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THE MEANING OF SCIENTIFIC OBJECTIVITY

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This is an attempt to shed some light on the problem of scientific objectivity. What do we mean by an objective scientific statement? Should we agree with those who claim that science is void of all values, apart from the epistemological value – that of being true? Or should we rather agree with some modern critics who maintain that there is not – and can never be – an objective scientific opinion? Any assertion to scientific objectivity reflects nothing more than a conscious or unconscious adherence to the values and norms currently held by members of the scientific community and by the social "establishment". I happen to believe that the problem of scientific objectivity is far more complicated and interesting than these two opposed opinions.

In the following I will restrict myself to the experimental, but not necessarily the natural, sciences. I am not dealing with the humanities nor with the social sciences other than to the extent these apply experimental methods in their work. "Experimental" must be understood in a profound sense. I will use it in reference to a well defined theory of scientific inquiry, to be discussed later, and not to merely the use of instruments and technical equipment in the process of knowledge gathering.

The evolution of a conceptual dichotomy

A natural approach to the problem of scientific objectivity is to start by investigating the conceptual dichotomy subjective - objective. Such an investigation may be carried out in three different dimensions: a semantic, an epistemologic and an ethic. It helps considerably to clarify the issue if the concepts are seen in a perspective of evolution offered by the history of ideas. It will be seen that we are faced with a surprising and significant inversion in the usage and connotation of the two concepts, subject and object, and of their derivatives.

Let us first consider the semantic dimension, i.e. the meaning and usage of the words themselves. "Subject" derives from the Latin subjectus, formed by sub, under or below, and jacere, to throw. In an analogous way "object" comes from objectus, the prefix ob meaning to or toward. In other words: something (the object) is thrown towards and under something else (the subject).

The original meanings of these words appear somewhat strange to the modern mind. This indicates that there has been a semantic change during the centuries that separate us from the Romans. This suspicion is confirmed by an inspection of the actual usage of the words, subject and object, at different times.

Not only Medieval scholastics but also Descartes and Berkeley expressed themselves in about the following manner: I (the object) am engaged in this activity (the subject). This is the opposite to the modern usage: I (the subject) am engaged in the study of this object.

Object and subject have interchanged their positions!

Strange as it may seem this remarkable inversion is perhaps rendered more credible by the observation that the Medieval usage is retained in modern English where it is perfectly correct to say: I am a student and my subject is physics. If physics is the subject what, then, is the object? Of course the student is exposed – or subjected – to the teaching of physics i.e. to objects of knowledge thrown towards him to be placed deep in his consciousness.

There must be some reason for this inversion. We may search for the cause
2) in the epistemologic dimension. How does the actual usage of the words relate

to the different ideas of the methods and grounds of human knowledge?

The scholastics, Descartes, and Berkeley considered the individual's conception, as such, the object. Thus "objectives" were attributes of this conception quite irregardless of whether these were true or false.

The realists, however, held the ego to be the subject conceiving an independent and external object of knowledge. Hence, for the realists, "objectives" were attributes independent of the subject and supposed to be true.

In an interesting and revealing fashion Kantian philosophy seems to mark the turning point. Kant made a distinction between two different kinds of subjects:

the psychological subject — the "real subject"
and the epistemological subject — the "formal" subject
(or Bewusstsein überhaupt)

Apparently what Kant means by "psychologically subjective" comes close to what is now meant by subjective, whereas his "epistemologically subjective" is about the same as our present objective.

In modern scientific contexts the subject may be said to denote the conception and the conceiving, whereas the object denotes that which is conceived. Subjective and objective are attributes of the subject and the object, respectively.

These are value loaded words. But how the values are to be placed is by no means evident. In the ethical dimension the following picture seems to emerge:

Traditional norms commonly accepted in industrialized societies

	Value		
subject	+	-	object
subjective	-	+	objective

fig. 1

These values may now be in the process of being completely reversed into something like the following:

Postindustrial norms emerging in highly industrialized societies?

	Value		
subject	-	+	object
subjective	+	-	objective

fig. 2

Critics of the industrialized society now degrade the traditional anthropocentric attitude while emphasizing the merits of holism and ecology: "Nature knows best". Othersconsider "objectivity" sheer hypocrisy in the service of a ruling elite. They advocate a "conscious and critical" subjectivity, engaged in the liberation of opressed social classes.

Reality and the experimental method

The curious semantic inversion discussed above, I shall venture to suggest, is primarily due to the impact of the experimental method and related to the rise of realism. If this is correct, then the current interest in the problem of scientific objectivity may be considered an aftermath of an early 20 th century crisis of realism. This crisis has been brought about by a development which has taken place within the fields of mathematics and physics.

