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Quantum Physics and the Future of Psychology

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Quantum theory is still novel in physics and new findings are regularly reported. The theory affirms that the atomic and subatomic universe consists of quanta: individual particles. Quantum theory coexists with traditional continuum physics, which posits gradual differences that are interpreted in a dichotomous manner, similar to diagnostics in psychology. The consequences of a quantized universe are revealing for understanding life, determining what happens inside living beings on the subatomic level, and how this affects consciousness and behavior. Hard-core evidence as to a relationship between quantum aspects and consciousness has been forthcoming. However, present theories that extrapolate theoretical insights from quantum physics to real-world actions, specifically psychological science, remain speculative and controversial. I argue that psychologists need to have a basic knowledge of quantum mechanics and be familiar with quantum terminology and its meaning. Consciousness theories, in a growing number, describe possible quantum effects on mind and behavior, which indicate a role in psychopathology. Any proposed "quantum treatments" require further critical evaluation before clinical use is warranted.

Keywords: psychology theory, psychopathology, quantum theory

The terms quantum psychology and quantum consciousness have been used since the 1990s to defend a non-Aristotelian and neo-skeptical concept of psychological "reality," in both a material and a conceptual manner (Wilson, 1990). Things never "are" but instead "appear to be" because quantum physics considers reality to be of a multiple nature, probabilistic in its tangible results. This implies that psychological values and conditions should always be considered temporary evaluations, dependent on the observer. In classic twentieth-century psychology, these evaluations are tainted with presumed values and interpretations, considered by Hegelian Max Stirner (1907/1995) to be "spooks": observations without scientific value other than being indications as to the characteristics of the individuals using these statements. Stirner proposed, as does quantum dynamic theory,

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that realities may be "caused" by the observer through the very act of observing. Present psychological theory and clinical knowledge is rife with "truths" that are defined and justified on a basis of observed or inferred phenomena, although their essence is unproven. In quantum science, however, the undefined-until-observed rule stands tall. In the present debate between absolute and interpretative truth, especially in psychology, elementary concepts of quantum physics are relevant for questioning what our previously established classic science, our philosophical tradition, and our history of knowledge still consider as "proven facts."

Clinically Relevant Quantum Concepts

Quantum theory is a foundation for modern physics to explain the behavior of matter and energy on the atomic and subatomic level. Quantum physics, quantum mechanics, and quantum dynamics are synonymous terms as used here. The term quantum is used for the smallest observable amount of a physical entity involved in an interaction, such as the photon in the electromagnetic field.[1] Thus light, or any electromagnetic phenomenon, is not a continuum but consists of discrete units: it is quantized.

All photons of a frequency have the same invariant energy, proportional to their frequency. However, the electrons they form may differ in energy depending on their original energy state prior to absorbing light. The positions of electrons are also quantized, meaning that an electron moves by instantly jumping from one position to the next, thus not moving in a continuous path. There is immediacy; there is no time lag.

Ralph Kronig discovered that electrons behave as if they rotate about an axis. They have "spin." If two electrons spin in opposite directions, they may occupy the same place and orbit. This is somewhat like a positive and a negative image occupying the same place. The same "place" can also be occupied through "superposition," theoretically of an unlimited number of elements. A laboratory set-up of a superposition of 20 qubits has already been created. This is a large number and indicates that millions of bits/data can be instantaneously shared when atoms merge with adjacent atoms. The merger simultaneously forms two opposite configurations or excitations occupying all even or odd sites. This way wave functions overlap, and superposition is created of the opposite configurations, a phenomenon known as the Greenberger–Horne–Zeilinger state (Omran et al., 2019).

Particles that originate from (are "born" in) the same atomic event have "entanglement": another form of instant communication. This condition may loosely be compared to psychological concepts such as "empathy" in the sense of

[1] Quanta are defined in physics as the smallest quantity of radiant energy, equal to Planck's constant times the frequency of the associated radiation.

unintentionally sharing a strong emotional link. However, entangled particles are demonstrated to be related in a physical and absolute sense. Changes in one particle happen instantly to the other particle, whatever their distance in the universe. When entangled particles form part of separate neural systems, changes exerting identical influences may affect consciousness in different systems.

When considering quantum particle communication, it is important to note that the mere act of measuring particle rotation changes the system the particle belongs to (or the particle itself). Therefore, the probability of a specific result of measurement is predicted by Schrödinger's "wave function." There is now enough evidence of quantum probability, spin, immediacy, entanglement and local realism, quantization, and matter/energy equivalency, to explicitly recognize their direct bearing on neural and thus psychological functioning (see Conclusion #3). In any case, not all the properties of any system can be measured at the same time and thus must be described by probabilities. Human behavior also relates to a system, and psychology works in terms of probabilities and (very) seldom in terms of absolute values.

