

Recent Conceptual Innovations and their Aptness for Resolving some QM Antinomies

Rom Harré

In this paper I explore the possibility of adopting a different group of concepts as the background to quantum mechanics, from those most discussions presuppose. I suggest these are particularly germane to the antinomies of quantum mechanics as a physical theory, which are still unresolved to everyone's satisfaction. Instead of taking substance, both in quantity and quality and with its correlative the space-time continuum, their pasts, presents, futures and their structures, as the basis of our thinking, I suggest we turn to procedures and their products, instead of struggling with the surviving aspects of the scientific metaphysics of the 17th and 18th century.

The four root concepts will be *disposition*, *affordance*, *umwelt* and *mereological fallacy*. These are not new concepts, and each has a well-established though not without some reservations, in a particular science, disposition and affordance are in use in psychology, umwelt in ecology and the mereological fallacies have surfaced and been discussed in neuroscience and in chemistry. Along with this proposal goes one simple but fundamental step: the word 'observer' as used to refer to the human beings in a research project, should be systematically replaced by the word 'experimenter'. An observer waits passively for something to appear while an experimenter is actively engages in probing nature, just as Francis Bacon thought was the essential attitude to take. We 'put nature to the question' – we do not play the role of onlookers. In almost all the papers presented to our symposium the human being in the research context is referred to as the 'observer'.

Dispositions

This concept has had an important role in philosophy since the seventeenth century and has come to particular prominence recently in the writings of and inspired by Gilbert Ryle. Most attributes of people and less complex material things are not displayed continuously, but only under certain conditions. A gold wire is ductile all the time but it is not being stretched most of the time, and it displays its ductility only when being stretched. It is always ductile, capable of being stretched, but only occasionally drawn out into a wire. A person is not talkative all the time, but he or she displays their loquacity only under certain conditions, such as being on the telephone. To render the sense of an attribution of ductility or loquacity we need a logical form something like this: if appropriately stimulated then the being in question will display such and such an attribute. If we pause to reflect on almost everything we might want to say about people and things they turn to be at root dispositional. But what about 'yellow' you might say? Have you ever seen anything yellow under a sodium street lamp? It looks black.

The dispositions of a being are displayed in ephemeral appearances, such as the feeling of despair of a depressive, the flames of a volatile hydrocarbon, while depression, flammability and so on are permanent or nearly permanent attributes of the relevant substance.

However, we take it for granted that the matter need not rest there. Even in the seventeenth century John Locke in the course of making the world safe for Isaac Newton, suggested that qualities such as colour are nothing but powers in the relevant substance to affect a sensitive organism in a certain way because of the corpuscular structure of the substance in question. And this was not dispositional. Dispositions are grounded in long lasting primary qualities. Even in Locke's time it was pointed out that Locke's permanent groundings of dispositions are themselves dispositions.

In the 1970s and 80s a number of philosophers of science set out arguments for a thorough going dispositionalism. This took the form of defences of the concept of causal power as the grounding of actual dispositions. Acidity is a disposition and a causal power of certain substances, which is explained by the presence of H⁺ ions the positive charge of which is expressible as a disposition to behave in certain ways in electric and magnetic fields, and so on. Whether one should read the 'and so on' as an invitation to try for another layer (and some looked to cosmic structures to ground mundane dispositions, for example Mach on 'mass') or perhaps the expression of a rule, not always capable being fulfilled that whatever the next step might be it too could be the threshold for a yet deeper layer of groundings.

For the purposes of this paper I will set aside this fascinating question and concentrate on dispositions in their role as relatively permanent attributes of material systems, displaying certain characteristic ephemeral phenomena when the 'if' conditions are fulfilled. The stationary supported canon ball falls when the support is removed.

Ryle (1949) called the ephemeral attributes that are actually displayed at a certain time and place 'occurrent properties', reserving the word 'disposition' for the attribution of a permanent tendency, power or capacity to whatever it is. He made no attempt to suggest that there must be permanent occurrent properties to ground dispositions and thus account for their permanence. In psychological matters I believe he thought this was the end of the story – but as I remarked above the natural sciences at least have made use of the idea of a hierarchy of dispositions linked as sequence of successive groundings into a sequence of levels.

I will attempt to show that there are certain moves in creating a complex kind of disposition that go some way towards resolving the simple QM antinomies, those under the label of the Bohrian complementarity patterns.

