Research Article

Occupation from a perspective of complementarity - Part 1 - Background to the development of a concept

David Turnbull[1], Ross Barnard[2]

1. The University of Queensland, Brisbane, Australia; 2. University of Queensland, Australia

'Occupation' is the focal point of inquiry in occupational science. In agreement with a recent article by Mary Lawlor, we consider that a complementary perspective is required in that discipline, to assist in its development. The current article provides background that is vital if occupation is to be understood from a perspective of complementarity. We turn in particular to Neils Bohr's (1948) account of complementarity in the context of physics, which he suggested has applications in disciplines beyond physics. At the core of the matter is the question: what is the phenomenon? Complementarity is understood as a relation between different phenomena, rather than between alternative representations of the same phenomenon. We discuss parallels in ancient Chinese philosophy in order to illustrate that complementarity goes beyond Western science and its typical worldviews. We also introduce Hussel's concept of intersubjectivity as a condition for the possibility that complementarity between phenomena can be discussed both in physics and in occupational science. In other words, the very notion of complementarity between phenomena relies on intersubjectivity. This article - Part 1 - paves the way for developing a more complete account in relation to occupational science in Part 2.

Introduction

The current article is one of a series of articles that begins with Turnbull and Barnard (2023a) and includes an article by Turnbull (2023) concerning *The Uluru Statement from the Heart*. The latter is a particular application of the concept of complementarity, the development of which is the focus of the present article and the next (Turnbull & Barnard, 2023c). Although the disciplinary context of these articles is the field of occupational science, which has been proposed as a way to study humans '*as occupational beings*' (Hocking, 2020), we take an interdisciplinary approach (Lawlor, 2021).

Occupation is not a narrowly circumscribed field of study, as is evident from the multiplicity and diversity of articles and books in occupational science, and the vast array of methodologies used. There are a number of competing definitions of occupation to consider, as we discussed in a previous article (Turnbull & Barnard, 2023a). In many respects, this inexactness concerning the phenomena under investigation is similar situation to the state of atomic physics in the 1920s. The very definition of what constituted the phenomena was then very much in dispute. The parallels between the two situations suggest that at the heart of the matter is a question about *knowing and the known* (Dewey & Bentley, 1949; Dicker, 1973).

In this article, we follow the contours of a dispute that broke out in physics, parallels of which continue within the context of numerous scientific disciplines (including occupational science and other social sciences from which occupational science draws, including biology, psychology and anthropology). The dispute involves the question: *what is the phenomenon?*

To begin, we provide a conceptual overview, in order to discuss parallels between physics and the (currently rather fragmented) situation in occupational science. This article then describes the situation in physics in greater detail. Then, in Part 2, we will apply what we have discussed in this article directly to occupational science.

An overview of a dispute in physics

Up until the 1920s, in physics, in accordance with the classical tradition of science, there was an assumed complete separation between a researcher and a phenomenon, the former defined as a subject and the latter as the object of inquiry. In 1925, Heisenberg produced the first quantum mechanical account in atomic physics. The object of inquiry was electrons, which in Heisenberg's account behaved as particles. Then in 1926, Schrödinger produced an alternative account in which electrons were described, probabilistically, by a wave function. A dispute occurred about which account was correct. This dispute was entirely to be expected, since it was in accordance with an assumption in classical physics that no two mutually exclusive accounts of a single phenomenon could both be correct. Either only one was correct, or both were false. In this case, both accounts were equally substantiated by the evidence along with their different, but internally consistent, mathematical descriptions. Leading theoretical physicists offered conflicting interpretations. Einstein proposed that whilst the theories were interesting and suggestive, neither was adequate. What the conflict between the alternative theories suggested to Einstein was that neither were descriptions of a yet-to-be-discovered, underlying reality.

In 1927 Bohr proposed that both the Heisenberg and Schrödinger accounts were '*complementary pictures of the phenomena*' (Bohr, quoted in Pais, p. 315; Bohr, 1928). Einstein disagreed with Bohr, as did Heisenberg. They did so whilst remaining firm friends, the dialogue continuing for many years. Based on the definition of the term 'phenomena' generally accepted at the time, Bohr's notion of complementarity was unintelligible to Einstein and other physicists, including Heisenberg, the latter offering his own subjectivist interpretation. The dispute between Einstein, Heisenberg, and Bohr is well discussed in Pais (1991).

