Commentaries on Article

Reply to Georgiev: No-Go for Georgiev's No-Go Theorem

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ABSTRACT

Danko Georgiev has published a series of papers that claim that the Quantum Zeno Effect that I employ in my explanation of how our minds are able to influence our actions is nullifies by environmental decoherence effects. I give here a simple proof that environmental decoherence does not nullify the quantum Zeno effect.

Key Words: quantum Zeno effect, decoherance, mind-brain

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Introduction

The two most recent of Professor Georgiev's papers on this topic are the preceding paper (Georgiev, 2015a), and a Monte Carlo simulation paper (Georgiev, 2015b) that was intended to illustrate his claim that quantum decoherence nullifies the quantum Zeno effect that I use. The Monte Carlo simulation is not a simulation of my theory. Moreover, it appears to validate, not invalidate, the *Quantum Zeno Effect* (QZE) in the presence of environmental decoherence. For, just below his Diagram 3 he says, in a context with environmental decoherence:

> *"In the limit Xi goes to 0 the electron in the brain stays with probability 1 in its initial state".*

But such a result would be an example of the QZE in the presence of environmental decoherence.

In the orthodox theory that I employ the state in question is a macro state of a perception-related subsystem of the brain. That state of that subsystem is the neural correlation of a perception, not as in Georgiev's model, the position of an electron. The QZE entails that if that subsystem is initially this "Yes" state, then in the limit Xi goes to *0* this subsystem will tend to stay in this state with probability 1 for a finite period of time. Here Xi is the temporal spacing between the elements of a rapid temporal sequence of identical probing actions by the mind of the observer upon his or her own brain. According to the orthodox theory, and evidently in Georgiev's Monte Carlo Simulation as well, this property holds in the presence of environmental decoherence effects: It is not destroyed by environmental decoherence.

Georgiev's evident Monte Carlo-based support, just cited, of QZE in the presence of environmental decoherence is reassuring, but hardly necessary. For the property is easy to prove algebraically.

Proof

I use here the standard notation and ideas described by von Neumann in the final chapter of his book (pp.420-425).

We are concerned here with two orthogonal subsystems, I and II. System I is a subsystem of the brain that contains the neural correlates of the possible upcoming perceptions specified by the repetitious sequence of probing questions posed by the mind of the observer.

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Subsystem II is the space of states that constitute the "environment" of the "environmental decoherence effect". Let the pertinent basis states of I and II be labeled by i and j, respectively. If "Rho" is the density matrix of the full system then the density matrix "rho" of system I is defined by taking the trace of Rho over the variables j of system II:

<i|rho|i'> = Sum over j of <i,j|Rho|i', j>.

The probing action is represented by

rho goes to (PrhoP + P'rhoP'),

Here P'= (1-P), and 1 is the identity operator in subsystem I. "Nature" immediately actualizes one or the other of these two terms, with the probability of obtaining PrhoP being

Prob(PrhoP) = trace PrhoP/Trace rho. (1)

Here (lower case) trace means trace in subsystem I.

The eigenstates i of P in system I with eigenvalue +1 of P, are the "Yes" states. In the initial condition of the QZE the mind-specified perception (specified by Process 1) occurs in conjunction with an immediate reduction of rho to the part of itself in which all of the initial and final P-eigenvector basis states i are "Yes" states: are states with P-eigenvalues = +1.

The initial condition at t=0 of the density matrix rho(t), in the subspace I has the form, according to von Neumann's basic trace rule,

rho(0) = Sum over j <j|Rho(0)|j>.

The condition that the mind-chosen action P acts in the perception-related subspace I, and not on the unknowable environment, is the condition that P act as the identity operator in the subspace II. Thus one finds that at the initial time t=0+, immediately after an initial choice. rho has gone to P rho P by nature's Process 3 choice,

rho(0+) = P rho(0) P = P (Sum over j <j| Rho(0)|j>) P

The evolution of Rho(t), via the unitary Schrödinger process in the full space, induces effects in the observable "Yes" part of rho(t), due to interactions between the subspaces I and II. This induced correlation between subsystem's I and II produces the environmental decoherence.

A new action corresponding to P followed by a "Yes" choice on the part of nature gives the new rho(t):

rho(t) = (Sum over j <j|P(exp-iHt)P Rho(0)P(exp+iHt)P|j>)

The first-order term in t is

Sum over j <j|(P(-iHt)P)(P Rho(0)P) +(P Rho(0)P)(P (+iHt)P)|j> .

The probability of this term the power-series-in-t expansion of rho(t) is obtained by taking the trace in system I, in accordance with the probability formula (1) given above. It is

(-it)Trace[(PHP)(PRho(0)P) - (PRho(0)P)(PHP)] =0

[For any two operators A and B, Trace AB =Trace BA].

Thus the first- order term in the expansion in t vanishes. The zeroth-order term gives no change in the probability of the initial state, in concordance with QZE. Hence the second-order term is the dominant term for change for sufficiently small t. But that dominance is precisely the condition that entails the quantum Zeno effects.

The flaw in Georgiev's reasoning is that whereas it is indeed true that environmental decoherence does progressively decrease the (originally unit) probability of the initial state, and that Process 3 cannot undo the diminishing of that probability, those two facts do not undo the QZE. For the effect of the shortening of the temporal spacing Xi to zero is, by itself, sufficient to reduce to zero the rate of the diminishing of the (originally unit) probability. There is no need for Process 3 (nature's collapse events) to rescue QZE, for this Zeno effect is entailed already by the tending to zero of the spacing of the repetitious probing actions!

References

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