Quantum mechanics applied to large systems should approximate their classic description, as per the correspondence principle. If this principle is bi-directional, the traditional knowledge of large systems such as brains implicates and contains the quantum properties of its components, however small or indirect. In traditional knowledge these underlying properties remain unexplained. The already experimentally established properties also apply to matters relating to consciousness. Negative consequences of quantum properties must be considered a possibility and relevant for a still hypothetical quantum psychopathology (see Conclusion #4).

Specific Issues for Psychology

According to the Newtonian worldview, everything observed has a physical origin and a thing's connections can be explained as mechanical (brain) "state" interactions. However, quantum dynamics researchers found that other causal mechanisms participate and construct "action" realities (Heisenberg, 1958; von Neumann, 1955). Thus, the dynamics of the human brain cannot be understood without the axiom of quantum dynamics that appears to separate the physical universe into two parts, each with a proper language. First there is the human observer and her measuring instruments. Then there is the system the observer is acting upon (Bohr, 1963). The brain's behavior depends on atomic and subatomic processes; some of the processes are explained by classical physics, and others are not. The brain's subconscious processing of any dilemma generates a host of parallel and partially conflicting models for action. As simultaneous processing of only two different tasks increases response latency drastically, the local processing of a great number of alternatives is ruled out by limited traditional neural capacity (however

large) [Fischer and Plessow, 2015]. Quantum systems within the neural systems have the much greater capacity needed for consciousness (Schwartz, Stapp, and Beauregard, 2005), which cannot be understood without quantum knowledge (see Conclusion #1). An unlimited simultaneity of alternatives is produced, but who chooses and how? What becomes reality?

Heisenberg's uncertainty principle contends that certain particle quantities, such as position, energy, and time, are unknown, except by probabilities, so accurate knowledge of complementarity pairs is impossible. One can measure the location of an electron, but not its momentum (energy) at the same time. This commonly is explained with Schrödinger's parable of the cat in a closed box with a cyanide capsule that may or may not rupture, thus only by looking inside the box can we answer the question of whether the cat is alive or dead.[2] Physicists warn that the question is meaningless and without probability value until the observation is made; that the "state of the system" is indeterminate until the box is opened, at which point the system "collapses" to some state, only the probability (and not the certainty) of which can be calculated using quantum mechanics. Wave/particle duality or uncertainty does not, however, negate real existence but it warns against singular explanations.

Quantum physics is part of this transdisciplinary psychological science as to how and why conscious perceptions come into (our) existence and what absolute value they have. However, affirmations that psychology has a "quantum basis" posit a characteristic that in psychology only exists hypothetically, at most. As said, quantum theory explains that not any "thing" exists in a permanent state of specific characteristics. Quantum science explains that any "is" necessarily includes all possible states of that reality for an observer, the latter being not a specific person but a hypothetical statistical entity comprising an infinite number of observations. The influence of the characteristics of "the observer" and the circumstances impinging on any "is" or perception should therefore always be considered.

Quantum theory changed scientific concepts such as capacity and probability, and parallel developments in classical psychology questioned the scientific meaning of the terms "is" (a perception) and "nothing" (a non-perception), especially in semantics (Quine, 1948/1949). Quantum physics offered a phenomenalistic ontology. The scientific foundation of this undetermined reality in psychology has produced a "cognitive science" that recognizes the influence of quantum effects in cognitive phenomena (Broekaert, Basieva, Blasiak, and Pothos, 2017; Bruza, Wang, and Busemeyer, 2015) and constitutes, in a novel multidisciplinary manner, a "science of consciousness." Since the early 1990s, the materializing overlap among physics, psychology, neuroscience, and mathematics forms the center of studies, among others by Hameroff (1998; see also Hameroff, Craddock, and

[2] The commonly used term "uncertainty principle" does not mean that the referred duality is not a certainty, or that the uncertainty only affects one alternative.

Tuszynski, 2014; Hameroff and Penrose, 2014) at the University of Arizona as well as Penrose's (1994) work at Oxford. Quantum theory and quantum realities form part of those efforts. Of interest to consciousness studies is that any intended or accidental "contact" with a particle will decide one-or-the-other final state of the observed. In a parallel with psychology, any interhuman contact necessarily will have psychological consequences, whether intended (therapy or manipulation) or incidental. In clinical psychology, the consequences of non-intended communication may prove hard to explain. As we have seen, quantum effects may produce such unintentional communication.

