Quantum Entanglement and Intentionality

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Abstract

Even though Quantum Mechanics is nondeterministic in nature, at first glance it does not seem to leave room for human intentions. It is suggested here that this may not be true when we consider special cases of quantum entanglement.

1 Introduction

Quantum Mechanics (QM) is intrinsically probabilistic, which while incompatible with classical determinism, doesn't seem particularly conducive to reasoning involving human intentions.

As illustration, consider the case of a quantum state $|\psi\rangle$ being measured by a measurement characterized by the basis states ϕ_i where $i = 1 \cdots N$, then according to QM, the probability of the measurement yielding the basis state ϕ_i is given by

$$P_i = |\langle\psi|\phi_i\rangle|^2$$

and this probability is independent of the experimenter's intentions and wishes. It may seem then that the probabilistic nature of QM only gives us random outcomes characterized by fixed probabilities.

This is indeed true if we only consider unentangled quantum states, but since human intentions necessarily involve the state of the mind, perhaps we should try to consider entanglement between the mind state with the appropriate quantum state(s) of the environment and see whether we get something that resembles intentionality. We argue here that this is indeed the case.

2 The Mind State and Entanglement

In the spirit of the Spherical Cow, we reduce the complexity of the mind to a simple quantum state $|\cdots\rangle_{mind}$, with specific intentions indicated by states like $|Intention_1\rangle_{mind}$ etc. Similarly, we denote the state of the environment by $|\cdots\rangle_{env}$ and of the world by $|\cdots\rangle_{world}$ etc.

The desired quantum entanglement will then be of the form

$$|\Psi\rangle_{world} = |Intention_1\rangle_{mind}|IntendedOutcome_1\rangle_{env} + the.rest \qquad (1)$$

in other words, the mind state $|Intention_1\rangle_{mind}$ should be entangled with the environmental state $|IntendedOutcome_1\rangle_{env}$, such that if and when the system collapses, the occurence of a state of intention in the mind is always accompanied by the occurence of the intended outcome. It should be noted that we didn't claim that the intention or the intended outcome will always happen, in many cases, they don't (i.e. cases when $|\Psi\rangle_{world}$ collapses to "$the.rest$"), but whenever the intention does occur, so does the intended outcome. It is in this sense that QM can accommodate intentionality.

3 Some Details

3.1 snowballing micro-intentions

It seems rather miraculous for the mind to be able to create just the right kind of quantum entanglement as given in Eq.(1) for $|\Psi\rangle_{world}$, but we shall see that this seemingly magical entanglement can be built up step by step from simpler entanglements.

It is reasonable to assume that neurons play an essential role in connecting the state of the mind with environmental outcomes. We thus consider a simplified model of a typical neuron which consists of a multitude of input dendrites and usually a single output axon (see Figure 1). We represent the neuron state we're

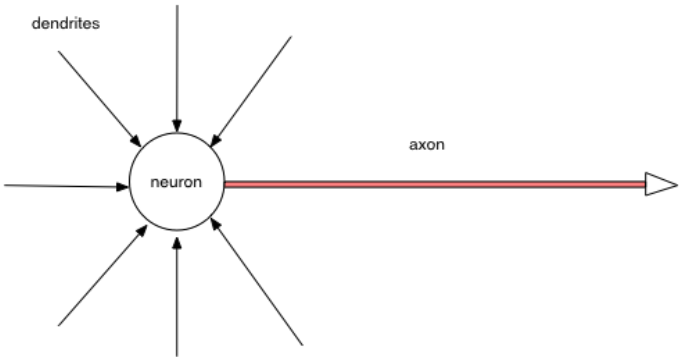

Figure 1: model of neuron

interested in as an entangled state between dentritic states and axon states:

$$|\phi_1\rangle_{neuron_1} = |DentriticState_1\rangle|AxonState_1\rangle + the.rest \qquad (2)$$

We further assume that the mind state $|Intention_1\rangle_{mind}$ is entangled with the relevant neuron states:

$$|\Psi\rangle_{world} = |Intention_1\rangle_{mind}|\phi_1\rangle_{neuron_1}|\phi_2\rangle_{neuron_2}|\phi_3\rangle_{neuron_3}... + the.rest \quad (3)$$

Substituting Eq.(2) into Eq.(3) we see how entanglement can be built up from simpler entanglements, eventually realizing Eq.(1).

