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There Are No Such Things As Schrödinger Cats!.

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ABSTRACT

The original Schrödinger`s cat *gedanken experiment* is analyzed from a new point of view. The arguments presented here suggest that Schrödinger's cat problem does not belong to the class of scientific problems because it is an abuse of daily language including the fallacy of misplaced concreteness. A corollary is that the idea that conscious observation collapsed the wave function also collapses.
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INTRODUCTION

The cat *gedanken experiment* proposed by Erwin Schrödinger in 1935 has been and is still the source of debates at different levels of knowledge (quantum mechanics, philosophy of science, pseudoscience, etc.). In several books Schrödinger's cat is briefly mentioned but nothing new of interest concerning this problem is offered to the reader [1-16]. Concerning the papers dedicated to the study of the eminent cat some of them offer quite interesting analysis but, as these analysis started from the very way in which Schrödinger presented his *gedanken experiment*, they suffer from the same basic error (see for example [17-47]. Some of these references are books written by different authors and one contains only reprints of important articles). There are also some comments about the cat in a very long and interesting informal exchange of opinions published in Epistemological Letters [48]. Here I present a new form of analyzing the Schrödinger's cat problem that applies only to the exact form in which this thought experiment was presented [49].

SCHRÖDINGER'S CAT

Schrödinger presents his gedanken experiment as follows: One can even set up quite ridiculous cases. A cat is penned up in a steel chamber, along with following diabolical device (which must be secured against direct interference by the cat): in a Geiger counter there is a tiny bit of radioactive substance so small, that perhaps in the course of one hour one of the atoms decays, but also, with equal probability, perhaps none; if this happens, the counter tube discharges and through a relay releases a hammer which shatters a small flask of hydrocyanic acid. The first atomic decay would have poisoned it. The ψ-function of the entire system would express this by having it in the living and the dead (pardon the expression) mixed or smeared out in equal parts. It is typical of these cases that an indeterminacy originally restricted to an atomic domain becomes transformed into macroscopic indeterminacy, which can then be resolved by direct observation. In technical language, if we call ψ_{cat} the wave function describing the state of the cat during a reasonable time interval (I say reasonable because if we wait one year it is sure that that cat will die by poisoning or by starvation) starting at the moment when the chamber is closed the system and ending just before opening it, it was proposed that we may write ψ_{cat} as:

$$\psi_{cat} = \frac{1}{\sqrt{2}}(\psi_{alive}^{cat} + \psi_{dead}^{cat}) \qquad 1.$$

Where, ψ_{alive}^{cat} and ψ_{dead}^{cat} are respectively, the wave functions of the alive and dead cat. Note that in each one of the two possible outcomes:

$$\psi_{alive}^{cat} \rightarrow \psi_{cat} \rightarrow \psi_{alive}^{cat} \qquad 2.$$

$$\psi_{alive}^{cat} \rightarrow \psi_{cat} \rightarrow \psi_{dead}^{cat} \qquad 3.$$

There are two discontinuities between the wave functions. Bernard d'Espagnat tried to clarify a little more the state of the cat inside the chamber and the role of the observer by stating: "Schrödinger then pointed out that under these conditions if the cat is considered as a quantum system and described by a wave function, its final state is necessarily a quantum superposition of the two states "cat alive" and "cat dead", so that it should in no case be considered either as being alive or as being dead. This state of affairs goes on until an "outside observer" opens the container and looks inside, for it is only through the latter process that the wave packet is reduced and that, in one case out of two, the cat is thereby truly killed" ([50], p. 302). In a letter to Schrödinger, Einstein made some comments regarding the experiment: "I am as convinced as ever that the wave representation of matter is an incomplete representation of the state of affairs, no matter how practically useful it has proved itself to be. The prettiest way to show this is by your example with the cat (radioactive decay with an explosion coupled to it) [in the original Schrödinger's gedanken experiment the cat is gassed]. At a fixed time parts of the ψ-function correspond to the cat being alive and other parts to the cat being pulverized [gassed]. If one attempts to interpret the ψ-function as a complete description of a state, independent of whether or not it is observed, then this means that at the time in question the cat is neither alive nor pulverized [gassed]. But one or the other situation would be realized by making an observation" ([51]

