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**Operant Subjectivity**
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# Complementarity in Q Methodology and Quantum Physics

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***Abstract:*** Complementarity is a term used in quantum physics that represents the idea that two contrasted theories are necessary to explain a situation. As an example, physicists can describe light (conceptually and mathematically) as a wave and, separately, as a particle. Individually, these two theories can only explain part of how light behaves. Stephenson drew on the idea of complementarity, with a nod given to philosopher, psychologist, and pragmatist William James, by linking his methodology to the principle of complementarity brought forward by Niels Bohr in quantum theory. Within Q methodology, Q technique and Q method are conjoined and result in a factor structure that provides states-of-feeling, each represented by a theoretical Q sort. In other words, each theoretical Q sort is itself self-referent, forged from individuals' states-of-feeling. In this way, Q methodology assumes multiple divergent views exist about a psychological event or topic, even within a single-case study. These multiple states-of-feeling are necessary to explain the subjectivities and behaviors at hand, whereas assuming a singular-view cannot provide that insight. Such a situation also represents the difference between classical and quantum physics. This paper will draw on complementarity in physics to help clarify how and why complementarity comes into play within Q methodology.

***Keywords***: complementarity, Q methodology and complementarity, quantum physics

## Introduction

Stephenson's approach to social science research within his creation of Q methodology blends ideas from psychology with physics. Brown (1992) stresses that Stephenson's drawing on quantum physics is far from analogous. Furthermore, Stephenson (1986a) explained that *thought* "requires quantum-theoretical exploration" (p. 519). With PhDs in both physics and psychology, Stephenson was uniquely positioned to combine these fields into something new and unique. However, Stephenson's published writings about the linkages between Q methodology and quantum physics began after his retirement from the University of Missouri in 1972. Moreover, Stephenson's writings about the quantum physics connections with Q have had very little effect on the larger Q community and Q publications. It is truly rare to see any mention of the quantum physics aspects of Q methodology in the literature. As Stephenson (1988c) stated, Maxwell Born had critics regarding quantum physics theory, but, his theories were eventually accepted. The same was not true for Stephenson who faced much criticism for his methodology. In as much as Born challenged classical physics, Stephenson's

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challenges to mainstream psychometrics and psychology seem to have been more problematic.

This manuscript addresses the use of complementarity in Q methodology in relation to complementarity in quantum physics, as introduced by Niels Bohr, with the purpose of improving our understanding of the quantum aspects of Q. Perhaps, if those interested in Q have a better understanding of its quantum aspects, including complementarity, we will see fewer studies that discuss how to "improve" Q by using more participants or fixing perceived statistical violations, among other suggestions (e.g., Akhtar-Danesh, 2017; Kampen & Tamás, 2014).

## Complementarity in Physics

Bohr introduced complementarity in physics in 1927 at a lecture in Como, Italy (Holton, 1988; Stephenson, 1986a). Bohr was a Danish physicist who made foundational contributions to understanding atomic structure and quantum theory, for which he received the Nobel Prize in Physics. Yet, he was also a philosopher and a promoter of scientific research (Holton, 1988). Bohr explained that quantum physics led to a complete revision of scientists' conception of the nature of matter (Holton, 1988; Wilson et al., 2010).

In classical physics, an observer can measure forces and motion directly, without affecting these values. Scientific laws and models, such as the kinematic equations, represent these observables and measurements. However, in quantum physics, quantum states (such as an electron's position) cannot be observed or measured directly. Additionally, measurement and observation influence the quantum state. Thus, whereas classical physics has the possibility of causation, this is not the case in quantum physics. Instead, quantum physics is based on indeterminacy, statistical descriptions, and probabilistic functions (Holton, 1988). Within the realm of light, propagation of light as a wave obeys electro-magnetic theory (classical physics) yet, once the subject changes to conservation of energy and momentum (such as the photoelectric effect), explanations must become based in quantum physics (Holton, 1988; Semat, 1963). Bohr's 1927 proposal was that the dichotomy (wave versus particle) should be accepted as complementary rather than reconciled, something that had not been fruitful within theoretical physics (Holton, 1988). In order to understand complementarity in Q it is important to understand the bases for both the wave and particle theories of light (Ramlo, 2022a).

### Wave-Particle Duality

In 1801, Thomas Young performed his famous double-slit experiment. In that experiment, a single, coherent light source is separated into two parts by passing through two, narrow, and closely positioned slits before striking a screen. If light was made up of particles, a single line of bright light would appear. Instead, the light provided a pattern of dark and light fringes on the screen. These fringes are the result of wave interference between the two light sources. Thus, Young, using his double slit experiment, demonstrated that light acts like a wave. A modern-day application of light acting like a wave is the use of non-reflective coatings on a lens such as that used in eyeglasses (Wilson et al., 2010).

