accompanies occurrence of another property (the so called constant property). For example: "for each x, if the x is a man, then x is mortal." Sometimes it is said that laws characterize what is unknown (as unexamined yet, e.g. concerning future) by what is known.

The laws claim that "it always happens as the observational propositions claim" or that "it frequently happens so."[38] The first proposition expresses the content of the general law, the second one – of the statistical law.[39] The law can bind more than one type of objects and more than one of their properties; the statistical laws ascertain the degree of convergence of constant properties.

To determine connections between events or objects and constant properties attributed to them is not an easy matter. The reasoning called *eliminative induction* may be helpful here, which allows raising the probability of accurate grasping of such connections. Especially the so called *Mills canons* permit to discern the interrelationships (e.g. the cause and effect relations) between events and in this way to bind permanently their features. Suppose we are interested in determining what factors are responsible of causing a specific effect, E, under a specified circumstances. The *canon of agreement* tells us to look for factors present on all occasions when E occurs. The *canon of difference* tells us to look for some factor present on some occasion when E occurs and absent on an otherwise similar occasion when it does not. The *canon of residues* applies when part of E is explicable by reference to known factors, and tells us to attribute the "residue" to the remaining circumstances under which E occurs. The *canon of concomitant variation* is used when E can be present in various degrees; if we identify a factor F whose variations are positively or negatively correlated with variations in E then we can state that F is causally connected with E.

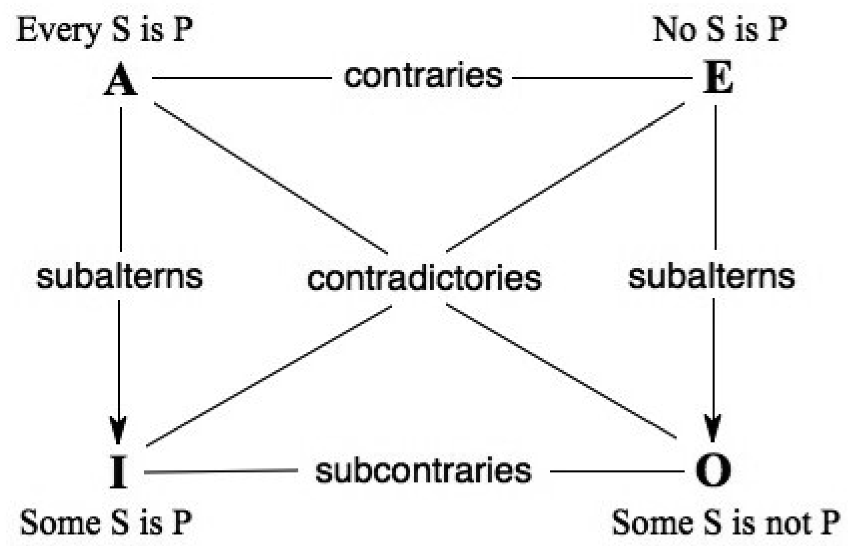
Another logical instrument which can be of assistance here is so called logical square (or square of opposition). The logical square is a graphic tool allowing useful description of relations among categorical sentences. A *categorical sentence* is a simple sentence containing two terms, subject (S) and predicate (P), in which the predicate is either asserted or denied of the subject. Every categorical sentence can be reduced to one of the following four forms:

- universal affirmative: "every S is P" (SaP)
- universal negative: "no S is P" (SeP)
- particular affirmative: "some S is P" (SiP)
- particular negative: "some S is not P" (SoP)

The symbols of variables S and P in these sentences can represent solely the non-empty names, because the extension of the empty name is subordinate to any non-empty name and its introduction into the logical square would disorder the regular relationship among sentences.

[38] Ajdukiewicz 1974, p. 285.

[39] We omit here further typologies of laws, which can be found in the handbooks of methodology.



Some theorems of the logical square useful in the methodology of science:

- the universal entails a particular sentence with the same quality. In the methodology of science this relation is used for inference about consequences of empirical scientific theories,
- the particular sentences do not entail the universal sentences of the same quality. However, their set gives the basis to carry out the inductive inference leading to forming the universal sentence. In methodology of sciences, this relation is used to form generalizations,
- the universal affirmative sentences (SaP) and the universal negative sentences (SeP) exclude each other (they cannot be both true at the same time), but do not complete each other (they can be both false),
- the particular affirmative sentences (SiP) and particular negative (SoP) complete each other (they cannot be both false at the same time), but do not exclude each other (they can be both true),
- the universal affirmative (SaP) and particular negative (SoP) and the universal negative sentences (SeP) and particular affirmative (SiP) exclude each other (they cannot be both true at the same time) and complete each other (they cannot be both false). Hence they are contradictory,
- the true particular negative sentence entails negation (indication of falseness) of the universal affirmative sentence. In methodology of science the relation is used to show the falseness of hypotheses with help of empirical counter-evidence (the negative result of the experiment results in the negation of hypothesis).

Explanations, hypotheses and scientific theories

The laws of science do not exhaust the results of scientific cognitive activities. Let us consider for example the Boyle-Mariotte's law of perfect gas stating that the product of the gas volume and pressure is a constant quantity. Although this fact itself is interesting and can be described in the way presented above, doubtlessly more interesting is the answer to the question why such constancy of the product of gas volume and pressure obtains. The laws noting the relation "if… then" between the properties of an object can give such an answer, but it is not satisfactory. The question "why the product of pressure and volume is the constant value," the laws answer: "because it is perfect gas." But the intention of our question "why" goes further, beyond this tautological answer. Asking "why," we would like to find a deeper, real cause for which the perfect gas has such qualities. We pose the question "why?" seeking another, deeper answer, which the laws of science considered above are not able to answer. Answering such questions demands reference to such matters as *scientific explanations*, *hypotheses* and *theories*.

The mutual relations between laws of science and theories – and even very meanings of these terms – are controversial issues, having no clear solutions. S. Amsterdamski[40] proposed for example the following interpretation of these terms: *Laws are propositions concerning directly observable objects, formulated and verified without any further additional theoretical premises… Theories do not have directly observable designates and could be verified only indirectly… Theories are free creations of human mind, whereas laws are just facts* (p. 84). However, such understanding assumes illegitimate premise that there are statements which are not theory-laden.[41] Therefore, we should point another difference between laws and theories. According to us, it lies in theories' ability to furnish scientific explanations, referring to deeper factors than steady co-occurrence of properties.