In 1948 Bohr published his conceptual breakthrough. To foreshadow what we will discuss in greater detail later: phenomena can henceforth be regarded as unpicturable *subject-object entanglements*. Bohr's (1948) proposal adds a level of complexity that is not present in the 1928 article. It recognises the involvement of the experimentalist in the production of the phenomena. The phenomena require a description of *the entire experiment*, one that invariably includes the experimenter. Bohr's (1948) reinterpretation avoids describing phenomena as *pictures of objects*, as was the case in the 1928 definition, one that led to an unresolvable dispute among physicists. It also introduces complementarity between phenomena as being about *knowledge*, rather than as being about objects assumed as distinct from the knower.

Parallels with occupational science

That dispute in physics has its parallels in occupational science. At issue is the question of what constitutes the phenomenon under investigation. In occupational science, the classical definition of occupation is *'all the things that people do'* (Wilcock, 2007). Such a definition is in accordance with the principle of a distinction between the knower and the known also operating in classical physics. Similarly, at the foundation of occupational science, is a distinction between a researcher in this field and the occupations they propose as their objects of study.

The parallels in the dispute in physics and in occupational science can be traced to the *taken-for-granted status* of what is considered to be the phenomena under investigation. In 1920s atomic physics, the phenomena were assumed (as "givens") by the terminology employed in classical physics. The terms 'particle' and 'wave' were pre-existing descriptions involving *distinctly different* phenomena.

doi.org/10.32388/DVG43L

The discoveries in atomic physics in the 1920s applied both these descriptions to the same phenomenon. The rules of classical physics had been breached. At issue was a basic concern with intelligibility. As Bohr was aware, in order for science to proceed, intelligibility had to be maintained. Since 'particle' and 'wave' are mutually exclusive descriptions, it does not add to intelligibility to refer to these as 'complementary' descriptions *of the same phenomenon.* This led Bohr to revise the definition of the term 'phenomenon' and also to broaden the concept of complementarity in such a way that it is amenable to uptake into other disciplines.

Complementarity, intersubjectivity, and ancient Chinese philosophy

Complementarity, in its broadest sense, is humanistic. In science, it is to do with the very humanistic interest in interpreting the ways science is able to produce and describe an enormous variety of phenomena. Even 'objectivity' in science has a humanistic meaning, which has led to the introduction of the term 'intersubjectivity' as originally proposed by the phenomenologist, Edmund Husserl (Husserl, 1931; Duranti, 2010). The introduction of this term from phenomenology lends itself to *interpreting* complementarity in terms of intersubjectivity. (We will return to the topic of intersubjectivity later in the article.)

However, interpreting complementarity in this way involves more than the substitution of synonyms for unfamiliar words. Interpretation is *a constructive process* in the building up of concepts. The useful distinction between interpretation and construction, as relied upon in law, is actually quite blurry in the production of science. That science is involved in the very production of phenomena, beyond an elementary and inadequate meaning of a phenomenon as *the behaviour of an object*, was not immediately obvious to Bohr (as is indicated by the difference between Bohr, 1928, and Bohr, 1948), a topic to which we will return shortly.

Such considerations led Bohr to interpret complementarity in the broadest sense using the Yin-Yang symbol of ancient China. Pais (1991) provides a fascinating account that demonstrates Bohr's prior understanding of at least some of the basic elements of ancient Chinese philosophy.

> *In 1947 Denmark's highest distinction, knighthood in the Order of the Elephant, was conferred on Bohr. Tradition demanded he acquire a new coat of arms.... Hanna Kobylinski, an expert on Chinese history, the wife of close co-worker Stefan Rozental, had an idea: use the Yin-Yang symbol. Formally known as Tai-Ji-Tu. This is the diagram of the supreme poles: Yang the active male, and Yin the receptive female principle. Bohr thought this was a great idea. And*

doi.org/10.32388/DVG43L

that is how Yin-Yang was chosen, with the added motto Contraria sunt complementa (opposites are complementary.) (Pais, 1991, p.24)

However the phrase '*opposites are complementary*' is misleading. *Not all* opposites are in fact complementary. Yin and Yang (as explained in the *I Ching*; see also Waley, 1939) are a *special case* of opposites in which the one is contained in, indeed invoked by, the other, as symbolised by the dots in the classical Chinese diagram. In 1975, Jung Young Lee wrote, in a very influential book:

