Review of: "Neural Quantum Superposition and the Change of Mind"

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Potential competing interests: No potential competing interests to declare.

The author deals with the topic of quantum cognition and in particular with the quantum-like description of decision making. On this subject there exists a wide literature (See, for example:

Busemeyer, J.; Bruza, P. (2012), Quantum Models of Cognition and Decision. Cambridge: Cambridge University Press

Khrennikov, A. (2010), Ubiquitous Quantum Structure: from Psychology to Finances. Springer

and references therein. One can also simply get a look to the references in the subject “Quantum Cognition” of Wiikipedia).

The more specific point of view of the paper is focused on the chemical processes in brain leading to decision making. The author proposes to connect the process of decision making to the double-slits experiment (DSE) in which a superposition of quantum wave functions, recalling classical wave interference, describes one of the most puzzling aspect of quantum phenomena, i. e. the quantum measurement process: if a measurment is performed to determine the “in what slit passage”, one observes “bullets signs” (classical probability law), while in absence of measurement quantum interference appears. The author associates to the quantum-like functions inside the superposition the answers “YES, NO” or “TRUE, FALSE”. Author refers to the well-known original analysis of Feynman of the DSE, in which a dichotomic choice is described between “bullet” (localized) and “wave-like” behavior. It could be interesting to remark that relevant forward steps have been petformed since the “Gedanken experiment” of Feynman, which show that the DSE is a more complex topic in which localized and wave-like aspects can coexhist with different weights depending on the involved parameters (see:

W. K. Wootters and W. H. Zurek, Complementarity

in the double-slit exyeriment: Quantum nonseparability

and a quantitative statement of Bohr’s principle, Phys.

Rev. D 19, 473 (1979)

D. M. Greenberger and A. Yasin, Phys. Lett. A 128, 391

(1988)

B.-G. Englert, Fringe Visibility and Which-Way Informa-

tion: An Inequality, Phys. Rev. Lett. 77, 2154 (1996)

In the last article a Mach-Zender interferometer has been considered, but the argument is conceptually equivalent to the DSE).

In view of the very complex phenomena considered in the paper, in a first approximation the Feynman description can be assumed, postponing hiring of more realistic descriptions to possible future developements (As a suggestion).

Some remarks:

1) We must remark that notations and procedure can generate some confusion in the reader when wave functions are considered. In fact, wave functions are complex functions, and their squares, introduced at the beginning and in many other parts of the paper, are complex quantities too and not probabilities. The square must be replaced by the squared modulus |\Psi|^2 = \Psi Psi^{*}. Eq.s 2 and 3 are correct but, again, the error is present in the Eq. at the end of the first page of the section “Neural Quantum States” (the right form is

\Phi = [\alpha (\Psi_a)^{*} + \beta (\Psi_b)^{*}] [\alpha \Psi_a + \beta \Psi_b] = \alpha^2 |\Psi_a|^2 + \beta^2 |\Psi_b|^2 + \Psi_a (\Psi_b)^{*} + (\Psi_a)^{*} \Psi_b

and accordingly must be corrected also the Eq. that follows the above one, and many other equations in the paper).

Incidentally: it would be opportune to enumerate pages in order to make the paper more organized. Furthermore, it is to be remarked that in general also the coefficients \alpha, \beta inside the superposition are complex numbers, but here one can choice them real. Finally, there is no reason to change the notation a, b for the coefficients in Eq. 1 with \alpha, \beta in subsequent equations.

2) There is some problem when imposing normalization in finite volume as \int_V \Phi dV when then \Phi is expressed in terms of wave functions. It can be clarified how it works?

3) It would be opportune to discuss a little bit more the question of the time dependence of the coefficients \alpha, \beta which are in competition with \gamma

As remarked at the beginning, there exists a wide literature on the subject of Quantum Cognition, and it is needed to enlarge references by including a suitable selection.

Moreover, on the argument of the double-slit experiment in connection with the physiological e decision making processes, I can report, for example, the reference

Sergey Rashkovskiy and Andrei Khrennikov, Psychological ‘double-slit experiment’ in decision making: Quantum versus classical, Biosystems 195, 104171 (2020)

but others could be selected.

In conclusion, I believe that the argument and the proposed developments could be interesting but that, before to be taken in consideration for publication, the paper must be corrected following points 1)-4).