In the language of methodology "to explain" means that while answering the question "why?" we should determine the relationship between the state of affairs (fact, phenomenon) we try to explain and a set of factors which brought it about.[42] The statements which describe what is to be explained we call *explanandum*, whereas the *explanans* consists of the explaining statements. And because the series of causes and effects has usually many elements we can obtain explanantia of increasingly deeper level – up to the so called *ultimate* explanations.

[40] See e.g. "Science and the world order," the chapter "The role of laws in the system of knowledge."

[41] We have already noted the inability to formulate such statements when discussing the postulates for the observational propositions.

[42] Please note that what is to be explained can be either the fact of in-sistence of a certain event or the state of affairs, or what it is like. In the first case we should seek for its realization factors, while in the second – its determination factors. A good theory should provide both these explanations.

In order to answer the question what a given state of affairs depends on, we have to propose the tentative explanans to our explanandum. In other words, we have to make some *hypothesis* concerning its possible determinants. Hypotheses are devised (consciously or not) via reductive inference, which means that we are looking for the unknown reason of the known consequence.[43] Provided what we want to explain is a state of affairs symbolized by sentential variable *q*, we then are to look for such p that the following formula obtains: $[(p \rightarrow q) \wedge q] \rightarrow p$, which unfortunately is the pattern that is fallible.[44] That is why the proposed hypothesis must next be submitted to verification in the light of empirical evidence. The aim of verification is to check if proposed hypothesis is justified or – to put it in another way – if the implication $p \rightarrow q$ is true.

In trying to justify a hypothesis we refer again to the observational propositions. However, the intention of this reference and the type of reasoning involved are different from those leading to generalizations and laws of science. Instead of the fallible reductive reasoning we use here the infallible deductive reasoning. To verify whether the proposed hypothesis is true we try to make *prediction* of the events, which should take place, if the hypothesis was true. Namely, from the conjunction of a given hypothesis (H) and the previously accepted knowledge (W) we draw some logical consequence (N) in the form of a possible observational statement. If it proves to be true our hypothesis receives empirical confirmation.

The above sketched reasoning leading to confirmation of the hypothesis had the following pattern:

$$\{[(H + W) \rightarrow N] \wedge N\} \rightarrow (H + W)$$

which unfortunately is fallible, for it could as well be the case that:

$$\{[(H + W) \rightarrow N] \wedge N\} \rightarrow \sim (H + W)$$

In other words, the individual empirical confirmation does not decide about the truth of the hypothesis. And, what is more, many positive confirmations neither do. The reason is not that we can in practice make only limited number of predictions. The reason is that the very form of the involved reasoning is fallible. However, in the everyday scientific practice gathering large number of confirmations and lack of cases speaking to the contrary is treated as the sufficient justification of the hypothesis (but not of its truth).

Of another character is procedure where we obtain the evidence that the hypothesis is false. Namely, if trying to confirm a hypothesis we encounter a prediction which is not confirmed by the experiments, the hypothesis in question is *falsified*. The reasoning then goes along the infallible pattern of modus tollendo tollens, namely:

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[43] That is why, it is sometimes said that while formulating the hypothesis, we explain what is known by what is unknown.

[44] This fallibility is easily understood when we realize that each state of affairs that we want to explain – symbolized in the above pattern by the sentence variable q – may be caused by many factors.

$$\{[(H + W) \rightarrow N] \wedge \sim N\} \rightarrow \sim (H + W)$$

To be precise, the counter-evidence indicates the falseness of *conjunction* of the hypothesis and assumed knowledge. But in practice in most cases it is the hypothesis which is considered false and consequently rejected.

We can conclude that certainty can be achieved only concerning the falseness of a hypothesis, whereas its truth is always uncertain. No degree of confirmation warrants its truth.

A theory in the empirical sciences is the hypothesis or the group of hypotheses which suffice to explain all the generalizations describing facts, phenomena and processes that are empirical consequences of this theory. Its main ingredients are generalizations of factual statements, laws and their explanations by way of hypotheses involving theoretical – i.e. non-observational – concepts and statements. They should be internally consistent (not to produce contradictory statements) and in agreement with outer reality.

There is no methodological rule which would decide when a hypothesis becomes a theory. Usually after gathering a reasonable number of confirmations and without lack of empirical counter-evidence the hypothesis enters the body of scientific knowledge – which means that virtually all scientific theories are hypothetical.

Explanation and the choice of hypothesis

The best known model of explanation is the model proposed by Hempel and Oppenheim,[45] usually called the deductive-nomological model, or the model of explanation through laws. The model conceives the process of making hypotheses as inferential process in which the explanans plays the role of premises that logically entail the explanadum. According to the model explanans must include at least one law which is the essential premise for the explanadum and have empirical content, i.e. allow deriving empirically verifiable consequences. The core of this model is thesis that the satisfying explanation of a certain regularity – described in the explanadum – consists in deriving it from one or more laws. Its extension is the deductive-statistical model of explanation which uses the concept of statistical laws mentioned earlier.

The above model of explanation is deficient (works of Scriven, Watkins, Putnam and of the Polish authors Amsterdamski, Wiśniewski and Grobler – see the respective entries in the literature). The most serious deficiency is identification of the answer to the crucial for the explanation question "why?" solely with the relation of logical consequence between the explanans and the explanandum and overlooking "why?" understood as occurrence of cause and effect relations or other real relationships among the events or states of affairs described by explanans and explanandum. And these two questions „why?" do not have

[45] Hempel, Oppenheim 1948.

the same meaning, though they are thoughtlessly considered equivalent. Now, departing from the narrow notion of explanation (reduced to logical implication or consequence), opens the way for accounting of knowledge-creative and predicative functions of hypothesis. This topic will be developed further while discussing the so called context of discovery. It also opens the possibility for the assessment and comparison of the competing hypotheses based on the concept of a better, more satisfying explanation.

What is the better explanation – more precisely: what difference in so called explanative power should occur between two explanations to acknowledge one as better than another? Analyzing the problem of the growth of knowledge Popper said that better hypothesis should explain all that its predecessors did and something more. On the other hand Laudan and Grobler claim that including new hypothesis to the body of the already accepted knowledge should be supported by the increase of the number of issues which can be solved due to such modification.[46] Both approaches are accompanied by more detailed, additional methodological criteria concerning the increase of testability, empirical content, simplicity, universality, accuracy, depth and predictability.