However, about one hundred years after Young, scientists could not explain the light (electromagnetic radiation) given off by hot objects, known as thermal radiation. Although calculations based on classical physics could predict thermal radiation at longer wavelengths (e.g., infrared, $10^{-3}$ to $10^{-7}$ meters), the same was not true for shorter wavelengths especially once those wavelengths entered the ultraviolet spectrum region ($10^{-7}$ to $10^{-10}$ meters). Physicists needed a new way to explain thermal radiation given off at these shorter wavelengths.

In 1900, Maxwell Planck found that he could explain the entirety of the spectrum given off by thermal radiation. An explanation required a new theory. He determined that light's energy must be quantized. In other words, each light particle has a discrete amount of energy that corresponds to the light's wavelength and frequency. This frequency is associated with the atomic oscillations of these particles. The product of Planck's constant, h, and the frequency, f, associated with a light particle (photon, or quanta) is called a quantum of energy. The word quantum comes from the Latin *quantus*, which means "how much." Einstein then used Planck's work to explain the photoelectric effect (one of his four great papers of 1905). Einstein's combined set of four papers (referred to as the "annus mirabilis" papers, a phrase taken from Latin meaning "extraordinary year") substantially contributed to the new "Modern Physics" era. A modern application of light as a particle, or photon, is the electric-eye circuit used as a safety mechanism in automatic garage door openers. Within that application, the light source shines on an electric eye to complete an electrical circuit. The door continues to open or close unless that beam of light is broken. The interruption in energy transfer by the light stops the door from moving (Wilson, et al., 2010).

Yet, the new idea of photons could not explain certain aspects of the earlier classical findings regarding light. This left two contrasting theories to explain light in different situations. Quantum physics was necessary to explain the photoelectric effect and other experimentally observed results. However, only classical physics (via the wave nature of light) could satisfactorily explain the physical observations of light interference and diffraction (Eisberg & Resnick, 1974). Therefore, sometimes physicists must apply classical physics theory (when dealing with light wave interactions) and at other times they must apply quantum physics theory (when light interacts within small, quantized systems that are at the order of magnitude of atomic dimensions). This dual nature of light, sometimes called the wave-particle duality, represents a form of complementarity in physics (Eisberg & Resnick, 1974; Semat, 1963; Wilson, et al., 2010). In fact, both electrons and photons exhibit wave and particle characteristics (Hewitt, 1998). The wave-particle duality represents an empirical matter (Stephenson, 1986a) that is addressed through complementarity (Bohr, 1928; Holton, 1988).

**Probability Functions**

Changes in quantum physics continued during the early 20$^{th}$ century. One of those changes was Erwin Schrodinger's conception of an equation that represents how matter waves (of multiple types of particles that act like waves) change when influenced by outside forces. Schrodinger's Wave Equation is as important to quantum physics as Newton's Second Law is to classical physics (e.g., $F_{net} = ma$ where the sum of the forces acting in one direction, $F_{net}$, is equal to the product of the object's mass (m) and its acceleration (a) in that same direction). As seems familiar to any Q methodologist, the matter waves of Schrodinger's equation are not directly observable (much like someone's subjective viewpoint). In Schrodinger's equation, the wave function is represented by the Greek letter psi, $\psi$ (Eisberg & Resnick, 1974; Hewitt, 1998). Additionally, the wave function is associated with the particle's kinetic energy, potential energy, and total energy (Wilson et al., 2010). This wave function, $\psi$, represents the possibilities that occur for a system. Yet, there are finite, rather than infinite, probabilities for finding a particle at a specific location or its energy values (Hewitt, 1998).

This is where Heisenberg's Uncertainty Principle comes into play. Heisenberg's Uncertainty Principle is another way of describing wave-particle duality. The uncertainty here has nothing to do with measurement instruments (e.g., accuracy or precision). Instead, the wave concept acts as a limitation for the particle concept. Heisenberg's Uncertainty Principle characterizes this limitation (Semat, 1963). In other words, Heisenberg's Uncertainty Principle is an expression of the indeterminacy that exists within the laws of quantum physics (Born, 1953; Eisberg & Resnick, 1974). However, indeterminacy, Heisenberg's Uncertainty Principle, and complementarity are all quantum theoretical characteristics that Stephenson (1982, 1986b, 1987a, 1988a) also attributed to Q methodology.

## Q and Complementarity

Classical psychometrics and psychology, like Newtonian (classical) physics, represent the idea of testing scientific laws and models. These laws and models are based on observations that have no impact on the observed. The focus is on large data sets, aggregate values, tests of reliability, statistical considerations, etc. (e.g., Stephenson, 1981, 1986a, 1988c). Additionally, "objective science characteristically speaks with one voice, with everyone's agreement" (Stephenson, 1987a, p. 39). In contrast, Stephenson (1953) described Q methodology as like a new house built from old bricks. Although Stephenson acknowledged that his methodology drew on existing principles, he also stressed that his novel, radical methodology was in itself something brand new. Among the principles Stephenson used to build this methodology was complementarity, taken from quantum physics, but applied in Q via Q technique and Q method. Yet, individually, Q method and Q technique are not Q methodology and cannot represent a quantum physics approach to subjectivity. Additionally, the quantum physics paradigm represents a different philosophy of science for Q methodology compared to more classical approaches in psychology.

