

Complementarity in the Philosophy of Mind: The Object/Subject Distinction

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This paper examines the concept of complementarity as advanced by the physicist Niels Bohr and focuses on both its epistemological aspects and its application to psychology. According to Bohr, 'complementarity' denotes a logical relation between two descriptions or sets of concepts which, though mutually exclusive, are nevertheless both necessary for an exhaustive description of a certain phenomenon or situation. The paper is comprised of two parts.

Part One discusses Bohr's principle of complementarity and its application in describing human conscious processes.

Several influences on Bohr's thinking are explored in Part Two. These include the mathematician Bernhard Riemann's theory of complex functions and the philosopher Immanuel Kant's notion of 'Transcendental Ego'. A comparison is also drawn between Bohr's ideas and philosopher and psychologist William James's similar pronouncements in his monumental work *The Principles of Psychology*, with which Bohr was quite familiar. A striking similarity between Bohr's and James's systems of epistemology is pointed out.

The principle of complementarity is usually conceded as being Niels Bohr's most profound contribution to the foundations of quantum mechanics. Nevertheless, by whatever historical route, Bohr did arrive at a doctrine of mutually exclusive, incompatible, but necessary classical pictures, such as wave-particle duality, in which any given application emphasising one concept *must* exclude the other. (Bohr, *Atomic Theory* 10) We explore complementarity as a hypothesis appended to the formalism of quantum mechanics and limit ourselves to examining it and its application to **psychology**.

Part One

1a. What is complementarity?

We start by briefly drawing the following ten distinct points in Bohr's usage of complementarity. These points cannot be reduced to one another, even though some are closely related. Together, these points map out the logic or structure of the complementarity relationship. (Blackburn 1003-1007)

(1) Unity

The complementary modes belong to one and the same object.¹ What appears to be a wave under some circumstances and a particle under others is in fact the same physical entity. In contrast, this could not be said of dualistic relationships like those between male and female, 'Yin' and 'Yang' or good and evil. Hence, complementarity is to be distinguished from **duality** or **dualism**.

(2) Common Properties

Going along with the unity of the modes is the fact that they share some common properties.

(3) Individual Completeness

Each mode is complete in itself in the sense that the object may be completely described, in a given situation, in terms of the appropriate mode without any explicit reference to the alternate mode. Only as the situation changes, does the alternate mode enter the picture. Another way of putting this is to say that each mode is well-defined in the sense that given a particular experimental situation (e.g., light propagating in free space), the mode of existence is unambiguously determined (i.e., the wave mode) even though the physical state of that mode (frequency, wave-length) is left undetermined.

(4) Co-Exhaustiveness

The two modes are co-exhaustive in the sense that together they are sufficient to exhaust all possible knowledge of the object under all possible conditions. In other words, the object is never known and never existed other than in one of its two modes; there is no third mode.

(5) Equal Importance

The two modes are equally essential, equally important and equally indispensable, in the sense that both together are necessary (as well as sufficient) for an exhaustive treatment of the atomic object. It follows that the modes are mutually irreducible; that is, one cannot be analysed in terms of the other.

(6) Alternation

The temporal evolution of the physical entity proceeds by a continual alternation between one mode and the other, as the entity passes from one situation to another.

(7) Co-Inherence

If the two modes pertain to a single entity, and that entity evolves by an alternation between the modes, then there must be some positive connection like an 'interpretation' or 'co-inherence' between the modes. A corollary of this co-inherence or interpenetration is that there is inter-participation or co-operation between modes. Whenever the actual mode does something, the potential mode participates in and co-operates with that action since it exists as a potentiality in the actual mode during the action.

(8) Mutual Exclusiveness

In spite of the element of co-inherence, each mode is complete in itself and the two modes are mutually exclusive, in the sense that they are conceptually incompatible and cannot be combined into a single picture. Hence, there is a relation of mutual exclusion between the corpuscular and undulatory characters of light (or matter) between 'space-time coordination' and the 'claim of causality' and between the application of the concept of stationary states to an atom and the description of the behaviour of the constituent particles. But, however incompatible these opposing aspects of quantum phenomena may be, they can never be brought into direct contradiction with each other because the experimental conditions required for their very definition are mutually exclusive. (Bohr, *Atomic Physics* 5, 9). In short, the two modes exclude each other in **thought, experience and in reality**.

(9) Conjugate Properties-Reciprocity

At least some the properties of an atomic object are not held in common by the two modes; they are well-defined in and characteristic of, only one of the modes, not the other. These properties occur in conjugate pairs like position and momentum, or time and energy. (Bohr, Atomic Theory 71, 73, 76, 95.) Bohr never called conjugate properties themselves complementary. Only the modes in which they are respectively defined are complementary. As the atomic object alternates between its two modes, the (complementary) modes alternate between being actual and potential and the conjugate properties alternate between being explicit and implicit.