This last category directs us towards one more feature attributed to a good explanation. The good explanans has the ability to accurately predict future events, i.e. ability to make projections and predictions. It also has the ability of post-gnosis, i.e. the explanation of the past events, which previously did not find good explanations.

And – last but not the least – the good explanation can answer not only the already posed questions. It can also pose new questions, and what is more – the ones which cannot be answered within it. In this way it outlines the issue field for new laws, new hypotheses and theories. Good explanation, by pointing own cognitive limitations and necessity to exceed them through a new explanation, inspires and accelerates the growth of knowledge.

Anticipating further considerations, let us say at advance that within the social sciences the explanation with the above characteristics is hardly possible. The social sciences do not include laws (in the above sense), cannot predict reliably any individual event, and the answer to the question: "why?" frequently takes the form of interpretation or understanding of motivations of human behaviour, and not finding the cause and effect relation. In other words, the question "why?" means there "what for?," "for what reasons?".

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The above described stages of scientific theory construction in empirical sciences are not to be treated as necessary. In scientific practice discoveries

[46] Grobler 2006.

leading to the construction of a theory are not subjected to any necessary procedure. A hypothesis can appear not only on the basis of the numerous and systematized observational statements – an inspiration for it can be just one anomaly. Scientific practice, however, is not in contradiction with this procedure.

Let us summarize in a few sentences features of a scientific theory in the empirical sciences:

– because of the empirical character of its basic propositions, the concept of truth appropriate for it is the classic one, together with the criterion of empirical verifiability,
– in its construction fallible reasonings are used; therefore it always is of a hypothetical character. Although many empirical confirmations can be obtained in favor of it, they do not decide definitively about its truth,
– however, the falseness of the theory can be unequivocally established by finding its empirical counter-evidence.

CHAPTER FOUR

Structure of scientific theories – deductive sciences

Deductive sciences are sciences developed by way of deductive methods of inference.[47] Such character possess various systems of formal logic and all mathematical sciences. In these sciences primitive propositions – those accepted without proof – are called *axioms* or *postulates*. When proving secondary theorems, deductive reasoning should be applied in them – application of another type of reasoning requires noting in the rules of inference. A proof of a statement is a sequence of valid inferences which starts with some axioms – or already proved theorems – as premises and ends with the statement in question as the conclusion. In other words, the statement must logically follow from the premises.

The above does not mean, however, that within deductive sciences only deductive inferences are allowed. This is so only concerning the stage of justification (i.e. proving) of *already formulated* statements (guesses, conjectures), whereas both in the way we achieve (discover) them and in the way we look for their proof, any kind of reasoning may be used. Deductive sciences are not, after all, developed in a purely linear, analytical way, i.e. by applying deductive reasonings to already accepted theorems ("let's see what may be logically extracted from them"), but by means of posing new problems and making conjectures how to solve them. And in trying to prove such conjectures one usually adopts reductive (hypothetical) reasonings, similar to these in empirical sciences, the difference being that instead of referring to laws of science, here we seek for axioms or secondary theorems as the necessary ground.

[47] Recall that deduction is a reasoning whose premises logically entail its conclusion. The direction of reasoning and logical consequence is thus the same: from premises to conclusion, from the antecedent to the consequent. It is infallible reasoning, from true propositions always leading to true propositions.

Axiomatic systems

When constructing a theory within deductive sciences, it is necessary to determine the following elements (axiomatic system in a wider sense):[48]

– a set of axioms (axiomatic system in a narrow sense),
– rules of defining,
– rules of inference,
– definition of a meaningful formulae (mostly sentence).

An *axiomatic system* in a narrow sense consists of some undefined (primitive) terms and a list of *axioms* expressed solely with the help of primitive terms. Construction of such axiomatic system begins intuitively. A list of primitive theorems is being open, consisting of statements adopted without proof and accepted due to their intuitive connection with a domain or a problem that one wants to deal with by means of the system. The list is closed when any new theorem one tries to add to it is not independent of the ones accepted previously (which means that it can be derived from them). The list contains not only a collection of theorems containing terms peculiar for the particular science, but also theorems of other sciences which are accepted without additional reasons, as is the case with a set theory in algebra or with classical logic in a set theory.

A theory in a deductive science is constructed by proving new (secondary) statements, called *theorems*, with the sole use of the axioms (postulates), rules of inference and previously proved secondary theorems. And since secondary theorems may contain terms not occurring in the axioms, the system must be equipped with rules of introducing new terms (*rules of defining*). The basic requirement herein is that new terms introduced in the secondary theorems should be *reducible* to the primitive ones, which means that they have to be defined either directly by the terms figuring in the axioms, or by the terms which are themselves so defined.

The *rules of valid inference* determine conditions on which one may legitimately accept new statements of a theory as being proved. They usually include all the laws of classical logic – e.g. the *rule of modus ponens* or the *rule of substitution*. If the system allows another kind of inference or another logic (e.g. multi-valued logic), it has to be clearly stated in the axiomatic system.

The *definition of a meaningful sentence* (within a given theory) determines rules for making sentences whose subjects have referents, i.e. are non-empty. For example: quantifier calculus (a name given to the branch of logic dealing systematically with quantified formulas) does not allow substituting empty names to quantified sentences because then they would constitute a "meaningless" sentence, i.e. correctly constructed declarative sentence which nevertheless is

[48] See: Ajdukiewicz 1974, p. 202.

neither true, nor false (e.g. "The present king of Poland is bald"), and therefore is not a sentence in the sense of logic.

The characteristics of deductive sciences

We will mention here some basic formal requirements concerning axiomatic systems, namely independence of axioms, their *consistence* and their *completeness*.

An axiom P of the axiomatic system S is *independent* if there are no other axioms Q of the system S such that Q logically implies P. The independent set of axioms is one of which every element is independent. The idea of independence thus allows one to limit the set of primitive statements accepted without proof to a minimum. If we suspect that some axiom P of a system S is not independent then we should be able to derive it from the others. Another method of checking if this is so is to use a proof *by contradiction* (i.e. by reasoning known as *reductio ad absurdum*), namely to add negation of P to the system and check if such modified system produces contradiction, i.e. entails a pair of contradictory propositions. If it does, then it means that P is independent.