### Q technique vs Q method vs Q methodology

Before delving into the case of the quantum aspects of Q methodology, it behooves us to delve into the distinctions between Q technique, Q method, and Q methodology. Spearman created factor analysis and mentored Cyril Burt and William Stephenson. According to Stephenson (1988c), Burt was the first to publish on how the mathematics of quantum physics and factor theory were identical and formulated for the same purposes. In both cases, the purpose was to understand natural phenomena, although the first was related to physics and the other to psychology.

**Q technique.** In psychology, to embrace the quantum world, Stephenson understood that a new way to capture the probabilistic data of subjectivity was necessary. The creation of Q technique, the sorting of self-referent items, provided this quantum-based way of collecting the internal, self-referent data required for Q methodology (Stephenson, 1981, 1988c, 1990a). Q technique also removed the need for definition of terms, large sample sizes, and tests of validity (Brown, 1980; Stephenson, 1953, 1981, 1986a, 1986b, 1988c, 1990a).

Stephenson (2010) explained that, although he did not realize it at the time, Q technique was the first use of quantum theory in psychology. It was Q technique, which he called a "new probabilistic," that offered a "new way to measure everything subjective" (Stephenson, 2010, p. 247). Thus, Q technique brought quantum theory to subjectivity (Stephenson, 1988d). In a 1992 paper, Steven Brown notes that "(q)uantum theory ended for all time the bifurcation of measurement and thing measured, or between knower and known, and this is particularly salient when using Q methodology under conditions of multiple performance by the same person" (Brown, 1992. p. 8). The measurement of subjectivity is complex, but the acceptance of self-reference offers a fundamental means of knowledge (Stephenson, 2010), much like photons offer a fundamental basis for quantum theory in physics. As a result, Stephenson (1987b) stressed that, within psychology, like in physics, the role of the observer is crucial and, therefore, so is the need for Q technique that offers the ability to provide the self-referent viewpoint of the observed. Thus, a participant's Q sort allows us to see what is inside, distinguishing the data used within Q from that used within Burt's factoring of persons where the data came from (external) tests. In other words, Cyril Burt's factoring of people did not provide states of feeling because he used tests rather than Q sorts for data (Stephenson, 1981, 1986a, 1986b, 1988b, 1990b). Similarly, Carl Roger's work did not provide states of feeling because he did not factor analyze the Q sorts he collected (Stephenson, 1988d).

In Q technique, a Q sample is drawn from a concourse of items that reflects the communications on a topic. Every person receives the same Q sample and distribution. The participant interprets the meaning of each Q sample item and places it within the distribution based on their internal viewpoint. This Q sort represents a probabilistic measurement of subjectivity for that person. As Brown (1980) discussed, the reliability of a Q sort is at least 0.80 (yet likely not 1.00). In other words, if a person sorted the same set of items into a distribution multiple times, under the same condition of instruction, the sorts would be highly correlated but not necessarily exactly the same. This is what is meant by a probabilistic measurement. Because it is a probabilistic measurement, Stephenson preferred the indeterminate centroid factor extraction for Q method, further embracing quantum aspects of Q. As noted above, in physics, the principle of indeterminacy is also known as Heisenberg's Uncertainty Principle (Heisenberg, 2007).

**Q method.** Q method represents the factor analytical stage of Q methodology. The sorter(s) and researcher are unaware of the underlying factors prior to the completion of this stage (Stephenson, 1953, 1987a). The goal of Q method is to find operant structure of the Q-sort data. Operant means that the structure reflects that of the natural phenomenon (i.e., reality). Thus, the goal of Q method is not based on statistical considerations, as was the classical psychometrics of psychology, but theoretical significance as described by Thomas and Baas (1993). Theoretical significance results in operant structure and thus reveals the operant subjectivities related to a topic. The researcher uses abduction, as Spearman originally envisioned factor analysis explorations, to seek this operant structure (Stephenson, 1990a, 1990b). The operant solution provides the necessary states of feeling to describe the divergent viewpoints that exist, based on the Q sorts, about the topic at hand (McKeown & Thomas, 2013; Stephenson, 1981, 1988c). In other words, Q method provides the necessary structure to the quantumstuff of the Q sorts (Stephenson, 1986a, 1988c). It is not until the structure is found that meaning can be made via interpretation (Stephenson, 1990b).

