Chapter 4
Folder C132. Perception Continued, Fact and Inference. July–September 1967

July 6, 1967

Dear Jeff

Thanks for your letter, which I'll answer in detail later.

My wife's family in Israel are all O.K. Nevertheless, we were very worried for a while, till we heard from them, because they live in Jerusalem. Even now, things don't look too good in the Middle East. Nobody knows when or whether there will be real peace.

How are you and your wife feeling about the situation now?

I enclose a copy of a reply to Jauch and Piron, and to Gudder,[1] whose articles I asked Dr Condon[2] to send to you. Because Dr. Condon is in a hurry to publish it along with the original articles, I have sent a copy directly to him assuming you will have no serious objections. If you have any objections, please let me know immediately, and I'll change the article.

Best regards

D.Bohm

[1]Theoretical physicists Josef Maria Jauch and Constantin Piron and, separately, S.P. Gudder had made criticisms of Bohm and Bubs' work. The reply was published in Bohm and Bub (1968)—CT.

[2]Edward Condon, a distinguished American physicist, editor of Reviews of Modern Physics at that time—CT.

C. Talbot (ed.), *David Bohm's Critique of Modern Physics*,
https://doi.org/10.1007/978-3-030-45537-8_4

[There follows a type-written document, which was published as the above Bohm and Bub (1968)—CT.]

JULY 17th, 1967

[Date added – CT.]

Dear Jeff

Thanks for your letter and article,[3] which I read with great interest. I shall comment in detail later. Meanwhile, let me say that Condon insisted on a short reply, so that subtleties of the type you mention cannot be put into it. All that can be done is to show that J. and P.[4] are in an absurd position. I'll leave it to you to analyze the whole story in detail.

I don't think that one would misunderstand Gudder's article in the way you suggest. I only said that Gudder had developed a broader class of models that are not compatible with hidden variables – not that his model excludes hidden variable theories. So there is no point in a serious modification in the letter. When I get the proof I may change a word or two, to clarify this issue.

With best regards

D Bohm

July 18, 1967

Dear Jeff

This is just a brief supplement to yesterday's letter. I'll send you the full answer to your letter a bit later.

You emphasize in your letter (and article) the notion that certain kinds of hidden variable theories are excluded by arguments, such as those of von Neumann. I would prefer to put it in another way. We can say instead that certain kinds of axiomatic structures (or "models") are not logically compatible with hidden variables. (Von Neumann's axiomatic structures are a case in point.) But each axiomatic structure is an assumption whose inferences have to be compared with fact. We have proposed another axiomatic structure, with hidden variables. This is a different set of assumptions, with different influences. In a limited range of experiments where times longer than τ, the relaxation time of the hidden variables are involved, the inferences from our axioms agree with those from von Neumann's. But more generally, we predict different results, and thus, it is possible to choose experimentally between the two sets of actions.

[3] See p. 102, n 6 below—CT.

[4] J. and P. refer to Jauch and Piron throughout the letters—CT.

In the article I sent you, I compared this to the choice between the axioms of Euclidean geometry and non Euclidean geometry.

I myself feel that no mathematical axioms can ever exclude hidden variable theories (any more than Euclidean axioms can exclude non Euclidean axioms). Rather, only the facts can exclude certain sets of axioms. Thus, the discovery that measurements satisfy the axioms of spherical geometry would exclude hyperbolic geometry. But the mere mathematical suggestion of spherical geometry cannot exclude hyperbolic geometry as the actual one that may be factually correct, over very long distances. Likewise, von Neumann's axioms cannot exclude hidden variable theories. They are merely logically incompatible with hidden variables, as Euclidean geometry is logically incompatible with spherical geometry.

So I do not think it is right to say that von Neumann's theorem factually excludes any kinds of hidden variables at all. One must remember that von Neumann's axioms contain assumptions that go beyond the facts (in this they are like all other axioms). We too make assumptions that go beyond the facts. But only the facts can ultimately show which set of axioms is a better reflection of reality. And there is no reason why any theory should be excluded, merely because it does not agree with von Neumann's axioms. Thus even the "naive" mechanistic interpretation of a particle criticized tacitly by London and Bauer[5] is not "excluded" by any axioms. It is given up only because it does not correspond to the fact of interference in the two slit experiment (We must not identify these facts with the contents of von Neumann's axioms).

This point is very important, if we are to understand how my 1951 papers on hidden variables fit into the picture. For here, I propose a "particle" model, in some ways similar to the model already "excluded" by analyses similar to that London and Bauer. But then I introduce a multi-dimensional wave, and include the apparatus as part of the whole system. In this way, I go beyond certain assumptions of mechanical separability that are tacit in classical physics. Thus, I come to a model that corresponds once again to the facts (at least in a certain domain of inferences). I think it introduces confusion to ask whether it is excluded by von Neumann's model or not. For this very question tacitly identifies von Neumann's model with fact or truth, and thus obscures the real issue – that we are choosing between two models, von Neumann's and my own. Indeed to fail to see this issue is the basic error of Jauch and Piron, who persistently identify their own models with "fact". I think you underestimate the importance of this point, when you bring in the question of what kinds of hidden variables are excluded by von Neumann's model. I would prefer to say that strictly speaking, von Neumann's model is logically incompatible with any kinds of hidden variables at all. But the question is: "Do we accept von Neumann's model, or some other one, that does contain hidden variables?" The respective advantages of these two approaches can then be discussed.

[5] London and Bauer (1983)—CT.

This is in essence the view proposed by Gudder, and it is the point of view that I wanted to express in the article.

Best regards

David Bohm

P.S. As a preliminary comment about your paper, I get the feeling that it combines two subjects that are rather disparate – a philosophical criticism of the notion of observation (as a structural process) and a detailed mathematical criticism of DLP.[6] Are the two subjects really all that closely related? Or is it not perhaps necessary to split the article into two papers, intended to follow directly on each other in the same issue?

PPS. I feel that we are also in danger of confusing the criticism of simple mechanistic explanations of quantum mechanics with the particular structures of axioms and algorithms proposed by Dirac, Jordan, von Neumann, etc. You are right to emphasize that the facts suggest very strongly that we need a structural-process point of view about the observing instrument. However, logically speaking, Bohr has proposed a set of axioms, in which everything is inherently vague in its definition. By this means, he avoids the detailed consideration of the mutual reflective functions of electron and observing instrument (though he considers them in a rough and general sort of way). His views are often said to be purely epistemological. But epistemology and ontology have a habit of mixing. Thus, Bohr's epistemology wouldn't be consistent, unless ontologically, nature were such as to produce an inherent vagueness in the reflective function. This vagueness is measured by Planck's constant, h, which is an objective quantity, not determined solely by epistemological considerations. In other words, Planck's constant, h, takes on a certain value. This value is an ontological feature of nature. Even if we accept Bohr's tacit assumption that the qualitative existence of Planck's constant follows epistemologically, surely its numerical value cannot be determined by such arguments, so that it must be an ontological feature of how things are. So I would insist that Bohr's axioms have an ontological side, no matter how much he and others might protest.

Now then, we have two alternative sets of axioms that are logically incompatible.
1. Bohr's involving inherent vagueness of reflective function, treated in the order of classical mechanics (x,p, etc.).
2. Structural process, involving clarity of reflective function, but not in the order of classical mechanics.

Unfortunately, structural process axioms have yet to be put in a clear mathematical form. So a test between 1 and 2 is not yet really possible.

But even now, the criticism of mechanism has very little direct relationship with Bohr's axioms or von Neumann's axioms. We can easily make the mistake of supposing that the aim of a deeper theory is to explain the axioms of Bohr or von

[6]Possibly an early draft of the two papers eventually published by Bub as: "Hidden Variables and the Copenhagen Interpretation–A Reconciliation", Bub (1968b), and "The DLP Quantum Theory of Measurement", Bub (1968a). See also C134, p. 219, n 12—CT.

Neumann. This would be a serious mistake. Its aim is to explain the facts, which are also explained by the axioms of Bohr and von Neumann, but in a very different way. Too much stress on the axioms may imprison us in unnecessary tacit assumptions, going beyond the facts, which prevent us from doing what has to be done.

In other words, it must be made clear that neither von Neumann's axioms nor Bohr's principle of complementarity are facts. They are both "models" from which inferences have been drawn that generally cohere with a certain range of facts. It is really very important to emphasize this point very strongly, as Rosenfeld also feels (like J. and P.) that complementarity merely expresses the facts. You are really underestimating the significance of this point.

All this is relevant to a deeper theory. What are the facts that it has to explain? Sometimes, it is said that it must explain classical mechanics. But classical mechanics is not a fact. It is a structure of axioms and inferences from these axioms. Not all these inferences are rigorously true (E.g., there may exist no orbit satisfying a second order differential equation). So our new structural process theory need not approach classical mechanics as such. It may approach a theory of rather different structure that explains more or less the same facts explained by classical mechanics.

The statement that in the large scale "classical mechanics is a fact" is the same kind of confusion as saying: "In a certain domain, von Neumann's axioms are mere statements of fact". It is not a sudden new development that people have been confusing axioms with facts. It is as old as the human race. It is crucial to clarify the difference between fact and axiomatic assumptions. It is not merely a "philosophical" question but a deep psychological and practical one as well.

About mechanism, one can be too strong and dogmatic about the need to transcend it. One does get a general impression that it should be transcended. But it is not possible to prove the need to do this. So there is no reason to exclude mechanical theories from consideration. Rather, they too have their place. By seeing in more and more ways how their inferences are inadequate, we may hope to be helped to see just what is the kind of non mechanistic theory that we need. But if a mechanical theory should work (and this cannot be excluded, a priori) then we would come to an opposite conclusion – i.e., that the facts under consideration do not force us to try to transcend mechanism.

In other words, it is best to avoid dogmatism. We have the facts, and we have assumptions, leading to inferences that imply an order in the facts. The inferences are observed to be either true or false. This observation is a higher order fact. Let us denote the two levels of fact by fact_1 and fact_2. Then we have

The fact_2 about fact_1 and the inferences_1 on fact_1.

This is a fact of second order. From here, we go to

The fact_3 about fact_2 and inferences_2 on fact_2.

Thus, the fact is built into an ever growing hierarchy of potentially unlimited order. It is this process that I have called "facting".

It is crucial to keep the order of fact and inference clear, or else we will be lost in confusion. Our inference is that mechanism should be transcended. But the next order of fact will be to observe whether in a better theory, mechanism is transcended or not. Thus we must keep away from the trap of dogmatism.

Notice that to see a fact requires an act of observation. Thus, it is not possible to infer a fact, or even to infer the correctness of inferences about a set of facts. Ultimately, there must be an act of direct perception, that is not conditioned and limited by the structure of inferences that is being evaluated and tested.

This act of direct perception may take place on the level of the senses or on higher levels, where we see the truth or falsity of certain inferences. In its totality, it is the act of understanding, which is continually putting the fact into a new order, as it tests the truth or falsity of inferences, and replaces false inferential orders and structures by newer ones that are in closer correspondence with lower order facts.

So we see that the act of understanding is always what is making the fact. Without understanding, it is meaningless to ask "What is the fact?"

I hope that you have begun to see the significance of direct and immediate perception on all levels. I shall go into this more in the next letter.

July 20, 1967

Dear Jeff,

Before sending you a detailed answer to your letters and discussion of your paper, I feel that it will be useful to go a bit into the question of the observer and the observed, which is really behind everything that you talk about.

Firstly, I want to emphasize that as I said in yesterday's letter, one set of theoretical assumptions can never exclude any other set. The two sets can either be logically compatible or logically incompatible. Only the facts can exclude one or the other of a logically incompatible pair of assumptions. I feel very strongly that you have not been paying enough attention to this point, especially in your article.

Now, I would say that Bohr's views are based on a certain set of axioms and assumptions. About these, we must first ask: "Are they logically consistent?" Bohr claims in no uncertain terms that his views are logically consistent. Whether his claims should be accepted is not yet clear to me. Nevertheless, let us, for the sake of argument, give him the benefit of the doubt. The next question is then: "Are these assumptions and axioms compatible with the relevant known facts?" Bohr claims that they are. This claim could also be questioned in certain ways. (In particular, I do not believe that Bohr's views permit a really adequate treatment of entropy.) However, let us again give him the benefit of the doubt, on this score. The third claim could then be that no other set of axioms and assumptions is possible that would be compatible with these facts, and yet have inferences that are potentially in contradiction with some of those that can be drawn from Bohr's axioms and assumptions. Whether Bohr actually claims this is not clear, because his language is ambiguous. Nevertheless, von Neumann did make an equivalent claim. And from the way Bohr writes, it looks as if he is least tacitly making such a claim.

It is here that Bohr is clearly wrong. The fact that his axioms are consistent and compatible with known facts cannot elevate these axioms to the level of facts. They are only ideas. These ideas cannot, by themselves, exclude any other ideas. I feel that you are trying to squeeze too much out of the work of men like Bohr and von

Neumann, when you try to use their results to exclude any kind of hidden variable theory whatever. Only the facts can exclude a theoretical idea. One theoretical idea can never exclude another. The belief that this is possible is what is leading to endless confusion in physics. Thus, classical mechanics is a set of theoretical ideas. We could never exclude another theory by saying that in a certain domain, where classical mechanics is supposed to be right, the new theory has a different structure from classical mechanics. Rather, we would have to see whether it leads to wrong inferences about the facts that have been regarded as basic confirmations of classical mechanics.

This can be done by showing that certain aspects of classical mechanics are some kind of approximate inference from the theory in question. But here, one tends to become confused. Which aspects of classical mechanics are to be recovered in this way? Evidently, it is not the whole structure of the theory that is to be recovered. Rather, there is a judgement of which inferences of classical mechanics are essential. But in this judgement, it is easy to make a mistake.

Thus, one now says that it is enough to recover from quantum theory certain average values of observables, which are inferred to satisfy the classical equations of motion. One does not require that one recover the property that the individual particle orbit is relatively well defined, and not spread over all the possibilities covered by the wave function. In my view, however, one should also require the latter. This is indeed the main motivation behind the introduction of hidden variables. And it is because DLP are confused about this requirement that their paper was written. On the one hand, they want to accept Bohr's point of view, which would make such a requirement both unnecessary and meaningless. On the other hand, they feel that something is wrong somewhere, and they would like to set it right. They don't want to see that their very feeling that there is a problem here that has to be solved is a sign that they don't really accept Bohr's point of view in its entirety.

What is Bohr's point of view? It is that the question is basically epistemological. Bohr's first assumption is that the division between observer and observed is of fundamental significance in every branch of knowledge and scientific research.

Whenever we talk about something or think about something, the observer is tacitly there, "doing the talking or thinking" from a certain standpoint. Thus, if I think about you, there is an image of you in my mind. But this image has a form which implies a perspective or standpoint of observation. (E.g., I could be "looking" from the right or from the left or straight on at you.) This perspective is seldom if ever mentioned explicitly. Yet, it is inevitable in every image. Similarly, every verbal description implies a perspective or standpoint, of the "observer" or the "describer".

Of course, we are talking only about an image of the observed object. Therefore, the implied standpoint is also only in the image. There is no real observer in thought. There is a (tacit) image of an observer, who is in the imaginary action of looking at the object of thought.

It is crucial to understand this point, or one will get hopelessly lost in confusion otherwise. For there is also an inference that there really is an "observer" in the mind, who is "looking" at the object of thought. But this latter observer is only an inference. One cannot locate him, either by anatomical analysis of the brain, or by looking

inward introspectively. If one looks inward, one sees only thoughts and feelings. Among these is the thought of the object, with its tacit standpoint of an observer. (E.g., if I think of a picture of the Earth, there is a tacit "observer" standing somewhere in empty space.) There is also the inference "I am the observer, and I am really doing the looking." This inference is supported by certain inferred feelings, that resemble those that would seem to be appropriate, if there really were an entity who was doing the looking. But in fact, the inference of this entity leads to endless contradictions (as I shall explain in more detail in a later letter). Let us therefore drop this inference. The plain fact is that observation is going on. But there is no separate observer inside the mind, who would be "doing the looking".

