SCHRÖDINGER’S CAT AND THE PROBLEM OF TWO CULTURES

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A mathematical model of the interaction mechanism for the intuitive-imaginative and heuristic-logical thinking responsible for the rift in the intellectual activity into two cultures has been suggested. The said model proceeds from the assumption that human thinking is based on the principles of the many-channel quantum-mechanical logic of the “both ... and” type surpassing the rigid confines of the “either ... or” type classical logic. The aggregate product of the person equally endowed in the said two-cultural space has been calculated. The interferential part of the latter achieves its maximum at the extreme values of such parameters as the inter-state exchange frequency and the difference of the states phases.

If we want to gauge the sky, the earth and the seas, we must first of all measure ourselves.
Hryhorij Skovoroda

Philosophy is neither a science nor a perceptual sermon.
Martin Heidegger

I

Let us begin to talk about the problem of two cultures with a survey of one of its aspects which is quite apparent in the university setting. When considering the phenomenon of two cultures we shall venture to suggest one of the possible mechanisms regulating the interaction between the heuristic-logical and intuitive-imaginative thinking [1].

Each of us is aware of being different from everybody else. We are trying to measure this extent of otherness all the time intuitively. Each scholar tends to give some thought to the fact that his creative work and intellectual activity happen to be quite different from what, say, writers or actors are busy with. This is a well-known fact which has always been intuitively recognized. It was also quite aptly worded by an English writer and physicist Charles Snow in the fifties of the last century. He introduced the term two cultures by which he meant the culture of those who in their own words deal with creating and whose activity is concerned with imaginative thinking and the culture which is created by those working in the realm of exact and natural sciences. Thus on the one pole we have the artistic intelligentsia and on the other pole we have scientists.

We can formulate the definition of the two cultures in stricter terms. All the people around us fall under two groups, namely those who are well-versed in maths and those who feel at home with something else. In everyday life we are only too often confronted with a dichotomy that there are people who like mathematics and there are those who dislike it. By this we do not mean to refer to abilities, a desire to work or exert effort on oneself. Such endeavours seldom lead to the desired effect as a person may be capable of creating something else falling back on the principles of imaginative rather than rational thinking.
However, there are some who fall out of this dichotomy. We know a number of people who are profusely endowed with the capabilities of either type. In what follows we shall speak about them.

A natural laboratory to study the mentioned phenomenon can be found within the walls of the classical university. In the words of Karl Jaspers the university as a phenomenon of culture brings together those who are willing to cognize scientifically and to live spiritually. As can be seen in this definition we can again trace the two marked aspects of human activity just as well as in the quoted words of Martin Heidegger concerning philosophy. A prime feature of the university environment lies in its encompassing many cultures and many disciplines. Within a classical university where there is an atmosphere of interweaving tones and halftones, rich colours and subtle tinges of humanities with exact as well as natural sciences not a single teacher or scholar can stand fully aloof from the problem of two cultures.

II

Sometimes people who are lucky to be endowed with the faculties going in both directions, i.e., along the path of intuitive creativity and logical-intellectual thought cannot fully implement these capabilities which may lead to dramatic or even tragic circumstances. In order not to lose your talent you must have it, but far more importantly, you must have a chance to set it free. Developing talent and setting it free takes some purposeful steps. A gifted person is forced to make an effort on one’s own self in order to attain self-realization. A person that is gifted in both these ways and that has a natural possibility to stay in the creative as well as logical state can be very successful by crossing over between them but at the same time there is a risk that the said cross-overs might lead to frustration. What factors are responsible for the specific outcome?

We shall not make an attempt to discuss the formation of these capabilities of a man at the level of physiology which might be motivated by certain genes or sets of genes [3]. It is also quite probable that specific intellectual or creative mechanisms are inherited even though their coming real is dependent upon a number of factors, including social factors, active both immediately before and prospectively after the birth of a human being.

In order to get some indepth insight into the problem of two cultures I suggest that we concentrate on one of the possible ways of its description which would be based on quantum mechanics principles. We shall speak about a certain analogy enabling us to draw qualitative conclusions and account for specific facts from real life. It may also go beyond the scope of a mere analogy.