One of the most interesting phenomena which both the I Ching and modern science share together is the complementarity of opposites. According to the I Ching, everything consists of Yin and Yang, which are the basic constituents of all things. In other words, when there is Yin there must be Yang. One does not exist without its counterpart. (Lee, 1975, pp. 70, 71)

In our analysis, we find that Lee proceeded to apply this concept to quantum physics without first raising the question we have raised here: what is the phenomenon? Lee applied complementarity directly to objects, mistakenly assuming that phenomena are directly describable as objects, thereupon assuming a subject-object duality as inscribed into the (then and still now) dominant Western philosophical worldview.

This idea seems to be realised in quantum mechanics as well. One of the most important discoveries that Paul Adrian Maurice Dirac of Cambridge made, deals with anti-electrons. This discovery began with his study of space as the limitless sea of negative energy. However, later he found a "hole" or bubble in the sea of negatively charged electrons. This hole is known as the negation of an electron; therefore it has a positive charge. Since the discovery of the anti-electron, many other anti-particles have been discovered. (Lee, 1975, pp. 71)

Complementarity involving activity and receptivity

Bohr's (1948) concept of phenomena contradicts the view put forward by Lee. Yang is active and Yin is receptive. Symbolically, the containment of one in the other is represented by two dots. A dot representing activity is in the centre of the Yin part of the diagram, whilst a dot representing receptivity is at the centre of the Yang part of the diagram. Hence, the kind of activity involved in Yang is in principle receptive; the kind of receptivity involved in Yin is in principle active. This mutuality and reciprocity of opposites is the logical basis for complementarity. One more point needs to be added, in order to signal what is to follow. It is this very notion of complementarity between active and receptive principles that introduces the notion of holism into various disciplines other than physics. We will return to this concept *via* a discussion of the importance and relevance of the complementary active and receptive principles for occupational science in Part 2.

Taking the concept of complementarity into disciplines beyond physics

In its broadest sense, complementarity belongs to ancient wisdom and insofar as that wisdom makes an entrance into modern variants of philosophy, brings it into the closest possible connection with science.[1] However, this is in the recognition that this wisdom does not need science to justify its most basic principles, including that of complementarity. Bohr himself tried to introduce this philosophical idea into other disciplines (without much success in his lifetime). As Pais writes,

> *Complementarity can be formulated without explicit reference to physics, to wit, as two aspects of a description that are mutually exclusive yet both necessary for a full understanding of what is to be described. Bohr attempted to apply complementarity in this broad sense to other fields such as psychology, biology and anthropology.* (Pais, 1991, p. 24)

In this article and the next, we follow the lines of development of what we shall term *'a complementarity perspective'* from physics into occupational science. In examining this trajectory we arrive at a point where we are able to propose a reconceptualisation of occupation from a perspective of complementarity that accords with Bohr's (1948) redefinition of the term 'phenomenon'.

Disciplinarity and interdisciplinarity

Before we proceed, a word of caution is in order. There is an issue that has to do with the difference between disciplinarity and interdisciplinarity (Barnard et al. 2008). The latter could be seen as coming into play once complementarity is applied in the disciplines that Bohr (1948) suggested might benefit from such an approach: biology, psychology and anthropology. In moving from one discipline (e.g. physics) to another (e.g. anthropology) there are different rules or conventions of interpretation that come to apply. Discipline-specific limitations on what constitutes a phenomenon may impose restrictions on what is considered examinable, in order to make it fit within the rules of that discipline.

This raises a problem for people (like us, the present authors) who are approaching occupational science from an interdisciplinary perspective. It may well be considered a prerogative of that discipline to regard occupation as a phenomenon that is completely amenable to study from within the current paradigm of occupational science. This will impose disciplinary barriers to receptivity concerning what we have to propose. That said, we wonder whether disciplinarity insularity is compatible with occupational science's claim to be holistic.

There are numerous examples where disciplinary barriers have been overcome, leading to revolutionary discoveries and 'paradigm shifts' (MacKinnon et al. 2010; 2013). The need for a paradigm shift is especially acute in occupational science, a discipline that is predominantly descriptive rather than explanatory, although there are calls for it to develop its explanatory potential by adopting a hypothetical-deductive model (Frank, 2022).