When the brain is thinking, however, every thought contains a tacit observer (just as every picture does). Just as we don't imagine that the tacit observer of a picture is a separate real observer, so we need not imagine that the tacit observer of a thought is a separate real entity. In reality, there is only a thought, with a tacit point of observation, and possibly a false inference that there is a separate entity at this point, who is "doing the observing".

I emphasise all this because I am going to question Bohr's basic epistemological assumption about subject and object. So I am pointing out, from the very beginning, that it is founded on certain illusory views about the nature of thought and perception.

If however, we accept Bohr's assumption, then we are led to ask: "What does it mean to have an objective description (or image) of things?" What it means is that in some sense, the content of the description (or image) can be regarded as separate and distinct from the entity who is "doing the observing" and "doing the describing".

But if the observer were totally isolated from the object, nothing could be seen. Therefore, we postulate that the two are different and separate objects, in interaction.

What has happened is that we have gone to a second level of thought, in which the observed object and the observer are both being treated as objects, under observation by an observer of higher order. We can go on to observers of higher and higher order in this way, but we never get rid of an ultimate "highest order observer", who is merely tacit rather than explicit. So, from a fundamental point of view, this procedure never solves the problem, which is this: "Is the highest order tacit observer separate from what he observes, and if so, how does he interact with the latter?" There is really no way to answer this question. For since the highest order observer has to be tacit, we cannot possibly think about how he interacts, without confusing him with a lower order observer, who is really an "object", under the "scrutiny" of the highest order observer.

Because this basic question is inherently confused, one is led to argue that there is perhaps an inherent purely epistemological need to give up the notion that the process of observation can be treated ontologically in full detail. Of course, such problems will not arise, if we do not try to give a detailed and precise account of the interaction between observer and what is observed. In a vague and general sense, a lower order image of the observer can "stand for" the higher-order observer, to give approximately valid conclusions about the latter. But clearly, there is more to the highest order observer than can be correctly reflected in this image. So we are

led to conclude that there is an inherent epistemological need for vagueness of all knowledge, inherent in the subject-object relationship.

One way to approach this problem is to assume that ontologically, we know the essence of the totality of natural law. The observed object is one part of this totality, while the observer is another. So we could perhaps investigate this relationship precisely, despite the above purely epistemological difficulties.

We may say that classical physics provides us with such a framework of concepts. It allows us to assume that the connection of the human observer to his instruments produces negligible effects. Thus, we are free to investigate the interaction of the observing instrument and the observed object.

But here, we come to the fact of the quantum of action. Because of this fact, we infer that not only does the response of the instrument reflect the state of the object, but that the response of the object also reflects the state of the instrument, in a way that cannot be known in detail. Within a certain degree of vagueness, determined by Planck's constant, these effects can be neglected, and the classical separation of instrument and object is recovered as an adequate approximation.

It seems then that nature itself is presenting us with the same confused questions about subject and object that we were led to earlier by purely epistemological arguments. Bohr therefore argues that we should treat the instrumental "subject" as tacitly present in the description of every object, rather than try to regard it as just another explicitly described object. Just as every picture has a tacit observer, so our physical theory has a tacit observer. When we look at a picture, all sorts of clues (e.g., converging lines) indicate the tacit observer. In physics, we get similar clues. Thus, in the position representation, the tacit observer is a position measuring instrument, and in the momentum representation, it is a momentum measuring instrument. Because the tacit observer is now seen to be inseparable from the object, it is wrong to go to a higher order of observation, which "looks" both at the object and at the observer, as if both were explicit objects.

Whether all this is consistent or not, I am not yet prepared to say. Bohr puts a lot of emphasis on the role of quantum mechanical algorithms here. The failure of various operators to commute is taken as a reflection of the incompatibility of different "standpoints" of observation. One could argue that the algorithms and their statistical interpretation provide a "metalanguage" within which the role of the observer is tacit. That is, instead of letting the observer be implied by the direct "language" of description of phenomena (taken to be classical physics) one supposes that the observer is tacitly indicated only in the "metalanguage" of operators and probabilities.

Be that as it may, it is my view that all this is irrelevant, because of the falsity of the basic assumption that the division of subject and object has a universal and fundamental epistemological significance (for all knowledge). In my view, the division of subject and object is a mistaken notion. Therefore, conclusions drawn from it do not really follow.

I would propose an entirely different point of view, which may be summed up as:

The observer is the observed.

Let me explain. Consider, for example, a tree. Its leaves are moving, in response to the wind. I want to argue that the leaves are observing the wind. Similarly, the light

responds to the leaves, and brings a moving structure corresponding to them to each point of space. So the light is observing the leaves. Likewise, the cells of the retina of the eye respond, so that they are observing the light. Cells further back respond to structural features (e.g., bright spot on dark background) of the responses of retinal cells. Similarly, cells yet further back respond to the structural features of the second order cells, and so on without limit, all the way into the brain, and up to consciousness. Each process that responds sensitively to the structure of another is observing the latter, thus fulfilling an abstractive and reflective function. This process takes place in nature, and is extended in man, in similar but different ways.

At no point is there a division or a break in this process. Thus, for a blind man, the stick is generally part of the observer. But for all of us, light rays act like millions of "sticks" probing the environment. Thus, the light is part of the observer. But then when we look at a tree, the leaves are part the observer. And so on without limit. As our attention moves outwardly, all that it encounters is part of the observer.

And if one looks inwardly, then as I have already indicated, there is also no division. Thus, genuine feelings can be regarded as "feelers", like millions of tiny leaves, responding sensitively to the "winds" and "currents" in the deeper layers of the mind. Thought is then a set of more definite "shapes" abstracted from these feelings (like the shapes one sees in clouds). The sensitive response of thought observes the feelings, and yet more sensitive responses observe the thoughts, going on to yield the totality of the act of perception and understanding.

At no point in this process is there a separate and distinct "self" who would be "doing the observing". As I indicated already, this is merely a false and delusory inference.

Anything whose rational order of movement is understood to some extent can serve as an observer of something else, because its contingent responses now reflect the necessary features of the order of what it is "observing". For example, we understand enough about the responses of silver atoms in photographic plates to realize that their responses can produce an ordered track that reveals various particles (electrons, protons, etc.) As we learn about these particles, we can use this understanding to allow the particles in turn to "observe" a yet deeper level of structure, by means of their responses (e.g., in a scattering process) and so on without limit. The more we understand, the more that our perceptions will be able to observe.

Vice versa, all errors in inferences produce further errors in observations. Thus, if the leaves of a tree were lacquered, they would not shake in the wind. And from this, it would be possible erroneously to infer that the air is still, when in reality, the wind is blowing. Likewise, wrong inferences higher up in order of abstraction can produce wrong perceptions. Thus, the inference that the "self" is the observer of everything implies that it must be protected at all costs, even if this requires manipulation of thought so as to produce delusion rather than true reflections of reality. Indeed, when the illusion of a "self " is operating, the associated inferences of pleasure and pain become the main observer. That is to say, all thoughts are evaluated by the pleasure-pain principle – so that ideas giving pleasure to the "self" are treated as true while ideas giving pain to the "self" are treated as false. Now, one usually supposes that the highest function of the "observer"

is to see what is true or false, right or wrong. It appears that this function is being carried out by the inferred "observer". But in fact, it is being carried out by the observed sensations of pleasure and pain. Thus, even when thought goes wrong, the observed is still functioning as the observer. But because it is wrong, what is observed is delusion and fantasy, rather than fact and reality.

Each aspect of the world, inward or outward, that is observed can then respond to other aspects, and thus it functions also as an observer. (This is the reflective function.) So in reality, everything is potentially or actually observing everything else. The human being is part of this totality of observation, similar to the rest in certain ways, different in others.

In physics, this implies that the attempt to discuss the role of the observer is meaningless and futile, as well as a source of confusion. What is needed is to produce a theory of deep and comprehensive scope, with many related orders, constituting structures, processes, etc., and forming a very large totality. This theory is still however only a set of ideas. It is not by itself a fact; and never will be.

How can these ideas be related to reality, without bringing in an observer? The answer is that from the total theoretical structure, one has to abstract sub-orders, which are similar to certain perceived orders of phenomenon. For example, in physics, one may abstract a theoretical order similar to the order of droplets in a cloud chamber or grains of silver in a photographic plate. One then assumes that these theoretically abstracted orders correspond to the perceived orders.

To test the theory, one works out the inferred responses of the abstracted theoretical order to other theoretical orders of structures that are deeper. If the inferred responses correspond to the perceived responses, this is a confirmation of the theory. Otherwise, it is a falsification.

Thus, there is no need bring in an observer anywhere. But one needs to develop a vast, rich, unified totality of theoretical orders and structures. This is a slow, difficult process. It will not give quick "results". Yet, it is the only way really to avoid getting confused about the observer and the observed. Whoever wants to use sketchy theoretical constructions to get quick "results" is very likely to introduce all sorts of arbitrary dichotomies that get him into confusion on this basic question.

To return to the general question, I repeat that each aspect or part of the universe is both the observer of others and observed by them. But now, consider the totality. The totality of all the "observing" aspects is evidently the same as the totality of the "observed" aspects. Thus, we complete the explanation of the statement: "The observer is the observed."

From this point of view, when I am observing the world, the world is also observing me. If other people are present, this is obvious. But even when no one else is present, inanimate nature is observing me. For its responses reveal what I am, inwardly and outwardly. Thus, if my ideas are mistaken or confused, this fact about me is revealed by the responses of external nature, when I take action. It is really revealed for all to see. But because I can have more detailed knowledge of my thoughts than other people, it is potentially revealed in most detail to me. In this way, it can be said that I am observing myself. But more deeply, the whole world is always the ultimate observer, for everyone.

The above is the germ of learning and intelligence. Intelligence requires not merely a sensitive response to the structure of the world, but also an outgoing action related to this response. It also needs a sensitive response the structure of this outgoing action and a perception of how it corresponds or fails to correspond to the structure of the world.

Whenever there is mutual observation of one aspect of the world by another, there is a basis for intelligence. But this can be realized only when there is learning, i.e., the ability to form abstractions and to act according to these abstractions, with further abstraction of how the results of this action correspond to the actual structure of the whole situation.

Perhaps all nature has a kind of intelligence. But man has his own special kind. If nature had nothing akin to intelligence, how could intelligent beings ever develop from inanimate matter?

With best regards

David Bohm

P.S. It could be said that the illusion of a separation between observer and observed is due to a false comparison between the body and the mind. Physically, I look out at the world and see that there is an implied center of perspective from which observation is taking place. At the place implied by this center, I see a human body. I notice that as this body moves and turns, the center of perspective moves with it. Also, I see that these objects that are felt with the hands are those that are near the center of perspective. From all this, I infer that the body is what is carrying out the process of perception. As Piaget showed, the infant does not do this immediately, but learns to do it over a year or two. But in us, it is now habitual.

One of the earliest forms of thought is to imagine an object or a set of objects (in an imaginary space). Since this act of imagination is an internal imitation of what is seen in direct perception, the imagined set of objects will have an imagined perspective implying an imagined center of observation. And it is only natural that one imagines that at this center, there is another object, which is an imaginary image of the body. One projects this image of the body in the imaginary role or function of looking at the imaginary objects. Imaginary feelings (and) sensations are projected into this image, which imitate the feelings and sensations of the real body, when it is looking at real objects.

It is only natural then for the brain to abstract from all this the assumption that inside the body is a mind, and that inside the mind, is a "body of the mind" (called perhaps the "self" or the "soul") which is "looking" at the whole of the mind, as the physical body is looking physically at the whole of the physical universe. But I emphasise that while the physical body is real and is really the center of physical (sense) perception, there is no "body of the mind" at all. This is a purely imaginary inference, entirely without factual support, and full of so many contradictions that even to entertain the notion leads.to absurdities without limit (as I have tried to indicate earlier).

In reality the mind has no permanent center of observation. As I indicated in this letter, observation is taking place "everywhere", in the sense that whatever is in the contents of consciousness is a part of mental action that is "observing" other aspects of the contents of consciousness. Any part or aspect may momentarily take a pivotal or focal role. But it is an illusion to imagine that there is a permanent center of the mind, which is the necessary center of observation.

What confuses us on this score is always the tacit perspective or point of observation in thought. It is necessary to realise that this center is merely being imagined or constructed in thought, and has no essential connection with the real process of observation or scrutiny. If you look at a painting or a photograph, for example, you will see a tacit (or implied) center of observation. As you walk around the painting, you will notice that there is some confusion, because the implied center of observation does not move with the body. Some paintings have several possible centers, and the brain jumps from one to another as you move. But eventually, you reach a place where it is no longer possible to imagine that the body is at the tacit center of observation. Then if you watch carefully, you can see the imaginary point of observation, standing out in empty space, with no "observer" there, who would eventually be "doing the looking". Similarly, in thought, one can learn to see that the "observer" is just as imaginary as what is being "observed". It is all "going on" in a vast emptiness, without a center or a periphery.

P.P.S. I now want to return to the subject considered at the beginning of this letter.

Perhaps you will now see why I disagree with your idea that the main point is to show that hidden variables are not a mere return to classical mechanical concepts. To be sure, this is an important point. But what is still more important is to see the difference between inference and fact.

No idea is a fact: From each idea, we can make inferences which either correspond to the order of the fact or do not correspond. Within each structure of thought are theoretical orders that correspond to directly perceivable orders. These theoretical orders are never observed. Most of the confusion comes from identifying theoretical orders with observed orders. Theoretical orders are assumed to correspond to observed orders. Theoretical orders are then subject to the process of drawing logical inferences from them, based on the whole theoretical model, and these are compared once again with perceived (or observed) orders.

Whenever we describe any order, there is a tacit perspective or standpoint, from which our description takes place. This is like the tacit point of observation of the picture. In reality, it has no very deep significance, because the content of theories is always that aspect of the description that is invariant to a change of perspective.

However, once we identify a theoretical order with a really observed order, it is implied automatically that the tacit centre of "observation" in the theoretical description is a real observer. Thus, we introduce the spurious "problem" of how this "real" observer is related to the orders that are really observed. Once we admit that a theoretical order is never an observed order, the tacit standpoint of "observation" in the theory is seen to be a pure abstraction, of no deep significance at all.

So the essential difficulty is always the confusion between factual order and the inferential order of theory. Whether the theory is mechanistic or not, this confusion

will bring in the false problem of how the "observer" is related to what is observed. So I must disagree with your assumption that to dissociate hidden variables from mechanism is the main point.

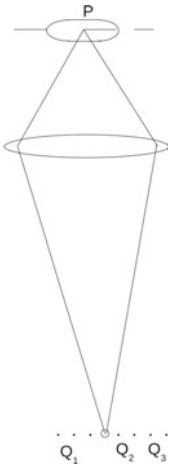
July 25, 1967

Dear Jeff

This is just a brief supplement to my letter on the "Observer and the Observed".

Firstly, I repeat that no theory (such as that of v. Neumann or J. and P.) should ever be accepted as completely equivalent to the empirical facts underlying quantum mechanics. Thus, even in classical mechanics, it is hard to tell which features are the essentially correct ones, that should be recovered in a broader theory. In quantum mechanics, this problem is even more severe. Should we, for example, regard every Hermitian as observable? (as v. Neumann does). This assumption goes enormously beyond the facts, and has been criticised accordingly (especially by Wigner in private discussions with me). Actually, only a few operators are known to be observable. A hidden variable theory might fail to agree with v. Neumann's axioms, by making only some Hermitian operators observable. Yet, it could agree with all known facts. So it is not necessarily reasonable to require of a hidden variable theory that v. Neumann's axioms can be recovered from it in some approximation.