A set of axioms is *consistent* (non-contradictory) if there is no statement such that both the statement and its negation are provable from the axioms. Consequently, a theory of deductive science is inconsistent, if it includes at least one pair of contradictory statements. Such theory would for obvious reasons be useless, since according to the law of logic $[(p \wedge \sim p) \rightarrow q]$ one could prove any proposition then.

The categorical proof of consistence of a given axiomatic theory can be formulated only rarely. In most cases the proofs are conditional: a given theory (e.g. geometry) is consistent if some other theory (e.g. arithmetic) is consistent. The proof of non-contradiction would be ultimate, if the theory would articulate all the possible propositions following from its axioms. Because it is hardly possible, it is assumed that a theory is consistent if, despite the attempts, no contradiction in it has been demonstrated.

A set of axioms is *complete* if, for any correctly formed statement in the axioms' language, either that statement or its negation can be proved, i.e. derived from the axioms and secondary theorems. Then, any problem which can be posed and expressed in the language of a given axiomatic system should be solvable. Such situation obtains in the case of the propositional calculus of classical logic. But in general proofs of the completeness of the axiomatic theory – like those concerning consistency – do not have the ultimate character.

Let us mention in this context two *Gödel's theorems* (or proofs, see literature), which undermined the previously accepted beliefs concerning the soundness of axiomatic systems. (Note that these are theorems, which means that they are proved).

The first Gödel's ("incompleteness") theorem states that any theory rich enough to generate elementary arithmetic cannot be shown to be both consistent and complete. Therefore, any consistent axiomatic system that includes a theory of natural numbers is incomplete: there are true arithmetic statements expressible in its language which are unprovable. To be more exact: there are meaningful arithmetic statements such that neither they nor their negation is provable. And since one of the two must, according to the law of excluded middle, be true, it means that there are true statements that cannot be proved.

To fully appreciate Gödel's achievement one should add that he showed that any system within which arithmetic can be developed is *essentially* incomplete. Therefore, even if the axioms of arithmetic were augmented by an indefinite number of other true ones, there would always be further mathematical truths that are not derivable from such augmented set.

On the other hand, Gödel also proved it impossible to establish the internal consistency of a very large class of deductive systems – including the above mentioned ones – unless one adopts principles of reasoning so complex that their internal consistency is as open to doubt as those of the systems themselves.

The consequence of the above theses, important for our argument, is first of all the statement that due to the impossibility to prove non-contradiction of the axioms in the deductive sciences the coherence criterion of the mathematical truth fails. We do not have in the deductive sciences the categorical proof of completeness, consistency and independence of axiomatic systems (but we can of course prove contradiction, incompleteness, and dependence). And until we prove them, theories of deductive sciences may be only provisionally considered correct.

The summary – comparison of the features of inductive and deductive sciences

Let us present the basic features of the two discussed types of sciences in the form of the following table:

	deductive (a priori) sciences	inductive (empirical) sciences
assuming primitive theorems	intuitive (axioms)	on the basis of evidence (observational statements)
rejection of original theorems	detected incorrectness of axiomatic system, e.g. dependence of axioms	theoretically impossible, in practice on the basis of a new evidence

forming secondary theorems	proof via inference rules admitted in a given axiomatic system	confirmation of laws and hypotheses by way of deductive inference of their empirical consequences and checking them by experiment never ultimate
rejection of secondary theorems	contradiction of sentences, incompleteness of theories (it may also lead to removing of axiomatic system, when the source of irregularity of the theory lies in it)	empirical counter-evidence (negative result of the experiment) it decides about the falseness of the theory or hypothesis

CHAPTER FIVE

Rationality of science in the light of selected views within the philosophy of science

Introductory remarks

We have already explained the usefulness of the methodology of science in the previous chapter of the course book. Let us add a remark concerning the benefits of practicing the philosophy of science – its usability for scholars. Now, methodology and philosophy are not the suppliers of direct instructions how to proceed in given research circumstances, how to assist a scientist who is facing research dilemmas. The constructions and standards proposed by the philosophy of science are not designed to form the rules of proceedings in specific scientific disciplines but they constitute a contribution to the reflection on the features of human cognition. The normative character of methodological standpoints and some of the views in the philosophy of science do not mean they can be exploited in any other way than shaping one's better comprehension of developments, mechanisms and processes taking place in science; in a word, the better comprehension of the phenomenon of science. Conducting them, getting known to them we surely are not given the instruction of conduct but we learn something important about science and cognition. It is our intention to hand down such knowledge.

It is not possible to present and discuss the basic views in the philosophy of science during such a brief lecture. Hence, we resolved to adopt the following method of the lecture: (i) we selected views of three outstanding philosophers of science representing three main 20th-century currents; (ii) we ignored the fundamental characteristics of those views as it can be easily found in literature and was presented during the lecture; (iii) we instead focused on such selected aspects which we deem particularly important for the question of the rationality of the development of science – the central axis of our considerations both in the present and previous chapters.

The first of the currents under consideration here strives to pinpoint the specificity of methods and cognitive acts of science (establishing, inter alia, the criterion of its demarcation) and to offer a rational reconstruction of the development of science through the widely-conceived logic and formal methods. The principal values of science to be secured by that reconstruction were truth and impartiality of scientific knowledge. According to this approach philosophy of science should be faithful to scientific *methods* and critical towards the scientific *theories*. Second, it is not interested in questions concerning genesis of scientific hypotheses, but solely in the context of their justification. Third, the internal mechanism of the development of science is deemed independent of external factors. The representatives of this approach were members of the Vienna Circle (verificationists), Karl Popper (falsificationist) and their followers.

The second current to be discussed has been given many names. The most frequent one to be found in literature is a descriptive name characterizing it as a current of historical, sociological and psychological studies of science, as the research concentrates on the mode of setting and accepting scientific enunciations basing on the testimony of those sciences. Kuhn, Hanson and Toulmin were among its leading representatives. The current emerged in the 50s and 60s of the 20th century and the breakthrough it brought about in the philosophy of science has been comprehensively described in the literature (see the bibliography of the course book and the lecture). Although the subject and the method of research differed here from those applied in the first current, its target was also to reconstruct and explain mechanism of the development of science. In "The Structure of Scientific Revolutions" Kuhn maintained that to discover how scientific revolutions erupt we have to study not only the influence of nature itself and logic of a scientific discovery on the contents of the theory but also persuasive methods within each group that is part of a scientific community.

