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THEORIES, FACTS AND THE THEORY–DEPENDENCE OF FACTS

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0. Introduction

That scientific theories are checked by putting them to the test of facts is an age-old truth, as old as modern science itself, at the very least. For the benefit of us all, Galileo spelt out, with the greatest clarity, the principle that all our hypotheses must be measured against the "*sensate esperienze*". On the other hand, that no facts exist which are not theory-laden is also a truth that is perhaps just as old. Galileo himself had occasion, more than once, to point out to his opponents that what they swore was an elementary observational fact — the fact that bodies fall perpendicularly — was actually the illusion created by a theory they had been suckled on.

Now, the existence of two apparently conflicting truths raises a problem. And that problem turns into a riddle if we are in the position of being unable to relinquish either of those two truths. In the case in hand, if we try saying facts are theory-free, we are in the position of no longer understanding why even the most apparently obvious facts are subject to revision, precisely in the light of theories. If, on the other hand, we try saying facts depend upon theories, the consequences are just as counter-intuitive and undesirable. The reason is obvious. One of the aims of science — perhaps its main cognitive aim — is to find true explanations of the world. Science strives to achieve this aim by creating theoretical constructions and testing them by means of observations and experiments. Now, if no facts existed by which to test these theories, it would not be possible for science to pursue such an aim. Let us suppose that theories exercise full dominion over facts. It would, then, be impossible to test them or to make comparisons between them : each one would be a world in itself. It would still be possible

to speak of facts, but only *within* their respective theories; and it still might be possible to talk of explanations, but these would take the form of *images of the world* and not of true or false *descriptions of the world.* In that case, on what grounds (if any) should we mark the difference between a scientific work and, let us say, a work of art ? The vindication of a proper distinction between facts and theories is then a preliminary condition of such concepts as explanation, truth, theory-comparison, scientific progress, etc. None of these concepts would otherwise make sense.

Today, a kind of strong constructivism — which, considering its degenerating Kantian-like ancestry, I have also called "hyper-criticist epistemology"[1] — is opposing any such vindication. As a secondary aim of this paper, I shall try to show that strong constructivism is untenable; it makes what may be considered a category-mistake over the expressions "theory" and "theory-ladenness of observations or facts". But I shall not discuss strong constructivism in detail; I am interested here in reconcilement rather than in criticism. The central demand of constructivism — that all facts must be recognized to be theory-laden — is surely indisputable. Even those who persist in maintaining that a distinction in kind between facts and theories exists are not so ingenuous as to hope to go back to the earthly paradise of empiricism, where that distinction was clear-cut and an apple was an apple whatever the language and the opinions of the local inhabitants. But, on the other hand, the main demand of empiricism — that theories have to be tested with independent facts — is also undeniable. How can we come to an agreement ? And, first of all, is a fair agreement possible ?

In the attempt to find a way out, the distinction between facts and theories has been reformulated by many philosophers in terms of degree or in pragmatical terms. I believe this move goes in the right direction, but it does not go the whole way. My chief aim, then, will consist in suggesting there may be a surer way to make that distinction.

The distinction I am searching for is a distinction in kind, the only, in my view, that can provide an independent and sure enough basis for science. To this purpose, I shall attempt to establish various kinds of theories and, correspondingly, of facts. I shall propose to talk of the theory-dependence of facts (or of observations) rather than of the theory-ladenness of facts (or of observations). If this is a step forward towards the conciliation of the constructivist and

empiricist demands, I maintain it is a step which follows along old criticist lines.

1. The tangle of facts

That I am writing at this very moment is a fact, that lemons are green is also a fact, and that the Earth is round is yet another fact. Nevertheless, even though we live in a world of facts and state facts all the time, it is not easy to say what a fact is. For the philosopher, the expression "it's a fact that", which appears to be so innocent to the scientist and the man in the street, is a nest of vipers; it hides a tangle of ontological, epistemological and semantic problems, all extremely complicated.

In order to unravel this tangled mass, two conflicting requirements must be borne in mind at one and the same time. On the one hand, we tend to think that, if something is a fact, then it is or must be a fact for good and all. In other words, we incline to think that facts — "the true facts", "the bare facts", "the real facts", as they are called in everyday speech — are invariant and permanent, that is, that they exist independently of our knowledge of them. Is it not a fact that the Earth is round, whether we know it or not ? On the other hand, though, we know from experience that facts change and that what is a fact for certain people is not necessarily one for other people; or what, today, is a "hypothetical fact", or a hypothesis, may, tomorrow, become a "real fact". For instance, that the Earth is round was not a fact before, let us say, Pythagoras. And the same is true even for the seemingly surest facts. That the sun rises on the horizon in the morning is not a fact, even though we are inclined to think it is on the basis of what we perceive and not on the basis of what has been known since the time of Copernicus. Whereas that there is life beyond our galaxy is a hypothetical fact which may become real.