In physics, observational communication may result from physical contact with a particle (photon) or by non-physical means such as wave harmonization, also called a "strong coupling." Thus, commencing an observation (focusing a spotlight, so to speak) does not necessarily require a physical means, and "awareness" of a particle through entanglement or a strong coupling is sufficient to alter the states of all affected particles. An "accidental" observation would produce information that was not sought but just perceived; however, it also changes the state of the object. It may depend on how one "looks" and what one is looking for, but the particle/wave duality is held to define itself (or "collapse") into one or the other state upon any, even an accidental, observation. Therefore, what is known as "reality" in quantum physics essentially depends on a fugacious link that was not necessarily sought. Another cause of wavefunction collapse may be observer-independent, such as a gravity-induced reduction in the neuron tubulin, leading to an objective (versus subjective) collapse, and known as the Diósi–Penrose criterion. In combination with what is known as the Zeno effect, the quantum collapse or change into a determinate state may either be delayed or accelerated, which shows the relative value of the term "measurement."[3] Does measurement reflect what "is" or does it merely fixate one aspect of a fluid, multiple, thus indeterminate, state with dual, triple, or infinite possibilities? If the latter is true, then a datum presented as a fact because it was "measured as such" would at most reflect an observed state which would have scientific relevance only insofar as the results of a great many identical measurements coincide. This point of departure is the essence of experimental psychology, and also of quantum physics. The important difference between the two is that statistics produce data from a limited (however large) pool of observations, while quantum physics postulates inherent uncertainty as a permanent and unavoidable characteristic of any "fact," thus converting fact into probability.

Classical psychology theory coincides with, but also differs importantly, from the dictums of quantum physics. A special effort is asked of psychologists

[3] For Greek philosopher Zeno of Elea and the arrow paradox: at any given instant in time, an arrow in flight is motionless; how then can it move? In quantum dynamics the "quantum Zeno effect" (QZE): observational acts can hold a positive feedback in place over an extended time interval (Misra and Sudarshan, 1977)

for understanding a series of difficult-to-explain and surprising concepts such as non-locality, non-time, superposition, teleportation, immortality (Verresen, Moessner, and Pollmann, 2019) and other quantum phenomena among which, perhaps most interesting to psychology, are the phenomena of "entanglement" and "superposition." As said and as experimentally confirmed, quantum mechanisms would provide consciousness with the capacity for processing the brain requires.

Again, most results of quantum concepts fit with existing experiential clinical knowledge. The caveat is that quantum concepts may explain in a completely different way how psychological means and methods exert influence on the workings of consciousnesses. "Quantum cognition" is one of the recent theoretical efforts to calculate a probable presence of quantum effects in psychology (Bruza, Wang, and Busemeyer, 2015). Evidential support for quantum relevancy for psychology is growing.

Further Support for Quantum Relevance

Propositions as to a psychologically relevant quantum mechanics have been forthcoming for decades (Aerts and Aerts, 1994; Margenau, 1967), but only recently with experimental support (Omran et al., 2019). Earlier approaches considered quantum reality the result of probability analyses, as is Bayesian statistics. The now available evidence pertaining to quantum entanglement confirms that unconnected elements and biologic entities may remain intrinsically linked since their origin, whatever the distance.

Entanglement is observed when particles such as photons, electrons, or atoms that have a common origin, keep behaving similarly however far apart. If one of them acquires Kronig's "spin" in one direction, then the other instantaneously spins in a corresponding manner. Research has experimentally confirmed quantum entanglement and has demonstrated instant information teleportation between an electron and a photon (Bouwmeester et al., 1997; Tsurumoto, Kuroiwa, Kano, Sekiguchi, and Kosaka, 2019).

Psychology studies communication and processing. According to the science of consciousness, human communication is partly quantum-based, specifically through entanglement (Tsurumoto et al., 2019). Using a nano-technological laboratory procedure called wave-technique Shi, Kumar, and Lee (2017) were able to make pairs of cell proteins turn (acquire spin) and observed ensuing entanglement between the members of these pairs. The resulting "communication" between pairs was instant, as theory proposes, which means that quantum effects may have a direct influence on the communication between living cells (see Conclusion #2). Some years earlier, Tegmark (2000) had calculated such consequences to be impossible on account of "decoherence": the effect causing the loss of quantum properties of a quantum object through interactions with the environment. Decoherence in living cell environments was thought to cause a rapid decay of quantum

properties before any influence on neurons could take place, so Shi's results were surprising. Moreover, Fisher (2017) found that other molecules may also play a role in quantum effects becoming biological. For instance, the nuclei of phosphorous atoms have spin (a quantum effect) and are omnipresent in the brain. They clump with other ions in "Posner molecules," and thus slow down decoherence, enough for quantum effects to have an influence on neurons.