The first hint at the analogy that the mechanisms of our thinking are quantum mechanic in nature comes from the fact that the retina of the human eye, being a component of the human brain, is capable of registering several photons (light quanta) [3,4]. It appears that the sensitivity of our eye is unexpectedly high. Its physiological threshold equals one photon which is sufficient for arousing the receptor. Yet for the brain to be able to take in the message it is necessary to have $5\div8$ photons. Thus the reception threshold equals several photons even though there might be pre-threshold reception. Our brain is set to motion by single light quanta. The brain begins to work at the atomic level. For the latter the quantum mechanics laws as well as the quantum mechanics mechanism of the phenomena are already fully binding even though the time, during which the electron stays in the coherent state, is substantially falling short of the time necessary for conveying excitations between neurons.

We may adduce other examples to the effect that quantum mechanics is binding on the microscopic scale that we are accustomed to. They are the phenomena of super-fluidity
and superconductivity or else, even more clearly, that of the laser.

Falling back on what has been said so far it might well be possible to suppose that the brain, being a macroscopic set-up, is likely to abide in its functioning also by the laws of quantum mechanics. The latter amounts to the many channel interferential quantum mechanics principle of the type of “both and” surpassing the classical logic model of the nature of “either or”.

Should the Reader of these notes believe that the adduced argumentation is insufficient or that it is unacceptable, the author will agree to the suggestion that this is just one of the possible microscopic level modelings of what is created by the observable phenomenon of two-culturalism.

III

Let us speak about those who are capable of combining these two cultures. In view of what has been stated above let us try and model their state as the state of the quantum system making use of the quantum mechanics assumption of the cat of Schrödinger who is both alive and dead at the same time.

Let us remember that in the wake of the creation of quantum mechanics in the years 1925–1926 a set of paradoxes was suggested to illustrate the seeming absurdity of its fundamental principles. The paradox suggested in 1935 by Erwin Schrödinger who was one of the founders of quantum mechanics says that the non-determined state of the quantum particle, for instance a photon, penetrating the semi-silver mirror with the probability of “1/2” and reflecting from it with the same “1/2” probability passes over the cat that is shut in a box. Should the particle penetrate the mirror, it will switch on the device killing the cat. Should it fail to penetrate the mirror the cat will stay alive. As the particle which abides by the laws of quantum mechanics is in the super-positional state, i.e., in the “both…and” and not “either…and” states, the said cat also finds itself in the same superpositional “alive-and-dead-at-the-same-time” state. Otherwise stated, should the quantum particle realize both the possibilities at the same time, the cat as a macroscopic system must simultaneously realize both its states at the same time. The essence of the paradox lies in the fact that after the photon gets into the mirror the state of the cat is seemingly non-determined. In true fact, non-determinedness disappears at the moment of the interaction of the photon with the device.

The very idea about the possibility for a system to simultaneously stay in two possible states at once is laid at the foundation of the present study. The Schrödinger’s cat paradox was referred to with the purpose of illustrating a possible direct link between micro- and macroworld. It shows that both the state of the cat and our perception of two-culturalism are a consequence of the processes taking place at the molecular level. The state of the classical cat becomes determined at the moment of the interaction of the photon with the device when the so-called reduction of its state amplitude occurs. The state of two-culturalism which is created by our central nervous system is quantum by nature just like quantum in principle are such phenomena as super-fluidity of liquid helium or laser radiation.

Let us now offer several statements. Polyculturalism is formed by different ways of thinking that can be split into two components: the intuitive-creative or imaginative thinking and the heuristic-logical thinking which can be called intellectual thinking. Further, for describing the intellectual-creative activity we shall make use of the notion of the state amplitude. It is a value which when squared gives the probability of staying in this state. Therefore, we tend to believe that there are only two reference states which can be called the state of imaginative thinking and the state of logical thinking. Each
of these states is described by its own amplitude. Likewise, polyculturalism can also be described as an overlap in varied proportions of just two constituents. By this we suppose that polyculturalism is two-dimensional. This resembles a well-known fact that any colour can be split into three constituents: red, green and blue. Similarly, mathematicians believe that any vector can be split into three reference vectors. This is tantamount to saying that in our case each vector in the polycultural space determines the state vector which in its turn is subject to decomposition into two reference vectors.

IV

The aforementioned preliminary remarks, at times, if anything, not very clearly defined, will now be formulated as several postulates developing our quantum mechanics approach and at the same time introducing the necessary notions and respective mathematical operations.