So, any definition or explication whatsoever of the concept of fact must meet the requirements both of objectivity and universality, and of variance and revisability. The former requirement naturally leads us to identify facts with things or objects and with states of things or events, all existing in themselves independently of our thinking and language; the latter requirement, to the contrary, compels us to identify facts with what true statements speak about, and so to link the fortunes of facts with those of our theories about the world. Philosophers have been tempted by both solutions, but

there are reasons for being dissatisfied with the one and the other. However, the former is far worse than the latter.

N. R. Hanson has quite correctly observed[2] that facts cannot be assimilated to objects, events, states of affairs, etc., because what is rightly stated about the latter becomes senseless when referred to the former. Indeed, I can say that I see snow and that I see it is white, I can touch snow, handle it, weigh it, and so forth; but I cannot either see or touch or handle or weigh *the fact that* snow is white; The demands of apophantic language and of the semantic theory of truth must not induce us to overcrowd our ontology. Things such as snow, and properties like whiteness, or other things like electromagnetic waves responsible for whiteness, can be said to exist; but the fact that snow is white or the fact that snow falls in winter do not exist in the same way, that is spatially and temporally.

Hanson, on the other hand, pointed out, too, that facts cannot even be identified with what true statements talk about. He maintained that "statements are not about facts. They state facts"[3]. Following in Strawson's footsteps, Hanson claimed facts are "wedded to that-clauses". *That* Marcello is now writing; *that* the Earth is round; *that* lemons are green : these are facts. Of course, not every that-clause expresses a fact; properly speaking, only that-clauses incorporated in true statements may be said to express facts. Statements state facts, but research is necessary to establish them.

This linguistic approach seems to provide us with a tool for unravelling the tangle of facts. On the one hand, since that-clauses are not statements, they are neither true nor false : this seems to meet the requirement of objectivity and universality. On the other hand, however, statements incorporating that-clauses are true or false; and this seems to meet the requirement of variance and revisability. *That* the Earth is flat is not a fact, but it was as long as the statements "The Earth is flat" or "It is a fact that the Earth is flat" were considered true. In the same way, *that* life exists outside our galaxy may become a fact if the statement "Extragalactic life exists" one day turns out to be true.

I am not sure this point of view is significantly different from maintaining that facts are what true statements refer to, even though Hanson is fairly likely to be right when he claims that "the question 'What is a fact ?' is ridiculous"[4]. Anyhow, from all this the conclusion may reasonably be drawn that facts, language and thought are indissolubly linked together. Facts do not exist *prior to* and

independently from statements : facts are brought into existence only by statements of fact.

This conclusion is still generic, however. It is certainly part of a constructivist epistemological and ontological view, since it says that a fact is a fact only for us and that a fact for us depends upon the way in which we think of it and state it, that is, upon certain theoretical elements. But two points still have to be cleared up : 1) the limits of such dependence. How far does it go ? and 2) the ways of dependence. Upon exactly which units of thought do facts depend ?

The cumulative answer to both questions given by strong constructivists, such as Hanson, Feyerabend and Kuhn, is that facts are "pervaded" by scientific theories to such an extent that they change when the theories change. From this point of view, the distinction in kind between facts and theories — and, as a consequence, a lot of other important things as well — is irreparably lost. Let us see whether it is possible to rehabilitate it, while meeting the main demands of constructivism and of empiricism.

2. Facts and theories. The roots of the distinction

As an initial approach to our question, let us take Galvani's research on animal electricity as an example.

According to his own reconstruction, Galvani began with the observation of certain phenomena and continued until certain theoretical conclusions were drawn. The first phenomenon he observed was the following. On the bench of his laboratory he had an electrical machine and a "dissected ... and prepared" frog near it[5] (See Fig. 1). He noticed, one day, that "violent contractions were induced in the individual muscles of the limbs and the prepared animal reacted just as though it were seized with tetanus at the very moment when the sparks discharged"[5]. Galvani later noticed another phenomenon, which, this time, did not happen by chance but as the result of an experiment. When he took his frogs out onto a terrace, he saw that "whenever lightning flashed, all the muscles simultaneously fell into violent contractions". Galvani carried on with his research and he was once again helped by chance. While making further experiments on the terrace, he happened "to press and squeeze the brass hooks which penetrated the spinal cord against the iron railing"; in these circumstances, he noticed "frequent contractions". When he repeated the experiment but with "other