Quantum entanglement, superposition, and spin, as well as empathy and belonging, are relevant concepts for consciousness by way of the "quale" concept. Qualia are unified and singular products of consciousness that form from experience, such as the color red or the smell of frying bacon. They combine information of different origins into a stable unit. How and where that occurs is "the hard problem" of consciousness, of the experience as such, but quantum characteristics explain qualia (Chalmers, 1995, following Nagel).

An equally tempting research question is to what extent psychological stimuli may, in any of their many applications, change the psychological support structure by altering the *physical* (brain) state of its subjects, as happens with some psychological treatments (Mason, Peters, Williams, and Kumari, 2017). Structural change may be due to the genetic mechanism of *mutagenesis*: when genetic information of an organism changes by accident or intent and results in a mutation. This may enhance or reduce genetic structure. A growing number of empirical studies confirms the neuroplastic capacity of directed attention and mental effort to systematically alter brain function. Thus, structural changes may be provoked by psychological or biological (including quantum) means, or both (Schwartz et al., 2005). Psychologists are familiar with techniques directed at changing people's behavior, for many purposes. Some of those techniques involve interaction, observation, and other elements of communication. As said, according to quantum notions, any psychological interest or contact would have quantum effects and determine the "state" of the entity (person) observed. Consciousness includes these involuntary and instant mechanisms. Consequently, nothing is excluded or hidden from this reciprocal flow of information and its consequences. This approach goes beyond earlier proposals as to a supposed interconnectedness of all biological constructs as a result of the quantum properties of the electrons of which a body is composed (Lipton, 2005). Present evidence puts in doubt that behavior influences genetics, and instead posits that one's conduct results from quantum-determined epigenetics. Barbara McClintock was among the first to develop a theory of epigenetics as the source of novel genetic variations which might "vary according to the nature of the challenge to be met" (McClintock, 1978, p. 25). She considers a gene to represent a field of possibilities through the interactions of orthochromatin and parachromatin components. Interactions produce possibilities, but no certainty. Quantum theory covers a similar uncertainty, but the application goes beyond the theoretical (Jorgensen, 2011). The determination of what "state" a gene will obtain reflects the influence of quantum mechanisms as

described above, making epigenetics an example of the biological reflection these mechanisms already may produce in the zygotic unicell (Torday and Miller, 2016). The process is not random, as psychological conditions will determine to what extent these biological reflections produce genetic change. This recent research begins to clarify the question as to the interrelevance of quantum properties and psychological mechanisms.

Biological Structure in Traditional and Quantum Psychology

Earlier we looked at how quantum properties affect consciousness, and their influence on genes, or biological (brain) structure. Since Hobbes and Descartes, comparisons between brain and machine have been frequent. Modern computational theory (Edelman, 2008; Edelman and Shahbazi, 2012; Fodor, 1975; Putnam, 1995, 2015) explains psychological processing in a different way. The brain processes qualia, which are complex neural images or concepts. So-called "neural" computer networks, said to imitate neuronal systems, must break down images or concepts into much smaller units which are then digitally processed while constantly adjusting for probabilities. This process differs essentially from how the brain processes information (Alvarez–Melis and Jaakkola, 2017).

The Newtonian suggestion that any existing thing has a physical structure should be considered a fallacy. There is no definite structure even after a first collapse of the wave/particle function has resulted in an identified state, or when referring to the protein strands known as microtubules and their function as neuronal or subneuronal "structure." Time turns anything we may call a structure into something "fluid." That also applies to the human neural structure which continuously changes its geometry and capacity. The child's brain is different from the adolescent or adult brain. The alpha-amino-3-hydroxy-5-methyl-4-isoxazolepropionic acid (AMPA) synapse receptors form and disintegrate continually, within a fraction of a second, rather than existing as stable entities (Morise et al., 2019). Structure is a temporary condition. But this conclusion does not need quantum science. In the medical and psychological fields, professionals are trained to consider any given physical or mental context as changeable and receptive to treatment.