This raises an interesting question about intentionality in simpler systems, e.g. what is intentionality at the level of the neuron? We propose that the entangled neuron state Eq.(2) is the answer. Theoretically one can go even deeper and ask where lies intentionality at the level of the elementary particles e.g., which we shall discuss in section 4.

3.2 conditional probabilites

To see how the above-mentioned entanglements imply intentionality, we need to examine how such entanglements affect the probabilities of measurement outcomes. More precisely we need to consider the conditional probabilities of the joint measurements of the entangled states.

For a perfect entanglement like Eq.(1), it's quite obvious that the conditional probability

$$P(IntendedOutcome_1|Intention_1) = 1$$

because whenever $|Intention_1\rangle_{mind}$ happens, so does $|IntendedOutcome_1\rangle_{env}$. In other words, perfect entanglement implies perfectly effective intentions. In reality, we don't always have perfect entanglements, so we should expect

$$P(IntendedOutcome_1|Intention_1) \leq 1$$

i.e. imperfect entanglement implies partially effective intentions.

3.3 problem of preferred basis

This refers to the fact that it may be possible to rewrite $|\Psi\rangle_{world}$ in Eq.(1) as a superposition of a different set of entangled states (similar to the example in [Zur91]), i.e.

$$\begin{aligned} |\Psi\rangle_{world} &= |Intention_1\rangle_{mind}|IntendedOutcome_1\rangle_{env} + the.rest_1 \\ &= |Intention_2\rangle_{mind}|IntendedOutcome_2\rangle_{env} + the.rest_2 \end{aligned}$$

This shouldn't concern us, however, since the mind state we're interested in, namely $|Intention_1\rangle_{mind}$, no longer appears directly in the alternative superposition of entangled states comprising $|\Psi\rangle_{world}$, and thus when such a state collapses, we end up with a mind state other than $|Intention_1\rangle_{mind}$, which can be grouped into "*the.rest*" in Eq.(1). Roughly speaking, this implies that even

if we manage to form the perfect entanglement between the mind and environment states, there's no guarantee that we'll end up with the intended mind or outcome states. Even more roughly speaking, our best intentions may have unintended consequences.

3.4 decoherence

Do we need to worry about decoherence, which tends to spoil quantum entanglements? Probably not, since we don't require quantum entanglements of a large spatial scale or long temporal duration in our model, thus the effect of decoherence should be quite negligible.

3.5 empirical verification?

There isn't any, yet. To verify that quantum entanglement entails intentionality, it's necessary to show that:

1. quantum entanglements of the type in Eq.(1) and Eq.(2) exist.
2. such entanglements are indeed relevant to intentionality.

To show that the kind of quantum entanglements in Eq.(1) and Eq.(2) exist, we first need precise definition and control of the mind state, which is still lacking, but hopefully not for long...

4 Implications

4.1 intentions all the way down...

In section 3.1 we see how complex entanglements can be built up from simpler ones, but so does intentionality, since we've identified intentionality with the entanglement between the mind and environmental states. This means that as we go down to the level of the neuron, and even further into the level of the elementary particles, for instance, rudimentary traces of intentionality may still be found in the entanglements among the constituents. At such rudimentary levels, however, what we refer to broadly as "intentionality" has already lost a lot of the original meaning of the word, but it never quite vanishes completely.

4.2 free will

Once the superposition of entangled states in $|\Psi\rangle_{world}$ of Eq.(1) is chosen, the rest follows from QM without the need for intervention from free will. If free will plays any role, it must be in the choice of the superposition of entangled states. This is essentially the same as the familiar problem of the choice of basis states in quantum measurement (see e.g. [Zur91]), but while in such discussions the observer is usually treated as a nuisance, unwanted but indispensable, here intentionality plays a central role. It shapes the entanglement of our mind state with that of the environment, making our will as "free" as QM allows.