I feel that all known forms of quantum mechanics are bad, in that they give a very poor treatment of processes in time. Usually, they treat each observation as essentially isolated, and do not attempt to put the time order of observations in any basic role. Yet, all observations tend to be ordered in this way. Consider, for example, a Heisenberg microscope, in which many light quanta were present. As the electron (P) crossed the field of vision with some momentum, p, it would scatter a series of quanta, which would be observed at Q_1, Q_2, Q_3, etc.



From these, one could deduce the momentum that the electron did have in its orbit. One would infer a process resembling Brownian motion. Why do we not regard the order of points in this "Brownian" orbit as the basic "observable"? In most cases, it is much closer to what we actually do observe than are the extremely abstract and schematic representations of "measurements" described by Heisenberg and Bohr.

If we accepted the above as the paradigm case of a measurement, we might make a new set of axioms, very different from those of v. Neumann, which still agreed with all known facts.

So I am dubious about the requirement of recovering v. Neumann's axioms from a broader theory. We did do this in our theory. But in my view, this need was psychological, i.e. to show that v. Neumann was either wrong or wrongly interpreted. Now that this has been done, we might be wise not to give too much significance v. Neumann's axioms. We

did learn that these axioms can be recovered only if we take a view which is close to that of reflective function in structural process (as you describe in your article[7]). We could take it as a generally plausible inference that this is required in any theory that transcends quantum mechanics. But v. Neumann's axioms are too slender a reed on which to anchor a "proof" of such a requirement. Ultimately, "the proof of the pudding is in the eating". Will we actually develop a new theory of this kind? So our present considerations are at best heuristic. It would be wisest not to be dogmatic about the non mechanistic nature of this ultimate theory, before we actually have it.

In my view, the main point of hidden variable theory has been:
(1) To clarify the confused questions around v. Neumann's proof of their "impossibility".
(2) To indicate a few experimental conclusions of hidden variable theories that are different from those of the usual theory.

As a by-product, we have seen that axioms of v. Neumann's type seem to require that the micro-order of movement shall depend on the general environment – and thus imply a step away from mechanism. But since v. Neumann's axioms are only ideas, this is not a "proof" that mechanism is inadequate.

Incidentally, a crucial point of hidden variable theory was to make it clear that v. Neumann's axioms are only ideas and not "facts". J. and P. still think that axioms can be facts (as does Rosenfeld in a different way).

You are quite right to emphasize that in a structural process, there may be no property corresponding to the "conjunction" of two properties. Thus, consider an object which can rotate about various pivots, A, B, C, etc. Evidently, there is no pivot which is the "conjunction" of these pivots. Likewise, when you have an eigenfunction of an operator, this determines an "invariant" vector or "pivot" in the motion or transformation implied by the operator. One could suggest that in a process, the "observables" are the invariant features (like "pivots") and not some sort of object, entity, property, quality, etc., satisfying the usual logic of set theory, with its relationships and classes. The non-commutation of operators then refers only to the fact that the corresponding two kinds of "pivots" cannot both be stationary together because when one is stationary, the other "rotates" around it. This removes the mystery about "incompatibility of observables".

Our theory does involve notions of this sort tacitly. When a really good theory is developed, the whole thing should be a lot clearer.

On the whole, I do not like your idea of supposing that axioms like those of v. Neumann or J. and P. could "refute" certain classes of hidden variable theories. Only facts can refute theories, and no axioms are ever facts. Axioms can be compatible or incompatible with theories (in a logical sense).

With best regards

David Bohm

P.S. When you discuss Bohr's notions on the unambiguity of observation on the large scale level, you might find it useful to keep in mind the following:

[7] Probably Bub (1968b)—CT.

(1) Once we admit the separation of observer and observed, then as I explained in the previous letter, the observer is always only tacitly present in the observed. If you try then to represent the observer as a particular object in the total field of the observed, there is always some ambiguity in this procedure, as we cannot tell how much of the action that is observed originates in the object corresponding to the observer, and vice-versa.

(2) So there is a kind of epistemological requirement of ambiguity inherent in the notion of the separate existence of observer and observed.

(3) The assumption that action is continuous enables one to postulate conditions under which this ambiguity is negligibly small. Thus, in the classical domain, we could agree with Bohr that the significance of what is observed need not in principle be ambiguous.

(4) But the existence of the quantum of action denies this conclusion. So we are back in the field of epistemological ambiguity, (that is characteristic of the subject-object problem).

(5) It is really wrong in such a case to put the observer on the same level as the phenomena that are observed. Rather, the observer is tacitly on another level. So Bohr is right to treat the observer (the instrument) in a special way.

(6) Bohr says that what the observer observes is always described in classical language. (The spots on the plate, etc.) But then, there is a "metalanguage", based on the algorithms of quantum mechanics. The statements in the "language" (position and momentum) have to be translated into statements in the "metalanguage" (eigenvalues and eigenfunctions of operators). This "metalanguage" has, according to Bohr, just the right kind of ambiguity, needed to reflect the epistemological situation properly. But of course, it has this only when its terms are given the usual probability interpretation.

(7) One finds in fact that experimental results do not repeat, but are distributed statistically in the way implied by the "metalanguage". So both epistemologically and experimentally, one sees that the statistical correspondence of classical language and quantum metalanguage expresses the kind of ambiguity that seems to be inherent in the relationship of observer and observed.

Thus one can make a reasonable argument for the consistency of Bohr's views. But if one doesn't accept the separation of observer and observed as fundamental, new questions are opened up. These are:

(1) The observer is the observed. Each feature of the universe observes all the others and vice versa (through reflective function).

(2) Certain features are directly perceived by the senses. These are not separate "objects". Nor are they mere combinations of "micro-objects". Rather, they are higher order abstractions of the total order of orders of action.

(3) These abstracted orders may be those of classical mechanics (i.e., a series of positions, linearly ordered on a coordinate frame, and a corresponding series of changes of position, called velocities or momenta.)

(4) However, they may also be far more subtle, involving complex hierarchies of order and structure that transcend anything that can be described in the framework of classical orders of positions and momenta of particles. There is no reason why

these cannot be just as "unambiguous" as is anything in classical physics. (E.g., one may observe curves of very high order, and regard this order itself as a basic item of data, thus specifying something that is not describable in the language of classical physics).

So Bohr's basic assumption may break down. But I feel that one must produce a concrete example before people will take this possibility very seriously. To try to suggest it by analysis of hidden variables will not convince very many people.

JULY 30th, 1967
(?)

[Date with question mark added – CT.]

Dear Jeff,

I shall now try further to answer your two letters, at least in part.

In your first letter, you emphasize how similarity is what is basic for you. That is why you like Jung's notion of archetypes. It explains a possible creative origin of what is for you a basic perception of similarities.

You point out that everything is different, thus implying that difference is not all that significant, because in the quality of being different, everything is essentially similar. Vice versa, this implies that similarities are what are really significant – and this is because they are all different. So underneath, you recognise that what makes things significant is difference after all. And you come to a part of my thesis; i.e., Things differ in that they have different similarities.

But you have overlooked the crucial fact that all differences are not only similar. They are also different. It is the difference of the differences that is really significant. That is what makes the world so rich and complex in its structure.

In the enclosed manuscript,[8] you will notice a very important difference between constitutive differences and distinctive differences. The constitutive differences are those whose similarities define the basic orders, that determine the nature of things. The distinctive differences are then the differences between different orders. I fear that when the word "difference" is used, people usually are referring to distinctive differences. It would be absurd to regard these as fundamental. I want to emphasize that in structural process, the similarities of constitutive differences determine the basic orders, therefore what is fundamental is constitutive difference.

With regard to Jung, I feel that the notion of synchronistic archetypes is a way of avoiding the fact that differences are primary. It is similar to Plato's notion of eternal ideas or forms, to which matter approximates. Plato equates these forms with thoughts in the mind of God. Jung says that they are eternally in the "unus mundus", which injects them synchronistically into external nature and into the minds of men. But Plato and Jung are basically alike in the fundamental regard that they say reality is understood through its similarity either with the idea or with the archetype. So

[8] Waddington (1969), pp. 18–40, see Introduction, p. 3, n 10—CT.

they regard similarity as basic. And of course I want to regard difference as basic. So I am suggesting the need to transcend this whole position.

In your letter, you are overlooking the basic role of differences in many places. First, you seriously underestimate the importance of contradiction between ideas and observed facts. You say merely that some ideas are "better" than others. But there are cases where the order of experience inferred from an idea is in conflict or clash with the order of factual experience. Thus, my idea may be that I can step out of the window and fly by flapping my arms. Whoever tries to act according to the idea is practically certain to fall and hurt himself. So the order of idea is that I shall move upward and enjoy myself. The factual order will be that I will move downward and hurt myself.

Similarly, the Arab governments have said that they lost the war because of Anglo American intervention. You would perhaps say that this idea is alright, but that a "better" idea is that there is no Anglo American intervention at all, and that they lost the war because of incompetence in operating modern military equipment. Wouldn't you agree that these two ideas imply quite conflicting orders of action, as well as conflicting general inferences?

One must see that a crucial feature of intelligence is the ability to perceive the difference between orders inferred from an idea and orders observed directly in fact. As I explained in a previous letter, it is not enough to infer the difference between inference and fact. It must be directly observed. When observed in this way, it leads to a fact of higher order. I explained the scheme in the previous letter as:

"The fact_2 about inference_1 about fact_1"

"The fact_{n+1} " inference_n " fact_n"

Thus, we obtain an ever changing hierarchical structure of fact. The observation of this fact on all levels is the act of understanding, which is "making the fact" or "facting".

In this process of "facting" or "understanding" what is called for is neither to accept an inference nor to reject it. What is needed is simply to see the fact about the inference. As I indicated in the earlier letter, one fact is given by the answer to the question: "Is the content of the inference true or false?" Here, your notion that "some ideas are better than others" is relevant. Thus, Newtonian mechanics is a "good idea" in the sense that it gives true inferences in a broad domain. However, Einsteinian physics is "better" in that it gives true inferences in a yet broader domain. What we do is to propose ideas. The "higher order fact" is then given by delimiting the domain of truth and falsity of these ideas, thus establishing which are "better" than others.

However, there are deeper structural questions hidden in this procedure. What does it mean that one idea is "better" than another? It means that it has a broader domain of non-contradiction with the lower order facts. In other words, the orders inferred from this idea concord with the orders observed more directly in the lower order facts. But how is this discovered? Surely, it is not that the "unus mundus" injects into the mind a perception of the degree of accord or discord between various ideas and the facts. Such an assumption would lead to a very artificial theory, in which the "unus mundus" would sometimes inject into the mind a very confused perception of the accord or discord between ideas and fact, and sometimes a more clear perception.

Sometimes (e.g., in the case of the Arabs) it would inject into the mind a persistent tendency to resist perceiving that the idea is not in accord with the fact.

Clearly, we must see the fact about the structures of our ideas as well as about their contents. Do they contradict each other, and do they contradict the lower order facts? Are they clear or are they confused? Do they tend to change, in order to become more clear and to accord better with the facts, or do they resist changes of this kind, in order to protect and preserve feelings of pleasure that are associated with them?

How could the theory of archetypes deal with these questions? Why does the "unus mundus" inject confused ideas into the mind? I can understand that it might inject ideas of limited domains of validity, which are later followed by "better" ideas of broader demands of validity. But confused ideas have no domains of validity at all. Moreover, they often lead to a tendency to ever mounting confusion. It would seem that the "unus mundus" has a malicious streak in it, because it tries to deceive us and mix us up, leading us to destructive courses of action, that cause tremendous suffering.

Moreover, the archetypal theory seems to make perception purely mechanical. Not only does the "unus mundus" inject ideas into us. It injects into us a perception of the degree to which these ideas correspond to fact or not. Sometimes it injects us with clear ideas and sometimes with ideas leading to unending confusion. It even injects into us a perception (sometimes clear and sometimes confused) of the difference between ideas and facts. We have nothing to do but respond passively to the arbitrary and generally meaningless whims of the "unus mundus", and to jump like puppets, every time the latter injects us with an archetype, (whether clear or confused).

On the other hand, if it is we who see what is a contradiction and what is not, what is fact and what is inference, what is confused and what is clear, then why do we need the "unus mundus" to inject us with archetypes? For in my view, the ability to see the above things is already basically of the nature of creativity. Once we can see these, it is not too great a step to see also what it means to be creative.

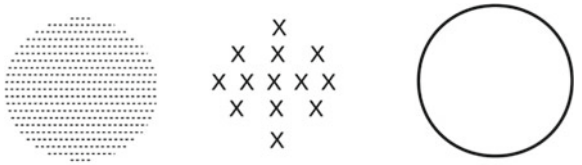
Consider, for example, the ability to see the difference between fact and inference. This clearly depends on a mental process of higher order that transcends the limits of any particular inferential structure of ideas. For a mental process that works within a given order of ideas cannot see what it means that the fact goes outside that order. There is a primary and direct feeling or sensation or sensitivity, which lets us know that inference and fact are in different orders, so that there is contradiction between them. As the corner of the eye can sense a change without sensing what it is that is different, so the mind can sense the difference between inferred order and observed order, without seeing just what the difference is. This primary perception is aesthetic – i.e., it senses a certain lack of harmony between order inferred from idea and the observed order. So the possibility of a new step is opened up by an aesthetic sensitivity of this kind.

Later, the mind begins to abstract the differences in more detail, coming then to the similarities of the differences, until it is able to specify in just what way the two orders clash with each other. This kind of action is indeed quite a general process. Thus, when the eye looks at something new, it first abstracts the essential constitutive differences and their similarities, thus presenting the order of the thing

to consciousness. If the order is really new, one may have no words for it. It will then take time to explore the use of language to discover an order of words that conveys or expresses the essence of the new order. But usually it is not new. In this case, the mind draws on memory, by evoking a remembered order of similar differences that is similar to the perceived order. But a vast and very rapid process of direct perception of the observed similar differences precedes this last step. We easily overlook the almost instantaneous process of direct perception of the constitutive order, and imagine that the basis of perception is similarity to the idea (or archetype).

We can thus be deluded because we pay so little attention to what is rapid and fleeting (differences) and so much to what is relatively fixed and permanent (similarities).

These remarks are relevant in connection with your illustration of perceptions of circular shapes. Thus you showed a lot of shapes, like



A B C

those above, and asked how one knew that they are all circles. You inferred that this is done by projecting the archetype of a circle into all these figures, and thus seeing their similarity to the archetype. I would suggest a very different explanation for this process.

In figure A, the eye abstracts the similar differences between the dots, to form the order of the dotted lines. Then it abstracts the similar differences of the dotted lines to form the order of orders of an array of parallel dotted lines. Then it abstracts the breaks (or ends or boundaries), of the dotted lines, which are indicated by differences between the area beyond the line and the line itself. The eye then sees the similarities of these differences, and thus abstracts the boundary of the two dimensional order of orders, presented as an ordered curve. The similar differences constituting this ordered curve are then related to similar differences in remembered curves, and it is noted that their order is similar to the order of similar differences in a circle. Then the curve is named a "circle". This whole process is so fast that only the last stage is likely to be noted. Thus, it appears that perception is based on projecting the archetype of a circle into what one sees. In reality, this is only a tiny part of the whole process, and not even its most basic or essential feature. Thus, to me, it seems that the archetypal theory of perception is an attempt to stand the pyramid of perception on its apex.