The resulting factors (divergent viewpoints) are quantumized in that they obey the principle of complementarity (Stephenson, 1986b). Multiple divergent viewpoints exist about the topic, even in the single case, but those views are complementary, meaning that to describe the reality of the subjectivity of the psychological event/topic, one must consider the multiple views that exist about that event. The idea of multiple, divergent viewpoints existing about such an event embraces a different philosophy of science than the idea that one can determine a single aggregate view based on a qualitative or quantitative study using instruments such as surveys. However, the "quantum realities" (p. 10) do not appear directly from the Q sorts (Stephenson, 1988c). Thus, the larger methodology of Q requires the conjoining of Q technique with Q method.

**Q methodology.** Yet the philosophy of science required to accept multiple divergent viewpoints (different states of feeling) is a core aspect of Q methodology as well. As already stated, the goal is to provide states of feeling, especially for single cases (Stephenson, 1988c). Yet, to provide these states of feeling, the Q methodologist must also embrace a certain philosophy of science and this philosophy requires the rejection of large numbers, statistical considerations, and researcher definitions. The latter represent the framework from traditional psychology and Newtonian physics. Instead, Stephenson presents the idea of probabilistic states of feeling that are in alignment with the probabilistic states in quantum physics (Stephenson, 1981, 1982, 1983, 1986a, 1986b, 1987b, 1988a, 1988b, 1988c). These are not absolutes but provide the bases for developing theory — whether in psychology or in physics — that reflect natural phenomenon. The structure consists of the states of feeling provided by the factor analysis of the Q-sort data.

### Stephenson, Quantum Physics, and Q

Stephenson wrote 14 published articles specifically addressing the connections between quantum physics and Q methodology (Stephenson, 1981, 1982, 1983, 1986a, 1986b, 1987a, 1987b, 1988a, 1988b, 1988c, 1988d, 1990a, 1990b, 2018) but only hinted at these connections within his earlier text *The Study of Behavior* (1953). Stephenson (1981) wrote:

> It was only late in the 1970s that I could satisfy myself about the pragmatics of quantum theory in subjective science (Stephenson, 1980): It required the putting together of communication theory, concourse theory, the operantcy of factors, and Newton's Fifth Rule, to make tangible what had previously been mainly an exciting analogy between physics and psychology, for matter and mind (p. 132).

Yet it is unclear if Stephenson simply delayed mentioning the quantum aspects of Q methodology or if this was something that did not occur to him until the late 1970's, after he had better established the framework for Q (Stephenson, 1981, 1988c). Certainly, there are redundancies of thought across most of these papers although each has a slightly different setting or narrative for the convergence of quantum physics and Q methodology. Stephenson's message is nonetheless clear: Q methodology is based on indeterminacy, statistical descriptions, complementarity, and probabilistic functions, just like quantum physics.

In his 1988c article Stephenson notes that the creation of Q technique in 1935 marked the beginning of bringing quantum physics to psychology. However, the origin of drawing quantum aspects into Q remains somewhat unclear. Yet, Stephenson (1988c) makes his psychological postulates clear:

> First: any psychological event (PE) can be transformed to "quantumstuff" by a concourse of self-referential statements belonging to the PE.

> Second: operant factor structure for a PE is subject to Bohr's principle of complementarity, providing psychological quanta, the fundamental phenomena in subjective nature. (p. 7).

**Relevant Publications by Stephenson**

Of Stephenson's 14 articles related to Q methodology and quantum physics, some discuss the linkages between Q methodology and quantum physics, including those with words like "quantum" and "complementarity" in their titles such as Stephenson (1981, 1986a, 1986b, 1988b, 1988c, 1988d). Other titles are a bit less direct including "How to make a good cup of tea" (Stephenson, 1987a).

Stephenson (1987a) begins by addressing how Harold Lasswell's idea of "conflicting possibilities" is a representation of complementarity. This seems typical of many Stephenson's later "quantum" papers where the impetus was an article or text written by another researcher. He then discusses this researcher's work, and then compares and contrasts it with Q methodology. For "How to make a good cup of tea," the title becomes clearer as Stephenson discusses the difference between the typical process of someone making a cup of tea and the subjective aspects that might be associated with such an activity. Subsequently, the article turns to a single-case study about how a certain gentleman might see the subjective aspects of making a good cup of tea under multiple conditions of instruction. Stephenson then describes the result on par with what Lasswell called "decision structures."

In articles such as "Cyril Burt, quantum theory, and Q: Historical note," Stephenson (1981) explained the importance of combining Q technique with Q method. He then draws on physicist Heisenberg's statement about the impossibility of separating the empirical process of observation from the resulting mathematical constructs (Stephenson, 1981, p. 125). In other words, Stephenson again drew on quantum physics to explain something important about Q methodology — that Q technique and Q method are part of a larger quantum-based methodology.