(10) Emergence

There is also an important element of asymmetry between the wave-mode and the particle-mode. The wave-mode allows a greater degree of stability and regularity than the particle-mode. This is evident in the contrast between stable atoms and free particles.

Bohr argues that “the task of philosophy may be characterised as the development of conceptual means appropriate for communication of human experience.” (Honner 107) The corner stone of the ‘conceptual means’ was his notion of complementarity. Complementary descriptions are never complete, but they are exhaustive. That is, taking all the conditions for observation into account, we acknowledge the limitations imposed on our descriptive concepts by the nature of observation.

Complementarity, in Bohr’s mind, replaces **causality** as the most general framework for linking the sequence of our observations. (Bohr, *Essays 1-7*) Whereas causality ties us to linearity, there is something circular about complementarity. It might be argued that Bohr’s notion of complementarity simply has to do with the paradoxical combination of quantum and classical theories. But Bohr wanted to take his ‘conceptual means’ further than this: “It was the *universal* significance of the role of complementarity which Bohr came to emphasize”, Holton correctly observes. (Holton 1045)

Bohr argues that “the nature of our consciousness brings about a complementary relationship, in all domains of knowledge, between the analysis of a concept and its immediate application.” (Bohr, Atomic Theory 20) Thus, we find parallels between physics and psychology, in dealing with the problems of observation and description and the subject/object dilemma. (Bohr, Atomic Theory 11, 27, 30, 76, 79, 93, 101.) Complementarity comes into play as soon as the practical univocity of our ordinary descriptive concepts breaks down, as soon as we are no longer present to that object to which we point as we utter our word for it, as soon as we use our words to

attempt to describe the significance of experience. In speaking of the complementarity of **psyche** and **physis**, Bohr is, however, indicating the difficulties we meet as soon as we go beyond pointing at nature to pointing to conceptualising about nature. This is not to say that we cannot know, but that we cannot achieve totalisation or closure. The only way that we could arrive at unambiguous description would be to take account of the particular conditions under which observations were made. Bohr would argue that we can make no sharp distinction between subject and object, but we can at least give an account of conditions of observations. In so doing, we can give unambiguous description within a particular plane of meaning. This is what he calls '**objectivity**'. For a full description, however, we must consider all possible other observations on all possible other planes of meaning.

In his complementarity argument, Bohr stressed the point that for specific pairs of variables (position and momentum) or concepts (waves and particles; space-time and causality) the empirically determined conditions of observations and the theoretical possibilities of definitions are deeply connected with each other. This means that in atomic physics the practice of physicists (experiments or observations under macro-physical conditions with measurement-instruments which could be described by classical physics) and the theoretical description of this practice (classical physical variables and concepts which are allowed under the empirical given conditions in quantum mechanics) connected in a way unknown to classical physics. The physical theory, therefore, should not be misunderstood as a sophisticated manner of talking about a nature-in-itself. We have to say what we are doing (or intending to do) by observing (or intending to observe) something. Situations, in which we cannot describe the behaviour of objects without describing the conditions of their behaviour, must be described in terms of complementarity. This is an objective description. And, if the theory is a complete one, then it is the only possible objective description. Bohr's interest in epistemology was aroused by the problem of describing human conscious processes.

Ib. Complementarity and Psychology

Bohr's suggestions regarding complementary approaches to psychological problems are the following: (1) No sharp separation between object and subject can be maintained, since the perceiving subject also belongs to our mental content; (2) The unity of our consciousness may be analogous to the quantum postulate in atomic physics; (3) 'Thoughts' and 'feelings' may be regarded as complementary; (4) Rational and empirical psychology may similarly be considered as complementary approaches to the same disciplines. Bohr opposed the idea of a non-physical mind interacting with or

directing the physiological being. As in quantum physics and biology, so in psychology, complementarity represents conceptual analysis, not dualism. (Bohr, Atomic Theory 52-91)

Psychology was Bohr's favourite field of application for the principle of complementarity. Brief comments on psychology appear in almost all of Bohr's writings. There are two distinct approaches to this subject in Bohr's writings: one is 'subjective', based on the problems of introspection, and the other is 'objective' based on the problems of applying the laws of physics and psychology to the study of psychic phenomena. In any unambiguous reference to our own conscious states, says Bohr, we must make a clear distinction between the content of consciousness, upon which we are focusing our attention, and the background which we call 'ourselves'.²

Bohr was particularly interested in the subjective approach to psychology based on introspection. It is to be noted that there are serious doubts about the capacity of introspection to serve as a scientific method. How could introspection, as a method, reconcile incompatible results when conscious experience is private? Could introspective analysis serve as a scientific method producing reliable data? There are limits to the reliability of introspective observations which makes it difficult for introspection to go beyond such limited observations. Furthermore, behaviourists <<http://www.answers.com/topic/behaviorism-1>> considered introspection as an unreliable method and regarded the subject matter of scientific psychology as strictly operationalized in an objective and measurable way. Hence, the focus of psychology is on measurable behaviour rather than consciousness or sensation. For cognitive psychology, introspection is not a valid method of investigation in comparison with scientific method.