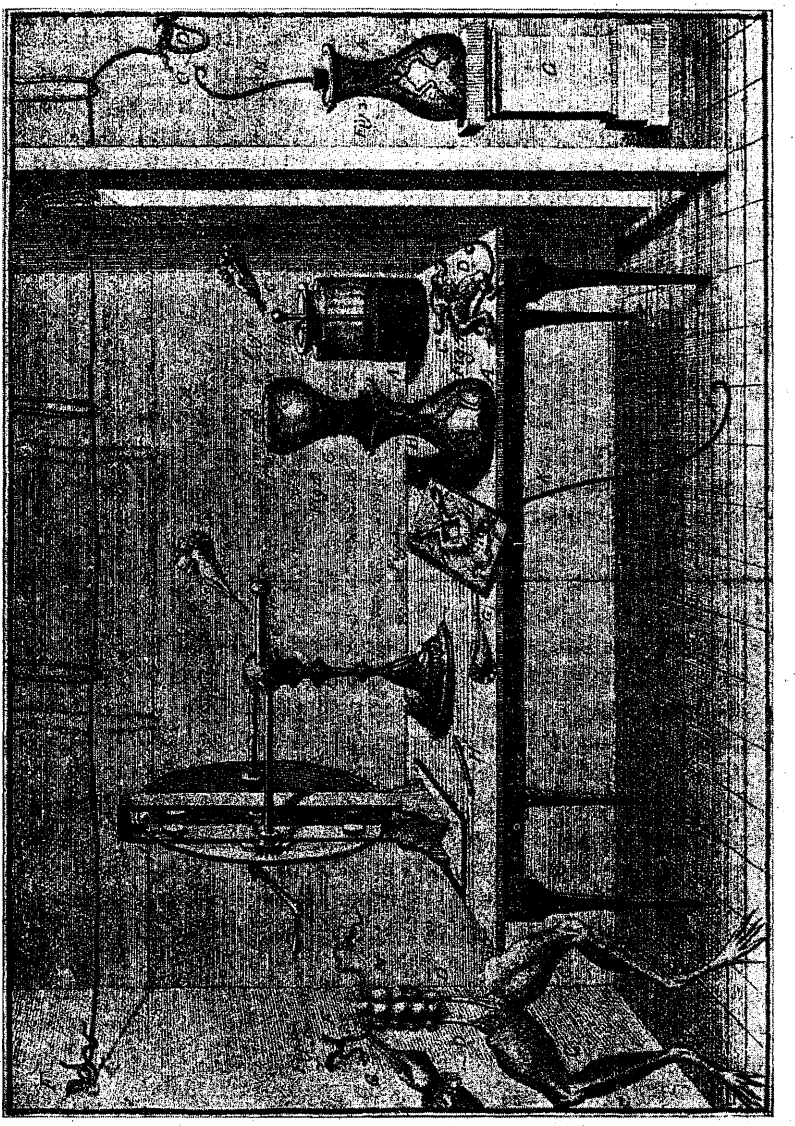

Fig. 1.

substances that were either non-conductors or very poor conductors of electricity", he observed no contractions. From all these experiments and observations, Galvani drew two conclusions : that "a kind of circuit of a delicate nerve fluid is made from the nerves to the muscles" and that there existed an "electricity ... inherent to the animal itself"[6].

For the sake of clarity, the crucial steps of Galvani's research can be reconstructed in the following series of statements:

(3.1) The frog contracts when sparks are discharged from the machine;
(3.2) The frog contracts when lightning flashes;
(3.3) The frog contracts when a two-metal circuit is closed;
(3.4) The frog does not contract when a circuit of non-conductors is closed;
(3.5) There exists a circuit of fluid between the nerves and the muscles of the frog;
(3.6) Animal electricity exists.

We may say that these six statements state as many facts. However, if we call (3.1)—(3.6) all facts, a distinction is necessary. This may be seen clearly if we consider that the clause "it is a fact that", put in front of (3.1)—(3.6) gives rise to different reactions. Let us imagine another scientist faced with the same steps as in Galvani's research. Take Volta, for instance. Volta would agree that (3.1)—(3.5) are facts; he would deny, however, that (3.6) is also a fact. He would say (3.6) is a conjecture, a hypothesis, a theory. Others would claim that (3.5) is not a fact, either, whereas presumably nobody would say the same for (3.1)—(3.4).

It is this behaviour that firstly suggests a distinction. At first sight, we may say that there exist facts like (3.1)—(3.4) which are directly ascertainable, and, on the other hand, facts like (3.5)—(3.6), whch are presumable and ascertainable only by inference from other facts. As our example shows, the former are facts accepted by all or, at least, by a large number of people; the latter are accepted as facts only by certain people. Moreover, the former are stable, that is to say, constant and invariant; the latter are subject to revision. Finally — and this seems to be the most important characteristic — the former are independent from particular theories whereas the latter clearly depend upon disputable interpretations or *are* interpretations.