Those two currents of the philosophy of science are essentially incompatible. Although their research goals share the above mentioned common approach, they refer to two different aspects of science offering complementary though separated images. Each of them, if formed in a consistent manner, was a one-sided image. As a result, postulates appeared of making syntheses – multi-aspect approaches of science, joining e.g. research work on logic with that on history or psychology, the context of a discovery with the context of justification. The idea of scientific research programmes of Lakatos, and Hanson's idea of "patterns of discovery" can serve as example of such syntheses. But those attempts could not be satisfactory due to their eclecticism. The inclusion of historical reconstructions in formal and methodological research (Lakatos) reduced them to the level of an anecdote. And attempts to legitimize the validity of inferences through the results of works by gestalt-psychologists (Hanson) were bound to strip the inferences of their logical character.

The aforementioned multi-aspect approach to science eventually resulted in the transition from an attempted synthesis into unconditional acceptation of the equality of views. Such is the message of the third current under discussion, which emerged and developed in the 80s and 90s of the 20th century and which is often labeled as *hermeneutic*. Here science is interpreted through its referring to the values extrinsic and superior to cognitive ones – for example to the realization of human dignity. The current is deeply rooted in existential philosophy (Heiddegger), in the philosophy of language (Wittgenstein, Davidson, Quine) and in the so-called epistemological anarchism (Feyerabend). Due to emphatic cognitive relativism and certain declared theses it may be legitimately labeled as *postmodernist*, while in view of its connections with American pragmatism – as *neopragmatic*. In the course book this current will be represented by R. Rorty.

Let us elaborate on the differences between those three currents pointing to their attitude towards the subject of philosophical research, goal of science and links joining science with its broader social environment.

Context of discovery and context of justification – two research perspectives in the philosophy of science

The roots of the distinction between the two contexts should be sought in an attack directed against psychologism in the works by Frege, Carnap and Reichenbach. The latter has formulated the very notions of the "context of discovery" and "context of justification," claiming that the theory of knowledge should take into account a logical substitute rather than the real process of constructing scientific theories. According to him, philosophy of science should reconstruct the process of the development of science in a rational way, i.e. to form a logical scheme of this process as subordinated to the rule of verifiability of appearing hypotheses. The rational reconstruction is carried out by superimposing a normative methodological pattern on the course of scientific research and presenting it in a way of how it should proceed, or how it would have proceeded if the cognitive process had not involved factors other than purely cognitive ones. The factual processes of reasoning of scientists are thus to be replaced with a sequence of statements that logically follow one another and head towards a result able to empirical verification.

So, according to Reichenbach, to determine the tasks of the philosophy of science it is necessary to separate a field of research concerning general schemes ruling the verification, confirmation, refuting, proving, hypotheses, in a word – to separate *the context* (area, domain, field) *of justification*. Within the context of justification it is then possible to ask questions about reasons giving grounds for a scientific hypothesis – and not about somebody's acceptance of it – as well as to examine its logical relations with other scientific statements, which are independent of whether someone is aware of them or not. Such were the concerns of, e.g., Karl Popper within his falsificationist approach to science.

Within the context of justification we are interested in already existing knowledge – its structure, verifiability and other such features. The other possibility is to investigate *the context of discovery* – the factual cognitive process of reasoning and research operations leading to formulation of hypotheses and theories. Here one is interested in circumstances influencing the emergence of certain hypotheses and their being accepted or rejected by actual scientists. So devised philosophy of science exploits the results of psychological, sociological and historical studies and thus takes into account factors of scientific progress recognized by justificationists as "external" and not content-related. A cognitive subject – both individual and collective – removed from the context of justification here becomes the main object of studies. Such approach was represented, for example, by Thomas Kuhn.

Rational reconstruction of the development of science: Karl Popper and the context of justification

Popper's view on the subject-matter of the philosophy of science boils down to the thesis that it is identical with the context of justification, while the context of discovery should be removed from it as a sign of psychologism, sociologism and historicism. Popper's methodology is thus strictly normative and limited to rational and diachronic reconstruction of the development of science. According to it one should distinguish the psychology of science dealing with empirical facts, from the logic of knowledge, which deals but with logical relations. Concerning the process of scientific discovery this distinction resolves itself into separating in scientist's work a phase of formulating a theory and a phase of its verification. The act of coining an idea or inventing a theory neither require a logical analysis, nor can be subjected to it, since the logical analysis does not deal with questions about facts but exclusively with questions about soundness and validity of cognitive theses. It asks questions whether the statement can be justified, and if it can be, then how? (see "The Logic of Scientific Discovery").

Popper's all works, including essays written in "The Logic of Scientific Discovery" and after contained in "Conjecture and Refutations" and in "Objective Knowledge," are characterized by programmatic limiting to the context of justification, comprehended as a domain of logical reconstruction of the scientific progress – also when Popper includes in the rational reconstruction the so-called "problem situation" and makes it one of the basic elements of the advancement of knowledge. According to the falsificational scheme of the scientific progress it takes the form of: P1 $\rightarrow$ TT $\rightarrow$ EE $\rightarrow$ P2, where P stands for problem situation, TT for tentative theory, EE for error elimination. The formal methodology covers here a sphere of not only hypothesis justification and its criticism, but also the phase of its formulating. This aspect of discovery can be also studied with logical tools, which consists in analyzing the starting problem P1 and its connections with the test theory TT, and a new problem P2 and its connections with errors elimination EE.

Popper's approach provides for the reconstruction of the scientific progress being the mainstay of the cognitive objectivity and classical truthfulness. Falsificationist methodology is a tool of verifying whether knowledge actually has such features. The method does not provide the knowledge with objectivity, but detects it inside, exposes it. Therefore the research method does not consist in posterior removing outer influences from knowledge, but in revealing its inherent properties.