In his 1981 article, and others, Stephenson reminded us that the factor analysis of people as suggested by Burt is not the same as Q methodology or even Q method. In short, when Q factor analysis groups people in ways that do not involve the collection of Q sorts, it is not Q methodology and cannot provide the necessary states of feeling. Thus, Q methodology requires the conjoining of Q technique (Q sort) with Q method (Q factor analysis). One without the other cannot provide the scientific exploration of subjectivities. Certainly, the work of Burt (e.g., Burt, 1941) often inspired Stephenson's writings (e.g., Burt & Stephenson, 1939; Stephenson, 1981).

The work of Bohr and William James inspired Stephenson (1986a, 1986b, 1987b, 1988b, 1988d) to publish a series of five manuscripts titled "William James, Niels Bohr, and complementarity" with the following subtitles:

I. "Concepts"
II. "Pragmatics of a thought"
III. "Schrödinger's cat"
IV. "The significance of time"
V. "Phenomenology of subjectivity"

One can choose to read these individually or out of order. Certainly, there are some repeated ideas and concepts within each. Yet, it is best to start from the beginning in our overview of this series.

The first article, “Concepts,” has Stephenson (1986a) introducing complementarity, including how James and Bohr envisioned it. James introduced the idea of complementarity in psychology in 1891. Although some have questioned whether Bohr was familiar with James’ work prior to his 1927 talk in Como, Bohr did close that talk with the following statement:

> 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, 1928, p. 590).

Stephenson (1986a) further explained in “Concepts” that Bohr’s quantum theoretical approach to nature led to the concept of complementarity in physics. He also described Bohr as interested in the subjective and objective in psychology. This is further revealed in another quote from Bohr:

> For describing our mental activity, we require, on 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 view point, 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. Indeed, 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, 1987, p. 96).

It is important here to mention that Bohr explained that the need to focus only on normal (classical) language restrains the ability to impose a clear separation between an atomic “object” and the experimental equipment (Holton, 1988, p 155). As Stephenson summarized after discussing Bohr and James in “Concepts”:

> …there is obvious indeterminacy of quantum action in every thought we have, in every experience of free will. The most obvious phenomena of all psychology, that of thought, was grasped by James and now by great physicists as demanding quantum theoretical exploration… Thousands of scientific journals, and tens of thousands of psychologists all over the world, continue, ostrich-like, enveloped in an "ideal causality" that cannot possibly explain a simple thought! (Stephenson, 1986a, p. 525).

In the second article, “Pragmatics of a thought,” Stephenson (1986b) differentiated his Q methodology from the classical and causality science of psychology by describing it as quantum theoretical. Specifically, Stephenson describes transformation of experience into operant factors as quantumization of the mind. He also expands the discussion on James’ conceptualization of transitive and substantive thought, which James called complementary, compared to complementarity in physics by Bohr.

Stephenson again, like the other articles in this series, states that Q methodology offers a new epistemology for the study of subjectivity that is based in transitive thought, complementarity, and quantum physics (Stephenson, 1986b).

In "Schrodinger's Cat," third in the series, Stephenson (1987b) calls for the rejection of classical psychology including causation, determinism, and reductionism. Instead, he calls on psychology to embrace the role of the observed, self-reference, communicability, and complementarity. Stephenson provides a single-case study to frame the concepts discussed across the first three articles in the series in *The Psychological Record*.

In the fourth article in the series, "The Significance of Time," Stephenson (1988d) discussed how, in Q methodology, "we seek to accommodate indeterminism in both psychology and physics by way of the quantum theoretical principles of Bohr, particularly with regard to complementarity as the focus of creative thought" (pp. 19-20). His discussion immediately turns to metaphysics in relationship to considering time and uses this as the basis to describe how the factors in Q are time independent (p. 21). Further discussions of time in subjective psychology leads to Stephenson's conceptualization of the single case where time (or specific experiences across a range of time) is part of the multiple conditions of instruction. However, these sorts are produced not across time but within a time that can be considered t=0, now.

The last of the series, "Phenomenology of subjectivity" (Stephenson, 1988d), discusses phenomenology as created by Edmund Husserl. Interestingly, Husserl, like Stephenson, had a background in physics and mathematics. Yet, Husserl focused his work on philosophy. Stephenson described Husserl's work as reducible to Q methodology because it embraces some of the same philosophy of science principles that Q does, including the idea of complementarity. More specifically, Husserl envisioned a system of interconnected propositions based on communications. These propositions would then reflect the natural phenomenon, regardless of the type of science under study. However, Husserl discusses consciousness rather than Stephenson's notion of communicability.

In other articles by Stephenson (e.g., 1981, 1982, 1983, 2018) he also addresses how Q technique and Q method, as well as the overall methodology of Q, fit within quantum theory. These articles capture Stephenson's excitement about quantum physics and the idea of bringing quantum principles to psychology. This quantum approach requires a new philosophy of science, removed from classical philosophy of science. Stephenson envisioned Q as setting the discipline of psychology free of its constraints to allow for the scientific study of subjectivity.