With the following words: "our disputes are about the observable world and not one of paper... let us proceed to demonstrations, observations and experiments". Galileo presents in a nutshell his revolutionary theory of science: the experimental method.

Galileo is well aware that our sense organs are ambiguous and unreliable sources of human knowledge. Yet, after having discussed this problem at length, he concludes [1]:

> I find myself necessarily compelled, in conceiving a material or corporeal substance, to suppose thereby that it is marked out and delimited by such-and-such a shape, that is large or small as compared with other bodies, that it has this position (or some other) at this moment of time (or another), that it is either in motion or at

rest, either in contact with another body or not. ... By no effort of the imagination can I conceive it apart from these characteristics. But that it should be white or red, bitter or sweet, noisy or silent, fragrant or evil-smelling — I do not find myself in any way compelled to think of it as necessarily possessing any of these characteristics. On the contrary, if the senses had not distinguished these properties, neither the reason nor the imagination alone would perhaps have arrived at the idea of them.

I conclude that tastes, smells, colours and so on, regarded as the properties of objects, are mere names: their true location is, rather, in the sensitive body (of the observer) — so that, if every living thing was taken away, all these qualities would vanish and be destroyed.

Here Galileo makes a clear distinction between what has later been called primary and secondary qualities. Primary qualities belong to Nature as such. All other qualities, colour, smell, sound, taste etc., exist only subjectively in our experience.

The distinction was made already in antiquity and may be considered an integral part of atomism.

The world is "observable" Galileo asserts provided we focus our attention on the primary qualities. It is also accessible to human reason provided we "proceed to demonstrations, observations and experiments". Each of these words has a special meaning.

By demonstrations Galileo means mathematically, usually geometrically, formulated hypotheses which we arrive at more or less intuitively. Then we proceed to observations in order to convince ourselves that our hypotheses are compatible with known observations. If the hypotheses prove to survive this first confrontation with reality we may continue to the third and decisive step, to experiments. Starting from our hypotheses we draw conclusions by logical and mathematical means. We predict what must happen under given conditions. These predictions we then try to confirm experimentally. If they prove to agree with our experimental results, our hypotheses have passed the decisive test. They are "experimentally verified" and may, according to Galileo, be regarded as true statements about reality.

'rimary qualities are the true and independent attributes of external reality. t is these qualities and only these, that can be investigated by scientific neans. They define the domain of physical inquiry: res extensa, to use a Cartesian expression.

For a physicist, at least, a precise definition of the phrase "primary qualities" becomes a matter of supreme importance. Hence, it is somewhat discomforting that the meaning of this term has varied considerably during he centuries as a brief inspection in the history of physics immediately discloses.

What is primary and what is secondary? For Democritus primary qualities were position, form and extension. For Descartes they were position, extension and motion. For Newton all of these, together with gravitational and inertial mass, were primary qualitites. 19th century atomists extended the list. They included electric and magnetic, optical and chemical qualities. In modern physics primary qualities are quantum numbers and quantized entities such as energy, momentum, spin, parity, electric charge, magnetic moment, strangeness, lepton number, hypercharge etc.

One might well ask: is there any common denominator among these various listed primary qualitites? The answer is yes. It has always been a matter of those qualities — and only those — which can be measured by current technical methods and expressed in numbers. As technology develops the domain of primary qualities expands. In practice, if not in theory, the definition has always been operational.

Superficially the quote from Galileo is a statement about the true nature of physical reality. But in fact it is a definition. Galileo defines reality as the totality of observables amenable to quantitative measurements, observations and experiments.

Needless to say these observables represent only a tiny sector of human experience. But it is within — and only within — this sector that the experimental method applies.

By this ingenious dialectics Galileo established a perfect parallelism betwe scientific language and physical reality. Reality is perfectly mirrored in language. Everything that can be expressed exists and everything that exis can be expressed. In the words of Wittgenstein [2]:

> Die Logik erfüllt die Welt; die Grenzen der Welt sind auch ihre Grenzen. *

What about all the rest? What about God, the meaning and purpose of huma life, the mystical experience etc. These belong to the secondary qualities: they do not exist in reality and have no place in an orderly structured scier tific language. Of these you cannot even speak and

> Wovon man nicht sprechen kann, darüber muss man schweigen.
> (Wittgenstein)** [3]

The astonishing successes and breathtaking discoveries of the physical sciences led people to take Galileo's claims at face value. Scientific statements are objective in the realists' sense: they are true because they can be "experimentally verified".