Popper claims that what he calls objective knowledge is independent of the cognizing subject. (Therefore, a factor that is able to transfer outer influences to knowledge is being removed from it). Popper develops those ideas within his concept of "three worlds." World One is the world of physical objects and states. Additionally Popper distinguishes knowledge and thought in a subjective sense, containing mental states or states of consciousness (World Two) and knowledge and thought in an objective sense, consisting of theories, problems and problem-situations, arguments, states of discussion, contents of libraries and so on (World Three). World Three, although essentially a man-made product, is not created fully intentionally and consciously and therefore maintains some independence of World Two. Firstly, although an indirect stage of its forming are states of human consciousness, the contents of thoughts are both the effect of those states as well as their inspiration; they result from man's intellectual work but also dictate its certain direction and outcome. Secondly, once having settled in World Three, its residents become autonomous. They become the knowledge without a subject. Confrontations leading to changes in knowledge take place only between elements of World Three, though, obviously, new elements of knowledge are delivered through channels leading above all across World Two. Thirdly, elements of World Three are not fully known by us; for example logical implications of existing theories and relations between theories might exist there before they became elements of World Two. Fourthly, almost all subjective knowledge from World Two depends on objective knowledge – World Two can be examined indirectly through examining World Three and only such studies can bring us to understanding the content of own consciousness. Fifthly, the structure of World Three and regularities that govern it are not obvious to us. Their cognition is the goal of epistemology – the theory of objective knowledge.

According to Popper, a guiding principle for scientists in their cognitive work should be looking for more satisfactory scientific explanations. The explanation is satisfactory when explanans meets Popper's conditions of correctness (methodological norms) – earlier mentioned in "The Logic of Scientific Discovery" as criteria of verification, empirical content, simplicity, universality and exactness. And as satisfaction concerning explanations is gradational, scientists should strive to arrive at explanations that are more satisfactory that those already existing. A new explanans is more satisfactory than its predecessors when it is given in terms of more testable laws, which always translates into their higher universality, richer empirical content and higher exactness.

The sequence of more satisfactory explanations has another property which is called by Popper "nearness to truth" or "verisimilitude" (Popper 1972, p. 143). This means that the development of science as reconstructed with the tools of logic and formal methodology is fully rational and progressive. A new theory that survived attempts of being refuted is nearer the truth than its predecessor and, therefore, is cognitively more valuable. Science is rational while heading to the truth and we can measure its progress.

Norms and rules guarding the reconstruction of the scientific progress against the interference of psychological, sociological and historical factors are particularly exposed to such interference in two situations: 1. while determining which sentences of a given science can be acknowledged as basic; 2. while determining what exactly has been falsified when the result of an experiment was negative. A commentary on the situation is offered by S. Amsterdamski in his "Między doświadczeniem a metafizyką" when he states that: *this very problem why certain statements – irrespective of whether they are basic or theoretical – are considered by science as reliable although they are not sufficiently justified – and as such they can be always either questioned or defended by accepting additional assumptions – this very problem is a question that cannot be solved by the logic of scientific discovery itself. Here we are facing an alternative: either – while seeking an answer to the question – we are forced to go beyond the studying of the context of justification, or to limit the scope of analysis to the context of justification that bans asking questions of non-logical character which would have to take into account historical, sociological and perhaps also pragmatic issues* (1973, pp. 135−136).

The other side of the development of science: Thomas Kuhn and the context of discovery

Kuhn, drawing from sociology and history of science, intended to offer a view of the development of science that also would assume a philosophical character and go beyond the subject-matter of those two sciences (sociology and history). Obviously, his proposal was a reconstruction essentially differing from rational reconstructions (e.g. Popperian), yet still universal, with well-documented empirical background and preserving the conviction that choices made by scientific communities are not arbitrary, being governed by specific rules, although not (epistemo)logical but social. In the foreword to his "The Essential Tension" (1985) T. Kuhn wrote that scientific knowledge is basically a group product and it is impossible to understand the way it is progressing without referring to the characteristics of social groups who are producing it; hence, without applying the tools of sociology or social psychology. He treats the history of science as a sphere of studies concerning the development of scientific ideas, methods and techniques. Such inner history of science examines the transformations of scientific contents within a *paradigm*.

Kuhn is mostly interested in the relation between novelty (new paradigms) and tradition (normal science) in the scientific progress. Paradigms are "self-confirming" monads. For, if the meaning of observational terms depends on their theoretical context (and such is the situation in the paradigmatic concept of scientific progress), then every hermetic theoretical system will always be eventually confirmed, since in the face of counterexamples or anomalies the system can always be modified so as to absorb them. Therefore, no observations and experiments can provide a sufficient reason to change a paradigm. And because paradigms are empirically incomparable (data supporting one system do not falsify the other), the choice of one of them becomes an extra-cognitive matter.

Kuhn asks why (on what grounds, if there are no logical and empirical criteria) a conceptual scheme emerging in the mind of one cognitive subject becomes next something mandatory for a community of cognitive subjects. His answer consists in pointing to the "common consent" (consensus omnium) setting the unanimity of the scientific milieu. The word "scientific" means here just "unanimous" (within a community of scientists). In this way Kuhn gives up questions of whether scientific theorems are true, and instead starts to ask if and how scientific concepts and theories become collective instruments of action, and what values and norms of scientific groups promote achieving *consensus omnium* within paradigms. Together with the elimination of the idea of truth, the criterion of verification was replaced in Kuhn's view with the criterion of effectiveness of scientific research, expressed by reference to "usefulness," "fruitfulness," and "effectiveness."

What is the origin of those norms, how do they emerge inside a paradigm, why scientists are willing to follow them? Are they in any way a reflection of what is going on outside a paradigm? Kuhn addresses those issues while polemicizing with Robert Merton who claimed that the scientific progress in the 17th-century England came as a result of technical and economic needs of that time, and of the similarity between the ethos of science and Puritan ethics. Thus

Merton combined developmental processes of culture (civilization) with the development of science itself. As a matter of fact, he acknowledged their mutual interactions. But Kuhn refuses to agree with even so mildly outlined interactions. He divides the development of science into two phases: the early and the mature one and argues that only in the early phase the main determining factor of a given discipline are social needs and values (see "The Essential Tension"). And the further development of the already formed specialization goes in a basically different way. People doing mature science are as a rule equipped with the developed and accepted theories and with mathematical, technical and conceptual methods, thus forming a special professional group whose members are the sole addressees and judges. Problems are no longer imposed on them from the outside – they are being effectively isolated from the intellectual climate of their non-professional life.

The impact of science on culture is not an important field of study for Kuhn, either. He argues that there is no stable relation, applicable to all scientific disciplines that would link them with civilization. He points that till the 19th century it was rather science that benefited from technical achievements than the other way round. For example, Carnot developed thermodynamics while constructing perfect heat engines – he adapted theory of their perfecting to the already existing practical improvements. Only from the end of the 19th century technology has been forced to advance studies on its own processes and products, hence becoming a social and financial base for the scientific progress. The history of science becomes here the history of groups of scientists and theories they cherish, and not of the whole science; and sociology becomes group psychology leaving aside social commitments of science.