Affordances

The word 'affordance' was coined by the psychologist J. J. Gibson (1977) to refer to what a certain situation made possible for a certain kind of actor. He proposed a general account of perception in terms of affordances – what we know about substances and material situations is what they afford to a human observer or a human actor in quite definite circumstances. A material set-up affords certain activities to a person or animal – such as diner/knife/cutting; wolf/ice/walking, but not to other animals. The same ice does not afford walking to an elk. It follows that the action potentials of situations exist only **as read by specific actors with specific capacities and procedural skills.**

'Affordance' has evolved into two expressions with different but related meanings:

- A practice or procedure made possible for a certain kind of agent by certain material things singly or in a group. 'A pond affords swimming but only to those who can swim, provided it is not frozen'. A sharp knife affords cutting to a competent butcher.
- A product of carrying out a possible procedure or practice in such a situation by a certain kind of agent. 'Using a sharp knife on a carcass by a competent butcher affords steaks'.

These chains that link procedures to products are of central epistemological importance

Both concepts have become prominent in the philosophy of chemistry, sparked by a paper by J. Earley (2003). Earley has argued that there is no salt in the sea, even though we all agree that the sea is briny. The apparent paradox is resolved when we realise:

Sea plus salt pan plus sun affords crystalizing to a person whose business is extracting salt. And that this procedure of crystalizing affords salt, the white crystals we use in cooking and so on.

Clearly this is a disposition story. 'If acted on in a certain in certain circumstances **then** the sea affords salt'. And this is the form of a dispositional statement.

If we are to treat physics as the exploration of material dispositions by the active intervention of experimenters of what are the products of such interventions to be affordances?

Attributes of Hybrid Set-ups

Equipment and Agent

The entity to which the attributes revealed by an experimental programme are ascribed is not the apparent analysandum, the substances acted upon, but an indissoluble hybrid of the

apparent analysandum and the equipment required to carry out the analysis. Each analysis of the apparent analysandum conducted by the use of a different analytical equipment is a property of a different hybrid entity.

The agent must also be included in the hybrid since analyses conducted by agents of different skills and knowledge are likely to be different.

Environment

How much of the total environmental setting must be included in the hybrid? J. J. Gibson took the environment to be a stable and common to each situation in which our perceptual systems afforded actions and so irrelevant as a contributor to the characteristics of an affordance, since it was, for the most part, an equal contributor to every affordance of the kind in question.

In all experimental programs the environment is an ineliminable feature of the hybrid entity whose affordances for a certain class of agents we are eliciting. However, for some practical purposes it can be presumed to be stable throughout an experimental program, so we have such simple formulas as 'at NTP'. Actively stabilising the environment and so eliminating it as an attribute of the relevant hybrid is a feature of many experiments – e.g. Michelson and Morley operating their apparatus only when the Cleveland trams were not running.

In physics the entity to which affordances are ascribed is an indissoluble hybrid of apparatus, experimenter and environment. My claim is simple – such a hybrid cannot be decomposed into components to which affordances can be ascribed. **They can be ascribed only to the hybrid as a whole.** To put this point another way, each substitution of one kind of apparatus for another, of one experimenter for another (Latour and Woolgar, 19), yields a different entity to which affordances are ascribed. Without the world in which the apparatus and experimenter are embedded there would be no experimental affordances either. But as several of the contributors to the conference noted we can say nothing about that world – so let us coin a word which has no connotations of at all – the world is just 'glub'.

There is an echo of David Bohm's distinction between the explicate and the implicate order in this account of the practice of physics', but with this qualification: the explicate order consists of the affordances of all sorts of apparatus as used by all sorts of experimenter's but the implicate order is indescribable (Bohm, 19). Any attempt to investigate it would add just more affordances. So it is a playground for theoreticians without a referee, except the good sense of the players. While we must assume that there is a universe beyond the boundaries of the hybrids to which affordances are ascribed, we can say nothing of it, except the empty remark that without a world into which the apparatus and experimenter are embedded there would be no affordances of any kind. A procedure makes an implicative order manifest, but as an explicative order, and certainly not as it is 'in itself'. The apparatus-person-glub to

which affordances are ascribed is a unitary being, which, with respect to experimentation is a singleton – though with respect to the laboratory assistant who punts it together and the administrator who pays for it, is a complex structure of lower order entities.

We should note that Gibsonian affordances include features relevant to core human practices – e.g. a sharp knife affords cutting – which can be extended into perceptual affordances, a drum affords audible beats and so affords the human practice of dancing, a radio-telescope plus computers affords the observing of galaxies and so affords the human practice of cosmology.

Here we encounter the idea of *Nested Affordances* –

- person/situation affords certain possibilities of action
- One or more of those possibilities of action when realised affords another open set of possibilities for action for a person (apparatus, or animal) engaged with the first person/situation complex.