## Q Sort as Quantumstuff

Subjectivity is akin to the subatomic world, which requires acceptance of indeterminacy and uncertainty (Brown, 1981). Yet, only a participant, the knower, can provide their internal viewpoint about a topic. Otherwise, the researcher can only infer someone's view. Thus, Stephenson (1953) rejected that subjectivity can only be inferred. Instead, measuring subjectivity is facilitated by Q technique, which provides the ability of a participant to capture their own viewpoint within their Q sort (Brown, 1980; Stephenson, 1953). Stephenson (1986b) emphasized that Q technique is based in quantum theory, where "observer and observed are conjoined in a self-referential form" (p. 529).

Thus, any concourse is the "quantumstuff'' of Q methodology (Stephenson, 1981, 2018). Stephenson (1982, p. 51) explained that quantum theory also applies to the collection of items sorted because this collection constitutes a “subjective event of referentiality” for a given context. During the sorting process, participants reflect on each item in the Q sample. The participants, not the researcher, interpret each item’s meaning. Based on their item interpretations, the participant then places each item into a grid of Most to Most. This sorting process is reflective and self-referent (Brown, 1980; Stephenson, 1953, 1986b).

The participant’s Q sort provides a snapshot of their subjectivity. However, the sorting process might influence the sorter as his subjective viewpoint comes into greater focus (Stephenson, 1953). This idea of the measurement tool affecting the object’s position is like the situation in quantum physics where the probability function is influenced by its interaction with the measuring device (Heisenberg, 2007). Stephenson (1982, 1986a, 1986b) explained that each Q sort provides a probability distribution (just like a quantum state). In turn, every subjective thought represents evidence of complementarity such that those thoughts are captured via Q technique (Stephenson, 1986b). Yet, unlike mass, which is a fundamental physical quantity that does not change — whether the object is on Earth or on Alpha Centauri — the probability distribution from a Q sort is not set in stone. However, this situation does not imply imprecision or inaccuracy. For both the Q factor structure and the quantum states for a system of particles, mathematical analysis offers the finite states of behavior. In other words, after Q technique is applied, the *quantumized* factors are found for a given context via Q method (Stephenson, 1982, p. 43).

**Finite States-of-Feeling**

Q method represents the factor analytic stage within Q. The mathematics of factor analysis and of quantum physics are identical (Brown, 1992; Ramlo, 2006). However, it can be easily argued that the factor analysis in Q is more mathematically and conceptually connected to quantum physics than R factor analysis. Stephenson (1986b) explained that factor theory, in its more general form, is quantum theoretical. Burt (1941) also described factor theory as quantum theoretical but was not speaking about correlating people in the same way Stephenson did. What separates R methodology from Q methodology, as well as Burt from Stephenson, was discussed in their co-authored paper (Burt & Stephenson, 1939). Although there was agreement, Burt and Stephenson’s differences of opinion were primarily methodological when it came to factor analyzing persons. Stephenson (1952) best explained this difference by stating:

> By postulation, R and Q always involve two quite different, and singly centered, tables of correlations, each subserved by its own distinctive quantitative and qualitative principles. It is therefore a mistake to argue as though all that is involved is a single matrix of data which, when correlated down the rows is R, and along the columns is Q (p. 484).

Stephenson (2018, p. 27) continued:

> *Observation* in quantum theory doesn't mean what we say when we observe flowers in a field: it refers to the *indeterminateness* of measuring the *simultaneous* values of various quantities. A particle in nuclear physics can have position and velocity, but not *both* simultaneously. The more we try to measure the one, the more the other is "deeply hidden." In Q technique, of the two influences at work *simultaneously,* one, pleasure-unpleasure, is rendered static at a mean of *zero* for

> every Q-sort; this leaves the other, for self-description, free for measurement by factor analysis.

This argument reiterates how factor theory in Q was adapted to fit the requirements of *states-of-feelings,* not individual psychological attributes (Stephenson, 2018). These states of feelings cannot be reached via the classical, causal manner of quantitative analyses. Yet the operant factor structure that emerges from factor analyzing the Q sorts provides us with descriptions of the *states-of-feeling* that exist within the context under study. Stephenson (1986b, p. 537) compared these *states-of-feeling* to quantum *states-of-energy*. Like the states-of-energy in quantum physics, the operant structure within a Q study is not arbitrary but intrinsic to the data provided by the Q sorts (Stephenson, 1953, 1986b). Yet, these states of feeling often supersede social and physical categories, offering something new that is not possible to study via classical psychometrics. These characteristics may be used to select a diverse P set but are not relevant when it comes to the states of feeling that emerge in Q (Brown, 2008).