For all these reasons, we call the former *observational facts* (or, simply, *facts*) and the latter *theoretical facts* (or, simply, *theories*). We shall see below that this distinction does not cover all the kinds of facts we can state. But even if it is an approximation, it seems fairly reasonable. Galvani accepted it, so much so that he always made a great point of stating where, in his opinion, the facts finished and the theories began. And yet this distinction immediately comes up against a certain number of difficulties. Let us go back to our example.

Galvani says he came across his first phenomenon "by chance". But, as Pasteur pointed out, chance helps only prepared minds, and Galvani's case is no exception to this rule. In the first place, before stating fact (3.1), Galvani had already raised the problem P of the causes of the muscular contractions; besides this, he was acquainted with a theoretical frame F consisting of various electrical and physiological theories including those concerning such contractions; finally, he had already formulated a hypothesis H or an expectation as to the existence of animal electricity. So, fact (3.1) became significant for Galvani only because of his knowledge of P, F and H. Generally speaking, this means that in the absence of previous knowledge no research may ever begin; in that case everything would be exactly the same for us. Indeed, it is previous knowledge that imposes certain constraints upon the (unlimited) field of observables. In certain cases, previous knowledge may even become such an imperative form of expectation as to distort the field of observables. With reference to an electrical theory — precisely Symmer's two-fluid theory — Priestley spoke of "the power of an hypothesis in drawing facts to itself". And Galvani himself, after having stated fact (3.3), said that "in experimenting it is easy to be deceived and to think we have seen and detected things which we wish to see and detect"[7].

Two consequences have been drawn from situations such as these. It has been said that, since hypotheses or theories are used to decide which facts are relevant, then hypotheses or theories cannot be inferred from facts. And it has also been said that, since facts do not speak for themselves, then nothing constitutes a fact without some hypothesis or theory.

The first consequence concerns the reconstruction of Galvani's research and, more generally, the very nature of scientific method. It expresses the basic principle of anti-inductivism. I have argued against this elsewhere[8] and I shall not go into the matter again here.

All I wish to point out is that *P* and *F* together form a sufficiently workable selector for a research to be begun and there is no need to add *H*, even though *H* is obviously a still more powerful selector. And, concerning the question as to whether *H* can be inferred or not, I should simply like to point out that Galvani himself considered conclusions (3.5) and (3.6) to be induced (or, as he said, "deduced") from facts[9].

The second consequence above is more directly pertinent to the question of the distinction between facts and theories. It is the basic principle of strong constructivism. Strong constructivists not only state that a relationship of *heuristic dependence* exists between facts and theories; they also claim there is a relationship of *constitutive dependence.* From their point of view, not only do hypotheses and theories draw our attention to the facts, but all facts are made up of hypotheses and theories. Hanson, for instance, states that "facts are what our hypotheses call to our attention" and that "nothing can constitute a fact unless understood in terms of some theory"[10]. Therefore, *"hypotheses facta fingunt"*.

I consider this point of view to be untenable. There are two lines of argument which must be kept clearly apart. In relation to fact (3.1) of Galvani's research, the two lines of argument can be expressed as follows :

(a) *P*, *F* and *H* are necessary because (3.1) is a relevant fact;
(b) *P*, *F* and *H* are necessary because (3.1) is a fact.

If we except *H*, which could be left out without it making any difference, (a) is correct. But (a) does not imply (b). Anybody who did not know Galvani's work, that is, without having his *P*, *F* and *H*, or anybody in possession of an entirely or partly different *P*, *F* and *H*, might have stated that, on the basis of his observations, it is a fact that a frog contracts when sparks are discharged from the electrical machine; in the same way, he might have stated facts (3.2)—(3.4). Such a situation justifies the distinction between observational facts and theoretical facts. Observational facts can be established on the basis of observation, independently from particular theories; theoretical facts alone depend upon theories and hypotheses. The moral we may draw is this : when strong constructivists maintain that nothing constitutes a fact unless it be within the terms of some theory or other, they either express a truism, if they refer to theoretical facts, or make a mistake, if they

also refer to observational facts. There is really no theory, in the proper sense of explanation, answer or solution, upon which facts such as (3.1)—(3.4) depend. When Volta stopped believing in (3.6), proposing instead his *theory* of electricity by the contact of conductors, this did not make him deny that (3.1)—(3.4) were facts. Scientific theories change but at least certain facts remain.