The range of the concept of 'affordance'.

According to Gibson the human being and the nature of human perceptual systems and activities cannot be detached from the perceptual phenomena experienced by human beings. So perception affords the possibilities of action generated experiences - it does not mirror material properties of things or processes. Manipulating and its results are as important as sensory activity and its results. The apparatus, its nature and way of working, cannot be detached from physical phenomena (observations). So experimentation affords physical and chemical phenomena - it does not mirror the material properties of material stuff.

We could call this 'muted mereology' - an experiment with electron producing apparatus is not displaying particulate constituents of the atoms from which they seem to come - but affords distinct and unique tracks. We assume that these tracks are tracks of particles. But another experiment in which 'streams of electrons' are produced affords an interference pattern. Thus we arrive at first QM antinomy – the setting for the use of complementarity conceptual structure proposed by Niels Bohr.

Affordances and Solipsism

We use equipment to discover the affordances of the complex created by attaching that equipment to the world and activating it. We presume the world is always generally continuously activated! Our probes impose a secondary activation not on the world, but on the equipment/world complex. **However:** we can take note only of what the equipment/world complex affords to each human being as agent who is an indissoluble part of person/equipment/world complex. Bohr was right – ordinary language links one observer's affordances to those of each and all others

Affordance analysis implies that we cannot have unmediated access to what is responsible for the coming to be of phenomena – apparatus is never transparent. At best we can make plausible models of agencies and causal mechanisms.

Affordances and Relativism

If the concept of an affordances is used to describe an indissoluble union of an indeterminate feature of the world and a determinate method of interacting with the world, then does not this entail that the way the world reacts to the practices of human knowledge is relative to the mode with which we interact with it. Indeed it is; each mode permits a certain gamut of activities to human beings and other organisms some of which are afforded by other modes of interaction; that is other hybrid systems.

We will link this insight to the concept of the *Umwelt*, the region of the world (*Welt*) within which human beings can live.

Umwelten: The Biology of Jacob von Uexküll

In taking the first steps to a general ecology, the great Estonian biologist, Jacob von Uexküll proposed that we should recognise that each species of animal and plant inhabits a unique region of the world (*Welt*). This is its *Umwelt*. The wide and indeterminate world (the *Welt*) is not available as a living space to each and every species of animal or plant. Each species has a determinate domain (its *Umwelt*) as its life space, its scope and availability determined by the of its members capacities to perceive, manipulate and think

The *Umwelt* of a species is determined by these powers and capacities which are partly determined by its anatomy and physiology and partly by its 'culture'. Each technical innovation (material or cognitive) opens up more of the *Welt* to be part of the human *Umwelt*. There may be distinct *Umwelten* for each person at each stage in their lives.

The *Umwelt* as an open set of available affordances as action potentials each species having its own unique repertoire, though some of these skills will also be characteristics of other species..

The Human *Umwelt*

For most species of animals and plants the *Umwelt* is more or less fixed and limited, slowly evolving under Darwinian selection pressures. Human beings have been able to enlarge the species *Umwelt* by innovations – clothes to inhabit cold regions, ships to explore distant

regions, microscopes to examine regions too small to be seen with the naked eye, and so on. Thus human beings can and do enlarge their *Umwelten* by incorporating regions of the indeterminate *Welt* making them determinate. Furthermore human beings can share these enlargements by sharing the equipment and skills needed to display them.

We assign wave lengths to electromagnetic radiations that anyone with the equipment and skill can replicate and so share in this enlargement of the *Umwelt*, even to the proposal of unseen infra- and ultra- colours. We once made maps of the American continent and now make maps of the far side of the Moon.

Note the importance of techno-science and the role of equipment in the enlargement of the human *Umwelt*. Even in the most mundane of everyday activities we can see what we are doing as **reshaping the** boundaries of our *umwelt*. We prepare the ground for gardening and farming, and we developing plant and animal species to do well in given environments.

Mereology

Part-whole relations have dominated physics since the last part of the sixteenth century – beautifully expounded by Robert Boyle and John Locke in the seventeenth. There is a hierarchy of structures linking up- corpuscles into more and more complex entities which display emergent properties. Atoms are colourless, says Wittgenstein, but surfaces composed of trillions of atoms are coloured. And so on.

However, recent debates concerning the foundations of neuropsychology have drawn attention to the down side of mereological analyses of entities and their properties. It is not always valid to ascribe a property to a part of something on the basis of the fact that the whole of which it is a part displays that property, or as we would now say, affords it in a suitable set-up. Nor is it always valid to ascribe a property to a whole on the basis of the fact that its parts (under some method of decomposition) afford that property. These are the ‘mereological fallacies’. Careful discussion of these issues is important because sometimes part-whole and whole-part ascriptions are valid, which raises the question of basis of the affordances which are germane to the distinction between valid and invalid mereological projections of attributes .