Hitch, Pépin & Stagnitti (2014a; 2014b) describe occupational science as having not lived up to its self-proclaimed mandate to be holistic. They situate their accounts on articles published (to that date) in occupational science and occupational therapy. As Hocking (2012) argued, most of the literature in those disciplines (to that date) originates from a Western, individualist, middle-class worldview. It is not surprising that Hitch et al.'s account reflects the values and human interests (Kinsella, 2012) of the researchers from whom they drew their information. Hitch et al.'s account assumes a high degree of disciplinary insularity of their profession. As they state, 'our understanding of the four dimensions and their interdependence is the basis of *our shared understanding and culture as a profession*' (2014b, p. 260, italics added).

On this point, we include a critical note introduced by Hitch and colleagues (2014b). They wrote

> *Some believe that occupational science provides a holistic approach to the study of occupation, in a world where sections of phenomenon are often isolated for investigation (Wilcock, 2007; Glover, 2009). However, this critical analysis found few examples of a holistic perspective in occupational science and/or OT research, suggesting their belief is not fully justified. Wilcock (2007) recognized the need for parts to be linked to the whole for better understanding, and an updated and expanded iteration of the OPH may be needed to provide clinicians with a framework for achieving an integrated, holistic approach. (Hitch et al. 2014b, p. 259)*

Taking these concerns regarding holism into account, we propose that what is needed is a hermeneutical bridge of understanding to enable readers to move from Bohr's (1948) conceptualisation of complementarity in physics to its application in occupational science. In order to

doi.org/10.32388/DVG43L

commence building this hermeneutical bridge, we begin from the side of physics, and the state of that discipline in the 1920s.

The emergence of a complementarity perspective in physics

There are two phases in Bohr's development of the concept of complementarity. The first dates to around 1928, when Bohr interpreted the 'particle' description (Heisenberg) and the 'wave' description (Schrödinger) of electrons orbiting the nucleus of an atom as '*complementary pictures of the phenomena*' (Bohr, quoted in Pais, p. 315; Bohr, 1928).

The notion of 'pictures' of phenomena is in accordance with Wittgenstein's (1922) theory about the language of science in his *Tractatus Logico-Philosophicus.* Wittgenstein wrote:

> *2.1 We make to ourselves pictures of facts. 2.11 The picture presents the facts in logical space, the existence and non-existence of atomic facts. 2.12 The picture is a model of reality.*

In Bohr's 1928 account, complementarity is between pictures of phenomena. In this early version of complementarity, pictures of phenomena are derived from different types of measurement (such as measurements of position and momentum). Such pictures lead to different mathematical models. A model is not the phenomenon (the thing itself). The model and the phenomenon are split. The problem confronting Bohr was that there was a further split, represented by the different models supplied by Heisenberg and Schrödinger.

In 1928, Bohr thought that the 'wave' and 'particle' models *were incomplete descriptions of the behaviour of electrons under different experimental conditions.* First, electrons were treated theoretically as particles, and experiments were designed to allow observation of their behaviour as particles. Next, electrons were treated theoretically as waves, and experiments were specifically designed to allow observation of their behaviour as waves. Both theories were experimentally confirmed. This implies, further, that 'the phenomena' were at least partly the result of a production under specific experimental conditions. The problem then is that in the setting up of experimental conditions, the model, the means of measurement and the objects under investigation are entangled, a possibility not anticipated in Wittgenstein's *Tractatus* in which the model of reality (in which we picture to ourselves facts) is split from the things themselves. (It is worth noting in this regard, Husserl's phenomenological alternative embodied in the motto, "To the things themselves".)

Heisenberg’s interpretation was that subjectivity is involved, first in the choice of experimental conditions, and also in the interpretation of the results. Bohr was not entirely satisfied with Heisenberg’s subjectivist interpretation, based on both logical and humanistic considerations. The possibility of two mutually exclusive ‘subjective’ models as descriptive of the same ‘objective’ phenomenon leads to complete relativism in science. The consequence is that the notion of objectivity is overthrown and science itself is relativised to one of many possible ‘language games’ (a position taken by Wittgenstein in his later years. See Wittgenstein, 1953).