Must we conclude, then, that observational facts are independent from all theories whatsoever ? The answer is no. If, as we have noted, facts are wedded to or dependent upon language and thought, then no facts exist which are not theory-laden. But, at this point, it is clear that the whole question rests upon the crucial concepts of "theory" and "theory-ladenness of facts". Strong constructivists have so wide a conception of theory — and, consequently, so pervasive a conception of the theory-ladenness of facts — that they miss the point. Curiously enough, given their Wittgensteinian ancestry, they do not seriously consider that "theory" functions differently in different contexts and that there are different kinds of theories with different logical status, pragmatic functions and epistemological roots. The most extreme conclusions they draw — such as the incommensurability thesis and the *Weltanschauung* or perceptive pattern view of scientific theories — all spring from this lack of conceptual analysis. I shall try to show that when different kinds of theories are distinguished, the existence of an independent factual basis for science may be vindicated. However, before attempting to attribute a more definite meaning to the theory-ladenness view, yet another obstacle to the legitimacy of the distinction in kind between theoretical and observational facts has to be removed. This obstacle comes from language.

3. Beyond the pragmatic view

Observational facts are stated by observational statements which, in their turn, contain observational terms. Now, the old and venerable division between observational and theoretical terms has been contested more than once, on the grounds that even observational terms are essentially theoretical. On this point, Popper definitively defeated the neo-positivists. His line of argument is well known and it is not worth elaborating on it here. To try to ward off its devastating effects, attempts have been made to replace the distinction in kind with a distinction of degree. The observational terms have been maintained to be those that depend upon more

elementary generalizations or upon a smaller number of theories. According to this point of view, a continuous scale of terms exists with, at one end, the most observational or the least theoretical, and, at the other, the least observational or the most theoretical.

Now, it is easy to agree that *all* terms, in as far as they are universal, are theoretical. We have learnt enough from the systematic failures of the attempts made by the neo-positivists to know that universals cannot be "reduced" to elementary experiences, and that the use of even the apparently most observational terms leaves margins of uncertainty which can be eliminated only at the cost of taking for granted a series of disputable assumptions. It may also be noted that some observational terms are perhaps less definite than many theoretical terms, in as far as they are loaded with vaguer theories. For instance, the use of the terms "electron" or "magnetic" depends upon much more definite theoretical criteria than those the use of terms such as "table" or "still life" depend upon. The discussions raised by a Cubist painting concerning the ways it can possibly be interpreted make this point clear enough. Even the game of trying to see some intelligible form in a shapeless blob shows the important part that criteria — in the form of laws, generalizations, assumptions, and the like — play in the use of observational terms.

All these circumstances, however, do not jeopardize the possibility of drawing a distinction in kind between observational and theoretical statements. Even if they contain terms which are theoretical to some degree, observational statements continue to have a privileged status. They possess a meaning which is contained entirely in the data involved, or in the circumstances in which they are pronounced : and this meaning can be learnt in an ostensive way. "This is a frog" or "the frog contracts" are statements of this sort. For a zoologist, "frog" may well be a theory-laden term, just as "contraction" may be for a physiologist. Nevertheless, the meaning of the statement as a whole can be learnt and transmitted without presupposing zoological or physiological knowledge.

Quine grasps this point very well when he says that "a sentence is observational insofar as its truth value, on any occasion, would be agreed to by just about any member of the speech community witnessing the occasion"[11]. From this point of view, though, a statement that was accepted as true by only part of the speech community would be theoretical.

Quine's distinction is pragmatic, since his criterion is behavioural. This distinction is certainly more effective than the distinction

of degree because it provides a more definite notion of observational statements and, with this, a more stable "gateway to language, as to science", as Quine calls them. Indeed, those who advocate a mere distinction of degree are then faced with the difficult, if not impossible, problem of drawing demarcation lines on a continuous scale of theoretical terms and statements and so they lay themselves open to the risk of finding no basis sufficiently stable to support a theoretical construction. To avoid that risk they may resort to only pragmatic criteria. On the other hand, though, those who resort to pragmatic distinctions such as Quine's find themselves at the mercy of psychology and neurophysiology. Indeed, it should be the job of such disciplines to establish exactly when the members of a speech community linguistically react in the same way because they are faced with the same stimulus situations.

Psychologists and neurophysiologists could, of course, perform this task with satisfactory practical precision. They ought, however, to base their theoretical conclusions on a considerable number of facts and rely on a corresponding number of observational statements, the truth of which they could no longer establish by turning to other psychologists and neurophysiologists. Besides, nobody knows better than the psychologists that identity of stimulus situations is not guaranteed to produce identity of speech reactions. This does not mean their work is useless; it does mean, however, that the problem of observational statements and, consequently, of observational facts *also* has philosophical aspects beyond the bounds of psychology and neurophysiology, and even beyond the possibilities and expectations of a "naturalized" epistemology.