The First Mereological Fallacy

It is [sometimes] a fallacy to ascribe a predicate to a part of an entity that gets its meaning from its use for an attribute of the whole entity. paradigm example is the analysis by Bennett and Hacker (2003) of the logical structure of neuropsychology demonstrating that it is a fallacy to ascribe a cognitive skill or mental state and so on, the meaning of which is fixed by its use for a whole human being, to a part of that being, for example declaring that the hippocampi remembers, the secondary auditory cortex listens., and so on. However, as we noted above, such an inference is not always a fallacy. It has been suggested (Harré, 2013) that the criterion

to distinguish the valid from the invalid mereological inferences may have to do with the principle that attributes ascribable to whole persons but not their parts are morally loaded. For philosophers this would be a special case of the **is-ought fallacy** since psychological concepts like 'remembering' are normative and the neurological concepts such as the 'neural nets' of the hippocampi have no moral implications. It is immoral to pretend to remember something when you do not! This point does have application to the work of experimenters in physics – their public pronouncements do come under moral scrutiny – was the announcement of cold fusion a mistake or a fraud? Some properties can be predicated of both wholes and their parts, e.g. mass. The same set-up is required to display 'mass-affordances' in each case, for example a chemical balance.

The Second Mereological Fallacy

It is sometimes a fallacy to project the products, that is the parts of an analytical interaction with a material substance, mass or individual, as the constituents of the original material substance as a whole. Just as the first mereological inference pattern is not always a fallacy there are cases in which this back projection is invalid. Again, what are the criteria for distinguishing the valid from the invalid cases? Dismantling a bicycle with spanner and screwdriver at NTP affords parts of the intact bicycle. Different analytical tools (e.g. acetylene cutter) bring into being different constituents of what must be different hybrid unities, because they afford different constituents of what at first sight would seem to be the same original object in a context which is rather warmer than that of the spanner and screwdriver. We have noted already that adopting an affordance based conceptual system inserts a relativist dimension into the way we must think about the outcome of experimentation as a performance. In the cases just described back-projections of products of experimentation as constituents of the original whole are not fallacious.

When is back projection of products as parts or constituents of wholes a fallacy? When the products are of an incompatible ontological category which would fit them to be parts of the original material entity. Mullikan seems to have chosen to describe the mathematical 'entities' of his analysis as 'orbitals' rather than 'orbits' to ensure that the mathematical 'look' of these formal structure did not tempt an interpreter into projecting electrons as products of the experimental manipulation of molecules back onto the prior analysed entities as things in orbits. A hybrid entity under certain manipulations affords particulate electrons, but electrons are not thereby to be taken to be constituents of molecules. By the same token memories, expressions of knowledge or belief about the personal past, meaningful symbolic representations, are not constituents of the brains that are parts of the hybrid entity that includes people asking questions in a certain language and in a certain social situation, all of which are absorbed into the hybrid unity that affords claims to recall the past.

Our world is the ever changing Umwelt. The Welt is known only as that which is **involved** in innumerable affordances but is never able to be detached and examined independently – attempting that would add yet another affordance to the catalogue of those that characterise the current Umwelt. However we unhesitatingly discuss the behaviour of electrons, ascribing properties such as ‘spin’, disciplining them with Pauli’s principle and so on. Making pragmatic use of the mereological reasoning that taken realistically would commit the second mereological fallacy we can construct **working models** of what could be the conditions for some of the affordances we can elicit.

But these have no ontological significance since the Welt is forever closed to us as such. To emphasise the point let us when talking about the make-up of the indissoluble hybrids that are the inhabitants of the Umwelt, call the Welt ‘glub’. No definite or indefinite article – neither substance nor non-substance. But without supposing that our hybrid apparatus is embedded in something, anything might happen in the Umwelt, but it doesn’t.

Affordances and the Quantum Mechanical Antinomies

The antinomies that are most salient for testing out the value of an affordance approach to the interpretation of quantum mechanics are Bohr’s three complementarities and the famous experimental, first in thought and then as a variety of actual manipulations of hybrid entities, we know as EPR.