Thus, the quantized operant factors of Q reveal the subjectivity (Stephenson, 1988d). In other words, the mathematics of quantum physics and Q have the goal of revealing a "genuine feature of nature" (Stephenson, 1986b, p. 537). Thus, whereas the quantum wave function, ψ, represents the finite states (energy, position) for system of particles (Hewitt, 1998), factors within Q offer states-of-feeling (Brown, 1992; Stephenson, 1953, 1981, 1986b). Yet both the quantum states-of-energy and the Q states-of-feeling offer the finite set of possibilities for behavior.

Each Q factor represents a unique viewpoint. These Q factors are representations of likelihoods, not of certainties (Stephenson, 1981, 1986a, 1986b, 1987a, 2018) despite the fact that the Q factors that emerge from the analyses are implicit and operant (Stephenson, 1982, 1986b). The same is true for the quantum states-of-energy in quantum physics as they represent probability functions. Thus, the connections between Q and quantum physics go beyond the mathematical foundations of factor theory in psychology (Ramlo, 2006; Brown, 1992; Stephenson, 1982, 1983, 1986b). Stephenson saw Q methodology as rooted in quantum theoretical concepts as noted in his writings discussed in this manuscript. Similarly, McKeown and Thomas (2013) described the factor analysis in Q as a means to reveal states-of-mind. These Q factors, as well as their representations of "states-of-mind," can be interpreted as indeterminate and probabilistic functions. They describe subjective communications as inherently indeterminate.

Recall that, in quantum physics, the wave concept acts as a limitation for the particle concept and that Heisenberg's Uncertainty Principle characterizes this limitation (Semat, 1963). In other words, quantum energy-states are mathematical entities that provide probability distributions for the system's behavior. Stephenson (1982, 1986b, 1987b, 1988b) linked complementarity and Heisenberg's Uncertainty Principle to Q methodology. Within Q, Q method acts as a limitation for Q technique by offering probability distributions (factors) based upon the measurements (Q sorts). Yet any mathematical solution (factor analysis) does not change the basic characteristics of the data but, instead, offers quantumized operant factors via Q method (Stephenson, 1982, p. 43) where these factors offer states-of-feeling. In summary, Q methodology applies quantum physics principles and philosophy of science to describe subjectivity. More recently, and without mention of Q methodology or Stephenson, Uher (2015) stressed the need for researchers to employ philosophy of science foundations to their studies.

## A Non-Q Example

Recall that divergent states of feelings cannot be reached via the classical, causal manner of quantitative analyses. However, what does this mean exactly? Stephenson frequently gave examples of how this complementarity played out in Q studies, especially single-case studies. Instead, I will offer a non-Q example. This example is one that I often use to explain why someone would use Q to study subjective opinions rather than another method.

Over a decade ago, my then-department chair went through a regular evaluation process. The evaluation primarily consisted of qualitative comments and the scoring of his skill at being a department chair using a 7-point Likert scale. The evaluation committee provided a summary of the results. For the Likert scale response, the mean was about 3.5. Nevertheless, the comments just did not seem to fit that result. Plotting the individual scores demonstrated that the view "in the middle" did not even exist within the faculty. There were at least two different views where one set of scores was around 1 and 2 (Most Disagree) and another set around 6 and 7 (Most Agree). Even by examining the comments, the differences could not be reconciled without determining the states of feeling via Q methodology.

Certainly, student evaluations of teaching (Ramlo, 2022b) and other similar evaluations have the above problem in addition to having the mean value accepted as representing the assumed singular view related to the topic or experience. This is the difference between a quantum view of subjectivity and a classical view of subjectivity. Yet the result from the classic view does not match the phenomenon at hand. To explain the entirety of a situation, such as evaluating a chair or a faculty member or a multitude of other events or phenomenon, the multiple states of feelings need to be found and described. In other words, we cannot understand the subjectivity of an event or situation without capturing and understanding the multiple views that exist. To understand only a single view when there are, for example, three unique views is to restrict one's full understanding of the situation. This is complementarity in Q.

## Extended Reflection

Conversations about complementarity in psychology have continued since Stephenson's passing, often without mention of him or Q methodology. Uher (2019) stated, "methods should be adapted to the properties of the phenomena under study" (p. 226). More specifically, Uher (2015) stressed that researchers need to use philosophy of science foundations and to match phenomenon under study with appropriate methodologies. Such a stance can be seen in works by Stephenson (e.g., 1953, 1986b). Nonetheless, Uher (2015, 2019) makes no mention of Stephenson or Q. Although she discussed research in the physical and social sciences, she differentiated the ability to find a shared perception of a physical phenomenon from one that is a psychical phenomenon. This position is similar to Stephenson's differentiation of classical versus quantum approaches to psychology.