Rejection of the logical and humanistic consequences of subjectivism (resulting in relativism) led to Bohr’s (1948) reformulation of the meaning of the term ‘phenomena’. He wrote,

> *Phrases often found in the physical literature, as ‘disturbance of the phenomena by observation’ or ‘creation of physical attributes of objects by measurements’ represent a use of words like ‘phenomena’ and ‘observation’ as well as ‘attribute’ and ‘measurement’ which is hardly compatible with common usage and practical definition and, therefore, is apt to cause confusion. As a more appropriate way of expression, one may strongly advocate limitation of the word ‘phenomenon’ to refer exclusively to observations contained under specified circumstances, including an account of the whole experiment.* (Bohr, 1948; also quoted in Pais, pp. 432, 433).

It is worth noting the shift in thinking from phenomena defined as the *behaviour* of objects (such as electrons) under different experimental conditions to ‘*observations contained under specified circumstances, including an account of the whole experiment*’. The difference is as follows:

If phenomena are described in terms of the behaviour of objects, then there is uncertainty as to the degree to which observation changes the behaviour, which is how Heisenberg understood the situation. Heisenberg's interpretation is based on the recognition that the observer’s relationship with an object is characterised by uncertainty as to the full extent to which the behaviour of the object is changed in the act of observation. The uncertainty relations take centre stage, which in Heisenberg’s view, introduced subjectivity into the heart of physics.[2]

Whatever the differences between Heisenberg and Bohr from 1928 into the 1930s, Bohr’s recognition that complementarity is *not* part of the uncertainty relations was eventually incorporated into the so-called Copenhagen interpretation (Heisenberg, 1959).[3] Complementarity describes the situation where phenomena (which consist of entanglements between the observer and the observed) are

doi.org/10.32388/DVG43L

regarded from the perspective of their relationship with other phenomena. Complementarity is about relationships *between* phenomena.

In Bohr's (1948) account, complementarity between phenomena includes both *what is observed* and what *cannot be observed because of limitations imposed by the conditions of observation*. A quasi-objective account is appropriately supplied, albeit one that is *'not susceptible to picturable interpretation'* (Bohr, 1948, p. 314). The very notion of a non-picturable interpretation does not entirely escape Heisenberg's claim that the very act of interpretation introduces what he (mistakenly) termed 'subjectivity'. A much better term is 'intersubjectivity', to which we will turn shortly. Part of what is non-picturable are the human (social) relationships involved in setting up experiments, in performing them, and in interpreting the results. What is unpicturable is that those relationships are an integral part of complementarity between the phenomena under discussion.

At the time of the emergence of quantum physics (1920s and 30s), all the physicists were involved in very intense philosophical discussions that went to the core of what physics, and what descriptions of phenomena, inherently involving subject-object entanglements, are about. Such philosophical discussions are part of what led to the concept of complementarity relations *between* the phenomena under investigation, in Bohr's (1948) redefinition. That the 'wave' and 'particle' descriptions came to be regarded as *different* albeit complementary phenomena, and not part of *the same* phenomenon, is attributable to these discussions.

Bohr's unpicturable form of objectivity might well be described as intersubjectivity. Intersubjectivity is an inherent part of the complementarity relations. The most intense and often intractable philosophical discussions were between Bohr and Heisenberg. As Pais (1991) describes it, Heisenberg was initially unconvinced that complementarity was even necessary. He thought his own experiments resulting in 'particle' descriptions were quite adequate and that Schrödinger's experiments in which electrons were described probabilistically, by a wave function, were probably wrong. What Bohr needed to convince Heisenberg about was the need for receptivity to Schrödinger's equally well-supported experiments. That Heisenberg eventually came around to Bohr's way of thinking, at least as far as Heisenberg himself has related the story, is evidenced in chapter 3 of Heisenberg (1959).

This was not just a dispute involving individual subjectivities; it went to the heart of how the entire sub-discipline of atomic physics conceived what it was doing. Many atomic physicists from 1927 onwards were unconvinced by the complementarity idea; most notably, Einstein. That Bohr was able to convince large numbers of physicists of his way of thinking owes much to intersubjectivity

doi.org/10.32388/DVG43L

involving receptivity and dialogue (rather than simply attributable to Bohr's having a forceful personality or some such psychological reduction). There could not have been a complementarity hypothesis (the so-called Copenhagen interpretation) in quantum physics without receptivity to Bohr's ideas and ongoing dialogue about them.