**Postulate I.** Let the state of the system’s intellectual-creative activity at the microscopic level be given by the amplitude $\psi$ dependent upon the time $t$ and “the generalized coordinates” $q$. The module square of the value $\psi$ equals the probability of the system’s staying in this state.

**Postulate II.** The space of the intellectual-creative activity is believed to be two-dimensional: one dimension is imaginative thinking, the other one is logical thinking. Let $\psi_1$ be the amplitude of the state of imaginative thinking and let $\psi_2$ be the amplitude of the state of logical thinking, the $\psi_1, \psi_2$ base being complete.

**Postulate III.** The amplitude of any state is determined in compliance with the quantum mechanics principle of superposition:

$$\psi = C_1 \psi_1 + C_2 \psi_2.$$  

Between the states $\psi_1$ and $\psi_2$ describing the two cultures transitions are possible which are characterized by the so-called exchange energy $A$.

The dependence of the amplitude $\psi$ upon time is determined by the factors $C_1$ and $C_2$ which can be found from Schrödinger’s equation that is the main equation of quantum mechanics [5,6]:

$$C_1 = \cos \Omega t,$$

$$C_2 = -i \sin \Omega t,$$

where the frequency of “exchange” between the reference states $\Omega = A/\hbar$ is a characteristic parameter of the system and is determined both by the intrinsic properties of the system itself and its environment. For the sake of definiteness it is taken that at the initial moment of time $t = 0$ the system is in the state $\psi_1$. Besides this, the given expressions do not take into account the time dependent phase multiplier which is irrelevant for us and which is removed by a simple replacement of the beginning of the measurement on the energy scale.

The full probability of staying in the two-cultural state equals the module square of the amplitude $\psi$. With this full probability we shall calculate the aggregate product of
the intellectual-creative capacity of a person which stands for what one manages to create in the course of the entire creative life.

Let the intellectual-intuitive creative capacity be described by the operator

$$\hat{K} = \hat{K}(q, t)$$

in the way that its observable value at the moment \(t\), \textit{i.e.,} the quantum mechanical average of the said operator by definition equals

$$K(t) = \langle \psi | \hat{K} | \psi \rangle = \int \psi^*(q, t)\hat{K}(q, t)\psi(q, t)\, dq.$$  

In the course of the creative life time span \(T\) of a person the aggregate product equals the integral of the average capacity

$$Q = \int_0^T K(t)\, dt.$$  

The beginning \(t = 0\) when the creative activity gets off the ground is dependent upon the IQ coefficient [3]. The end of the creative life when \(T = t\) and when one exhausts oneself is dependent on many factors, not the least quite accidental.

With the purpose of simplifying the notation without losing the final conclusions we shall separate in the operator \(\hat{K}\) the dependence upon time \(t\) and the coordinates \(q\):

$$\hat{K}(q, t) = \hat{Q}(q)p(t),$$

at the same time we shall normalize the function \(p(t)\) so that

$$\int_0^T p(t)\, dt = 1.$$  

We will place this operator in the expression for \(K(t)\) and taking into account the explicit form of the amplitude \(\psi\) and the coefficients \(C_1\) and \(C_2\) we will find that

$$K(t) = p(t)\left[ Q_{11} \cos^2 \Omega t + Q_{22} \sin^2 \Omega t + i(Q_{21} - Q_{12}) \sin \Omega t \cos \Omega t \right],$$

where the matrix elements of the operator \(\hat{K}\) equal:

$$Q_{11} = \langle \psi_1 | \hat{Q} | \psi_1 \rangle, \quad Q_{22} = \langle \psi_2 | \hat{Q} | \psi_2 \rangle, \quad Q_{12} = Q_{21}^* = \langle \psi_1 | \hat{Q} | \psi_2 \rangle.$$  

By its content the operator \(\hat{K}\) is self-correlative and expressed positively, thus \(Q_{11} > 0, Q_{22} > 0\), the non-diagonal element being written as a complex value through its module and \(\delta\) phase.