It appears, then, to be necessary to resort to epistemological and logical tools. From this point of view, the most promising approach would seem to be as follows : if observational facts should be considered to be theory-laden, just like theoretical facts, while, at the same time, being permanent and stable, just as their function as the basis of science requires them to be, then we must distinguish between various kinds of theories and of theory-ladenness. This is the point which, finally, has to be ascertained. Strangely and ironically enough, it leads us to a new kind of fact, half-way between observational facts, *strictu sensu*, and theoretical facts, which we have not yet taken into consideration. As we shall see, it is these new facts that do some justice to the strong constructivist view, while, at the same time, revealing its category mistake.

4. The theory-dependence of facts.

It is worth beginning with a look at observation and at the different contexts in which expressions like "I observe" or "I see" are used. For this purpose, we can once again go back to Galvani.

Suppose Galvani lets a servant into his laboratory, points at the bench (Fig. 1) and orders him to dust the electrical machine near the frog. The servant might look around in astonishment. He would certainly see a lot of things on the crowded table, yet he could *not* say

(5.1) I see an electrical machine

because this would require, on his part, a knowledge of at least some principles of electrology which, *ex hypothesi*, he does not possess.

This is a very simple and well-known case of the theory-ladenness of observation. Observation transcends sense data. Different people, such as Galvani and his servant, see different things even if they are immersed in the same stimulus situation because they have different cognitive equipment and their previous experience also differs. Therefore, observations such as (5.1) — for instance, the observations concerning certain diseases on an X-ray plate — are the least sure, the most uncertain. For the sake of a name, they may be called *perceptive hypotheses*, to emphasize they are revisable and always subject to doubt, even if closely linked to actual sensorial stimuli.

The doubt may be raised, however, whether the word "see" is proper in contexts like (5.1). Would it not be better to say that both Galvani and his servant see the same thing but *interpret* it in different ways ? The reference to interpretation does not seem wrong, at least in cases such as this; nevertheless, let us consider what there might be that both of them actually do see.

Galvani might say to his perplexed servant, in an attempt to make things easier for him :

(5.2) I see a glass disc between stiff rods and rubbing cushions.

At this point, the servant would presumably say he sees the same thing as Galvani. Does this mean the two observations are now not theory-laden ? Certainly not. A third person, a child, for instance, might not see the same thing. Some knowledge is required even in

order to see a glass disc; for the term "glass" to be applied, certain assumptions, at the very least, need to be accepted as true, for instance, generalizations about solidity, impenetrability and the resistence of bodies. The same goes for the terms "rods" and "rubbing cushions". Therefore, not even (5.2) would meet with universal agreement, even though the agreement it does actually encounter is very general and certainly much more general than in the case of (5.1). For this reason, observations like these might be called *perceptions*, to emphasize they are states of direct acquaintance with things or events and they are hardly at all problematic.

The agreement over observations could, however, be extended even further. Let us consider another context. Faced with situations such as those emerging from Figures 2 and 3, anybody whatsoever would say :

(5.3) I see incomplete circles and half-round shapes.

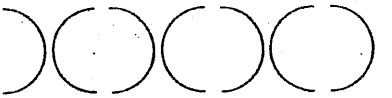

Figure 2

Figure 3

It would seem hard to get down to observational facts lower than these. They are, presumably, the most elementary ones. If someone cannot see even what (5.3) is referring to, it is doubtful whether he can see at all. Perhaps he could be said to suffer from sight-disease. Observations like (5.3) are usually considered to be the atoms of vision and for that reason they may conveniently be called *sensations*. But it is clear that not even sensations are entirely theory-free. Seeing incomplete or half-round shapes in Figures 2 and 3 —

or, better, seeing Figures 2 and 3 *as* incomplete and half-round shapes — means that the perceptive field spontaneously organizes itself in certain ways. It means, for instance — as *Gestalt* psychologists have shown — that closure prevails over nearness, as happens in Figure 2, or convexity over closure, as in Figure 3. But closure, nearness, convexity and the many other groupings like these, such as continuity, regularity, etc., are specific ways of going beyond the information, that is to say, they are ways of filling the gaps of seeing — seeing is *always* incomplete — according to certain expectations. And expectations are theoretical points of view which are added to the perceptive field and not inferred from it.

Any kind of observation, then, is theory-laden. But, at this point, we have enough material to allow us to make a crucial distinction. As we can see, behind each of the three kinds of observation we have distinguished, there are three different kinds of theory upon which, in their turn, three different kinds of fact depend. So, instead of speaking of a generic theory-ladenness of observation, we may talk, with greater precision, of different kinds of theory-dependence of observation, according to the different kinds of theory involved. The same holds for facts. Let us examine this point.