The immense richness of mental life is due to the variety of possible locations for this subject/object boundary and the continual shifting back and forth. "The rich vocabulary used in the communications of the states of our mind refers indeed to a typical complementary mode of description corresponding to the continual change of the content on which attention is focused." (Bohr, Atomic Physics 101).

Normal healthy people instinctly adapt to these alterations and so hardly notice them, but there are psychiatric cases of 'confusion of the egos' or 'split-personality' in people who fail to make the necessary adjustments. Alternatively, Bohr argues that a sharp distinction between psychic phenomena and their conscious perception is never possible since any act of introspection shifts the subject/object boundary inwards and automatically alters the content of consciousness. Either way, an emotion felt and an emotion analysed are two different things, not to be confused. The same is true of a decision

made and a decision analysed. The analysis of one's motives can never provide an argument against free volition because the two phenomena are complementary and therefore never in direct conflict. In the same manner, Bohr frequently spoke of complementarity between seriousness and humour, (Bohr, Atomic Physics 79-80; Essays 15) thoughts and feelings. (Bohr, Atomic Physics 21, 27, 52, 93; Essays 28)

Thus, according to Bohr's shifting-boundary model, mental life proceeds by a continual shifting of the subject/object boundary so that at one moment a thought or feeling or perception is indwelt (subject) and at the next moment it is analysed (object). If we view this process from the rest frame of the subject/object boundary itself, then it will appear that the thought moves back and forth across the boundary line as it changes from one mode to the other. What, then, is the relationship between the consciousness or mind and the body? Bohr suggested that the usual view of 'psycho-physical parallelism' could be generalized and reinterpreted in terms of complementarity "... it must not be forgotten that, in associating the psychical and physical aspects of existence, we are concerned with a special relationship of complementarity which it is not possible thoroughly to understand by one-sided application either of physical or of psychological laws." (Bohr, Atomic Theory 24, cf. 100, 101; Atomic Physics 11)

There can be no violation of causality in the physiological processes of the nervous system since the laws of physics and biology fully account for those phenomena in which they are well-defined. However, such a detailed analysis of another person's nervous system is clearly incompatible with his exercise of free will. (Bohr, Atomic Theory 24, 100, 117)

Therefore, the laws of physics and biology are not applicable to mental phenomena themselves, and the fact of free will, which we know intuitively, must be taken as an irreducible postulate in psychology just as the existence of life in biology. "Thus, words like contemplation and volition, referring to situations which are mutually exclusive but equally characteristic of conscious life, have been used in a typical complementary manner since the very origin of language." (Bohr, Essays, 21-22; cf. 13, APHK, 21, 77, 93)

"This use of concepts, in fact, not only is to a large extent suppressing instinctive life, but it stands even largely in an exclusive relationship of complementarity to the display of inherited instincts" (Bohr, Atomic Physics 28; cf., 27, 76) and knowledge and belief. (Bohr, Atomic Physics 80-81, 11, 78) In fact, the only way to predict another person's actions while respecting his freedom is to put oneself in his place.

"The decisive point is that, if we attempt to predict what another person will decide to do in a given situation, not only must we strive to know his whole-background including the story of his life in all respects which may have contributed to form his character, but we must realize that what we are ultimately aiming at is to put ourselves in his place." (Bohr, Atomic Physics 78)

For Bohr, mind and body are the two modes of the human being: to indwell man as man is to know his mind (tacitly), and to analyse him as an animal is to know his body (specifiably). Hence the relationship between mind and body is one of complementarity.

When we treat the mind as complementary to the body, we automatically avoid the pitfalls of dualism (by the condition of unity) and epiphenomenalism (by the conditions of individual completeness and equal importance.) A human being is a single being existing alternately in one of two modes, the mental and the physical where the physical mode or body is further subject to modal existence.

A full representation of the human being's existence would look something like this:

Human being

/ \

body mind

/ \

atom organism

/ \

particle wave

A human being can be treated either as a group of particles (physically) or as a compound of atoms and molecules (chemically) or as a living organism (biologically) or as a conscious mind (psychologically), and all four of these views are correct in their respective circumstances. In fact the four modes must alternate in time in accordance with the hierarchical structure of their relations. The alternation itself is unobservable (by definition). None of them can be reduced to the others. Of course, the real situation is far more complex: the atom-organism unit is really an abbreviation for the more elaborate structure shown on this diagram, and a more detailed investigation of the mind-body unit would undoubtedly reveal a series of intermediate levels there as well. However, the basic structure is not affected by these refinements, and the underlying logic is most vividly portrayed by a simple model

like this one. At this stage we can better understand the nature of the use of tools with which we began our study of complementarity.