This process of perception of a whole set of orders and orders of orders of differences and similarities is, in a certain sense, "synchronistic". That is to say, although some time may be needed to "take in" the data, the act of understanding, which presents this totality of orders of orders is essentially something that does not involve

a time sequence of causes and effects. We always feel that each act of understanding occurs "in a flash". My proposal is that this is a manifestation the true synchronicity of the process which establishes the perception of a new order in consciousness. I would say that we tend to fail to notice this, because of the tacit assumption that all necessary features of process are causally ordered in time, while all synchronous features are contingent (like initial conditions in the laws of mechanics). But I propose that both in nature and in the mind, some synchronous features are necessary, while some features of temporal order are contingent. In a way this unites space and time even more thoroughly than relativity does, for it attributes both necessity and contingency to both space order and time orders.

However, I disagree with Jung in his giving similarity a basic role, by saying that the "unus mundus" projects archetypes synchronistically into external nature and into the mind. Rather, I would say that both in nature and in the mind, the movement of process is such that the (synchronous) differences produced by it tend to have all sorts of similarities in them. Thus, the very law of process is that the new synchronous orders are always being created, both in nature and in the mind. We do not need to assume a special act of creation by the "unus mundus". For creation of new orders (and dissolution of old orders) is the very essence of the character of all process. The only question is how the creative process of the mind is related to that of external nature, so as to produce a reflection of the latter. And of course, all processes reflect the totality. The human mind creates a particular reflection. One of its special features is that the human being acts on the basis of this reflection, and the mind can then reflect whether the resulting fact is in the order of the reflection or not. If it is not, the creative processes of the mind naturally give rise to new reflections, until accord is reached. Exactly how this happens is a vast process, which science has barely begun to explore. But we understand enough of it already to see that it is not a mere mechanical copy of nature, injected by the "unus mundus" into the mind.

In the enclosed manuscript,[9] you will see some notions bearing on this point. Thus, I proposed that in quantum mechanical field theory, all movement is described as the "creation" of a new quantum state and the "annihilation" of an older one. But as explained in the manuscript, each quantum state corresponds to a certain order. Thus, movement is creation and dissolution of orders. In this movement, there is first of all a set of constitutive differences. The similarities of these constitutive differences lead to constitutive orders and to constitutive orders of orders (structural process). When these are analysed into sub-orders, one finds that the different sub orders are related, so that they reflect each other. Thus, the total creative process inevitably contains reflective functions, such that each aspect reflects all others. It is this which is at the basis of perception of what is new, and not the injection of archetypes.

As I indicated earlier, new orders are always being created, and this is indeed the basic law of movement and of the existence of the creative process. It is not that the world is basically mechanical, and that from time to time, the "unus mundus" projects or injects something new into it. (If it were that way, then one would in

[9] Waddington (1969), pp. 18–40. For details see Introduction, p. 3, n 10—CT.

fact need something like an archetype to explain what happens.) Rather, the world is basically a creative process, in which whatever is created is also reflected in all other aspects of the world. Thus, we need no further explanation of how the mind becomes aware of the creation of what is new. For the very law of the creative process is such as to be always providing the foundation of such awareness. The creative process is working reflectively everywhere, including the human brain. The process of abstraction is working everywhere also (E.g., the light rays reflect the universe by their function in each point of space). The human brain has a particular kind of abstraction, similar to that in nature in some ways, different in others. When the human brain abstracts the differences in the function of the creative process in the field of consciousness, it discovers the similarities in these differences, thus becoming aware of the constitutive orders of creative process. This perception is then tested by action in the way I described earlier and this leads in turn to new perceptions, in a process that is the essence of learning.

In this whole process, the ability to see contradiction is, as I have explained, a key feature. When contradiction is observed, the old order of ideas that is responsible for it must "get out of the way", because it is incompatible with the new order that has to be created. To allow this to take place is psychologically the hardest step of all. For it leaves the mind in an uncomfortable state of being empty and uncertain, as to what is the right order of action. The principle barrier to creativity is that the mind turns to "escape" this uncomfortable state, by "jumping" to another known idea. If however the mind can stay in this empty state, without falling asleep, one observes that it becomes extraordinarily sensitive and active in all sorts of subtle ways that are difficult to specify. In this action, exploration is taking place at a fantastic speed. What is being explored are all sorts of orders of orders that the mind is creating, not totally at random, but in the light of the whole fact as it is known thus far. Suddenly, the mind sees that a certain order of orders is right for this situation, and it is presented in a "flash" of understanding.

The total order of the mind in such a process is (like that of external nature) almost like a kind of music or art, rather than like a mechanical process of computation. But we have been trained for thousands of years not to notice this, and to pay attention almost entirely to the utilitarian mechanical order of action in time, which is given top priority in our perceptions. A few artists and musicians are still somewhat aware of the vaster non temporal order of reality (called beauty). But they are regarded as "odd bods", who are useful to entertain the rest of us, but whose perceptions are not to be taken too seriously. In my view, this is all a trap, that has caused untold misery for thousands of years, because it has condemned us to live in delusion and self deception, in all issues of real depth and subtlety.

The basic structure of the trap is in the confusion that arises between inference and fact. Thus, in propaganda, the basic trick is to slip inferences across in the role of facts. But this is always tending to happen spontaneously as well. For example, one may describe a fact, such as: "This boy is stealing". Someone else may say: "This boy is a thief", not noticing that he is making an inference of a "thieving structure", implying that the boy will always steal, because a thief is what he is. Therefore, he

will cease to observe the fact about the boy's behavior which might well reveal, for example, that the boy steals to attract attention.

The error in the above is the confusion of an inference with a fact. Inferences are O.K., as long as one realizes that they are only inferences and not facts. Then one knows that it is necessary to observe the fact about the inference; (Is it true or false?) One thus forms the beginning of the hierarchy of "fact_{n+1} about inference_n about fact_n". But if one confuses "inference_n" with "fact_n", then the whole process screwed up, from there on. "Fact_n" is like the input of the n^{th} stage of a computer, of which inference_n is the output. If we connect up "inference_n" in the place that is proper to "fact_n", this produces a "feed-back loop", which will disrupt the whole order of the entire structure of fact and inference.

The major confusion between inference and fact is in the "self". This latter is only an inference. Thus, as I indicated in the previous letter, one can never discover the "self" by anatomical analysis of the brain. Nor can it be seen introspectively by "looking inward". When this takes place, one observes only thoughts and feelings, and these are inferred to belong to an entity called the "self". This entity is inferred to be unseen, because he is the one who would be doing the looking, at the point tacitly attributed by thought to the observer.

When we have an idea leading to all sorts of contradictory inferences, we are led to consider the notion that the idea may be false. But the "self" has a vast set of contradictions that would, in any other case, have led to its being dropped as false and meaningless. For example, one of our favourite inferences is that the actions of the self are always right. This inference gives rise to pleasure. When someone presents evidence that the "self" is wrong, there is a violent reaction of pain, and a "self protective" effort to cover up and distort the evidence, to make it look as if the "self" were right, so that pleasure can be resumed. This reaction is contrary to one's real interests, which are to recognise one's mistakes and learn from them. Similar contradictions can be observed without limit in everyone, which develop from moment to moment. But each person is prevented from seeing his own contradictions by a "censorship mechanism" that makes him blithefully unaware of them, though everyone else can see them without any difficulty at all.

The essence of the "self" is the inference of pleasure. Now, there are real feelings of enjoyment and pain, which are informative. Thus, when all is going right, there is a sense of enjoyment, which is a by-product, and also an indicator that all is well. Pain should normally indicate that something is out of order. But there can also be an inference of pleasure (e.g., the "foretaste" of an expected pleasure) and a similar inference of pain (which we feel before we get into the dentist's chair). When the inference of pain or pleasure is attributed to the "self", it is confused with the fact of pain or pleasure. Thus, a "feed-back loop" is set up. The inferred pleasure is sensed as real but incomplete. It demands that something be done to "set it right" or to "complete it". Since it is all thought (i.e., inferences), this demand causes thought to move to increase pleasure, rather than to try to make inferences correspond with facts. So it all goes wrong. As it goes wrong, it leads to the inference of pain, which is called suffering. This creates a demand for yet more pleasure, etc., etc.

It is in this vast but delusory structure of inferred pleasure and suffering, mistaken for real enjoyment and pain, that mankind has been trapped for tens of thousands of years. Once it has been set into motion, this delusory order of operation tends to spread to other fields. For the whole structure of thought is one. If inferred pleasure is mistaken for real pleasure, the resulting distortion of thought may operate even in mathematics, to give the impression of pleasure coming from the delusory believe that one's ideas are right, when in fact they are wrong.

So it is crucial for mankind to see the difference between inference and fact. This may indeed be the most important thing that science has to teach us. Thus, in science, it is not proper procedure to "stick up" for an idea. Rather, we draw inferences from it, and see whether the facts confirm or falsify the inferences. Either way, we are learning. But in other fields (e.g., ethics, politics, etc.) people are afraid to operate in this way. They accept inferences as facts, and feel impelled to "defend" these inferences, as if they were necessary to the whole order of life.

Of course, everyone can see contradictions in other people (E.g., "he says one thing and does another"). But what is called for is the scientific approach of seeing contradictions in one's own ideas. One can only gain by seeing where he is wrong. Why do we defend our wrong inferences as if they were facts about something that is supremely precious?

Until the scientific attitude can spread into the whole of life, no real happiness is possible for people.

But this in turn calls for the artistic attitude. This is to see both beauty and ugliness, wherever they are.

We have a persistent tendency to want to see only beauty. But as I have shown, contradiction is sensed aesthetically as a kind of disharmony or ugliness. To refuse to see it because it is unpleasantly ugly is to doom oneself to delusion, and therefore to an ugly state of mind, which leads to suffering.

Real beauty can arise only in the mind of one who factually sees beauty and ugliness as they are. Then we have:

"Beauty_2 of Beauty_1 and Ugliness_1."

Beauty_2 is a higher level of beauty, open to one who sees the lower level of beauty and ugliness and how they are related.

All this is the artistic attitude. The scientific attitude is to see:

"Fact_2 about Fact_1 and Inference_1."

But it is necessary to approach life as a whole, not in a one-sided way. So each man needs both the artistic and the scientific attitudes. A man who recognises this has the religious attitude, which regards life as one, unbroken, and interconnected, in all its aspects. (As organised religion is not true religion, so organised art is not true art and organised science is not true science).

With best regards

David Bohm

P.S. If one were to ask what is the basic "theme" of religion, I would say it is:

"The Oneness (Undividedness) of the One and the Many."

To begin with, direct and immediate perception is One. Then, thought splits it into the Many aspects and parts. But these still belong to the One. First of all, there is the fact that:

"The Many reflect the One."

It is this that opens up the possibility of reflective function. Then there is the fact that:

"The One becomes the Many."

In physics, this shows itself as the wave particle duality. (The point event becomes the curve.)

Then we have:

The Many is the One.

That is to say, in the totality, the One includes the Many.

In ancient religions, the One was called by the name of God. Unfortunately, people began to regard God as an entity or a being possessed of qualities. But this in effect limited the One and tacitly distinguished it from Another One or Others. Thus, the One ceased to be a true unity and became One among Many. But the true One includes the Many. So every attempt to define the qualities of God in any way whatsoever (good, kind, merciful, like a father, etc.) made religion false and contradictory. The One is the Unknown. It is not the Unknown that we could in principle come to know. Rather, it is the Unknown that is, and in which everything known rests, and has its being as an abstraction.

Some people put the Unknown up in the sky or far away, or in some mysterious realm. Others say that it is immanent in all things. Both these views are confused, because they attempt to give the Unknown qualities and thus set limits on it. Once the Unknown is limited, then it becomes a known and partial sort of thing, set over against something else, and therefore divided as well. Thus, if it is immanent, it is not transcendent, and if it is transcendent, it is not immanent. Even if we say it is both, we are still caught in confusion. For what it is supposed to transcend is "things" and what it is supposed to be immanent in is "things". Therefore "things" are taken as logically prior to the Unknown. First, we imagine all sorts of "things", and then we suppose the Unknown to transcend them while it is also immanent within them. Thus, we "slip in" the tacit acceptance of the "thinghood of things". But this is just what has to be called into question. In the structural process point of view, for example, "things" are always abstractions from the ever changing flux of process (like the shapes that we see in clouds). In reality, there are no "things" in the universe (except as abstractions introduced by thought). What can it mean for the Unknown to transcend what does not exist or to be immanent within it? Evidently, this is absurd. The only sense in which the Unknown transcends "things" is that the Unknown is real and exists, while "things" are mere abstractions of thought. Indeed, "things" are abstractions from the Unknown.

Whatever we say the Unknown is, it isn't. What then can it mean to us? The answer is that we are the Unknown. We are not always aware of this however. So the real question is that of being aware of the Unknown that we are (and that everything else is). This Unknown cannot be something far away that transcends us (for it is the

very essence of what we are). Nor can it be immanent within us. For the very word "us" represents only an abstraction from the Unknown that we are.

This may all seem a bit "metaphysical". And it would be metaphysical if it were taken only as a nice verbal formula or intellectual idea. But I mean it as a description of what is properly the norm for a healthy life, physical and mental. This norm implies the need for one's life and perception to be following the order indicated by the three great themes:

1. Seeing the fact about fact and inference.

2. Seeing the Beauty of Beauty and Ugliness.

3. Seeing the Undivided Oneness of the One and the Many (which is the Unknown that we are and that everything is).

These theme are common to the whole of humanity. At bottom, everyone can see their necessity and reasonableness, when they are properly discussed and understood. They deal with very deep aspects of the mind and of the whole being of each one of us, as well as with the whole of the universe. When we discuss these themes seriously, we inevitably come together on a common ground. But as soon as we begin to give first priority to our own personal peculiarities, our particular emotions and prejudices, our beliefs about religion, politics, nationalism, science, art, or any other subject, we start to be divided and to enter into conflict.

So what is needed is that the mind shall put first things first. To live in the order implied by these three themes is infinitely more important than is any particular thing, like nation, family, career, beliefs, etc. For unless one is living in this right order, the rest must go wrong. (Thus, to fail to distinguish fact from inference will turn family life into a destructive hell and misery.) And if these three themes are alright, then everything else is bound to come into a right order.

Before one can properly look into what it means to be creative, these three themes must be deeply understood. To try to discuss creatively without such an understanding is to make empty noises. But once you have some notion of these themes, you will directly see that they imply a creative order rather than a static order. Thus, to see the fact about inference and fact is just a step in an unending journey of discovery, which is always creating new orders of perceiving the fact and thinking about it. To see the beauty of beauty and ugliness is to see how to end ugliness. To see the Undivided Oneness of the One and the Many is to see unity of ever higher orders. For each perception of Oneness becomes a part of the Many and this latter has in turn to be perceived anew in a Oneness of higher order. So the whole of existence, physical and mental, is seen as creation.

Creation is not to be understood in terms of the order of time. At any moment, the whole creative process is. It is not the result of a chain of causes and effects (though it is compatible with the existence of such chains). Thus, the beauty of a tree or a flower is in the vast harmony of orders of orders with which the tree or flower operates within the brain, right now. The movements of the parts of the tree or flower may well follow the laws of mechanics, in quite a good degree of approximation. But

the vast hierarchy of ever changing and developing orders of orders that is the beauty of the tree or flower is simply not capable of even being mentioned or described, in terms of the quantities appearing in the laws of mechanics. The same holds for the beauty of an idea, of a person, of a work of art or music, etc. It is simply an order that exists and whose essence cannot be referred to the order of time. Thus, it is a kind of quality of "synchronous order" (provided that we do not mean "exact synchronism" but only "general coexistence").