For Kuhn, the area of incentives and decisions of scholars is the area of inner determinants of a paradigm – scholars focus their activity not on refuting the existing theories (as Popper suggests) but on solving problems the theories bring about. They try to develop those theories and to make them more exact, while the cases of criticism and refuting them are quite rare. In a word, scholars try to solve "cross-word puzzles" brought about by a paradigm, using methods also belonging to the paradigm. Such is their individual and collective goal (see "The Structure of Scientific Revolutions"). The tradition and methods of solving puzzles become for Kuhn a criterion demarcating science from other fields of intellectual activity.

The question about the goal of science as a whole would require an answer to the question: why and for what purpose (purposes) do scientists solve puzzles? There is no direct answer to that question offered by Kuhn; therefore one has to take a closer look at what puzzles are and what are the rules of solving them. The description can be found in "The Structure of Scientific Revolutions;" it can be summarized as follows:

– the importance of a puzzle consists not in the importance of the result of its solving but in the way it is achieved – we know that each puzzle within a paradigm must find a solution, and how fast it is found depends on intellectual efficiency of scholars,
– showing skillfulness in solving puzzles is one of the most important reasons of undertaking scientific work,
– the solving of a puzzle is achieved with the use of rules set in a paradigm, which cannot be altered,
– the criterion of accepting solutions is not their "truthfulness" but the unanimous consent of a community of scientists guided by a paradigm.

Hence, it is clear that together with the issue of truth and truthfulness any epistemological goal of research has been eliminated. Paradigms – basic units of transformation in science – can be themselves goals for scientists and because they are subject to change, the choice among competing goals-paradigms is a question of a decision that must be motivated but by some non-cognitive regards. With the elimination of the truth, the purely epistemological criterion of empiricism was replaced in Kuhn's instrumentalist concept with the aforementioned criteria of effectiveness, which are of evaluative character and form a kind of universal methodological goals. In "The Essential Tension" Kuhn argues that the choice between theories is made on the basis of such methodological norms as accuracy, consistency, generality, simplicity, fruitfulness, with the reservation that they do not function as univocal criteria but rather as scientific values. They may conflict with each other and the way of their application (to theory valuation) is not straightforward.

The values in question can be common to many paradigms. Thus, there is a certain common supreme resort – a collection of values accepted by the whole community of scientists that regulate also research proceedings of normal science – which, while not imposing any viewpoint, nevertheless enable communication among supporters of different theories.

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Let us summarize Kuhn's reflections on the process of the development of science. As far as epistemological (the truth, other properties of knowledge) and methodological goals of science are concerned, Kuhn rejects the former while reducing the latter to the form of rules of accepting "consensus omnium" by scientists, i.e. to the rules of successful solving puzzles characteristic of a paradigm. The success of a scientist consists in showing that the adopted theory can be effectively applied to solve a paradigmatic puzzle. And the point here is not in seeking a new mode of arranging the world of human experience, but in confirming the already existing order; not in seeking the truth, but in exploiting the already set down claims. According to Popper, the goal of science is striving for truth and Popper's methodology is to serve it. Kuhn's normal science is to serve exclusively the solving of problems brought about by a paradigm. Kuhn's vision of normal science ignores the fact that solving puzzles is not a goal in itself, through which a scientist shows to his colleagues his skills in the game, but that it is a fragment of a bigger "puzzle," solving of which has been the goal of science since the beginning of its existence.

According to Kuhn, the goal of science is set solely through decisions of groups of scientists, and such decisions are a derivative of the aforementioned rules of attaining unanimity. The rules are determined by ideals of practicing science – historically variable, but strongly present in the consciousness of scholars so that they actually implement paradigmatic goals automatically and without questioning them. Such autonomous goals of science emerge in the phase of mature science enabling its isolation from the influences of the social environment. The implementation of external goals, social constrains, etc., is considered as a symptom of immaturity of a scientific discipline, of the lack of own method and rules of attaining scientists' unanimity. Mature science is a monad (or Ivory Tower, to use a more suitable metaphor) governed by its own rules, setting its own goals. Its actual immersing in social world merely enables its functioning (it is its realization factor), but is irrelevant concerning rules of this functioning (it is not its determination factor). And validity of scientific contents comes from unanimous decision of scientists steered by the rules of a paradigm.

The change of a paradigm happens when a new paradigm offers a more useful perspective of conducting research. The choice and adoption of a new paradigm determines a new set of puzzles to be solved by scientists after the revolution. In the phase of mature science there is no possibility for a scientist to discover any other problems that those determined by a paradigm. The only moment of independent (of paradigmatic directives) work of a scientist is the moment of formulating a hypothesis being the basis for a new paradigm. But Kuhn does not study this phenomenon! The research perspective adopted by him – the study on intra-paradigmatic mechanisms of a professional group's behavior – would not let him do this. The circle is thus closed. The goals of scientists are determined by a paradigm – which allows for their realization until it exhausts its power of producing effective puzzles – and at the same time the goal of a paradigm is set and fulfilled thanks to the work and reasoning of scientists – their individual and collective goals. Which determination is stronger? Kuhn leaves no doubts: it is a paradigm that assumes a dominant position in relation to the goals of scientists. With one reservation, however. Tradition prevails over novelty and individualism in the phase of the advancement of a paradigm which he calls "normal science." It is a revolution, an inter-paradigmatic transfer that actually changes this relation.

How then to explain the existence of supra-paradigmatic rules? Where the ideal of practicing science contained in a paradigm comes from? What is justification of its adoption? Does it perform any epistemological functions? Does it to any extent reflect the goals that are external to science? Is there any "supra-paradigmatic goal of science" that lasts despite changes?[49] Kuhn's approach fails to give answers to those questions.

Seeking answers to the above – and similar – questions had in effect to direct philosophers of science towards another kind of research – one in which the comprehension of a phenomenon of science would not stem from studying specific mechanisms inside it and demarcating its boundaries through pointing to its difference from a cultural environment, but, on the contrary, by telling what social functions it fulfills and therefore by regarding it as an element of such broader whole. It means a transition from the internal history of science to the history of culture (or civilization), and – on the other hand – from a normative to hermeneutic approach. It also completely changes the comprehension of what are the goals and tasks of science.