That intersubjectivity does not itself resolve disputes has to be understood. Furthermore, describing intersubjectivity as 'empathy' (as is commonly done in many psychologically oriented theories) is not an adequate way to understand it, especially as an integral part of complementarity.

As we discuss below, we take an interpretive point from Duranti (2010), who in a scholarly article on the topic of intersubjectivity (a term originally proposed by Husserl, 1931) described intersubjectivity as 'conditions of possibility' that are inherent, both consciously and unconsciously, in human social relations of any sort (including between physicists).

Intersubjectivity as part of complementarity descriptions in physics and in disciplines beyond physics

Husserl's notion of intersubjectivity, as a way to conceptualise complementarity, because it has been explained in various ways even by Husserl himself, needs further explanation in this context. In what follows, we understand intersubjectivity, first, as an ideal, acknowledging that intersubjectivity involves less-than-ideal conditions of possibility for social relationships.

The Husserlian idea is that intersubjectivity is the *basis for* social relationships (the conditions for their possibility), rather than *produced by* (i.e. constructed from) social relationships (Duranti, 2010). In the latter (social constructivist account) intersubjectivity, as a relationship between an 'I' and a 'you' is derived from a pre-existing social 'we'. Here we (the current authors) turn to Dan Zahavi's (2021) alternative account. Zahavi argues against an extreme social constructivism that regards intersubjectivity as entirely the product of an existing social 'we'. He writes,

> *Rather, within a we, differences must be preserved and experienced in order to make possible a genuine being-with-one-another. One might express this by saying that the interpersonal differences must be bridged rather than erased. Heterogeneity is an essential part of communal life. But if this is so, the attempt to derive the I from the we, the suggestion that the we precedes and enables individual differentiation – be it on the level of identity or on the level of experience – must be rejected as incoherent. (p. 13)*

doi.org/10.32388/DVG43L

Both the ‘I’ and the ‘you’ are necessary conditions for the existence of ‘we’. Zahavi (2021) aligns his account with that offered by Martin Buber:

> *The idea that the you is important for the we can not only be found in Buber – “Only men who are capable of truly saying Thou to one another can truly say We with one another” (Buber 2002, p. 208) –, but also in classical phenomenologists such as Husserl and Alfred Schutz. (Zahavi, 2021, p. 17).*

This notion of the ‘Thou’, as being a necessary condition for ‘we’, in turn, can be understood as the mutuality of the ‘I’ and the ‘Thou’ as necessary *ethical* conditions of possibility for ‘we’ (the social). Of course not all socially constructed versions of ‘we’ conform to such ethical criteria. A social ‘we’ constituted as slaves is not the kind of ‘we’ that Buber, Husserl and Schutz had in mind when it came to expressing ethical ideals. Furthermore, on Buber’s and other phenomenological accounts, in differentiating between Thou and You (or *Du und Sie* in German), ethics is not simply a subjective, individualist preference or liking, nor is it a happy co-occurrence where two people meet and find that they have ideas in common. An ethics of ‘I and Thou’ involves a fundamental deep regard and respect for the other, which in Levinas (1974; 1991) is taken even further, as an infinite (unlimited) sense of responsibility for the other, called forth by the ‘the face’ of the other. Such occurrences require conditions of possibility where people can meet others, including complete strangers, sometimes in situations of dire need (or dire threat as in the case of the production of atomic weaponry). In such instances, there is a prospective or anticipated ‘I and Thou’ before there is a socially constituted ‘we’. There is no reason to believe that such matters are of no relevance to physics.

The upshot, following Bohr’s (1948) redefinition, is that complementarity is inclusive of the intersubjective relationships of those who are participants in the situation. What was at stake was finding a way to accommodate multiple phenomena within an overarching theory about the state of knowledge in physics. Complementarity between phenomena is about knowledge, not about the phenomena themselves. Descriptions of complementarity between phenomena include the limitations of knowledge, the observational equipment in use, along with accounts of conceptual and theoretical frameworks, and the worldview of the experimenters. Stated quite simply, phenomena consist of subject-and-object entanglements. The crucial change is that instead of complementarity being regarded as pertaining to alternative descriptions of *the same* phenomenon, they are now regarded as pertaining to relationships between *different* phenomena.