These who are able to make observations (5.1)—(5.3) can, of course, state these three facts :

(5.4) An electrical machine is on the bench;
(5.5) A glass disc is between two stiff rods and two rubbing cushions;
(5.6) Incomplete or half-round shapes lie on black or white backgrounds.

Because of the theory-ladenness of any observation, each of these facts is wedded to or linked with (let us use, for the moment, these vague expressions) some theory or other. However, the theories which facts (5.4)–(5.6) are wedded to differ considerably from one another. We can label them, for the time being, as T_1, T_2 and T_3. They differ for at least three sorts of reasons.

Logical type and strength. T_1 theories are specific hypotheses; for instance, "Electricity is a fluid which is set in motion by friction". They are tested by experiments and observations and are greatly exposed to risks of falsification. T_2 theories, on the other hand, are general, usually metaphysical assumptions concerning the

constitution of the world or of parts of the world; for instance, "Bodies are made up of indivisible and impenetrable atoms". Properly speaking, they are not tested but argued for; experiments and observations may be relevant but are not crucial for them, because they generally function as norms or regulative principles of inquiry. Finally, T_3 theories are forms of perception and understanding, such as the laws governing the organization of the perceptive field; for instance, the laws of the constitution of backgrounds, or of the completion of figures, and so on; or, as far as understanding is concerned, the laws governing the connections between objects, such as the law of cause and effect. All these theories have the maximum strength; they are not submitted to the test of experience; to the contrary, they submit experience to themselves, they are conditions of experience.

Pragmatic function. T_1 theories are explanatory theories about well-defined domains of phenomena; they are answers or solutions to specific problems. T_2 theories, on the other hand, are overall theories which specify the general classes phenomena belong to, their intrinsic nature or essence, and the ways in which they have to be understood. They express the ontological and epistemological commitments of research traditions in Larry Laudan's sense. Finally, T_3 theories are constitutive theories, in the sense that they are conditions of our thinking or of our perceiving phenomena; without them, no phenomenon would be a phenomenon for us.

Epistemological status. T_1 theories are *a posteriori* theories; they are hypotheses inferred for explanatory purposes. T_2 theories are ambiguous; considered statically as regulative principles, they precede our hypotheses or explanations of phenomena; but, looking at them from a dynamical or evolutionary point of view, they appear to be connected to the results of previous scientific theories or the findings of our most common observations. Finally, T_3 theories must be considered to be logically *a priori;* genetically, they are inborn expectations even if they are, perhaps, a product of the evolution of our sense organs and brain.

We can now give proper names to these three kinds of theory. They can be conveniently divided up into *explanatory theories* (or simply *theories*), *interpretative theories* (or *interpretations* or *assumptions*) and *categorial theories* (or *categories*). Three kinds of facts can then be distinguished, depending upon these three kinds of theories, that is :

Theoretical facts. These depend upon explanatory theories and,

a fortiori, on interpretative and categorial theories; for instance, the facts :

(5.7) An electric fluid passes through the nerves and muscles of the frog;
(5.8) The Earth moves.

General facts. These depend upon interpretative and categorial theories; for example, the facts :

(5.9) The frog is a condenser;
(5.10) Bodies fall perpendicularly.

Observational facts. These depend upon categorial theories; for instance, the facts :

(5.11) The frog contracts;
(5.12) This body falls to the ground.

"Dependence" here has to be taken in a technical, narrow sense, that is : *a fact is said to be dependent on a theory when it changes to the extent that that theory changes.* The dependence relation is stronger than the ladenness relation. A fact may be laden with a theory, even without being dependent on that theory. For instance, fact (5.9) is, in different historical contexts, laden with different electrical theories (one fluid, two fluids, electrons etc.); it is not, however, dependent on such theories.

Now, theoretical facts obviously depend on explanatory theories because they change when these theories change. For instance, fact (5.7) changes when Franklin's theory of electricity and the 18th-century theory of nervous-electric fluid change. On the other hand, observational facts do not change when explanatory theories change. For instance, fact (5.11) is the same whatever explanation of it may be put forward; for this reason, observational facts are stable, constant, even though they are not absolutely immune to revision, since they, too, are theory-dependent. Such revision, however, is an exceptional event, because it could only happen if there were a change in the forms of our perceptive and intellective equipment. As far as the so-called general facts (for want of a better term) are concerned, these, too, change. For example, as Feyerabend has clearly shown, fact (5.10) changes

when the (natural, as he calls it) interpretation, according to which any kind of motion is operative, changes; and, as I have tried to show elsewhere[12], fact (5.9) — which was opposed by Volta, who saw the frog as an electroscope or a battery — changes when a biological versus a physical interpretation of the domain of the phenomena of contractions is upheld. Even though they are not exceptional, changes of this sort are few and far between, generally; they are deep changes which occur during scientific revolutions.