Science and its social functions – Richard Rorty's neopragmatism

For anybody who faced the third current in the philosophy of science it is obvious that it questions traditional epistemology and methodology (and also specific cognitive objectives of science they determine) as well as any normative view of science. Science becomes here understood as an element of a broader social whole, and its "autonomy" and all other characteristics turn out to be derivatives of its social functions. According to this view science may have its own, inner purposes, but science is not self-purposeful activity, being a function of goals that are external to it – such as mastering the nature, facilitating realization of social interests or other extra-cognitive human needs (e.g. human dignity). Inner goals of science assume, in the social context, a status of a means to implement human social and generic objectives.

What is worth stressing is the fact that this subordination of the inner purposes of science to social objectives does not prevent both scholars and philosophers from treating science – its goals and methods – as autonomous. Science is something else sociologically and something else intentionally. The subjective sense of freedom, disinterestedness and impartiality of scientists may go hand in hand with social, generic or other constraints by social goals, interests,

[49] Here one should rather follow Amsterdamski (1985) and accept the historical changeability of the ideal of science. Only after that one will be able to think of science as a certain synchronic whole with a common goal – and not as a collection of disciplines with a basically differentiated set of goals, and, possibly, common norms of approaching consensum omnium. Kuhn however would not consent to such view arguing that it is not possible to speak about science as a whole since there is nothing that would be common for all scientific activities, focusing instead his interest on particular disciplines and small communities of scientists.

structures and mechanisms, which is possible due to the social division of labour and to the fact that those constraints are mostly unconscious, imperceptible to scientists like the air they breathe, because they come from the sphere of everyday life where both science and scientists have their roots.

According to this view, science should be characterized not via its purported internal categories but via external factors, concerning its social conditions and constrains, its place in society and civilization. Only after it is done can questions be asked about means to meet those constraints, hence about the method of science and its internal goals.

Neopragmatism programmatically denies the goal of science that stems from the specificity of a scientific method and the accompanying methodological norms. But its major attack is directed towards undermining the epistemological idea of the very possibility of pure, objective cognition. According to Rorty, it is an illusory idea; nothing in culture can be independent of it. This concerns science, too.

Analyzing the goals of practicing philosophy Rorty (see "Philosophy and the Mirror of Nature") argues that scholars in humanities use different tools in their work than the gnoseological mind. They are rather interested in goals of its practicing than in the method, since they believe that the value of intellectual considerations comes from the goal they are working for and not from the methods of implementing this goal. Hence, they assume a different view concerning rationality of conduct within the scientific milieu. Traditionally, science is perceived as a supplier of "hard," "objective" truths understood as correspondence with reality. Now, if it is declared that science should abandon striving for purely cognitive values, focusing instead on socially useful ones, then "rational" means something completely different than "rationality" of methodology represented by approaches of e.g. Popper. It means respecting others' opinions, willingness to listen, relaying on persuading, inciting to adopt views for the sake of practical benefits. It may be a rather "civilized" discourse instead of a "methodical" one, a tendency for discussing any subject without coming to cognitive conclusions, hence avoiding dogmatism. We should be satisfied with this weaker version of rationality and avoid the belief that there is any specific value in the procedures of attaining knowledge and in criteria of progress in its attaining.

The key role in neopragmatic characteristics of science is played by the category of "solidarity" introduced by Rorty in his well-known article "Science as Solidarity." Rorty plainly states that pragmatists have no theory of truth, that their account of science is based solely on ethics and not on epistemology or metaphysics. They want to replace the striving for objectivity conceived as maintaining contact with reality, with striving for solidarity with a group engaged in a discourse. The only sense in which science can be a model for other spheres of activity is the one where it is a model of human solidarity. Institutions and practices characteristic of scientific communities provide guidelines as to the mode of a possible organization of the rest of culture. Such approach, applied so far mostly in the humanities, should be adopted by the whole science. One should replace "objectivity" of knowledge with unconstrained agreement of views, reject the idea of an "epistemological model" or "cognitive status" of the proclaimed assertions as the goal and characteristics of science, do without the traditional distinction between knowledge and opinion. Neopragmatists believe that relaying on persuasion, respect for the opinions of colleagues, curiosity and eagerness for new data and ideas are the only important qualities of scientists. They do not believe that apart from those personal qualities there exist such intellectual virtues as rationality, objectivity, striving for the truth or other goals traditionally attributed to science by epistemology.

From the point of view of traditional epistemology, participants in a scientific discourse constitute *universitas* – a group united by common cognitive aspirations and methodological standards. According to neopragmatism, they constitute *societas* – a collection of persons whose paths through life crossed and who to engage in discourse do not need any systematically applied methods and the more so any common theoretical ground – sociability is enough. Scientific discourse is another kind of face to face conversation and not facing reality to uncover its mysteries.

Rorty calls his view "epistemological behaviorism" and argues that understanding the rules of language games in any sphere of culture meets all cognitive needs concerning explanation why in a given game certain moves are applied and certain ways of solving problems are proposed. According to him, reference to "objective reality," "correspondence with outer world" and other epistemological ideas that help to decide (at least in the opinion of an epistemologist) what view to adopt as the best one, is impossible and unwelcome fantasy.

Conclusion

The three approaches to the problem of scientific rationality we have presented above are as different as different are epistemologies constituting their foundation. This diversity enables one to perceive science from many perspectives and realize that reflections on it do not offer easy solutions.

An attentive reader will easily recognize approaches of Popper, Kuhn and Rorty as definite paradigms of rationality presented in chapter 1 of this course book. Let us recall that within the framework of proper rationality emotions and will are moderated by the requirement of realism. In the paradigm of semi-rationality (or restricted rationality) decisions of a person are determined by empirical knowledge-based cognitive elements (i.e. by knowledge concerning facts and factual realities) with the additional reservation that evaluative statements do not count as knowledge. Now, this is exactly the case of traditional methodology of science represented here by Popper and – with some reservations – Kuhn. And neopragmatic stance of Rorty is unequivocally a version of pseudo-rationality.

A question arises if there is possible an account of science – especially concerning social and economic sciences and humanities – which could legitimately be qualified as full rationality. We shall try to answer it during lectures on axiology.

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