

## Commentary on Elio Conte's "On the Possibility that We Think in a Quantum Probabilistic Manner"

Huping Hu

### Abstract

Conte shows that indeterminism, entanglement and interference in quantum mechanics can be formulated with Clifford algebra. These formulations then allows him to address possible quantum-like properties in human cognition. Conte also proposes a new logic to connect cognitive function to measurement in quantum mechanics. This new logic is based two new mathematical theorems proven by him and it is the reverse of the matrix logic proposed by von Neumann. Conte and his colleagues have also carried out important experiments demonstrating quantum-like entanglement and interference in human cognition.

**Key Words:** Clifford algebra, Pauli matrices, indeterminism, interference, quantum mechanics, logic

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In this work Conte presents a new & brave synthesis of quantum-like cognitive functions based on his theoretical work on Clifford algebra formulation of quantum mechanics and experimental work on quantum-like entanglement and interference in human cognition (Conte, 2010).

Conte begins his paper with eye-opening and insightful accounts on several topics. They include currently available technologies for studying the brain; works done by others such as Walker, Eccles, Beck and Margenau on possible quantum effect such as electron tunneling in the brain; systems such as the Zak & Zbilut's model which violate classical determinism (e.g., the

Lipschitz condition); Mumford, Jaynes and Cox's work in probability theories; and his own Clifford algebra formulation of probability in quantum mechanics.

Conte's main points here are the following: (1) The probability field in quantum mechanics associated with mental events trigger/determine physical/neural events; (2) Aristotelian logic is part of probability theory which in turn can be deduced from the single primordial idea involving information; and (3) Human thinks in quantum probabilistic manner as follows:

*[A human has] a given background knowledge... information<sup>l</sup>, [his/her] brain work[s] in a manner so that it has the ability to attribute a degree of plausibility to any new statement... A...on the basis of the background knowledge<sup>l</sup>. I [in turn is] relate[d to] the human mental condition that he has [at] the moment in which<sup>A</sup> is posed... his knowledge, feeling, rationality, emotions, and so on. [That is,] brain*

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Corresponding author: Huping Hu, Ph.D., J.D.,  
Address: QuantumDream, Inc, P.O. Box 267, Stony Brook,  
NY 11790.  
e-mail: hupinghu@quantumbrain.org  
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*attributes a degree of plausibility by evaluating the real quantity  $P(A/I)$  in the context dependent condition in which  $A$  is posed... [So, a]t the level of [neural] structure, according to Eccles, Beck and Walker, we have probability [intrinsically associated with] the irreducible indeterminism of quantum mechanics.*

Next, Conte details and elaborates on how "we think in a quantum probabilistic manner." Here he first reformulates Aerts' work on possible violations of Bell's inequality in concept combinations. Then Conte discusses and formulates with Clifford algebra the notion and properties of self in line with Jung's work on the subject. Conte and his colleagues have designed and carried out important experiments in an attempt to verify if Jung's theory has a possible quantum formulation. Remarkably, their results seem to confirm this. As Conte put it, "[i]n particular, psychological functions and attitudes seem to realize in a large percentage of cases quantum entanglement." Through out the text, Conte lists five pieces of evidence including several experiments did by him and his colleagues to show that quantum mechanics is directly involved in the dynamics of the mental states.

Conte begin the last part of his work by asking "[a]re such experimental results sufficient to establish in a final form that consequently we think in a quantum probabilistic manner?" He then proceed to describe briefly his two new mathematical theorems related to two types of Clifford algebra respectively. The importance of the two new theorems, accordingly Conte, is that "by giving proof of such two theorems [he shows] that such two algebras are strongly linked and that the [second] algebra is obtained when [one] attribute[s] a precise numerical value to a basic element in the given [first] algebra."

Conte then give ten (10) statements about the properties and relations of these two Clifford algebras and concluded that:

*1) The logical origins of quantum mechanics...runs about two basic foundations: an irreducible indeterminism and quantum interference. The origins of such quantum fundamental phenomena...do not lie in physics itself but in the logic. We have here a profound link with human*

*cognition considering in particular the fundamental task that ... we considered that a quantum measurement must be considered before of all a semantic act.*

*2) ...in quantum mechanics the truths of logical statements about dynamic variables relating matter structure become dynamic variables themselves, and thus the cognition becomes in itself an immanent features that operates symbiotically with the matter phenomenology that traditional physics aims to represent. Conceptual entities non more are separated from the object of cognitive performance.*

As such Conte affirms that "we think in a quantum probabilistic manner."

In my opinion, Conte's this new theoretical and experimental synthesis is very insightful, important and refreshing. It may even turn out to be ground-breaking and constitute major advance in the field of quantum mind/brain studies. Time will tell. I would also like to mention that we theorized previously the role of spin as self-referential processes and its possible role in consciousness (e.g., Hu & Wu, 2002). Although the elements in Conte's Clifford algebra formulation are abstract entities which are fundamentally important in his work, these elements are usually expressed as Pauli matrices associated with spin in standard quantum mechanics. Thus, since matter is, according to Conte, interfaced with cognitive feature, it is possible that this interface is accomplished by the important role of spin at the neuro-physiological level.

In short, Conte's work shows that quantum properties such as indeterminism, entanglement and interference can be formulated with Clifford algebra. These formulations then allow Conte to address possible quantum-like properties in human cognition and propose a new logic to connect cognitive function to measurement in quantum mechanics. This new logic is the reverse of the matrix logic proposed by von Neumann and it is based on Conte's two new mathematical theorems. Conte and his colleagues have also carried out important experiments demonstrating quantum-like entanglement and interference in human cognition. The importance of these experimental results plus those of other

groups such as Persinger's group and our own is obvious: quantum effects play important roles in brain/cognitive functions despite of the denials and suspicions of the naysayers and skeptics.

#### **References**

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