When not being used, a tool is simply a compound of atoms and molecules. In the case of a machine, it may be a thermodynamic (or some other kind of higher) system. But, when it is used by man in accordance with its proper function, it becomes an extension of man's body and enters into complementarity with man's mind. In other words, there exists a relationship of complementarity between every artifact and the idea which originally inspired its design and continues to inspire its proper use. The ideas exist properly only in the mind of man so they may be distorted or even forgotten. We are surrounded by the lifeless artifacts of previous generations whose meaning or purpose has been lost in this way. Nonetheless, they bear silent testimony in the sense that they 'point' to the ideas which gave them meaning and thus tantalize the research worker, so that the rebirth of those ideas always remains a potentiality within them (conditions of pointing and co-inherence.)

Human beings, then, are characterized by the ability to extend the limits of their own bodies through the use of tools. In fact, the subject/object boundary can be involved outwards to include a whole series of artifacts as in games of skill like billiards where three or four artifacts may be indwelt at a time. Sub-human animals like chimpanzees can design and use simple tools under special conditions but their ability to extend themselves in this way is severely limited. Moreover, man is not limited to indwelling objects of his own making. Science, history and religion are all based on his ability to indwell and interpret objects and events in various ways. For instance, by constructing and indwelling appropriate models (systems of ideas) with his mind, man is able to extend his subjecthood into the natural world indefinitely. And in the religious experience of ecstasy the mystic attempts to indwell all of nature and extend his subjecthood to include the universe as a whole.

If complementarity is valid here, this indwelling should point him beyond nature to God. Man is also capable of shifting the subject/object boundary indefinitely inwards. Just as one can treat an external object as a part of one's body by indwelling it, so one can treat a part of one's body as an external object by exteriorizing or alienating it. If I concentrate on my arm as an object, it becomes lifeless as if paralyzed. In order to move it I must reoccupy it as subject, but then it ceases to be an object for me. This exteriorization or alienation is a common technique in forms of meditation like Yoga. These methods involve a withdrawal from the world and a retraction of subjecthood in a movement of ecstasy, which can be understood as the direct consequence of man's ability to shift the boundary between subject and object.

From the complementarist viewpoint, then, we may define mind as the capacity for subjecthood, i.e. the ability to extend the limits of one's body, to enter into complementarity with external objects (as with one's body) and fill or indwell the proximal side of the subject/object boundary (whether or not these are under one's control) and to recognise the proper function of objects, the meaning of symbols, and even the presence of God.

Furthermore, it is by the creation and 'manipulation' (interiorization and exteriorization) of ideas or thoughts that our minds exercise this capacity. In order to use a tool properly or interpret an event correctly and, thus, include it within his 'body', man must discover the function or significance of the tool or event and indwell it with his mind.

Hence, there are two dimensions of complementarity involved in the everyday behaviour of human beings: a 'horizontal' complementarity between a tool analysed and the same-tool-applied (on the bodily level) or an idea-analysed and the same-idea-applied (on the mental level-this is Bohr's 'subjective' use of complementarity in psychology discussed above, and a 'vertical' complementarity between each tool and the idea behind it parallel to that between body and mind (Bohr's 'objective' use of complementarity in psychology).

Hence, Bohr's two uses of complementarity in psychology are intimately related, though quite distinct. Here, we cannot avoid the issue of the existence of a world of ideas comparable to the world of physical objects. Ideas exist only in the mind, but do they exist separately in many isolated minds or is there a single world of ideas common to all (or most) men?

In other words, are minds of human beings isolated like their brains, or is there some higher unity in the realm of ideas, some kind of common mind? One would expect from the logic of complementarity that a higher degree of unity would be possible in the mind than in the body, just as a higher degree of unity is possible in an organism than in a group of atoms, or in the wave-mode than in the particle-mode (condition of emergence).

A kind of mirroring or imaging of the whole enters into psychology while it is absent from physics and biology. 'Mind' can be related both to the individual and also to the entire human race (or at least large portions of it). Hence, the individual is a microcosm, reflecting or imaging in some sense the being of essence of man as a whole. On the one hand, the individual does not exist except as a part of the whole, and, on the other, the whole is fully present within each individual.

This paradox is quite distinct from the general problem of particulars versus universals or of parts versus wholes, since it only occurs for social

relations and is not present in the case of particles in an atom or atoms in an organism. It is related to the problem of individuality- the electrons of an atom completely lose their individuality because they are identical to each other. The same is true of atoms of the same kind in an organism. However, an organism is utterly unique and cannot lose its individuality even when it enters into social relations. Instead it internalizes these relations in the forms of language, emotion, a self-image, etc., all the characteristics of 'mind'. Therefore, an individual person cannot be isolated or abstracted from social relations as an individual atom or even as an animal can. A person embodies those relations and carries them around with him, as it were; they enter into his very being. Hence the ambiguity of the word 'man': it may refer to the individual or else to the entire race.