Clinically, however, this dictum may not always be applied to its full extent, and mental disorders usually receive standard or manualized treatment, resulting from a consensual systematization of past experiments, ideas, statistics, or even serendipity. Out-of-discipline identifiers, such as incidental biological vulnerabilities to mental disorder, are seldom discovered through scientific process. In our case, quantum properties are to be considered out-of-discipline identifiers. As we saw, any change in structure related to neural processing may be produced immediately or may take place epigenetically, over time. Resulting changes in consciousness and mental process may be subtle or drastic and affect behavior in different ways. Quantum processes may serve as epigenetics, converting changes

into "hard" features. This implies that observation of and contact with the patient may in itself produce structural changes. We are aware that when a patient learns to prevent or reduce anxiety, structural changes will be forthcoming, but quantum physics argues that even when there is no perceptible learning process there will still be structural changes. We do not know beforehand their direction or impact.

The Plastic Brain and Quantum Physics

Psychology assumes that any application of rules resulting from a specific model depends on choices made and experiences lived. The decision process pertaining to rules uses simultaneous and multi-concept or "fuzzy" logic (Zadeh, Klir, and Yuan, 1996) which may be quantum based. Changes to a rule may become encrusted in the genes (Dawkins, 1989). As indicated earlier, many studies document psychological mechanisms underlying biological changes to the brain. Ever since Ramón y Cajal, we know that neuronal structures respond to use. Experience and training may be reflected in structural aspects of the brain after a relatively short time. A neuron may form a new dendritic spine and synapse(s) within 20 minutes, structurally reflecting knowledge stored. Neurons, dendrites, and synapses grow and retract, depending on requirements. The brain keeps changing and growing at least into mid adulthood (Gage, 2004). Age or health-related shrinkage or atrophy in brain structure occurs (Burgmans et al., 2009) but use-related influences continue. Neurogenesis in the hippocampus has been confirmed to occur not only at a young age but throughout life (Boldrini et al., 2018; Sorrells et al., 2018). Circumstances, in the form of psychological and biological influences play a role in brain structure change (Thomaes et al., 2014).

However, quantum dynamics is an independent system underlying and parallel to the known biological neuronal system. Neuronal microtubules contain quantum systems for non-computable consciousness processing (Hameroff, 1998). The proposal has been criticized (Baars and Edelman, 2012; Tegmark, 2000) but has found support in new evidence (Hameroff and Penrose, 2014). The quantum systems underlying brain processing indicate entirely different ways in which consciousness and psychological states may originate and be transmitted. Specific changes may occur instantaneously, for instance, through entanglement or superposition. This phenomenon is not to be confounded with unfounded theories as to genetic changes being produced at will (Lipton, 2005).

Clinical Psychology Manuals and Quantum Effects

Therapeutic content and efficacy differ considerably across persons, treatments, and therapists. Manualization of therapies has improved results to some degree, but personally adjusted approaches remain more efficacious. A good therapeutic relationship and client variables are considered discriminating factors

for treatment efficacy (Campagne, 2014; Hubble, Duncan, and Miller, 1999). As quantum factors affect communication, do they have a role in in clinical psychology? To answer this question, we must realize that quantum factors are not (yet) manageable. They cannot be applied at will. They are always produced, at a quantum level, separate from, although affecting, consciousness and cognition. We have no specific means for their measure. Nevertheless, if their presence explains aspects of neural functioning and thus consciousness, then psychology should be aware of possible implications. Quantum-produced pathology should be further investigated (Hameroff, Craddock, and Tuszynski, 2014).

Conclusion

There is growing evidence of atomic and subatomic processes and occurrences influencing mind, consciousness, and behavior. As a result, a general knowledge of quantum physics and its most salient phenomena has become relevant for psychology, both in theory and in practice. Psychologists need to have an open mind for these implications. Primary indications are:

1. Human neural processing capacity is many times larger than originally thought, if quantum capacity is considered.
2. Consciousness and psychological functioning are co-dependent on the influence quantum processes have on living cells.
3. Psychologically important phenomena, in classical reality without scientific explanation, such as entanglement, immediacy, teleportation, and immortality have been demonstrated to exist at a quantum level.
4. Psychopathology may have origins in underlying quantum processes, a possibility that needs investigation.

In the wake of this growing research evidence, non-scientific explanations of supposed "quantum effects" in psychological processes have appeared, with unsupported therapeutic propositions. Caution as to supposedly "quantum" psychologic therapeutic propositions is warranted. Therefore, professionals need adequate information to separate fact from fiction. Applied quantum-psychological transdisciplinary research is still a terra incognita and requires further research.

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