As I mentioned before, the human race is heavily conditioned to a belief that this synchronous order of beauty is of no real significance in nature. It is believed that the really significant order is the utilitarian order of cause and effect, carried out in time. Beauty is regarded as "subjective" and "personal", while the mechanical order is taken to be "objective" and "impersonal". What I want to emphasize is that reality (which is the Unknown) is in the order of beauty, rather than in the mechanical order of time. The mechanical order of time is an abstraction from the "synchronistic" order of beauty. And this is where science is going badly wrong today.

Jung's mistake was to identify the synchronistic order with an idea (called the archetype). It is too vast and dynamic, too much in a process of change of orders of order, even to be comprehended in an idea.

Ironically enough, the scientist's emphasis on utilitarian cause and effect is matched by the modern artist's emphasis on the apparently opposite belief that the artist can create anything that he wishes to, in quite an arbitrary way. The older artist recognised that he had to study the necessities and contingencies of his medium. When he understood these to some extent, he could create a new order in his medium, by taking advantage of the contingencies, without coming into conflict with the necessities. But the modern artist seems to feel that in his field, there are only contingencies and no necessities. So he can apparently do whatever enters into his mind.

There is a kind of "division of labour". Thus, the scientist is regarded as the man who deals with the dull utilitarian iron bound necessities of life, while the artist specializes in a domain where there is absolute freedom, and where all takes place according to his whim or fantasy.

But of course, this whole picture is a fantasy. The artist is still bound to the necessities of his medium (which involve the orders of space, form, color, and light). The universe that the scientist studies is still a universe whose basic order is that of timeless beauty, and not that of utilitarian time-ordered necessity. Nevertheless, the artist's belief that he is free of necessity helps confirm the notion that the scientist deals only with utilitarian time ordered necessity. Thus modern science and modern art work together to enslave the mind of man (in this way doing what the priest used to do in the past).

So I think it is crucial to see the timeless order of beauty as the basic expression of the Unknown, which is reality. Our conditioning against doing this is vast; having gone on in every phase of life for thousands of years. Unless mankind can break through it, there will be no end of delusion and suffering.

To this end, the understanding of what Jung called "synchronism" is crucial. However, the very word "synchronistic" is misleading, because it emphasizes time as being of the essence. Let us instead discuss the timelessness of the

order of beauty. By this, we mean that the order is not essentially related to the order of time (and not that it is permanent or everlasting). The fact is then that the timeless order is our most direct contact with the unknown reality. The order of time is an abstraction from the timeless order, made in the process of thought.

What then does it mean to be aware of the Unknown, in its basically timeless order of beauty? Firstly, it means that the divisions and multiplicities introduced by thought are not to be given a fundamental role of top priority in our mental processes. To meet the undivided wholeness of the unknown, the mind needs an undivided kind of perception. But immediate and direct perception is always a totality, which is then analyzed and divided by thought. However, since thought too is real, this kind of immediate and direct perception is no longer adequate, since it is now set over against thought, and is therefore divided, rather than total. What is needed is a higher order of direct perception that is aware both of lower order direct perception and thought, and of how they are related.

To have this kind of higher order direct perception is crucial for the health of the mind. For ultimately, it is the only possible way of seeing that inferences are not being confused with facts (with the disastrous results that I described earlier). But even more, it means that there is no reason to seek the Undivided Oneness of the One and the Many. For in this higher order direct perception, the mind is this Undivided Oneness of the One and the Many. Therefore, it does not have to seek the Unknown, since it already is of the basic nature of the Unknown. Only when the mind thus is of the nature of the Undivided can it have a truly religious (unbroken, unfragmented) attitude to the whole of life. And with such an attitude, it no longer tends almost always to create divisions and conflicts. Thus it lives in harmony with itself and with the whole universe.

In such a state, the timeless order of beauty that is being observed is similar to the timeless order of beauty with which the mind itself is operating. Thus, the order of the mind is of the same nature as is the timeless order of reality as a whole. So the division between the observer and the observed has ceased.

In our ordinary state of perception, we feel that reality is more or less mechanical, while the observer (the "subject" or the "self") is an entity who appreciates beauty, sees truth, and has very delicate and wonderful feelings and emotions of every kind, whose value infinitely transcends the mechanical. Thus, there appears to be an absolute gulf between the nature of the observer and the nature of the observed.

But of course, in this state, the observer is actually the inference of a center, full of pleasure and suffering. This inference is the most mechanical thing in the whole field of perception. In reality, the apparently mechanical world and the apparently non mechanical observer are of the same illusory nature, projected by the same mechanism of thought and its inferences, mistaken for fact.

When the mind functions from the undivided state of perception, then the observed and the observing mind are of the same nature. Each is only an aspect of a yet broader and deeper reality, which is one and undivided, and which moves in the order of timeless beauty (while time is seen to be a functional abstraction from this order).

But as I indicated in a previous letter, one can say even more than this. For the observer is the observed. The process of perception is not only of the same order of

timeless beauty as is what is observed. Even more, this process is being carried out by what is observed, inwardly and outwardly, in its totality. The total reality that is observed is also the observer. This is perhaps the deepest truth of all, and it is hard to appreciate simply, (in direct and immediate perception, rather than merely as an inference of thought).

Sept 8, 1967

Dear Jeff

Thank you for your letter of Aug 16. I think you are right in trying to work out these difficult questions for yourself, rather than to absorb what I say about them. Nevertheless, there are a few points which I would like to call your attention to, in your meditations on these questions. Perhaps it will help you to do so. At any rate I hope it will at least facilitate communication between us (which is, as you say, very difficult through correspondence). I shall look into the question of when it is convenient for me to come to Minneapolis, where we can at least discuss verbally. Please let Feigl[10] know that I am resolved to come at some time, but cannot yet say exactly when.

First, a few remarks on Fact and Inference. As I explained in an early letter (or did I?) , we can call Fact_1 the immediately observed fact and Inference_1 the immediate inferences about Fact_1 that spring to mind. Inference_1 imposes order and structure on Fact_1. Without it, fact_1 would be only a set of isolated bits of information. But inference_1 calls for a further act of observation to answer the question: "Is it true or not?" This leads to Fact_2 about Inference_1. From Fact_2 we go to Inference_2 about Fact_2, then to Fact_3 about Inference_2, etc., etc. Thus we see that the total body of fact has a hierarchical structure.

In this structure, each element can play two roles. It may at one level be treated as Inference_n while at the next level, it can become Fact_{n+1}. No "fact" is so elementary that it does not contain lower level inferences, which have been so well confirmed that they can be treated effectively as parts of the fact. For example, Australia is for me an inference, (as I have never seen it). But it is confirmed in such a vast hierarchical structure of observations and experiences that I can treat this inference as a fact, for most purposes. Nevertheless, to be clear about the order of operation of the mind, I must maintain the distinction between the inference of Australia and the observed fact of Australia. At this deep level, Australia is still for me an inference, but one that can in general be treated as effectively confirmed in every respect.

One sees then that the total body of fact is not identical with truth. For it always contains inferences that are yet to be tested observationally. Some of these may well be false. Nor is the fact identical with reality as a whole. For even the whole body of fact is but an abstraction from this reality, which is vast and immeasurable, being basically unknown in its totality.

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[10] See C130, p. 21, n 9—CT.

The fact is what we have made or established. It is always being established and re-established. Thus, it is the outcome of a dynamic process, which is the act of learning. This learning is not merely the accumulation of knowledge. Rather, it is basically discovery, which is made possible by seeing the truth and falsity of inferences in the already established body of fact. This perception lays the groundwork for the drawing of new inferences, that become the "growing points" in the "living body of fact".

Where does this process go wrong? Of course there are the normal "errors" in our inferences, which are an inevitable part of the of the process of learning and establishing the fact. If the mind is operating in a healthy order, these are sooner or later noted and corrected. But there is another kind of "error" in the process, which represents not merely a "false content" in the process of thought. Rather, it is the result of a wrong order of operation of the mind, leading to a wrong structure of thought. This wrong structure does not tend to correct itself. Rather it tends to get worse and worse, leading to entanglement in ever growing confusion and delusion.

Basically the wrong order of operation is to confuse Inference$_n$ with Fact$_n$. For example, the description of Fact$_n$ may be "This boy is stealing". But the observer may say instead: "This boy is a thief", not noticing that this latter statement is an inference, which implies a "thieving structure-function", inherent in the boy's nature. Thus, we may infer of a motor car "It is powered by a gasoline engine". This inference can then be tested by further observation. But when one says: "This boy is a thief", one usually does not notice that this is an inference requiring further testing. Rather, one tends to suppose that his "thieving nature" is an observed fact (Fact$_n$), so that one knows factually (and not merely inferentially) that "he will always steal". As a result, one does not observed Fact$_n$ carefully, and one fails to see for example, that the boy steals, not because of his thieving nature, but because he is trying to get some attention.

The above is typical of the wrong order of mental operation leading to a wrong structure of thought. What happens is either that one imagines one has actually observed the boy's thieving nature as Fact$_n$ or else, that this is so well confirmed an inference that it is, like the existence of Australia, for all practical purposes equivalent to a fact. Whichever form this error takes, the results are destructive. For in effect, the function of thought is now caught in a "feed-back" loop. It is as if the output of a computer were fed back into the "factual input", rather than to a higher order computer or to a circuit controlling the activity of a machine. Such feedback would create self maintaining and self exciting cycles of meaningless activity, which could generate endless confusion. Similarly, when inference$_n$ is taken for fact$_n$, then we form new false inferences$_n$ based on the original inferences$_n$, rather than on fact$_n$. These in turn can be fed back as another part of fact$_n$. For example, one may infer that the boy's thieving nature can be "beaten out of him". This too would be taken as part of fact$_n$. When beatings fail to do this, one may infer that the boy has a "hopelessly criminal nature", which is also taken as yet another part of fact$_n$.

It is evidently crucial to maintain the distinction of inference$_n$ and fact$_n$. This requires a never ending sensitivity, permitting a perceptive act of discrimination, from moment to moment. What is needed is thus to pay attention to the order of the

fact, and not merely to its reflected content. By this, I mean the order of the process of learning or "facting", which is what establishes the factual content of this process, as this content changes from moment to moment.

We are generally taught to pay attention only to the factual content of our perceptions, and not to the higher order fact, about the order of operation of the process of "facting" itself. This is a serious and perhaps even fatal defect in our education. For we are taught "what to think" without being taught "how to think". It is urgently necessary for each one of us to start to remedy the defect, to the best of his ability. Only thus is there any hope of changing the generally meaningless and destructive course that most of our history has been taking, for thousands of years. For as long as we confuse fact and inference, the result is a tendency to systematic and ever-growing self-delusion. And whoever is guided by such delusions can never produce the results that he intends.

Here, one sees the root of the problem of evil. For the truth is that deep down, all men desire the good. But because they are deluded as to what is the good, they accomplished evil in almost all that they do. And this is inevitable, as long as men are thus deluded. But such delusions stem ultimately from the confusion of facts and inferences. Even the vast evil and ugliness brought about by the Nazis stemmed ultimately from such delusions, in which inferences about the sublimely beautiful and powerful nature of the German "Volk" were confused with facts (Incidentally, how would you reconcile the actions of the Nazis with your thesis that evil and ugliness do not really exist, in a deep sense?)

The notions that I have described above are summarized in the "theme": "The Factuality of the Total Hierarchy of Fact and Inference." In other words, while Fact and Inference are aspects of each item of information, the over-all structure gives rise to the ever growing and changing body of the "fact as a whole".

It may help clarify this structure to point out that thought is not merely an image or a reflection of reality. It is also a model. Such a model reflects not merely the structure of what is modelled, but also its function. So thought models the structure-function of reality as a whole. From this model, we draw structural-functional inferences, which test the model. Indeed, to understand a given field is to create a model of that field as a whole, from which coherent sets of structural-functional inferences can be drawn. A model may be visual, verbal, mathematical, or of some yet other form.

One can go further and say that immediate perception also contains a kind of model of the world. Thus, when I see a table, I "feel" its solidity and hardness before I even touch it. This is the result of a model, based on past experience going back to early childhood. It is crucial to note that this model (including mechanical, geometrical, and emotional features) directly interpenetrates the structure and function of all that we perceive.

One may convince himself that perception contains (among other things) a model of the world, by noting that the world remains unchanged in perception, as one turns the head and the body. This is the result of an orientation process, regulated by the inner ear. When this process goes wrong, one becomes "dizzy" and the world seems to "spin". What is happening is that the model of the world is no longer properly oriented.

It is crucial to note that generally speaking, both physically and mentally, we respond to this model of reality, and not directly to reality itself. Thus, when the model is wrong, our responses are wrong. By perceiving this, the brain is led to change the model in an appropriate way (provided that it is operating in a normal order). But since the model contains structural-functional inferences, projected directly into perception, this change is possible, only when the brain is properly and freely aware of the difference between fact_n and inference_n. If it takes inference_n as fact_n, its new model will be wrong. And the perceptual cues that would show it to be wrong are misinterpreted, because they are combined with other data, wrongly taken to be factual, rather than inferential (in the context in question).

In a way, this implies that there is no such thing as illusion. We see whatever we see. But we draw wrong inferences from it. All the magician's "illusions" are based on his skill in leading us to wrong inferences. When we see various patterns that lead us to wrong estimates of size and shape, this too is only a kind of wrong inference. So there is no illusion. There are only wrong inferences and delusions. (The latter being wrong inferences resulting from a wrong order of operation of the mind, mixing up inference_n and fact_n.)

It is important to note that even the physical, chemical, and emotional responses of the body and brain are determined largely by the model presented in perception. For example, the Nazis thought of the sublimely beautiful and irresistibly powerful nature of the Nordic German "Volk", and a model of all these qualities sprang into his consciousness. Thus, he apparently directly perceived what Hitler was talking about, not realising that words can give rise to models, full of feelings, color, and emotional effects. Then Hitler spoke of the dirty, cheating, cowardly, wicked Jews, with their crooked and long noses, who were corrupting the noble purity of the Aryan race. All this was "modelled" in perception. As a result, the adrenaline flowed, the glands functioned, the brain filled with blood and a feeling of "righteous indignation". At that moment, surrounded by a hundred thousand people all imitating each other's reactions, he felt an ecstasy of violence that swept away all reasoning power. This whole process was then recorded in the "memory banks" as a "programme". So whenever such a man saw a Jew, the "model" sprang into his perceptions so rapidly that he could never perceive its inferential character. Rather, it was fact to him. And remember, none of us can do other than act in accordance with the model of reality presented in his perception. Any man, poisoned mentally by the Nazi model, cannot do other than destroy himself and everything around him as he tries to do what appears to be right and good, but what is actually false and evil. More generally, as each man perceives so he acts, and so he is, inevitably and necessarily. A change of man's nature can follow only on a change of perception. If his perceptual models are right, his actions will be right, inevitably. If they are wrong, his actions will equally inevitably be wrong. Only a right order of mental operation can correct wrong perceptual models. So all depends ultimately on perceiving the order of mental operation, as well as its modelled and reflected content.

Here, one tends to become confused by thought. As direct perception contains structural-functional models of reality, so the brain is able to abstract these models, and thus to imagine or think about the structural-function of objects that are not

present in direct and immediate perception. Indeed, the two year old child has learned to imagine a whole world of such objects, each ordered in its place in space, and one of these objects being himself. If you will keep such a process in mind, you will perhaps find an answer to your question as to the nature of a perception that is not direct. When you are thinking, you perceive the imaginary "objects" of thought. These "objects" are not being directly perceived. Of course, if you are sensitively observant, you will directly perceive something else – i.e., that you are thinking. So we have three things; direct perception, its model in thought, and a direct perception of a higher order, which perceives that thought is a model, and also perceives how this model is related to lower orders of direct perception. So we have an important further theme:

"The Direct Perception of Direct Perception and How it is Related to its Model in Thought"

This theme evidently gives rise to a hierarchy, since each order of direct perception can in turn be modelled in thought, and directly perceived at a yet higher order.