Hence, in the transition from physics to biology there is an emergence of 'correlation' or 'propriety' between the states of the alternated modes, and in the transition from biology to psychology there is an emergence of this 'mirroring' or 'imaging' of the whole in each individual. It should be noted, therefore, that the logic of complementarity is not a rigid scheme that can be imposed *a priori* on new areas of study. Rather it is a flexible tool that must be adapted at each level of application in accordance with the progressive changes in the levels themselves. Knowledge of the individual levels and of their corresponding sciences must always be presupposed.

Part Two

II. Some Mathematical and Philosophical Influences on Bohr

Ila. Bernhard Riemann and Consciousness

Bohr had the idea of representing the difficulties of describing one's own consciousness through an analogy with Riemann's analysis of multi-valued functions of a complex variable. Thus, in attempting to describe one's own consciousness, i.e., the consciousness one directly experiences, one must inevitably make a distinction between that consciousness as the object of description and the subject consciousness which experiences it.

This distinction is essentially a Kantian's distinction between empirical and transcendental egos. The "transcendental ego" is the absolute "I" that must be assumed in order to explain the unity of an individual's consciousness. However, it cannot itself become an object of experience to that individual. The "empirical ego" represents the various images of oneself, both inner and outer, that appear to us in space and time. Thus, these images are only relative to each particular situation and do not constitute the essential core of who we are. All attempts to describe the experiencing subject in its

experiencing activity, the '**transcendental ego**', necessarily elude the grasp of the descriptive concept. For as soon as one attempts to describe that subject, it becomes the object of the experience, the '**empirical ego**', thereby shifting the distinction between experiencing subject and experienced object.

If one is not careful to observe this shifting distinction, the attempted description becomes hopelessly ambiguous; referring to different egos each time the distinction is implicitly moved. The incautious would-be observer of his own conscious states becomes lost in a labyrinth of his own egos generated by being unaware of the shifting reference, the ambiguity, of his descriptive concepts.

This situation is analogous to the multi-valued functions of a complex variable. The theory of complex functions is one area of mathematics where multi-valued functions arise. Each complex number can be represented unambiguously as a point on a two-dimensional plane. But the multi-valued function may have potentially an infinite number of values, each a complex number, for each value of the independent complex variable.

Riemann (1826-1866) proposed to map such functions as different 'branches' of a single curve, each on a different plane, and each one representing a curve of a single-valued function. In this case, as long as one follows the curve in the same plane, the function can be mapped continuously without any ambiguity arising in the point number relationship. However, for each function the origin point on the plane is a 'singular point', resulting in the mathematical consequence that when a closed curve is traced around the origin, such that it returns to the same value of the independent variable, the value of the function now differs by a constant factor. Were we to continue to map the function in the same plane, the value of the function would become ambiguous in the graphical representation. (Ablowitz 46-69) The chance for ambiguity arises if we fail to note that when we trace a closed curve around the singular point of the origin, we must move to a different plane. (Petersen, *The Philosophy of Niels Bohr* 299-310).

Riemann had proposed to eliminate this mathematical ambiguity of a point on a single plane representing many possible values of a complex function by turning the multi-valued function into a series of single valued functions represented in different planes. Bohr proposed that the different references of a term refer to different 'planes of objectivity', each analogized to a different meaning imparted to the 'object' of the experience as a consequence of different ways of drawing the distinction between experiencing subject and experienced object.

Thus, for Bohr, the attempt to describe the self is like drawing a closed curve around a singular point. The concept of the self, then, is analogized to a multi-valued function, which may take on different references. Thus, in attempting to describe the subject self, **transcendental ego**, we must map that meaning onto one plane of objectivity, but in doing so we make that subject self the object and thus effectively shift the subject/object distinction. Therefore, when we return to the subject self, it is not the same self as was the subject before we began to describe it. We must then recognise that the reference of the term 'self' has moved to another plane of objectivity.

While Bohr may have explored this line of thought well before complementarity appeared, this early approach falls perfectly in line with the epistemological lesson of complementarity. As early as 1927, Bohr had concluded his **Como lecture** with the remark, "I hope, however, that the idea of complementarity is suited to characterize the situation, which bears a deep-going analogy to the general difficulty in the formation of human ideas, inherent in the distinction between subject and object." (Bohr, Atomic Theory 91).

In his most revealing description of the general epistemological situation, Bohr writes:

For describing our mental activity, we require, on the one hand, an objectively given content to be placed in opposition to a perceiving subject, while, on the other hand, as is already implied in such an assertion, no sharp separation between object and subject can be maintained, since the perceiving subject also belongs to our mental content. From these circumstances follows not only the relative meaning of every concept, or rather of every word, the meaning depending upon our arbitrary choice of viewpoint, but also that we must, in general, be prepared to accept the fact that a complete elucidation of one and the same object may require diverse points of view which defy a unique description.... the necessity of taking recourse to a complementary, or reciprocal, mode of description is perhaps most familiar to us from psychological problems. (Bohr, Atomic Theory 96)

He, then, draws the analogy between the '**unity of our consciousness**' and the '**physical consequences of the quantum action**', which makes for the individuality of atomic processes.