The following table sums up all the above distinctions and correspondences. The general approach suggested here is neither positivst nor merely constructivist. it may be considered criticist because of the

Observations	Facts	Theories
Perceptive hypotheses	Theoretical facts	Explanatory theories
Perceptions	General facts	Interpretative theories
Sensations	Observational facts	Categorial theories

emphasis it lays on the rôle theories — at any logical level — play in the constitution of our own experience. It must be admitted that a number of things have still to be looked into further; more subtle epistemological analyses are needed and accurate examination of case-studies has to be carried out to check these analyses or to obtain new suggestions. However, the criticist approach seems to offer certain advantages. It holds that a difference in kind exists between facts and theories and not only a difference of degree or pragmatic differences. Like the distinction of degree view, it agrees that any observation or fact is theory-laden, while it explains better why, in spite of this circumstance, observational facts are stable, or stand up more to revision. Like the pragmatic distinction view, it maintains that observational facts meet with virtually universal agreement, while it gives reasons, not merely psychological, for this.

But the main advantage of a criticist approach perhaps is that it offers a vindication of the factual basis of science without falling into the dangers of positivism, while allowing this basis to be revised without running the risks inherent in strong constructivism. The fault of positivism is to set facts completely apart from theories; the fault of strong constructivism is to equate facts to theories. This happens because strong constructivists identify explanatory

theories with interpretative theories and totally neglect categorial theories. So doing, they are led to take the theory-ladenness of observations and of facts in the strongest form of theory-dependence and to draw the conclusion that scientific theories are patterns of perception, each of them having its own facts. But here lies a category mistake. "Theory" is an overall term, embracing different things which have to be sharply distinguished. Indeed, in many cases that may be a difficult business, but it is not impossible.

The criticist approach enables science to achieve its explanatory aim and for scientific theories to be compared by means of a neutral, common, factual basis. It does not deny the existence of phenomena like incommensurability. When the interpretative theories change, the entire area of thought also changes and an object which was seen in one way (as a condenser, for example) is seen in another (as a battery, for instance). As the controversy between Galvani and Volta shows, explanatory theories exist which are observationally equivalent; in cases such as this — where no crucial experiment is possible — almost everything depends on the preference given to one of the interpretative theories involved. This does not mean, however, that our preference cannot be critically argued for and that a rational discussion, on the basis of shared observational facts, is not possible. Anyone who so desires can always measure his theories against the "*sensate esperienze*".

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NOTES

[1] Pera (1982), Chapters IV—V.

[2] Hanson (1969), Chapter 11.

[3] Hanson (1969), p. 195.

[4] Hanson (1969), p. 197.

[5] Galvani (1791), pp. 45—47.

[6] Galvani (1791), pp. 57—60.

[7] Priestley (1775), Vol. I, p. 322; Galvani (1791), p. 59.

[8] Pera (1981).

[9] Galvani (1794), p. 194.

[10] Hanson (1969), p. 217 and 216.

[11] Quine (1974), p. 39.

[12] Pera (1984).

REFERENCES

GALVANI, Luigi (1791), *Effects of Electricity on muscular motion*, trans. by Margaret Glover Foley with notes and a critical Introduction by I. Bernard Cohen, Burndy Library, Norwalk, Conn. 1953.

GALVANI, Luigi (1794), *Dell'uso e dell'attività dell'arco conduttore nelle contrazioni de' muscoli*, in *Opere edite e inedite*, a cura di S. Gherardi, Accademia delle Scienze dell'Istituto, Bologna 1841.

HANSON, Norwood Russell (1969), *Perception and Discovery*, edited by W.C. Humphreys, Freeman, Cooper & Co., San Francisco.

PERA, Marcello (1981), "Inductive Method and Scientific Discovery", in M. D. Grmek, R. S. Cohen, G. Cimino (eds.), *On Scientific Discovery*, Boston Studies in the Philosophy of Science, Vol. 34, Reidel, Dordrecht-Boston.

PERA, Marcello (1982), *Apologia del metodo*, Laterza, Bari.

PERA, Marcello (1984), *La rana ambigua. La controversia sull'elettricitità animale tra Galvani e Volta*, Einaudi, Turin (forthcoming).

PRIESTLEY, Joseph (1775), *The History and Present State of Electricity*, I—II, Third Edition, Johnson Reprint Corporation, New York and London 1966.

QUINE, Willard Van Orman (1974), *The Roots of Reference*, Open Court, La Salle, Ill.