Uher (2019) stated that psychical phenomena like emotions and opinions can only be perceivable by each individual. Thus, she appears to be in agreement with Stephenson (1953, 1986b) but does not cite him or mention Q methodology. Moreover, Uher (2019) stressed that it is crucial to distinguish methods that enable investigation of psychical phenomena from methods that are incapable of doing so. *Introquestive methods* are what Uher (2015, 2019) called those research procedures for studying phenomena that can be perceived only from within the individual. Uher (2019, p. 234) specifically states:

> Introquestive methods are needed to help individuals become aware of and conceive the psychical phenomena under study, such as through inner self-observation. The introquesting individual must then externalize the outcomes of its introquestion to make them accessible to others, such as through self-report. These externalizations can only be made by the individual under study. Therefore, introquestion denotes not only trained or guided inner self-observation as this is common for introspection but broadly denotes all methods relying on inner self-observation and self-report.

Her comment about finding means to externalize the internal reflects the ideas of the self-referent Q sort which provides the necessary quantumstuff for any Q study. However, it is worth noting that her notion of introquestive methods is not really compatible with Stephenson's view when it comes to rejecting the bifurcation of the knower and the known. Nonetheless, both Bohr (1987) and Uher (2015, 2019) discuss the need for fields such as psychology to explore complementarity. Stephenson's writings and methodology provide this necessary complementarity in psychology, specifically, and social sciences more broadly. Yet, it is to be regretted that Stephenson's work in this area continues to be ignored by those within and external to the Q community.

## Conclusions

Stephenson (1987b) explained that objective science aims to determine a singular voice that embraces agreement. However, Stephenson's Q methodology seeks something entirely different for the scientific study of subjectivity. Stephenson recognized that the agreement sought by objective science did not fit the study of subjectivity. Instead, complementarity, establishing and describing the multiple subjective views about an event or topic, is necessary for subjective science. As Bohr (1987) explained, we must be prepared to accept the fact that a complete elucidation of meaning defies a singular, unique description. Thus, Q methodology is based on indeterminacy, statistical descriptions, complementarity, and probabilistic functions, just like quantum physics.

For this reason, it is important for the Q community to have a better understanding of Stephenson's views about the quantum aspect of his approach to subjectivity. Certainly, the complexities and novelty of Q methodology require moving beyond the processes of performing a Q study. Examining wave-particle duality, the emergence of quantum physics, complementarity, and Heisenberg's Uncertainty Principle helps to explain much of what Stephenson was talking about when he blended quantum physics principles with Q methodology.

Stephenson's (1982, 1983, 1986a, 1986b, 1987a, 1987b, 1988a, 1988b, 1988c, 1988d, 1990a, 1990b, 2018) discussions connecting quantum physics, including complementarity, with Q methodology further demonstrate that Q is a unique and esoteric methodology that borrowed old bricks to build something new that was often misunderstood and misinterpreted. Stephenson knew that physicists describe light (conceptually and mathematically) as a wave and, separately, as a particle. Individually, these two theories can only explain part of how light behaves. Studying the mind is much like studying light. Initially, there was the classical approach, based on direct observations and external tests. These studies involved large numbers. Yet, matters of the mind and of internal subjectivities cannot be observed directly. Physical characteristics, such as male/female and short/tall, and societal characteristics are unrelated to a person's internal subjectivity (Brown, 2008). To scientifically study subjectivity, a new epistemology was necessary (Stephenson, 1986b).

Studying mind/subjectivity requires probability functions and indeterminism, taken from quantum physics and embodied in Q (Stephenson, 1981, 1986a, 1986b, 1987a, 2018). Stephenson (1987a, 1987b, 1988b, 1988d) provided examples of complementarity and probability functions in Q by offering a variety of single-case studies. In each of these examples, a single participant sorted the Q sample under multiple conditions of instruction. The states of feeling that emerged offer insight into the mind and behaviors of the participant. This is complementarity in Q and in psychology. Nevertheless, those outside the Q community such as Uher (2015, 2019) discuss the need for complementarity and ways to determine the internal subjectivities of participants but never mention Stephenson or Q.

Additionally, Stephenson (1981) explained that the empirical process of observation cannot be separated from the resulting mathematical constructs, an idea based on the work of physicist Heisenberg in relation to quantum physics. The same is true for Q technique and Q method. To describe the divergent subjectivities about a topic, whether within a single-case study or one with multiple participants, a researcher must employ both Q technique and Q method, within the larger methodology called Q. Social and physical categories are superseded by states of feeling in Q. If the Q sort and factor structure are not used in tandem, states of feeling cannot be determined, and the quantum aspects of Q are not fulfilled. Additionally, those interested in Q must abandon thoughts of large numbers, statistical improprieties, etc. To do so is to reject the classical view and embrace quantum thinking and Stephenson's vision of Q methodology. Our work as Q methodologists must move beyond discussing the processes of Q, from Q sample to interpretation, as well as uncovering a set of views about our topic. As Steven Brown posed to our ZoomQ community in 2022, as examiners of subjectivity, Q methodologists should also discuss subjectivity at its core as well as addressing the complementarity and other quantum aspects of Q. They also need to read closely and draw further on Stephenson's work.

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