IIb. Bohr and James

In the interview recorded the day before he died, Bohr said: "I was a close friend of Rubin [a fellow student, later psychologist], and, therefore, I

read actually the work of William James. William James is really wonderful in the way that he makes it clear that I read the book, or a paragraph, called... 'The Stream of Thoughts,' where he in a most clear manner shows that it is quite impossible to analyze things in terms of don't know what to call it, not atoms. I mean simply, if you have some things... they are so connected that if you try to separate them from each other, it just has nothing to do with the actual situation.... I know something about William James... I thought he was most wonderful." (Holton 1034).

There has been some controversy over the date of Bohr's first exposure to James. In 1962, Bohr himself remembered definitely having read James before 1912, i.e., long before complementarity appeared in 1927. In an interview with Thomas Kuhn and Aage Peterson, which he gave before his death in 1962, Bohr stated that he read James before going to Manchester in 1913. (Holton 1035) In many ways, complementarity closely parallels James's philosophical problems in the descriptive task of psychology.³ For complementarity, as for James, experience is ultimate; the 'subject' and 'object' which interact in the production of experience are terms that refer to abstractions invoked for describing experience. The earliest use of the term 'complementarity' is in science and also its earliest occurrence in the scholastic curriculum is undoubtedly the geometrical expression 'complementary angles.' (Jammer 88-89).

Petersen pointed out that although Bohr was deeply interested in the foundations of geometry and in the relations of mathematics to language, it was probably not this geometrical expression but James's application of the term which had an impact on Bohr's mind. (Petersen, *The Philosophy of Niels Bohr* 8-14).

In his discussion of hysteric diseases,⁴ James described an experiment performed by the psychologist Pierre Janet, who like Freud was a pupil of J. M. Charcot and specialised in the field of disordered personality. (James 202-213) Studying a patient called Lucie, Janet covered her lap with cards, each bearing a number; he then told her that on waking, after the present state of trance, she should *not see* any card whose number is a multiple of 3. To the 12, 18, 9, etc., she was blind. But the *hand*, when the sub-conscious self was interrogated by the usual method of engrossing the upper self in another conversation, wrote that the only cards in Lucie's lap were those numbered 12, 18, 9, etc., and on being asked to pick up all the cards which were there, picked up these and let the others lie. (James 206-207).

James quoted this experiment as an illustration of the fact that "in certain persons the total possible consciousness may be split into parts which co-exist but mutually ignore each other, and share the objects of knowledge

between them. More remarkable still, they are *complementary*.” (James 206) “Few things are more curious,” wrote James a few pages later, “than these relations of mutual exclusion.” (James 210) In James’s psychology the sum total of complementary parts, as exemplified by Janet’s experiment, makes up the normal totality; in Bohr’s physics the sum total of complementary descriptions makes up the description of classical physics.

One of James’s principle claims in *The Principles of Psychology* is the *wholeness, or unity, of each conscious thought*. Each thought has components, but the whole he claims, is more than just a simple collection of its components. The component thoughts are experienced together in a particular way that makes the experienced whole an essentially new entity. It is these whole thoughts that are the proper fundamental elements of psychological theory, not some collection of ‘elementary components’ out of which our thoughts are assumed to be formed by simple aggregation. Thus, each thought, as given, is a unified whole that cannot be reduced to a collection of parts without destroying its essence.

Bohr was impressed by James’s ideas and declared that: “the apparent contrast between the continuous onward flow of associative thinking and the preservation of the unity of the personality exhibits a suggestive analogy with the relation between the wave description of the motions of material particles, governed by the superposition principle, and their indestructible individuality.” (Bohr, Atomic Theory 99-100).

In 1929, Bohr was still liable to the confusion of speaking as though the observing process ‘disturbs’ the object. Thus, at this time he carries over the same confusion in the psychological analogy. He writes:

The unavoidable influence on atomic phenomena caused by observing them here corresponds to the well-known change in the tinge of the psychological experiences which accompanies any direction of the attention to one of their various elements.... When considering the contrast between the feelings of freewill, which governs psychic life, and the apparently uninterrupted causal chain of the accompanying physiological processes, the thought has, indeed, not eluded philosophers that we may be concerned here with an unvisualizable relation of complementarity. (Bohr, Atomic Theory 100).

The reference to a ‘change of tinge’ and the unity of consciousness suggests that Bohr’s thoughts about psychology here were influenced by James’s thoughts in ‘The Stream of Thought.’

The pragmatism of James was quite congenial for Bohr. In his article on the Copenhagen interpretation, Henry Stapp suggested that it represented ‘a

shift to a philosophical perspective resembling that of William James'. (Stapp 1098-1116) One of the main conclusions of James's conception of truth is that ideas must be judged by their success and utility in the world of ideas and experience, and in this consists their agreement with reality, rather than on the basis of some intrinsically incomprehensible agreement with non-ideas.