The crisis of realism

Geometry certainly derives from practical experience as witnessed by the very name of this science (from geo, the Earth, and metro, I measure). However, already in antiquity empirical geometry was transformed into a deductive discipline of mathematics. From a basis of axioms, considered t be self evident, geometrical propositions were deduced by pure logical reasoning. There was no need for "experimental verification". Yet, it was taken for granted that Euclidean geometry was the geometry of physical space. Other possibilities were excluded. They were, according to Kant, "unthinkable".

(5.61) * Logic fills the world: the limits of the world are also its limits.

(7.) ** Whereof one cannot speak, thereof one must be silent.

'he emergence of non-euclidean geometries was a deathblow to this pre-sumption. 19th century mathematicians consciously liberated geometry rom the restrictions posed by physical credibility. Four, five and n-dinensional geometries with euclidean or non-euclidean metrics were elaborated.

This emancipation of mathematics posed a grave problem for physicists. Now one had a number of mathematically equivalent geometries to choose among. Which – if any – of these applies to physical space?

The empiricists, Gauss, Lobatjevskij, Riemann, Schwarzchild, and others maintained that only experimental observation could settle the question. And such experiments were indeed performed.

It was against these aspirations that Poincaré raised his ponderous objection:[4)]

> "If Lobatjevskij's geometry applies, a very distant star must exhibit a finite parallax, if Riemann's holds it must be negative. These are observations that seem to lie within experimental reach and people have expressed hopes that it will become possible for us to decide between the three geometries. However in astronomy a "straight line" simply means "the path of a light ray". Thus, if we find negative parallaxes or if it turns out that all parallaxes exceed a certain limit we have two alternatives to choose among: we may renounce the Euclidian geometry or we may modify the laws of optics and suppose that light does not propagate exactly along a straight line. Needless to say that the latter alternative will be deemed preferable. Thus Euclidian geometry has nothing to fear from new experiments."

Poincaré's anticipation has proven wrong. Euclidean geometry has in fact been renounced in some cosmological contexts. But his essential point remains valid: we cannot find out experimentally how it is in reality. We cannot make any meaningful scientific statement at all unless we are willing to accept certain conventions. And these conventions can never be justified on empirical or logical grounds only. They contain by necessity a component of non-scientific nature, a component of metaphysics.

This is the "crisis of realism". No wonder it has become necessary to reconsider the problem of scientific objectivity.

What should we mean by an objective scientific statement?

In reference to what has been said above it seems prudent to distinguish between three different components in science: facts, theorems, and norms.

A fact is generally said to represent a thing that has actually happened or is true. This notion, rooted in realism, I consider untenable. Among other flaws the definition has the serious drawback of being too broad. A study of facts as they actually occur in scientific practice, discloses that facts represent nothing but communicable human experiences. By "experimental verification" we do not prove our results to be "true" but we do prove that they can be communicated, i.e. understood and repeated. Such experiences — and only such — are accepted as facts by the scientific community.

A theorem is a logico-mathematical structure. It is important to note that mathematics tells us nothing about the external world. Mathematical theorems are empty tautologies: all bachelors are unmarried. They provide "the rules for our description of the world but do not contribute to the content of that description" (Reichenbach).

Scientific routine is entirely confined to the level of facts and theorems (cf. fig. 3). It is a matter of correlating large amounts of facts by the use of theorems into theories (or laws). We may, for example, determine the pressure of a given amount of gas at different volumes. Mathematics provides a simple expression which summarizes our results: the product of pressure (p) and volume (v) is constant:

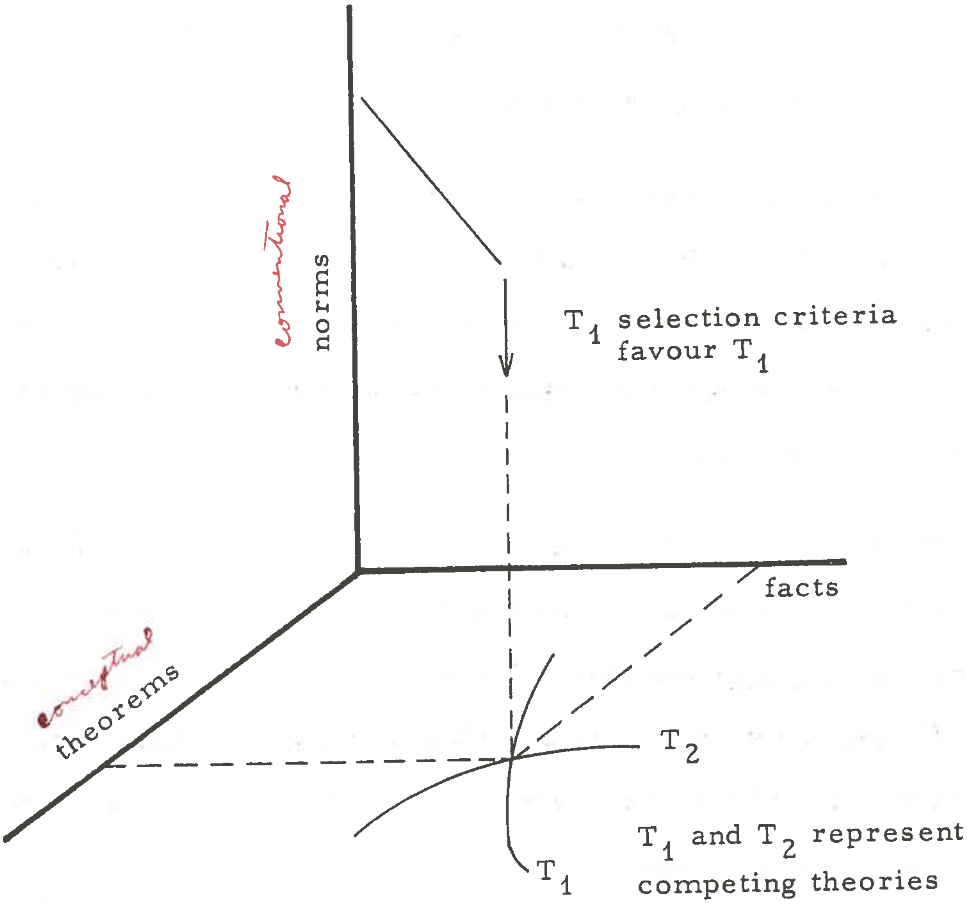
$$p \cdot v = \text{const.}$$

This simple theory, Boyle-Mariotte's law, applies reasonably well, but not exactly and not always. The pressure must not be too high, the temperature has to be kept constant. It holds, exactly only for "ideal" gases and there are no ideal gases in nature.

It is not without some pushing and harmless fraud that we manage to force the raw material of facts into the matrices of mathematics.

So much for the scientific routine. The point made by Ponicaré, however, is that facts may be codified into theories in alternative ways and that the choice between those alternatives can not be made on experimental grounds. In his own words: "La géométric euclidienne n'a donc rien à craindre des expériences nouvelles". 4)

This element of arbitrariness necessitates the inclusion of a third dimension — the norm axis of fig. 3.*



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* The author has been much inspired by Gerald Holton's pertinent remarks, in particular by his thematic analysis of science.

If theories can not be distinguished by "demonstrations, observations and experiments" what then? What criteria do we apply? In fact science works with an ill-defined assembly of norms, many of them mutually inconsistent. Norms frequently called upon are comprehensiveness, predictive power, precision and simplicity. But no doubt cultural tradition, esthetic appeal, historical circumstances and social impact are powerful factors at work.

We finally arrive at the conclusion that the experimental sciences indeed are tinged by external values and norms. This, however, does not mean that there is no such thing as an objective scientific statement.

We may denote the scientific community as the knowledge gathering subject – the conceiver – and the result of this activity as the object – that which is conceived. Then objectives are attributes of the object, the body of scientific knowledge.

A scientific statement may then be said to be "objective" if it, when expressed, represents currently held theories and generally accepted facts. This objective statement is neither "true" nor value neutral. But it does represent the current scientific consensus. A consensus which has been formed by strict adherence to rules of a sociological nature. These rules for human relations define the experimental sciences. They are characterized not by the nature of the knowledge as such or by the objects of their inquiry but by the very nature of their knowledge accumulating process.

The conclusion that an objective scientific statement is nothing but the currently formed consensus, neither "true" nor value neutral, sounds modest. And it is. Yet, this consensus is the strongest force at work in transforming our human conditions. Scientists are charged with a heavy social responsibility.

That science is powerful is readily recognized by members of the scientific community. That there are limits to the power of science is far less frequently appreciated – unfortunately.

References

1) Galileo Galilei: Il Saggitore (The Assayer) 1623

2) Ludwig Wittgenstein: Tractatus Logico-Philosophicus 1921 proposition 5.61

3) ibid. proposition 7.

4) Henri Poincaré: La Science et l'Hypothèse, 1902.