$$Q_{12} = |Q_{12}|e^{i\delta},$$

note that since \(Q_{21} = Q_{12}^*\),

$$Q_{21} = |Q_{12}|e^{-i\delta}.$$
Now, the formula for $K(t)$ can be written as follows

$$K(t) = p(t) \left( \frac{Q_{11} + Q_{22}}{2} + \frac{Q_{11} - Q_{22}}{2} \cos 2\Omega t + |Q_{12}| \sin \delta \sin 2\Omega t \right).$$

As we can see an essential dependence upon the phase $\delta$ arises. Integrating this expression by the time $t$ we have

$$Q = \frac{Q_{11} + Q_{22}}{2} + \frac{Q_{11} - Q_{22}}{2} p_\Omega' + |Q_{12}| p_\Omega'' \sin \delta,$$

where we have introduced the real and imaginary parts of the Fourier coefficient of the function $p(t)$:

$$p_\omega = \int_0^T p(t)e^{i\omega t},$$

$$p_\omega' = \text{Re} \, p_\omega, \quad p_\omega'' = \text{Im} \, p_\omega.$$

The found expression for $Q$ happens to be the main formula providing the basis for the entire subsequent analysis.

V

Rather than seeing our task in comparing the intellectual capacities of different people we are primarily concerned with finding out more about the circumstances under which one can fully implement one’s own abilities in compliance with the individual’s own potential. That is why it is natural to assume the measuring unit of the value $Q$ to be a half of the sum $(Q_{11} + Q_{22})/2$ which we will refer to as a classical meaning of the aggregate product. Thus, we will be concerned with the scaled aggregate product

$$Q^* = Q \sqrt{\frac{Q_{11} + Q_{22}}{2}}.$$

Proceeding from the main formula we will receive

$$Q^* = 1 + \frac{Q_{11} - Q_{22}}{Q_{11} + Q_{22}} p_\Omega' + \frac{2|Q_{12}|}{Q_{11} + Q_{22}} p_\Omega'' \sin \delta.$$

As we treat of a person equally endowed with talents, i.e., when $Q_{11} = Q_{22}$ this expression is simplified:

$$Q^* = 1 + \frac{|Q_{12}|}{Q_{11}} p_\Omega'' \sin \delta.$$

Let us pass over to the discussion of the established formula. The maximum possible exhaustedness of a creative personality equals a half of the sum of what originates from each of the two reference states (otherwise said from the intellectual and creative states) together with the interference crossed term. The crossed term which is refuted by the classical logic appears, as can be seen, from the doubled product during the unfolding of the square from $\psi$ as a sum of two terms at the calculus of probability. This interferential contribution into the aggregate product is dependent on two parameters: the frequency $\Omega$ of switching over from one type of activity to the other as well as on such a subtle, almost transcendental notion as the phase $\delta$. 

6
The crossed effect can enhance or decrease the implementation of the person’s potential depending upon these parameters. In order to implement one’s talent to the full it is necessary first and foremost to harmonize the switching over frequency with the length of the creative life so that the value of $p''_{2Ω}$ be maximally positive. Secondly, we must set the phase $δ$ to equal $π/2$, so $\sin \delta = 1$. Then the contribution of two-culturalism into the aggregate product will be not just maximal but will also have a positive sign.

If the phase $δ$ equals zero or the switching over frequency is high $Ω → ∞$, $p''_{2Ω} → 0$, a gifted person does not tend to fully unfold one’s own abilities and turns into an ordinary person with half a sum of the aggregate product $(Q_{11} + Q_{22})/2$ realizing the classical values of $Q^* = 1$. Should the phase $δ$ equal $3π/2$, we will have a sign which is opposite to two-culturalism and then the person in question is not merely a lost talent. We may have to deal with a tragedy as a gifted person has failed to come up to the achievements of an ordinary person.

Hence, purposeful efforts are needed to obtain self-implementation and ensure harmony with oneself as well as intellectual and aesthetic satisfaction. These efforts should be directed at setting the input parameters characterizing the intellectual creative activity of a person.