The significance of this viewpoint for science is its negation of the idea that the aim of science is to construct a mental or mathematical image of the world itself. According to the pragmatic view, the proper goal of science is to augment and order our experience. A scientific theory should be judged on how well it serves to extend the range of our experience and reduce it to order. It does not need to provide a mental or mathematical image of the world itself, for the structural form of the world itself may be such that it cannot be placed in simple correspondence with the types of structures that our mental processes can form.

James was accused of subjectivism - of denying the existence of objective reality. In defending himself against this charge, he introduced an ontology consisting of three things: private concepts, sense objects, hypersensible realities. The first are subjective experiences, the second are public sense realities, i.e., sense realities that are independent of the individual. The third are realities that exist independently of all human thinkers. Our knowledge of the third is forever uncertain, we can never even think of such things without replacing them by mental substitutes that lack the defining characteristics of that which they replace. The second are sense realities and hence belong to the realm of experience. Yet they are public: they are independent of the individual. They are, in short, objective experiences. The usual idea about experiences is that they are personal or subjective, not public or objective.

The idea of experienced sense objects as public or objective realities runs through James's writings. Throughout Bohr's writings, there is a tacit acceptance of the idea that the external world exists, and that our physical experiences are caused, in part, by the course of external events. This is quite in agreement with pragmatism: James admits the existence of hypersensible realities. But there is no commitment by Bohr to the idea that the macroscopic world really is what we naively imagine it to be. The focus is on the descriptions of our physical experiences and the demand that they secure unambiguous communication and objectivity.

Bohr's notion of complementarity is altogether pragmatic: As Ideas should be judged by their utility; physical ideas should be judged by their success in ordering physical experiences, not by the accuracy with which they can be believed to mirror the essence of external reality. The use of

complementary ideas in complementary situations is a natural concomitant to pragmatic thinking. In this context, one can refer to the close relationship between pragmatism and instrumentalism, which represents the pragmatic, not the ontological, approach to science. According to instrumentalism in the philosophy of science, concepts and theories are merely regarded as useful instruments. What measures their value is their effectiveness in explaining and predicting phenomena.

Both James and Bohr admit that human experiences are not the whole of reality but are probably merely a part of the whole that is related to the rest via some sort of causal-type connection. The critical question is not whether there is in fact a world out there, but rather what the connection is between the world out there and our ideas about it.

Bertrand Russell argues that we can make plausible inferences, based on the structure of our experiences, and build up a reasonable idea of the outside world.⁵ James would insist that this whole structure is nothing but a structure of abstract ideas built upon our common experiences, and that the trans-experiential world that may somehow cause our common experiences never enters into this structure at all. James evidently believes that his idea of a table is similar to yours and mine. In general, different people's ideas about sense objects are not identical, but they are similar enough to form the basis of effective social communication. There exists, in this sense, a realm of public or shared experiences that form the basis of inter-personal communication. This realm constitutes the primary data of science. The aim of science is to construct a framework of ideas that will link these common, or public, or shared, experiences together in ways that reflect various aspects of the empirical connections that exist between them. Thus the whole structure of science is, quite obviously, a structure that is wholly confined to the world of ideas.

Both William James and Bertrand Russell held that the psychical and the physical, like consciousness and content, are essentially made of the same stuff. Russell's neutral monism is based on the view that both the mental and the physical can be reduced to some sort of third substance. Accordingly, both the mental world and the physical world are constructed out of components which are in themselves neither mental nor physical but neutral. James talked about the 'stream of consciousness', that is, the consciousness of the observer. He also refers to consciousness as a derivative function of the neutral bits of experience. Hence, we have the world of pure experience.

The possibility of using mutually contradictory notions for the description of the same physical situation, argued Bohr, arises from the indeterminateness of the concept '**observation**.' For the interaction between the object of

observation and the agency of observation - which interaction in accordance with the quantum postulate cannot be neglected as it could in classical physics - makes it impossible to separate sharply the behaviour of the atomic system from the effect on the measuring instrument whose behavior must be expressed in classical terms. By combining the atomic system with different classically describable devices one may measure complementary variables, and by expressing the results of these measurements in classical terms one may describe an atomic system in terms of complementary classical pictures.

Bohr's insistence on the indeterminateness of the concept of observation, in so far as it depends upon which objects are included in the system to be observed and which in the agency that observes, showed a striking similarity to James's analysis of the notion of observation in psychology. Bohr concluded his 1927 paper with the statement that "the idea of complementarity is suited to characterize the situation, which bears a deep-going analogy to the general difficulty in the formation of human ideas, inherent in the distinction between subject and object." (Bohr, Atomic Theory 91) - a statement which clearly referred to one of the main issues dealt with in James's *The Principles of Psychology*. Similarly, in a subsequent paper published in 1929, (Bohr, Atomic Theory 92-101) in which Bohr resumed his discussion on the impossibility of a strict separation of the phenomenon from the means of its observation, he re-emphasised the analogy between physics and psychology: "...strictly speaking, the conscious analysis of any concept stands in a relation of exclusion to its immediate application. The necessity of taking recourse to a complementary, or reciprocal, mode of description is perhaps most familiar to us from psychological problems." (Bohr, Atomic Theory 96)

III. Concluding Remarks

To sum up, several points emerging in this application of complementarity to psychological descriptions bear a resemblance to Bohr's analysis of complementary relationships in atomic physics.