Evidently, just as the models of direct perception can fail to correspond to the order of reality, it is even easier for the models in thought to be arbitrary, and fortuitous, not having any essential relationship to the objects that they are supposed to model. Here, we must recall that the notion of fortuitous (essentially unrelated) orders is part of the basic concept of natural order as a whole. Thus, in the absence of traffic signals, the orders of cars in two intersecting roads is fortuitous. Hence, they will not be coordinated, so that collisions will be able to take place, which destroy the cars. A traffic signal serves to coordinate these orders. Similarly, arbitrary thoughts have only fortuitous relationships to what they are supposed to model. It takes an intelligent process of perception and learning to establish thought models that are properly coordinated to the objects that they are supposed to model. In other words, thought does not simply and mechanically "reflect" reality (as if it were a mirror). Rather, it is a special kind of reflection, which models the structure-function of real things. Such a model has to be created and established by the action of perception-learning.

Of course, thought models are full of feeling, emotion, color, etc., as well as capable of functioning and in other ways. So it is often difficult to distinguish thought models from models that are inherent in direct perception. Indeed, it is well-known that the young child often thinks that people can see his thoughts, as if they were objects in the room. It is therefore not surprising that adults as well as children often mistake the models of thought for directly perceived reality. For example, the convinced Nazi actually perceives the "Jewish" qualities that Hitler talks about, as if they were visible before his eyes, so that his wish to exterminate the Jew seems just as natural to him as would anybody's wish to kill a dangerous snake that was ready to bite him. One is not aware of how words can cause the corresponding "models" to be projected into what appears to be direct perception.

I hope you see that not only do we have perception of models in thought, but that also, such models can quite easily interfere with direct and immediate perception, even when one does not seem to be thinking. So what is called for is a sensitive discrimination between direct perception and its model either in thought or in pro-

jection into what at first sight appears to be direct perception. Our education totally neglects this key requirement, without which real mental health is impossible. As a result, confusion, delusion and neurosis are practically universal, and have been so for thousands of years.

It is essential to stress that thoughts can be false in two ways. First, they may fail to reflect the order of the real structure-function of things. Secondly, they may in themselves have a wrong order of structure-function, which confuses Inference$_n$ with Fact$_n$. It is crucial to remember here that thoughts are not mere reflections of structure-function of reality as a whole; they are also in themselves structure-functions, which make up parts of reality as a whole (physical and mental). So it is necessary first that thoughts be in a right order. Then they will be able to reflect a right order, as well, provided that their order is coordinated to that of perception in the act of learning. But unless they are in a right order to begin with, they cannot reflect in a right order. Rather, they will be inherently deluded so that further perception will only lead to additional entanglement in confusion. This underlines the importance of perceiving the order of the thought process, as well as the order of what it reflects. So we need:

Direct Perception of the Order of Thought and Its Relationship to Direct Perceptions of a Lower Order.

It is evident that humanity is caught up in a vast structure of delusions about ambition, family, career, religion, nationalism, race, and a thousand other things. But these are all generated by what I shall call "The Central Delusion of the Human Race". This delusion has to do with man's notions about himself, especially how his mind functions and what he is, psychologically speaking. As we can see, it was only natural for man to develop such deluded notions about himself. Thus, the young infant develops a picture of an imaginary "space", full of modelled "objects". The model of the "object" is seen from a model of a "point of view" or "center of perspective". At this "centre of perspective" is placed a model of the body of the observer. This model is useful and necessary, as it helps to orient a person in his thinking about his own actions and experiences (E.g., it enables one to imagine how to go from one place to another).

Thus far, then, all is well. But trouble begins because the model of the body also contains a model of its feelings (pleasure and pain) and a model of its urges and intentions (felt as desire and will). So the model becomes very convincing, and is easily mistaken for a real entity or a "soul", which acts like an "essence of the mind". Terrible confusion may result when thought takes its challenge to be the preservation of the "welfare" of the model of the body, rather than that of the body itself. For the model of the body is merely a picturesque and lively way of presenting some of the inferences of thought or consciousness. If thought takes it as a challenge to have a nice pleasing model of the body, full of "good feelings" resulting from a model of "euphoria", then it will start to order its thought in a wrong way – i.e., to accept as true those thoughts that seem to "benefit" the model of the body and as false, those which seem to "hurt" it. Thus, one is entangled in the pleasure-pain principle, which is the road to delusion.

The pleasure-pain principle can work only by confusing Fact_n with Inference_n. Thus, the thought: "I am a sublimely beautiful entity whose actions are always right" creates a model of pleasing and euphoric "glow of good feeling" in the model of the body. When someone shows that my actions are wrong, this model of a good feeling is interrupted. Thought takes its challenge to be the restoration of the model of "good feelings", rather than to model the true state of affairs. So it presents false models, in which my actions are still "right" in spite of evidence to the contrary (which is thus misinterpreted if not suppressed). The inference "I am in my very nature and structure a perfect being who is always right" is confused with a fact, and projected into the model of the body, as if it were actually an observed fact.

So one sees how the pleasure-pain principle leads necessarily to delusion, and to a wrong order of operation of the mind.

But of course, the model of pleasure is not real enjoyment. Everyone senses this, and can feel that "something is missing" in such "pleasure". How is it that we fail so persistently to see that this model is an unsatisfactory counterfeit, which leads, not to enjoyment, but to endless confusion and suffering?

The answer is to be found in a further feature of the "self". As I indicated earlier, the "self" is only an inference. But I now add that this inference is projected into consciousness as an active and functioning model, full of feelings, that are models of pleasure and pain, models of urgent needs and models of real intention. At first sight, it looks as if the model "feels" and "desires". Actually, of course, it can do nothing of the kind. It is the mind as a whole which attributes all this [to] the model. But even more, there is a yet deeper source of confusion. It is this:

The model of the body is "located" in a model of a "world" and is engaged in a model of a process of "looking" at this "world".

This is something very confusing and subtle, which requires extremely careful thought. Because the model of the body is engaged in a very convincing process of imitating the feelings, actions and experiences of the real body, it gives a deceptive imitation of the process of perception itself. Thus, the models projected by thought seem to be "perceived facts" and not models at all, because the model of the "self" seems to be "doing the looking".

In this whole deception, it is crucial that the model of the observer is projected as if it was separate from the model of the world that is observed. In reality, of course, both models are parts of a single unitary process of thought. But because what is observed (e.g., pleasure-pain) seems to be separate from the "observer", the former seems to be a real fact, "perceived" by the "observer". So the pleasure-pain in the model seems to be a real fact and not the counterfeit that it actually is. However this "fact" is interpreted as "incompleteness" of pleasure. So there is always a challenge to "complete" the pleasure and get rid of the pain. The mind perpetually escapes perception of the fact of contradiction in its "pleasures" by means of the delusion that these are "separate" from the "observer" who can "choose" to do something that will remove the contradiction. But this is impossible, since the contradiction is built into the whole process of thought, which projects the model, in the first place.

This delusion about a "self" who "observes" the mind is responsible for making all the other delusions plausible and credible (because it makes them seem to be

"observed facts" rather than "models that are projections of inferences"). So the key to liberation from all this needless and useless suffering and confusion is to see that the "self" is only an inference projected as a model.

I am not sure whether all this is clear to you. But I wanted to emphasize that the understanding of the delusion of an "observer" would go very deep, and would indeed transform each of us individually as well as the society collectively. At present, social relationships are based largely on delusions, such as status, prestige, race, nation, etc. Such delusions seem credible only because the model of the body (called the "self") is engaged in a model of a process of perception, which makes the model of what is observed seem to be "Fact$_n$" rather than "Inference$_n$". This confusion spreads into all human activities, including physics (I shall discuss its implications for physics in another letter).

Now, to come to the question of beauty and ugliness. You ask: "Why is a city ugly while a forest is beautiful?" To you, the functioning of a city seems beautiful. But is it really so? Consider the traffic congestion, the slums, the mediocre dwellings of the middle class, the fouling of the air and water, the noise and confusion, the dirt, the loneliness of the family isolated in a flat or of single people living in isolated rooms, the lack of recreational facilities, the expensiveness of all entertainments, the poor public transport, etc., etc. How can all this be thought of as beautiful? Is it not the function of a city to make possible healthy, happy, fruitful life for its inhabitants? Do not modern cities lead to race riots, criminal violence, etc. on the part of the poor and drug taking as an "escape" by the middle class and wealthier youths (along with alcoholism and all forms of sexual amusement)? Are the cities themselves not paradigms of ugliness and mediocrity, as buildings, streets, etc., are laid out in a fortuitous manner, aimed only at profit or "saving public funds"?

I feel that there really is such a thing as ugliness, and that it leads to disharmony and destructive conflict in function. Isn't the Viet Nam war a very ugly thing indeed? Can you find beauty in it?

A city could be as beautiful as a forest. And some of the older cities have been so. But modern cities are generally ugly and disharmonious in their function. This is because their structure was determined in a fortuitous way, with no over-all view as to what was happening.

Of course, all ugliness is relative to certain levels and orders of process. More deeply, beauty is fundamental. That is what I meant by the theme:
"The Beauty of Beauty and Ugliness."

For example, one can see that no man can ever violate the real order of nature. No matter what he does, he is following the laws of nature. So when we say that science teaches us to control nature, this is a delusion. The real state of affairs is otherwise. When we understand the laws of nature correctly, our actions generally lead to their intended results. When we do not understand, we still inevitably follow nature's order. But this order is such as to lead to results that were not intended.

This is something very beautiful indeed. On the positive side, it is our crucial clue to nature's order. Whenever we don't get the intended result, this shows some sort of misunderstanding, which if inquired into, will bring us a deeper knowledge of nature's order. On the negative side, it means that nature's order is such as to make us

suffer, as long as we persist in delusion. In all this, there is great beauty. But it does not deny the ugliness of disharmonious and conflicting actions, based on delusion. Our perception of this ugliness can be a significant clue to the fact that we are in delusion. But if we escape perceiving the fact of ugliness, we lose this clue, and condemn ourselves to go on with delusion and its inevitable suffering.

Finally, I would suggest that the key question is not the generation of illusion, but rather, the generation of delusion. As I have indicated, this arises when inference$_n$ is confused with fact$_n$. The central delusion is the inference of a "self" who observes the "rest of the mind". This is projected as a functioning model, full of apparent feelings of pleasure and pain, apparent desire and will, etc. (actually, these are only models of real feelings). This model is engaged in a model of the function of "observation". So what is "seen" is apparently an "observed fact" rather than a model, expressing a set of inferences. This "fact" of the "self" is modelled on the "supremely precious and vulnerable center of existence". So thought takes its challenge to be the "protection" of this "center" and the securing and enhancement of the "pleasure" in it. Thus, delusions without end are introduced in the models, to accomplish this aim. Such delusions lead to endless suffering, followed by more delusions, whose aim is to relieve the suffering, but whose actual effect is to make it worse. This has been the fate of humanity for thousands of years. And unless it comes to an end soon, it will probably lead to the end of the human race.

I shall comment on the questions about physics that you raised in a later letter.

Best regards

David Bohm

P.S. Please send this to Beiderman when you are ready.
P.P.S. I hope you see that direct and immediate perception is not nearly as common as you implied in your letter. Consider, for example, how hard it is to see another person, without projecting what one knows about him as a model. Do we not see the Jew, the Negro, the Communist, etc., rather than the individual human being, in all the complexity of his qualities and behaviour? Do we not look at the wife, the husband, the colleague, etc., as a model based on past experience? Actually experiments show that people seldom notice others, except insofar as they are assimilated into certain standard features of the model. Likewise we seldom look at nature, except through our conditioning, expressed as a model. We say "This is more beautiful than that" not noticing that the model of beauty is thereby made to replace the infinitely subtle and complex fact of beauty. Whenever we compare two people with regard to their value, we get a similar substitution of the model for the fact (Inference$_n$ for Fact$_n$). Whenever we compare ourselves to another (thus giving rise to envy and jealousy) we set the models of ourselves and the other in the place of the fact.

Very rarely do we have direct and immediate perception, uncontaminated by inferential models mistaken for parts of the directly perceived fact. Indeed, if we had such perception, the entire order of society would be seen immediately to be absurd, meaningless, dangerous, and destructive. Nationalism, racism, envy, jealousy, status-seeking, would be seen to be poisonous trivialities, and would cease to loom so large

as to be major factors in determining the order of society. One would see that if we say "A is an American, B is a Russian, C is a Jew, D is an Arab, etc." we are putting verbal models in the place of real facts. Such a projection of verbal distinctions into models creates divisions between people that can never be bridged, until people see the fantastic triviality of this whole process, and how we are allowing these trivialities to destroy everything that is worthwhile.

It is like saying: "The boy is a thief", rather than saying "He is stealing". So one should say: "A is conditioned with American 'tapes', so that he believes he is an American, and acts according to this delusion. Actually, he is a human being, but doesn't realize that this means something, while being an American means nothing". Evidently, as long as A believes that he is an American, the "American model" of the "self" will be projected into A's consciousness. Similarly, the "Russian model" is projected into B's consciousness. Since each model of the "self" contains the inference of sublime perfection and supreme value, the other person's behaviour is taken to threaten the very essence of all that is good and beautiful. No wonder then that people are ready to destroy the whole of civilization in an atomic holocaust, in order to preserve the "American model", the "Russian model", "The Jewish model", "The Arab model" of the "self". For it seems that these models are the very source of whatever is good in life. Actually, of course, they are petty trivialities, put together by the manipulation of words. But very few people really see this, in direct and immediate perception. If more people saw it, it just couldn't go on. It is really too insane, as well as dangerous and destructive.

Sept 15th, 1967

[Date added – CT.]

Dear Jeff,

This is a continuation of my answer to your letter of Aug.16, to discuss the physics questions that you raise there.

I am not at all sure that everyone (including Jauch and Piron) would really argue that only facts can confirm or exclude sets of axioms (such as those of v. Neumann). Of course, everyone would be ready to give assent to these words. But deep down, many would continue, in a confused way, to assume sub-liminally and "unconsciously" that certain sets of axioms are either facts or practically the same as facts. If you read my answer to the letter of Jauch and Piron[11] (which I sent you some time ago) you will see a quotation from J. and P. to the effect that their "propositions" are in essence indistinguishable from facts. In my previous letter, I cited the existence of Australia as an inference which is so well confirmed that nobody would do other than take it as being effectively a proven fact. In my opinion, J. and P. regard their "propositional axioms" as being no more inferential than the existence of Australia. What tends to happen in such cases is that the imagination supplies a "model" in which it seems

[11] i.e. Bohm and Bub (1968) see p. 99, n 1—CT.

that vast quantities of data are "confirming" one's assumptions. The the fact is that J. and P.'s "propositional axioms" are confirmed in only a limited number of cases, to a limited degree of approximation, and in limited contexts of investigation (E.g., the randomness of successive observations has hardly been tested at all). But in the minds of J. and P., I feel sure that there is a vision of an overwhelming mass of data of every kind, which tests their axioms in every conceivable way, so that to question their axioms would be similar to questioning the existence of Australia.

Unless one can somehow bring this kind of confusion out into the open, it will be a waste of time to try to use axioms of v. Neumann or J. and P. to draw reasonable inferences. In my view, J. and P.'s paper is nonsense, based mainly on the pleasure-pain principle which accepts as true the pleasing assumption that the axioms of quantum mechanics are indubitable facts, and suppresses or discards all evidence to the contrary. It is no use trying to convince J and P of anything, as long as they think in this way. However, we must answer them, to help others to keep out of confusion, if they have a serious interest in doing so.