What henceforth defines complementarity in science is not that various descriptions 'oppose' each other; it is that there are certain *different* descriptions of phenomena that are each recognised as scientifically well supported both theoretically and by evidence. It is also recognised that since each of these descriptions has aspects of indeterminacy factored in (as formalised mathematically by Heisenberg), no one description can be regarded as complete. Since individual descriptions are recognised as incomplete by themselves, it makes sense to regard at least some of the incomplete descriptions as complementary parts in the production of a more complete account of the whole. This notion of the 'whole' (i.e. holism) is a philosophical way to conceive of an overarching unity on the basis of incomplete knowledge. It is realised that one can only perceive an unknown proportion of an underlying or overarching unity.

Such considerations are of utmost importance, as we move from physics into occupational science. We understand occupational science's claim to be holistic as being about an overarching unity on the basis of incomplete knowledge (as it is for physics). We will take this into consideration as the basis of our argument in the next article.

Conclusion

Although, in this article, the conceptualisation of complementarity has been provided in the context of physics, such a concept has applications beyond physics, as Bohr suggested. The foregoing considerations are relevant to the ways in which occupation is understood, particularly in occupational science. This article has provided historical and conceptual background that leads towards a different understanding of occupation than simply as 'all the things that people do' (in Wilcock's, 2007, initial formulation). 'Doing' in that definition might be regarded as the observed behaviour of a research subject. The observed behaviour and the perspective of the observer are regarded as distinct. That definition can be considered congruent with Bohr's (1928) early conceptualisation of phenomena based on a subject-object split. In that case, various behaviours were considered in isolation from the observer, in the same way 'waves' and 'particles' were first considered as different descriptions of the behaviour of an electron from different observers using different kinds of experimental apparatus involved in the observation.

We propose that Bohr's (1948) revised answer to the question - what is the phenomenon? - paves the way for a new understanding of occupation from a perspective of complementarity. It is towards investigating that proposal that we turn to in Part 2: Proposals for the emergence of a complementarity perspective in occupational science.

Footnotes

[1] In his book *In search of immortality: An introduction to Indic world-views,* philosopher-scientist Jaidev Dasgupta (2014) draws attention to complementarity in the Purusha hymn in the Rig Veda (pp. 45,46), noting a 'vague resemblance' between the Indic creation myth and 'the scientific picture of creation known as the Big Bang' (p. 47). Dasgupta states, 'the Purusha hymn also has the idea of production of opposite sexes from the Primeval Being that has bearing on the continuity of creation, especially, of living beings and creatures through procreation' (p. 47). During the creation process, male and female - 'the two opposite and complementary polarities' that originate from the Primeval Being - are born of each other (p. 48). He notes similarities between this hymn, 'the Book of Genesis', and 'the concept of Yin and Yang in Chinese philosophy', and, that 'modern science has its own version of the idea of contradictories as integral and complementary aspects of a single underlying reality' (pp. 48,49).

[2] This, incidentally, is a restatement of the Cartesian worldview in which doubt and uncertainty is methodologically elevated to a position whereby no ultimately authoritative utterance is possible. The logical inheritor of the Cartesian worldview is Popper's falsifiability criterion concerning the meaning of statements in science.

[3] See Howard, 2004, for a statement of the underlying difference between Heisenberg and Bohr. See also, Heisenberg, 1959, esp., chapter 3. What is unclear in Howard's account is the date of that difference, and any account of how that difference came to be resolved, even if only in part.

References

- Barnard, Ross T., Damian Hine, and Philip Mackinnon. (2008). Interdisciplinarity and Interprofessionalism: Implications for Biotechnology Education. *The International Journal of Interdisciplinary Social Sciences: Annual Review* 3 (3): 163-172. doi:10.18848/1833-1882/CGP/v03i03/52559.
- Bohr, Neils. (1928). The quantum postulate and the recent development of atomic theory. *Nature* 121, 580–590. https://doi.org/10.1038/121580a0