(1) What has most been understood as a problem concerning the nature of reality (Are electrons really waves or particles?) is understood in a different manner as a problem in the use of concepts for describing some aspect of experience.

(2) Two modes of description are required. In one, the object is described as interacting directly with the subject or the observing system. In psychology this mode of description is introspective, allowing the subjective feeling of freedom to characterise the object; in physics it allows the application of the conservation principles. However, if it does not include a description of the whole phenomenon involving the agencies of observation such a

description is ambiguous, because what is described is the whole phenomenon of interaction in which subject and object cannot be unambiguously distinguished. In psychology this is the actor describing his own decision to act, in physics it is the interaction between systems in the quantum domain and agencies of observation. Thus to make the description objective, i.e., to be able to describe the object unambiguously, a second mode of description must be combined with the first. In this mode the object is described as isolated from an observing interaction. But in so describing it, the descriptive terms must be understood as referring to an abstraction necessary for a causal description of the observing interaction, not a picture of independently real object.

(3) Any unambiguous description must necessarily distinguish between the observing agency and the observed object. This distinction may be drawn at any point, making it possible to describe the phenomenon as the observation of different phenomenal objects, each requiring a different description on a different 'plane of objectivity'. To avoid ambiguity, the description of each phenomenal object must specify how the distinction between observed object and agencies of observation has been drawn. Failure to do this renders the description liable to ambiguity due to the implicit shift of the subject/object distinction.

(4) Failure to be sensitive to such ambiguities has given rise to the appearance of genuine metaphysical problems about the nature of reality, which will disappear once the complementaristic analysis is employed. Problems such as wave-particle dualism or free will versus determinism are not metaphysical conflicts about the nature of reality. Instead, these problems are confusions created by failing to realise that such different descriptions refer not to the same object but to complementary phenomena, which only together provide an unambiguous description of the nature of the objects which give rise to these phenomena.

(5) The improvement of our understanding of nature made possible by adopting the framework of complementarity occurs not through the invention of newer, more sophisticated concepts for describing experience, but through understanding the conditions required for the unambiguous employment of the descriptive concepts. This epistemological lesson, summed up in the reminder that we are actors as well as spectators in the drama of existence, results in widening our conceptual framework which Bohr calls a 'rational generalization.'

(6) Complementarity involves an attitude of 'epistemic neutrality.' Thus, Bohr does not answer the question whether electrons really are waves or particles. His position is that it is necessary to conceive of them in both of

these ways under different conditions in order to explain all known phenomena. According to Bohr, "we are both onlookers and actors in the great drama of existence." (Bohr, *Atomic Theory* 119) Quantum mechanics has brought the realization of a deep wholeness in nature, of an essential inseparability of those aspects of nature that have formerly been conceived to be separate.

(7) The most significant outcome of modern physics is the place it allows for human minds. Consciousness is no longer considered as a passive spectator of the course of physical events, which operate according to the laws of mechanics. Conscious events can be identified with 'certain kinds of quantum events, namely quantum events that create large-scale integrated patterns of neural activity in human brains'. (Stapp 213)

Endnotes

- 1 - "Information regarding the behaviour of an atomic object obtained under definite experimental conditions may... be adequately characterized as complementary to any information about the same object obtained by some other experimental arrangement excluding the fulfillment of the first conditions." (Bohr, *Atomic Physics*, 26; cf. *Atomic Theory*, 96).
- 2 - The question is important because in his chapter entitled "The Stream of Thoughts", James argues against the Kantian approach to the description of experience. So if Bohr thought that his position is close to James's, then by implication it is opposed to Kant's. Kant's position is viewed by Bohr as a priori rationalist attempt to justify the universality and necessity of the framework of classical physics, which is the very view which complementarity was designed to replace.
- 3 - See Bertrand Russell's *Human Knowledge: Its Scope and Limits*, Part 3, "Science and Perception", where he argues that what we know about the physical world comes to us from inference or interpretation of the visual data. We can infer what physical structures are like which exist in a physical space-time continuum.
- 4 - Bohr writes: "Every unambiguous communication about the state and activity of our mind implies, of course, a separation between the content of our consciousness and the background loosely referred to as 'ourselves', but any attempt at exhaustive description of the richness of conscious life demands in various situations a different placing of the section between subject and object." See Bohr's *Essays*, 12-13.
- 5 - See Popper's chapter entitled 'On the theory of the objective mind' in his *Objective Knowledge: An Evolutionary Approach*.

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