The Complementaries

As we were reminded by Patricia Kauark-Leite there are three – particle/wave, space-time/causality and momentum/energy. To illustrate the use of the affordance approach as a resolution of the Bohrian antinomies I will discuss only the particle/wave case. A certain apparatus will reliably display point scintillations as consequences of the projection of an electron beam. A different apparatus will reliably display a diffraction pattern as a consequence of the projection of an electron beam. Apparatus of each of these types cannot be constructed at the same place at the same time. Apparatus One displays electrons as particulate phenomena while Apparatus Two displays electrons as wave phenomena. The story I have just told makes use of a vocabulary that gets its sense from models, as if we could project back into the world particles and waves. In the laboratory we have two different hybrids, indissoluble unites of experimenter, apparatus, including something which in accordance with either model we call the ‘source’, and glub. Apparatus One affords an experimenter scintillations and via the model, particles. Apparatus Two affords the experimenter light and dark interference rings and via another model, waves. There is no antinomy – there is a display of the distinct affordances of two distinct material systems as manipulated by an experimenter. It is just this pair of manipulations that affords the displays that call forth the two models – the experimenter could probably have used the equipment to make a cup of tea. Perhaps the appearance of an antinomy is the consequence of the fact

that the source of the electron beam in each case is the same in design and use, and maybe the very same equipment is used as a source in both experiments. I take care not to say 'the source of *electrons*'.

EPR and the impossible linkage

The initials are enough to recall this famous 'experiment'. The thought experiment devised by Einstein and his graduate students was intended to demonstrate that quantum mechanics was not a complete theory. But it did not disclose what was to be added to fulfil classical Laplacean ideals at least for physics. The features of the experiment I want to draw attention to arise from the linear arrangement of a left side detector, L, a right side detector, R, and a central source of a pair of particles, A and B, let us say electrons. L and R are separated in space and seemingly independent of one another. We switch on the apparatus. We choose to measure the spin along the X axis at the L detector. This act fixes the complementary spin measurement on the R detector, which can be carried out before a signal could be received from the L detector as to which of the possible measurements we have decided to make, but after L detector has been activated.

The Aspect experiment and its replications were conducted in the real world with pairs of real photons and with detectors sensitive to their polarity. Applying classical concepts within which to frame the quantum mechanical details we have to suppose that if reparability and independence of the components of the equipment are to be preserved the choice of what to measure on the left hand detector causes a complementary 'collapse of the wave-packet' at the right detector by some superluminary process. There are no superluminary processes allowed for in physics, so where do we turn? From the point of view of the laboratory assistant there are three material entities assembled in Aspect's laboratory – polarimeters 1 and 2 and the source of pairs of photons. According to the affordance view of physical experiments the whole set up is just one entity which affords correlated polarized photons when it is switched on. If we take it to pieces there are very different affordances to be manifested. Some of the equipment might be reassembled as a hybrid device the affordances of which could be used as a test for sunglasses. There are now new hybrids, not parts of old hybrids, if we think in terms of affordances, that is in terms of what can be done with them by an experimenter.

Since the totality of the equipment for the Aspect experiment is one thing there is no question as to the nature of the linkages, if any, between its parts. It is a mereological fallacy to suppose that because we can take it to pieces for use the next time we need to demonstrate the EPR effect the parts so obtained should be projected back onto the totality as its parts. Considered as the hardware for an Aspect experiment it has no such parts. How do we know it is just one entity? From the fact that we get the EPR effect! Here we reach rock bottom, just as we have learned not to question the fundamental character of constancy of the velocity of light in all inertial frames. Michelson and Morley can be seen as having demonstrated that there is no ether, but more importantly, that any further questions as to the fact that the velocity of light is the same in all inertial frames are empty. We have learned not to ask for an account of how

this can be. That is how it is. Similarly separability and independence of finite physical systems were as characteristic of the Newtonian world view as was the instantaneous propagation of light. The Aspect experiments should lead to a similar conclusion to the Michelson and Morley experiments but now about the properties of systems where the salient properties are those characteristics of subatomic entities, such as spin and polarity. That is how it is.

References

Bennett, M. R. and Hacker, P. M. S. (2003) *The Philosophical Foundations of Neuroscience*. Oxford: Blackwell.

Earley, J. (2003) 'Why there is no salt in the sea' *Foundations of Chemistry*, **7** 85 – 102.

Gibson, J. J. (1966) *The Senses Considered as Perceptual Systems*. Boston: Houghton Mifflin.

Llored, J-P. and Harré, R. (2011) 'Mereologies as grammars of chemical discourses' *Foundations of Chemistry*, **13** 63 – 76.

Harré, R. (2013) 'Discussion: Persons, higher animals and fatal semantic fractures'. *Philosophy* **88** 607 – 615.

Ryle, G. (1949) *The Concept of Mind*. London: Hutchinson.