- Bohr, Neils. (1948). On notions of causality and complementarity. *Dialectica,* 2: 312-319. https://doi.org/10.1111/j.1746-8361.1948.tb00703.x
- Dasgupta, Jaidev. (2014). *In search of immortality: An introduction to Indic world-views.* Manohar
- Dewey, John & Bentley, Arthur, F. (1949). *Knowing and the Known*. Boston: Beacon.
- Dicker, Georges. (1973). Knowing and Coming-to-Know in John Dewey's Theory of Knowledge, *The Monist*, Volume 57, Issue 2, 1 April, Pages 191–219, https://doi.org/10.5840/monist19735723
- Duranti, Alessandro. (2010). Husserl, intersubjectivity and anthropology. Anthropological Theory, 10: 1-2 https://doi.org/10.1177/1463499610370517
- Heisenberg, Werner. (1959). *Physics and Philosophy. The revolution in modern science.* London: George Allen & Unwin.
- Hitch, Danielle, Geneviève Pépin & Karen Stagnitti. (2014a). In the Footsteps of Wilcock, Part One: The Evolution of Doing, Being, Becoming, and Belonging, *Occupational Therapy In Health Care,* 28:3, 231-246, DOI: 10.3109/07380577.2014.898114
- Hitch, Danielle, Geneviève Pépin & Karen Stagnitti. (2014b). In the Footsteps of Wilcock, Part Two: The Interdependent Nature of Doing, Being, Becoming, and Belonging, *Occupational Therapy In Health Care*, 28:3, 247-263, DOI:10.3109/07380577.2014.898115
- Husserl, Edmund. (1931). *Ideas: general introduction to pure phenomenology.* [Trans. by W. R. B. Gibson]. Macmillan.
- Hocking, Clare, (2020). Editorial, *Journal of Occupational Science*, 27:2, 155-157, DOI: 10.1080/14427591.2020.1757396
- Howard, Don. (2004). Who invented the Copenhagen Interpretation? A study in mythology. *Philosophy of Science* 71: 5. http://www.jstor.org/stable/10.1086/425941
- Lawlor Mary C. (2021). An untold story: A unifying narrative of the discipline of occupational science, *Journal of Occupational Science,* 28:2, 208-220, DOI:10.1080/14427591.2020.1844041
- Lee, Jung Young. *(1975). The I Ching and modern man: Essays on metaphysical implications of change.* Secaucus, NJ. University Books.
- Levinas, Emmanuel. (1991). *Totality and Infinity: An essay on exteriority.* Kluwer Academic Publishers.
- Levinas, Emmanuel. (1974/1998). *Otherwise than Being or Beyond Essence.* (Tr. Alphonso Lingis). Duquesne University press.
- MacKinnon, P., Rifkin, W.D., Hine, D. and Barnard, R. (2010). Chapter 2: Complexity and mastery in shaping interdisciplinarity. Davies, M., Devlin, M. and Tight, M. (Ed.) *Interdisciplinary Higher Education: Perspectives and Practicalities* (*International Perspectives on Higher Education Research, Vol.*

5), Emerald Group Publishing Limited, Bingley, pp. 29-53. https://doi.org/10.1108/S1479-3628(2010)0000005005

- MacKinnon, P.J., D. Hine & R.T. Barnard (2013). Interdisciplinary science research and education, *Higher Education Research & Development,* 32:3, 407-419, DOI: 10.1080/07294360.2012.686482
- Pais, Abraham. (1991). *Neils Bohr's Times, in Physics, Philosophy, and Polity.* Oxford: Oxford University Press.
- Turnbull, David J. (2023). The Uluru Statement from the Heart – A consideration from three perspectives. *Qeios.*
- Turnbull, David J. & Barnard, Ross T., (2023a). A preliminary investigation of what occupational science is doing. V.2 *Qeios.*
- Turnbull, David J. & Barnard, Ross T., (2023c). Occupation from a perspective of complementarity, Part 2. Proposals for situating a complementarity perspective in occupational science. *Qeios.*
- Waley, Arthur. (1939). *Three ways of thought in ancient China.* London: Allen & Unwin
- Wilcock, Ann A. (2007). Occupation and Health: Are They One and the Same? *Journal of Occupational Science,* 14:1, 3-8, DOI: 10.1080/14427591.2007.9686577
- Wittgenstein, Ludwig. (1922/2001).*Tractatus Logico-Philosophicus.* (Tr. D.f. Pears & B.F. McGuinness). Routledge Classics.
- Wittgenstein, Ludwig. (1953). *Philosophical investigations.* Macmillan
- Zahavi, Dan. (2021). We in Me or Me in We? Collective Intentionality and Selfhood. *Journal of Social Ontology*, 7(1), 1-20. https://doi.org/10.1515/jso-2020-0076

Declarations

Funding: No specific funding was received for this work.

Potential competing interests: No potential competing interests to declare.