I do not think that J. and P. or von Neumann were trying to say that they had good reasons for proposing their axioms as reflections of the structure of certain real processes. If they had been thinking in this way, they would never have identified their axioms with facts. Rather, they would have said "I have such and such reasons for accepting these assumptions". Von Neumann insisted in many places that to contradict these assumptions would be to conflict with the facts, not with his reasons for accepting his assumptions. J. and P. talk in a similar way. It is not an accident that von Neumann's reasoning is so confused, that one cannot see what he has actually proved. It is, in my view, a consequence of a deep confusion in v. Neumann's attitude to physical theory. This kind of confusion is not uncommon.

I am sure that J. and P. do not think that any other axioms are logically compatible with the existing facts. Therefore, the first job was to show that other axioms are possible, which do fit the facts. Whether these axioms are "better" or "worse" than those of v. Neumann was not, in the beginning, the main point. Rather, the main point was to show that they are possible, while v. Neumann and J. and P. were arguing, in a confused way, that they are not possible. We can now come to the question of which axioms are "better" or "worse". But this is itself a confused question, because most of your criteria of "better" or "worse" are based on little more than the pleasure-pain principle. 19th century physicists would all have regarded v. Neumann's axioms as "terrible" and would have sought an ether-theoretical explanation of the whole thing. 20th century physicists have been conditioned in the opposite direction, to get pleasure out of purely mathematical models of the world. So they are ready to accept v. Neumann's axioms easily, to pay little or no attention to the large number of problems that these axioms simply avoid (e.g., how are "observables" really made accessible to perception, and how is a time-sequence of process to be described?) One of our problems is to be able to decide which axioms are "better" or "worse" in a way that is not largely subjective and fortuitously dependent on what happens to give pleasure to most present-day physicists (or to ourselves).

As to why v. Neumann proposed his assumptions, this is itself not a clear question. No doubt, he may have had some valid reasons for doing so. But the first

question is: "Why did he forget (or become confused) about the fact that his assumptions were only assumptions?" The reasons for this were probably psychological, being grounded most likely in the pleasure-pain principle. Once this point has been thoroughly cleared up, then it is useful to ask what were v. Neumann's valid reasons for proposing these axioms, if any. Do you have some suggestions as to how to answer this question? I think it is an interesting but very difficult question.

In answering it, I wouldn't say that q. mchs excludes "simple" or "reasonable" classical models because, as you say, it is so difficult to see what these words really mean, in this context, other than "pleasing to present-day physicists". Rather, I would say that the classical models existing at the time of the onset of qu. mchs were excluded. For the very fact of stationary states and interference excluded the existing concept of the electron as a "little ball" moving according to Newton's laws in the force-field of the atomic nucleus. It did not exclude more subtle classical models. For example, if you make the equations of motion non-linear, it is easy to come to a set of stable orbits (called "limit cycles"), around which oscillations are taking place. A probabilistic theory of transitions between such discrete and stable "limit cycles" arises naturally, if one averages over an ensemble of states of oscillation around such "limit cycles". Non-linear equations would give rise to linearized approximations, resembling the super-position principle of quantum mechanics. Whether this theory could be made to work quantitatively is at present unknown. But qualitatively, it gives the right sort of results. However, nobody has seriously considered it, because it is mathematically difficult, and because current prejudices in favor of formal mathematical explanations make it seem hardly worth while to inquire into something so difficult and arduous, for purposes that appear to be so unimportant (i.e., to give a physical as well as a mathematical account of the process). On the other hand, in the 19th century, this question would have been given crucial importance. So the conditioning of physicists, according to the pleasure-pain principle, is deciding what is to be regarded as "simple" and "reasonable".

It is therefore not at all clear just what kinds of theories are "ruled out" by arguments of London and Bauer, v. Neumann, J. and P., etc. London and Bauer certainly do not rule out non-linear theories with discrete stable limit cycles that give a model of stationary states – or if they do, I am not aware of the arguments involved in leading to such a conclusion.

You say "This is physics, not logic." But I don't see the difference, in this context. If you can't rule out a theory logically, then the plain fact is that it just hasn't been "ruled out" and that is that. There could easily be an infinite set of very subtle "classical" theories, as yet unknown. How are these to be "ruled out"? Until we propose them, we can't rule them out. To rule them out before we propose them is to close our minds to them in a dogmatic way, so that research is channelled for inadequate reasons, away from the direction of exploring them.

Of course, it is useful to articulate in what way certain axioms are false or inadequate, as well as to give explicit reasons favoring their adoption. If you can do this with v. Neumann's axioms, this is fine. But aside from being false or inadequate to the facts, what else would be wrong with any particular set of axioms? Only that one has made a mistake in logic, or that he has made assumptions which were confused

with facts. When one removes the latter from v. Neumann's "proof", all that is left is that these particular axioms are not compatible with certain kinds of explanations in terms of hidden variables (i.e., explanations in which quantum-mechanical averages would be obtained from statistical ensembles, like those explaining thermodynamics, in which micro and macro states were independent of each other). We have already done this in our papers. What more do you wish to do, other than to emphasize this point (which could of course be valuable, in a certain context)?

It might be interesting in this connection to ask how a theory of classical "limit cycles" escapes being "ruled out" by v. Neumann's axioms. The answer is that the quantum-mechanical "observables" are not basic concepts of the theory. Rather, they are abstractions, whose relevance may well depend on the general large scale environment (including the "observing instrument"). In other words, the limit cycles determining what are called "stationary states" in q. mchs. depend on the whole context in which the system under discussion finds itself. It would be useful if you could show how v. Neumann tacitly assumes that "hidden variables" never have this property, at all, so that his "proof" is irrelevant to this class of "hidden variable" explanations of qu. mchs.

In my opinion, there was a very peculiar state of mind prevalent among physicists when the quantum theory was being developed. It is difficult to describe it, from this distance in time. But it was based to some extent on the spread of positivist prejudices, resulting from misinterpretations of the theory of relativity. This latter theory had also predisposed physicists to accept purely mathematical explanations of nature. Notions of simplicity and symmetry were widespread. None of these were entirely wrong. But they were full of a great deal of confusion. The pleasure-pain principle is always operating, to make people ready to feel that they have solved a difficult problem, when in reality they have not done so. Classical physics always contained mechanistic features, which were ugly. It seemed that one could now quite easily "escape" all this, by exaggerating the extent of quantum-mechanical achievements. So one readily assumed that the great "anti-mechanistic revolution" had already been carried out, when in reality, only some semi-phenomenological theories of the new domain had been set up. Because of sneaking doubts about the whole thing, people were anxious to set up arguments "ruling out" the unwelcome possibility of new classical explanations. That is why people were so ready to confuse inference with fact.

It is now necessary to take a cold hard look at the whole story. What has really been proved, and what is wishful thinking? All of us would like to believe that quantum phenomena force science to transcend mechanism. In my opinion, such a conjecture is not unreasonable, in view of presently available facts. But it is necessary to be very clear, and not to get caught up in delusions once again, by treating this mere conjecture as a fact.

In my opinion, a worthwhile project would be more or less as follows.

(1) See if you can find some compelling reasons (other than the pleasure-pain principle) why the current axiomatic formulation of qu. mchs. (according to Dirac, Jordan and v. Neumann) was adopted. Of course, it fits certain facts (e.g., stationary states, interference, transition probabilities, etc.). But why was (and is) there such

confidence that no other scheme can possibly fit these facts? Why were certain questions of fact simply overlooked? (Consider, for example, the question of which Hermitian operators are actually observable, and how any operator is actually made accessible to perception, as well as that of whether we ever actually observe anything that is not a sequence of events in time, which is therefore totally outside the scope of a theory which can only discuss observations, all of whose aspects carried out at the same time). Why were physicists so ready to assume that the detailed order of a physical process in a transition is in principle unobservable, as well as meaningless?

In my view, the main reason behind all the above steps is that physicists wanted to feel that their scheme was in essence complete. It is disturbing in an emotional sense to have to commit one's whole life to doing work in terms of a scheme that is obviously provisional, partial, and subject to radical revision. The pleasure-pain principle leads one therefore to formulate delusory arguments, which serve to convince one that at least the basic scheme of things is clear, even if a lot of the details are still unclear or uncertain. This reaction is as old as the human race. It occurred with Aristotle's scheme. Then it occurred with Newton's scheme, then with Einstein's, and then with qu. mchs. If a new scheme going beyond qu. mchs. is developed, it will take place once again (as is happening today in biology with regard to genetic schemata involving DNA). So the key thing to call attention to is the falsity of the whole effort to get an emotional sense of security by seeking arguments that seem to guarantee the permanence of our general theoretical schemata. Rather we need arguments showing why our schemata are not likely to be permanent (if we are to avoid complacency).

What is called for is not only a revolution in the content of scientific theories. Even more, we need a psychological revolution in the way science is to be thought about. Scientific theories must always be seen to be inferential in nature, with a certain degree of factual confirmation and falsification, which varies from moment to moment. There is no room in science for the wish to feel secure emotionally about one's "fundamental ideas". Indeed, there is no room in any field whatsoever for such a sense of emotional security, which is evidently an invitation to accept delusory notions of every kind. Emotional security is appropriate to the infant or the small child. But it is poison for the supposedly mature individual. Indeed, it is essential to mental health and maturity that one be emotionally vulnerable. Only a complete vulnerability of one's state of mind will allow one to be open to the fact as it is, even when the latter is not as one would like it to be. But wherever "self", family, career, ambition, race, nation, etc., are involved, few are vulnerable to the fact, which might be very disturbing in an emotional sense. Nevertheless one should be disturbed, when something is wrong, rather than made comfortably somnolent by a pleasing sense of emotional security and invulnerability.

With best regards

David Bohm

P.S. If you are in doubt about how J. and P. are thinking, consider what happened when they learned from Bell[12] that v. Neumann's conclusions were based on the assumption of linearity, which goes beyond what is given by experimental fact. Instead of seriously considering the possibility that v. Neumann's conclusions might be wrong, they immediately assumed that some minor change in the system of axioms would save his conclusions.

Was there not here an a-priori conviction of the "rightness" of v. Neumann's conclusions, issuing from a certain state of mind, which is "committed" to these conclusions, rather than from "reasons" based in fact on theoretical considerations. In my view, they see a "mental model" of a vast body of facts, which directly confirm all of v. Neumann's conclusions, rather than his premisses. So when his premisses were shown to be wrong, this did not seriously disturb J. and P. For they "knew" that the conclusions were "right", and deduced from this that some other premises were needed, (which they were not slow in "finding"). Even if their new premisses were shown to be wrong in a way that convinced J. and P., the latter would still be "sure" that some further modifications of the premisses is all that is needed, because they are convinced of the factuality of the conclusion: "Hidden variables are impossible." Indeed, for J. and P. (as well as for v. Neumann), I think that the basic premisses were always: "Hidden variables are impossible" and that in reality, their choice of axioms is a conclusion based on this premiss. Only if they give up this premiss will they be open to real discussion on this point.

In saying this, I do not wish to blame or censure J. and P. In a way, we have all been trained to work similarly. Each of us has "pet" ideas which he apparently "supports" with arguments based on premisses. But in reality, this "support" is delusory. The premisses are usually chosen just because they do seem to "support" what appears to be the "conclusion" (but what is in reality the basic regulatory assumption). Part of the necessary "revolution" in science would be to bring this practice to an end, so that people would, for example, openly say: "I believe there are no hidden variables. From this belief I have been led to propose the following axioms, which are compatible with this belief, and which, as far as I know fit the facts."

If someone were to argue in this way, he could be making a useful contribution to science. For his statement could then reasonably be taken as a challenge by others, who could say "We believe there may be hidden variables." In answering this challenge, they would be led to propose an extended meaning to the term "hidden variables" (as we have done). The believers in no hidden variables would then have to meet this new challenge (e.g., by criticizing these extensions for lack of "simplicity"). Thus, the "dialogue" could go back and forth, and progress could be made, at least in clarifying the issue. But this cannot readily be done, while people like J. and P. refuse to admit that their ideas on hidden variables are no more than beliefs, and while they confuse them with "facts". And more generally, as long as people feel

[12] i.e. John Stewart Bell, well-known for his proof of Bell's theorem. See Freire (2019), pp. 156–162 on Bohm and Bell—CT.

the need to make existing general schemata appear to be permanent and necessary (thus allowing for a sense of emotional security), confusion on basic questions is inevitable.

PPS. I hope you see that v. Neumann and J.&P. have no really "good reasons" for proposing their axioms as "facts". Very probably, they imagined vast masses of data, confirming these axioms in every possible respect, and in this way their statements come to seem right to them. I can remember a similar experience when I first mastered the quantum theory. It seemed so powerful and overwhelming in its impact as to make it appear that all of its assumptions were indistinguishable from self evident facts.

Of course, you yourself may be able to discover "good reasons" for certain axioms. You won't find them in the writings of v. Neumann or J. and P. because these writings contain no such reasons.

But if you do this, you must also go into the "reasons" against these axioms (E.g., they don't discuss the "measurement problem" at all, they make the order of quantum processes incomprehensible, and they assume, in contradiction with evident fact, that all measurements consist of operations carried out at a particular moment of time, or in a very short single interval of time).

However in this regard, you must face the fact that most physicists do not regard these reasons against quantum axioms as having very much weight. Rather, they believe that facility and fluency in computing and predicting experimental results is the essence of understanding, at least in the field of physics. So the reasons "against" v. Neumann's axioms would not count very much with such people. When you come to decide which axioms were "better" and which were "worse" you would run into trouble here, based on different psychological points of view about what science is supposed to be. If you restricted yourself to purely physical arguments, this would be a source of confusion, interfering with real communication. For you would not be sharing a common set of premisses with the vast majority of physicists, about what the purpose of physical theories actually is. In my view, this is the real source of most of the confusion that hovers around the subject.

To understand why certain axiomatic structures were considered adequate at a given time, it is not enough to restrict yourself to fact and logic. You must 'project yourself' into the psychological state of mind of the people concerned. For this is the main factor determining our general metaphysical notions, especially when we are unaware of our metaphysics (as is indeed usually the case). And because this is very difficult, the problem that you have set yourself is a tough one. If you don't go into these deeper psychological and metaphysical questions, I fear that you won't really advance very much toward clarification of the issues involved.

Ultimately, you will probably have to state your views on the subject openly, and call attention to how they conflict with the prevailing views. Then what you say will at least be clear, and perhaps a few physicists will see that tacitly they have always agreed with your views and resisted the prevailing ones. These will be able to accept your arguments and seriously criticize them. The others will realize that argument is useless, because there is no agreement on basic premisses. This is the kind of clarification that one can reasonably aim for, in my opinion.

PPPS. A good exercise would be to "project" oneself into a state of mind that is probably similar to that of J. and P. It is important in doing this neither to blame them nor to accept their point of view. Can one just be "neutrally" aware of the problem? After all, when I think of certain ideas, I can also feel the impulses that are implicit and tacit in their structure. Usually, I reject such feelings when I think of the ideas of J. and P. But now, let me neither reject nor accept these feelings. Just let them "be", and reveal their full content to awareness, whatever that may be. In this way, my feelings will probably resemble those of J. and P. in crucial respects. For all thoughts contain similar structures of feelings. When I think of the Nazi ideology, I can feel the ugly feelings that this produces in me, the tending to delusion, etc., etc. – I can feel the impulse to violence, when I watch a riot on television. It is my own violence, my own delusion, that I feel. But as such, it is very likely basically similar to what happens in other people.