VI

With the purpose of giving numerical characteristics of these qualitative conclusions we will study the model systems. Let us first consider the symmetrical case when $|Q_{12}| = Q_{11} = Q_{22}$. We will give $p(t)$ as a step function, i.e., let us assume that $p(t)$ remains constant from the beginning of one’s creative life $t = 0$ till $T = 0$ when the creative life comes to an end:

$$p(t) = \begin{cases} 1/T, & 0 \leq t \leq T \\ 0, & \text{otherwise} \end{cases},$$

the Fourier coefficient

$$p_\omega = \frac{1}{T} \int_0^T e^{i\omega t} dt = \frac{e^{i\omega T} - 1}{i\omega T},$$

and the imaginary part

$$p''_\omega = \frac{\sin^2(\omega T/2)}{(\omega T/2)}.$$

Consequently,

$$Q^* = 1 + \sin \delta \frac{\sin^2 \Omega T}{\Omega T}.$$

The maximum value of $Q^*$ brings about $δ = π/2$ as well as the parameter $x = ΩT$ which complies by the equation (the condition according to which the derivative from $Q^*$ by $x$ equals zero)

$$\frac{\tan x}{x} = 2,$$

from where $x = 1.165561$. At this

$$Q^*_{\text{max}} = 1 + \frac{\sin^2 x}{x} = 1.7246.$$
Hence, the interference member tends to additionally increase the classical value of $Q^*$ by 72%. It is also curious that in this model when one’s creative life is cut short at once at $x = n\pi$, $n = 1, 2, \ldots$ interference disappears and the value of $Q^*$ becomes classical too. If the frequency of switching over $\Omega \rightarrow \infty$, then $Q^* \rightarrow 1$. For that matter, a frequent change of interests tends to smear the interference effect of one’s intellectual-creative activity, the said effect being the essence of one’s unusualness. When a person is able to set the parameters of $\delta$ and $\Omega$ to their extreme values he possesses a many-sided and well manifesting itself talent.

Let us now consider a more realistic model of the function $p(t)$. Let $p(t)$ be the analytical function of the time pending to zero both at $t \rightarrow 0$ and at $t \rightarrow \infty$:

$$p(t) = \gamma^2 t e^{-\gamma t},$$

where $\gamma$ is a decrement of the subsidence of the intellectual-intuitive creativity whose presence allows to detract the parameter $T$ to infinity ($T = \infty$). In compliance with our requirements this function is normalized by one, the climax of the creative activity falling on the time $t = t/\gamma$. By definition we shall calculate the Fourier coefficient

$$p_\omega = \frac{1 - (\omega/\gamma)^2 + 2i\omega/\gamma}{[1 + (\omega/\gamma)^2]}. $$

Let us take from here $p''_\omega$ at the frequency $\omega = 2\Omega$ and for $Q^*$ we will have:

$$Q^*_\omega = 1 + \frac{2\nu}{(1 + \nu^2)^2} \sin \delta,$$

where $\nu = 2\Omega/\gamma$. This function also falls to zero at $\nu \rightarrow \infty$. And it reaches its peak at $\delta = \pi/2$ at the point $\nu = 1/\sqrt{3}$:

$$Q^*_{\text{max}} = 1 + 3\sqrt{3}/8 = 1.6495.$$

The interference effect in this model increases the classical value of $Q^*$ by 65%.

VII

It seems likely that each of us carries his own problem of two cultures inside himself. Both an artist and a scholar often act without the awareness that they themselves are at the crossroads of these cultures. The suggested quantum-mechanical mechanism of creativity gives a paradoxical intertwining of imaginative and logical thinking. This intertwining is capable of creating something which looks entirely new and cannot be reduced to anything or split into constituents. It should rather be seen as an interference effect. The contribution of two-culturalism into the aggregate product understood as the interferencial crossed effect can alter slightly depending upon the specific model. Yet it is this effect which makes the difference between potentially talented people and people that implement their talent.

Ultimately, let us remark that these conclusions can pertain not only to specific individuals who find themselves in two states at a time but also to a community of people that are forced by the historical circumstances to live and act in the conditions of multiple cultural cross-overs.

One of the two quotations placed at the beginning of this paper is from the work of the outstanding Ukrainian thinker Hryhorij Skovoroda. It refers us once again to the fundamental philosophical principle of getting to know oneself which has always been
attractive to people even though with varied intensity at different times. With an ever-growing vigour we are obliged to get to know our own selves, researching and opening anew our activities in versatile spheres. It is not only quite interesting in itself but also increasingly important in view of the fact that we happen to live in an ever more interrelated and globalized society when the fate of each of us is dependent upon the activity of everyone else.

References

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