4.3 origin of intentionality

When and why did intentionality arise in living organisms? This is pure speculation, but in the early history of life, intentionality must have offered significant evolutionary advantages: a primitive organism that can selectively control itself and its environment has a much better chance to survive and proliferate than simple automatons that either follow a fixed routine or else act randomly. And as the complexity of the organism evolved, so does the complexity of its intentions. One may even speculate that this evolution of the complexity of intentions eventually led to the emergence of consciousness...

4.4 non-locality

Quantum entanglements often, though not necessarily, imply non-locality. It is pehaps premature to ask what, if any, implications our model of intentionality has on the question of the non-locality of intentions and intended outcomes, but it's an intriguing question that merits further investigation.

4.5 neuropsychology

Again, this is pure speculation, but by examinig more closely the relation between the various mind state and how they intereact and entangle with the environment, we may be able to gain insight into the workings and pathologies of the mind.

4.6 how to train your intention

Is it possible for us to learn to tweak the entanglement between our mind states and the environment so as to achieve certain desired state of mind or being, or to be able to control our environment in ways unheard of? This may sound far-fetched and science-fiction-like right now, but who knows...

4.7 interpretation of Quantum Mechanics

There's already foreshadowing of our work dating back to von Neumann[VN55]. In the chapter on the quantum measuring process, von Neumann considered the role of the observer in quantum measurements and noted that the boundary between the observer and the measured system can be blurred by entangling the observer's quantum state with that of the system being measured. Similar discussions can also be found in works related to the many-worlds or many-minds interpretations of QM (e.g. [Eve57][AL88]). These works were concerned mainly with a consistent interpretation of QM without explicit mention of intentionality. What we suggest here is look at things from another point of view, one where intentionality may play a significant, maybe even primary, role in the interpretation of QM.

Instead of the generally ill-defined quantum measurements and ambiguous demarcation between quantum and classical realms, we propose to regard intentionality as a primary agent in the realization of quantum potentialities. But notice that we're using "intentionality" here in the broader sense of the word as discussed in section 4.1 so it doesn't necessarily have the anthropomorphic connotations usually associated with it.

We will not discuss in detail the so-called collapse of the wave function in QM, since it doesn't appear directly in our model of intentionality. All we require in our model is that the wave function does "collapse" from time to time, but the details of the how, why and when don't concern us. In this way our model is consistent with most major interpretations of QM, with the subtle addition of the primary role played by intentionality in the disguise of quantum entanglements.

5 Conclusion

We have proposed one plausible way intentionality may be described in QM. It is quite remarkable that quantum entanglement seems to be at the heart of many seemingly unrelated physical (and otherwise) phenomena in our world. We've only touched lightly on the topic, and undoubtedly much more can be said, e.g what is the exact nature of the mind state? How exactly does the mind achieve the desired entanglements? How do neurons (and possibly other body cells) achieve the desired entanglements, and what are the underlying molecular mechanisms? What is the exact chain of entanglements that leads from the mind to the desired environmental outcomes? What is the evolutionary history of intentionality? Is intentionality non-local? How can we test our intentionality model experimentally? what implications does our model of intentionality have on the nature and emergence of consciousness? Does our model have anything to say about the nature of mental dysfunctions like schizophrenia, which may be the result of disorder of the entanglement of the mind state with the environment? etc. etc. We think this is a promising line of queries which may lead to a better understanding of intentionality, our minds, and their roles in the larger scheme of things.

References

[AL88] David Albert and Barry Loewer. Interpreting the many-worlds interpretation. *Synthese*, 77(November):195–213, 1988.

[Eve57] H. Everett. "Relative State" Formulation of Quantum Mechanics. *Reviews of Modern Physics*, 29:454–462, July 1957.

[VN55] John Von Neumann. *Mathematical foundations of quantum mechanics*. Number 2. Princeton university press, 1955.

[Zur91] Wojciech H Zurek. Decoherence and the transition from quantum to classical. *Physics today*, 44(10):36–44, 1991.