When I look at the ideas of J. and P. in this way, I get the following thoughts and feelings: "After all, any observation can be reduced to a series of propositions, having "Yes" or "No" character. When an electron goes through two slits, it either arrives at a certain spot on the plate, or it does not. Everybody knows this. It is absolutely certain. Only an idiot could try to question this fact and then, it is a fact that if one observes the electron going through one of the slits, this will interfere with the observation of the electron, as it arrives at the photographic plate. So the two kinds of proposition are evidently incompatible. Only a deluded physicist could doubt this. Two non commuting operators obviously express this incompatibility, in a way that is a perfect reflection of the observed facts. Surely not even Bohm and Bub would say otherwise. So how can anyone doubt that the structure of propositions is a fact, or at least a completely indubitable structure of inference? How could one even imagine an experiment that would not confirm this structure? After all, everybody knows that every experiment is built out of "Yes" or "No" propositions, and that it has been proved that some of these propositions are incompatible, and therefore equivalent to non-commuting operators. It takes only a little bit of elementary mathematics to show that hidden variables are not compatible with this propositional structure. Those who question it must have something wrong with their minds. It is entirely incomprehensible in any logical sense why they do so. Perhaps they are deluded in some way. They are not satisfied with the inescapable fact that physics consists of computing the results of experiments. They have romantic notions that physics should explain how things happen. These notions have been exploded by the factual development of modern physics. Clear headed individuals like us can see this quite easily. But confused and deluded physicists are still trying to do what is evidently impossible and meaningless. Why won't they accept the fact as it is? Perhaps it is because they are seeking in physics the kind of thing that one should properly obtain in other fields, such as art or religion or sex. Hard-headed individuals like us can see that computation of experimental results is the proper field of physics. Deluded and misguided romantics are always confusing the issue, on this point["].

As one thinks and feels in the way described above, it never enters one's head that all the statistical consequences of the propositional structure have not yet been factually confirmed in experiment. It seems impossible to imagine an experiment that

would not confirm this structure. It seems meaningless to consider a set of hidden variables that would determine both the slit through which the particle passes and the interference pattern. For this conflicts with the propositional structure, which is an indubitable fact. Indeed, all possible consequences of this structure have already been confirmed, at least to a very high degree of approximation. There is nothing more doubtful in this structure than in the inference of the existence of Australia.

Finally, let me sum up what I feel to be the main point at issue in our correspondence. To you, it does not seem to be interesting merely to note that someone "has forgotten that his assumptions are only assumptions." You want to see what is wrong with his reasoning, if you do except his assumptions. But to me, the confusion of assumption (or inference) with observed fact is extremely interesting. As I indicated in the previous letter, it is the principal source of human misery, suffering and confusion, and has been so over the ages. It therefore appears to me to be very interesting to see how this is happening even in science, which is among the most rational of all man's activities.

In addition, it seems to me that unless we are clear about the confusion between inference and fact, which is the source of all delusion, our further deductions as to what is wrong with people's reasoning will be lost in confusion. For unless we are very clear about how people like J. and P. are confusing inference and fact, we will find ourselves "slipping in" some of their tacit premises, when we fail to notice just what we are doing. Here it is important to note that reasoning doesn't proceed along a straight line, like "Premiss through deduction to conclusions". Rather, the same premisses are often introduced into the argument at several stages. So you have to be on the lookout for confusion of inference and fact all the time.

To illustrate this, let me write P_F standing for factual premiss and P_I for inferential premiss. A typical chain of reasoning is (where S stands for intermediate steps in reasoning)

$$P_F + P_I \rightarrow S_1$$

$$S_1 + P_F + P_I \rightarrow S_2$$

$$S_2 + P_I \rightarrow S_3 = C = \text{final conclusion.}$$

Now, if we confuse P_F with P_I, it is not enough to correct this in the first step. You have to watch for this confusion in all the subsequent steps

What is even more important to emphasize is that P_F is being confused with P_I for psychological reasons (mainly pleasure and pain associated with P_I). So there is a tendency to "protect" P_I, by introducing a host of further premises ($P_I{}^1$,$P_I{}^2$,$P_I{}^3$ - - -), all of which are confused with ($P_F{}^1$,$P_F{}^2$,$P_F{}^3$ - - -). Unless you are very very alert, you will allow yourself to "slip into" confusing $P_I{}^N$ with $P_F{}^N$ (where N is fairly large). After all, the brain becomes weary after a while. Just to "be finished with the whole dull story", you accept $P_I{}^N$ as equivalent to $P_F{}^N$. And then, you are trapped once again in the confusion of J. and P.

So so it may well be that nothing is wrong with J. and P.'s reasoning, except a continual series of confusions of $P_I{}^N$ and $P_F{}^N$. This is in fact what I think to be the case. But this kind of error is a paradigm on what tends to go wrong in all discussions of fundamentals in physics and in every other field. So when we look at it in this way, J. and P. have done us a service, by presenting us with such good paradigm of confusion in reasoning in basic problems.

In particular, whenever J. and P. talk of hidden variables, they are tacitly confusing P_I with P_F. For they have certain inferential notions about hidden variables, which they confuse with facts about hidden variables. Therefore, they probably do not even admit that what we talk about are really hidden variables. For they already "know" factually what are the essential qualities of all hidden variables. Therefore, to J. and P., what we call "hidden variables" are really "nonsensical statements in conflict with the evident fact." For this reason, when people like J. and P. talk of our papers, there is no real meeting of minds. The whole discussion tends to be lost in cross-purposes.

Sept 20, 1967

Dear Jeff

This is just a brief supplement to my two previous letters.

When I say that "if a theory of hidden variables is not ruled out logically, it just isn't ruled out", I did not mean to suggest that we have to consider all possible models as equally significant. Of course, one will use intuitive, heuristic and other "sub-liminal" cues, which will lead one to favor a certain direction of thought instead of another. But one also knows that these cues are very often wrong. So it is necessary to have a certain kind of humility about such notions, which allows them to be vulnerable to a broader perception of the fact, in the way that I described in a previous letter. It is advantageous if different people will explore different kinds of intuitive suggestions, and compare notes in a friendly and cooperative way. For a-priori nobody knows what is the "right" model. Arguments that "rule out" certain models on inadequate grounds may well be harmful, in this respect. They are particularly harmful when their tacit aim is to give one a feeling emotional security and safe invulnerability, with regard to one's fundamental ideas in physics. What is necessary, above all, in physics and in every other field of life, is to be able to live with the fact of uncertainty. Only thus can the mind be sensitive and open to the tiny promptings and cues which are its first response to the unknown.

Here, I don't mean to argue for indeterminism or for Heisenberg's "uncertainty principle". Indeed most physicists today are absolutely certain that the uncertainty principle is right in every respect. What I am emphasising is the fact of psychological uncertainty, which has no essential relationship to the question of whether physical phenomena are in principle predictable or not. Psychological uncertainty, when recognised properly, implies humility and vulnerability, two qualities not shown in

any great measure by Bohr and Heisenberg, when they assure us of the absolute truth of physical uncertainty.

As I explained in my previous letters, the chief trouble with fundamental discussions in physics is lack of humility and vulnerability. It is this which leads to the search for security, which is "guaranteed" in a delusory way by the confusion of a large number of inferences with facts. It is no use blaming people for such reactions, since they are not even aware of what is actually taking place in their minds. However, if one simply rejects their arguments out of hand, as is justified by showing their contradictions, one is imitating the defensive attitude that is basically the source of all the trouble. For basically, all defense implies offense and aggression. Both physically and mentally, one can defend oneself only by taking violent action aimed at destroying the "danger", or else by setting up walls, to keep the danger out. But if one takes violent actions or tries to use arguments that "demolish" one's opponent, one resembles him in being proud and invulnerable, therefore basically impervious to the truth. Likewise, the wall that keeps the other fellow's ideas out also keeps out the truth. So we have to be open and vulnerable to von Neumann, to J. and P., to Danieri, Prosperi and Loinger and to Rosenfeld. If we do detect contradiction in their arguments, we have to try to "project ourselves" into their frame of mind, which would show us why they are so ready to accept contradictions that seems so ugly and meaningless to us.

In doing this, one will usually discover one of two things. Either the other fellow has confused inference with fact in order to give a delusory appearance of security to his basically metaphysical notions. Or else, one will find that his tacit assumptions about the basic purpose of science are different from one's own, so that he evaluates as unimportant certain difficulties that one is evaluating as crucial. For example, DLP do not regard a coherent logical physical model as an essential theory in physics.

To them this a dispensable luxury. They are not against it, but it does not disturb them if it is absent, provided that their ideas are in principle able to approximate the facts to any desired degree of approximation. A purely logical contradiction does not disturb them, because they see physics as a means of quantitative approximation to the observed phenomena. Or at least, so their attitude seems to me.

So if you want to meet their arguments, you will have to bring out their tacit assumptions to make them as plausible as possible, then contrast their assumptions with your own, and explain why you favor your own. You may never convince DLP in this way, but at least, the "neutral" reader will have a chance to see what all the fuss is really about, so that he can make up his mind for himself.

With best regards

David Bohm

P.S. With regard to basic metaphysical notions, I had an interesting experience at the Bellagio Conference in Theoretical Biology[13] for which the paper on Order sent to you was prepared.

I observed in the first four or five days that everyone was talking at cross-purposes, because his basic metaphysical assumptions were different. What was crucially significant to one man was of no importance to another, and vice versa. And this was inevitable, because each man's deep tacit assumptions led to different inferences as to what is essential, what is superficial, etc. So nobody really understood why others got so excited about certain things, and why nobody properly responded to his own contributions.

At a certain point, I plunged in and presented my own metaphysical notions.[14] In doing this, I explained that each person inevitably has some kind of metaphysics, which is just a set of general and basic assumptions about reality as a whole.

Even the most "practical" man has such a metaphysics, but it is tacit rather than explicit. Such metaphysics is the most dangerous, because does one doesn't know one has it. It seems to be fact rather than metaphysics. So it is important to be aware of one's own metaphysics, and to see its inferential and assumptive character. To have some kind of metaphysics is inevitable. The destructive thing is not to know that it is metaphysics.

Thus, the ancient creation myths were forms of metaphysics. Then came the Greeks with "All is becoming," "All is fire," "All is water," "All is air," etc., etc. The Pythagoreans said "Number is the essence of all things". Plato said that the essence of all things was in their idea. Aristotle compared all things to living organisms. Democritus put the basic and essential character of all things in the atoms. More modern physicists said "mechanics is the essence of all natural law." Present day physicists say that the essence is in mathematical formalism. Some people at the Conference wanted to explain all things as structures of automata or computers. Some biologists said that fortuitous mutation of genes selected according to survival is the essence of all evolution.

Whenever anyone says anything about "all," "everything," "essential," "basic," "fundamental," "always," "never," etc., etc. he is talking metaphysics. It is evidently some kind of assumption. For clearly he does not really know the totality of existence. Yet, science is impossible without some such assumptions. The important point is to see their assumptive character, not to confuse them with perceived facts. Failure to do this is the ultimate source of almost all confusion in discussions of the fundamentals of science.

I explained that when you are confronted with someone else's metaphysics, you generally feel seriously disturbed, because your own basic notions are thus tacitly if not explicitly challenged. But you should be disturbed. Otherwise, you will never

[13]The 2nd Symposium on Theoretical Biology, held August 3-12, 1967. The proceedings are published in Waddington (1969). See Introduction p. 3, n 10 for details. The paper for the first of Bohm's contributions "Some remarks on the Notion of Order" (pp. 18–40) had been sent to Jeffrey Bub, see p. 115, n 8 and p. 119, n 9—CT.

[14]Waddington (1969), "Further Remarks on Order", pp. 41–60. See Introduction p. 3, n 10—CT.

know that you have metaphysical notions, confused with facts. If you can face the disturbance and confront the other fellow's metaphysics against your own, then you begin to be aware of all kinds of metaphysical assumptions. Eventually you may drop your own assumptions, without necessarily accepting the other fellow's. Rather, your mind is now open to form new general assumptions, of which you are aware. These assumptions are always being questioned, and always changing. So your metaphysics is no longer rigid and fixed. Instead, it is a dynamic and living thing, which is useful rather than destructive.

The positivists saw the destructive effects of a rigid metaphysics. But their reaction was to condemn all metaphysics. In doing this, they did not notice that such an allness assumption about metaphysics is itself a form of metaphysics. Because they were unaware of this metaphysics, it became rigid and therefore destructive. What is needed is not to condemn metaphysics, but to be aware of it, thus allowing it to change and develop.

After I explained all this at Bellagio, I found that almost everybody wanted to get up and present his own metaphysics. In reality they had always wanted to do it, but had been afraid. For in their minds was the "model" of the scientist who is free of such silly things as metaphysics, and who has his "feet on the ground." When this model was dropped, everyone discussed his metaphysics, and thereafter, people began to see at least what the other fellow was trying to say. They didn't always agree. But at least, people's minds began to meet, so that a real challenge was possible, when they failed to agree.

In my opinion, our discussions of fundamentals of quantum mechanics should, as far as possible, have a similar aim.

Sept 28, 1967

Dear Jeff,

I have just been reading Feyerabend's chapter in Beyond the Edge of Certainty, edited by Colodny (Prentice-Hall).[15] He gives a very good illustration of much of what I mean by the notion of fact and inference. In particular, he points out how a great deal of confusion in science is the result of allowing inferences at various levels to be mistaken for directly observed facts. This mistake tends to support conservatism in scientific thinking. For it causes us to overlook the uncertainty of a great deal of what we "know", insofar as incompletely confirmed inferences are regarded as equivalent to "solid" and "indubitable" facts. This is one of the points that I have been making. The work of people like J. and P., D-L-P, Rosenfeld, etc., always leads to the conclusion that current ideas do not need to be questioned deeply, because they are either merely systematic statements of directly observed fact, or else inferences that are as well confirmed as the existence of Australia (and therefore equivalent for all practical purposes to facts).

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[15] Feyerabend (1965)—CT.

He also mentions the empiricist notion that we should hold onto an idea until there is definite evidence against it. He contrasts this with the critical and pluralistic attitude; i.e., that we need many different theories, whose terms do not reduce to each other completely, either in content or in meaning. A new theory of this kind may call attention to different phenomena which refute the old theory, but only when the new theory is adopted. The role of the new theory is to connect phenomena (perhaps already known) with the older domain. Without the new theory, one would not realize that the "new" phenomena actually do refute the old theory. This is what happens in hidden variable theory. Thus, such a theory suggests that successive observations may fail to conform to the ensembles of quantum mechanics. Such a phenomenon would constitute a refutation of quantum mechanics.

Feyerabend brings out the essential point at issue here – i.e., in the confrontation of different theories of the same field, one either obtains a very strong refutation of the old theory or a very strong confirmation. In either case, knowledge is advanced significantly. The confusion of certain inferences of the old theory with facts leads to dogmatism and ossification, because it prevents such confrontation. This is the basic criticism of Bohr, Rosenfeld, DLP, von Neumann, J. P., etc.

With best regards

David Bohm

P.S. The situation with Bohr is not that he is an empiricist. On the contrary, he says that the structure of language is first. In other words, the structure of all possible unambiguous concepts (taken to be equivalent to that of classical physics concepts) is supposed to determine what is communicable and therefore what can be the subject matter of physics (and other sciences). Bohr seems to take it to be an evident fact that what is communicable is fixed within immutable limits. This inference is what he confuses with a fact. Once we accept this, the rest follows. As is usual, the confusion of inference with fact leads to dogmatism and conservatism. However, Bohr is concerned, not so much the empirical fact of physics, but rather, the fact about epistemology, which is a fact at a higher level of abstraction. Thus, Bohr is an anti-empiricist, in a certain sense, since he puts epistemological limits first, ahead of all actual sense perception. Nevertheless, he is still a dogmatist, who confuses inferences about epistemology with facts about epistemology.

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