August, 9, 1939, p.35). In a letter dated December 22, 1950, Einstein insists in his position: "You are the only contemporary physicist, besides Laue, who sees that one cannot get around the assumption of reality – if only one is honest. Most of them simply do not see what sort of risky game they are playing with reality- reality is something independent of what is experimentally established. They somehow believe that the quantum theory provides a description of reality, and even a complete description; this interpretation is, however, refuted, most elegantly by your system of radioactive atom + Geiger counter + amplifier + charge of gun powder [a small flask of hydrocyanic acid in the original experiment] + cat in a box, in which the ψ-function of the system contains the cat both alive and blown to bits [gassed]. Is the state of the cat to be created only when a physicist investigates the situation at some definite time?" ([51] p. 39). On his side, Stephen Hawking also mentions Schrödinger's cat. After describing the cat experiment (Hawking changes the small flask of hydrocyanic acid by a gun pointing the cat) we find the following statement. "If one opens the box, one will find the cat either dead or alive. But before the box is opened, the quantum state of the cat will be a mixture of the dead cat state with a state in which the cat is alive. This some philosophers of science find very hard to accept. The cat can't be half shot [gassed] and half not shot [not gassed], they claim, any more than one can be half pregnant" ([52], p. 45).

WHAT IS A CAT?

We, as primates, evolved in such a way that we are endowed with something called "consciousness", a term that has never been the object of a full definition satisfying all the people involved in the study of this question [53]. As a serious discussion cannot begin by employing a debatable concept, I will tentatively employ the concept of field of consciousness developed by Aron Gurwitsch and defined as the totality of copresent data [54]. Gurwitsch states that "every total field of consciousness consists of three domains, each domain exhibiting a specific type of organization of its own. The first domain is the theme, that which engrosses the mind of the experiencing subject, or as it is often expressed, which stands in the 'focus of his attention.' Second is the thematic field, defined as the totality of those data, copresent with the theme, which are experienced as materially relevant or pertinent to the theme and form the background or horizon out of which the theme emerges as the center. The third includes data which, though copresent with, have no relevancy to, the theme and comprise in their totality what we propose to call the margin" [54]. An example pertinent to the analysis of Schrödinger's gedanken experiment is that the chamber, the cat and the rest of the associated paraphernalia belong to the first domain, an automatic filming device employed to capture the experiment could belong to the thematic field and all the remaining objects or phenomena belong to the margin (this is completely true only in the case of a scientist completely dedicated to the cat's experiment). Let us focus our attention on the content of the copresent data. These data is the final result of a brain processing of all the information received from the "external world" and it is hardware-dependent (for example a totally blind subject is not receiving and processing visual data, compare with the Indian story of the blind men and an elephant). In other terms, the field of consciousness contains, at a given moment, objects (cat, chamber, etc.), sounds, odors, etc. At every moment, and in the field of consciousness of each one of us, "units" (a cat for example) appear as entities distinct from a background and a background as the domain in which entities appear.

How do we know that there is a cat in our field of consciousness? Probably our first knowledge of what a cat is appeared when we were children and somebody pointed to one while saying something like *this is a cat* (the ostensive definition). This kind of definition works for almost all children because it seems that our field of consciousness is the product of evolution and seems to be structured in a similar form in all us (I say *almost* because some genetic anomalies can alter the structure of the field of consciousness). In a similar way we were taught to recognize something called a *dead cat*.

We can define the intension of a cat (as we see it), I(cat), as [55]:

$$I(\text{cat})=\{P_1,P_2,P_3........P_n\} \quad 4.$$

Where, P_1, P_2, etc are properties that a physical body must have to be called properly a cat (as a macroscopic object). The set of the P_i's must be of such nature that, if all the objects existing in the macroscopic universe are examined and classified accordingly to 4, the set containing the objects fulfilling Eq. 4 must be identical with the set comprising all the cats existing in the universe. Note that the number of elements in the set of cats varies with time: new cats enter after they are born and some disappear because they stop to be cats. We may go deeper and select those properties that are both necessary and sufficient to distinguish a cat from any other body in the universe by defining the core intension of a cat, I_{core}(cat) as [55]:

$$I_{core}(cat)=\{P_1,P_2,...P_k\} \quad 5.$$

with k<n ($n<\infty$) and $I_{core}(cat) \subset I(cat)$. With a pen and a paper the reader will notice that the building of 4 and 5 for a cat is not as trivial as it appears at a first sight (include meowing in I_{core}(cat) if necessary). Note that the property "*to be alive*" must be contained in I_{core}(cat) to separate cats from planets, stars, clouds, dark matter, etc. I add that I_{core}(cat) must be time-independent to keep intact the cat (if a P_i is lost, by the very definition of I_{core}(cat), a cat is no more a cat). Note that the set $\{P_1,P_2,...P_k\}$ contains only macroscopic properties provided mostly, if not all, by all our sensory organs. It is unnecessary to argue to state the trivial fact that in quantum mechanics it is not possible to write a macroscopic wave function (Ψ) composed by the elements of I_{core}(cat), the corresponding Hamiltonian, and the operators ($\hat{P}_j$) for Eqs. 4 or 5 satisfying for example:

$$\hat{P}_3\Psi\left[I_{core}(cat)\right]=P_3\Psi\left[I_{core}(cat)\right] \quad 6.$$

Where, $\hat{P}_3$ could be the operator for *to meow* and P_3 are the different "eigenvalues" (the several kinds of *meowing* if *to meow* is included in I_{core}(cat)). I think that nobody will argue against this.

A MICROSCOPIC CAT

Now, let us examine the microscopic composition of a cat. If we could take an instantaneous photo (a *static* or *frozen* cat) of the particles composing a cat and count them we shall see that he is composed by a really great number of microscopic particles (atoms, ions, molecules, macromolecules, etc.). For this unique instant we can write an approximate wave function $\Psi^{cat}_{static}=\Psi(q_1,q_2,...q_z)$ (something like a "*Born-Oppenheimer cat*" from quantum chemistry). To deal with a real cat it is necessary to add the time variable and build the corresponding time-dependent Schrödinger equation. A serious problem to deal with is that the number of particles composing a cat is time-dependent: the cat eats, urinates, breathes, etc., and we need to consider this change in the number of particles. A more subtle problem is related to the determination of what particles we must include in the cat's wave function: shall we include for example the air particles that exist between the hairs of the cat's skin and travel with him (most of them)? Shall we include the air's atoms and molecules that are inside the cat's lungs and that will be expelled out of them? Supposing that all these problems and related ones are solved, and that we have enough computational power and time to solve the equation we will be finally in possession of the wave function of the microscopic cat and can determinate its states. By means of the corresponding operators we may obtain several quantum mechanical observables. But all this procedure only determinates the behavior of a very large set of particles and does not contain any information allowing us to state that we are dealing with a cat. I hold that if we provide all the aforementioned microscopic data to a scientist to solve the time-dependent Schrödinger equation, but without informing him that he is dealing with a cat, there is no way for him to know this fact. Now, let us consider the microscopic description of a healthy cat having water and food at will and living a happy life. This cat will die at an old age. The microscopic description of such a cat needs a time-dependent Schrödinger equation containing enough border conditions allowing its natural death at the exact moment. It sounds complicated but it is logical. I repeat again that no quantum mechanical observable obtained from the equation for this ensemble of microscopic particles is a member of $I(cat)$ or $I_{core}(cat)$.

WHAT IS A DEAD CAT?

Any cat has a special macroscopic property called "*to be alive*", property that must be included in $I_{core}(cat)$ to distinguish it from non-alive objects. Now we shall discuss "*dead cats*" by analyzing the following gedanken experiment (before explaining it, I must declare that I live with dogs, birds, fishes and plants and that I like very much cats). A scientist and a cat are inside an airplane flying at 35,000 meters above the Earth's surface. At a certain moment, the scientist opens one of the plane's doors and throws the cat out. We have the possibility of filming all the falling of the cat and record a quarter of a million frames per second. The cat will end its fall on the surface of a very hard material incapable of being deformed by the collision. For the sake of simplicity, we shall consider that the cat is falling with its snout pointing to the surface. Nobody doubts that the cat is still a cat at this moment. Unhappily, in this gedanken experiment there is a model human primate family camping close to the impact site. A small girl is watching the sky and suddenly she cries "Oh my God, a cat is falling from the sky!" Her parents and her kid brother also watch to the sky and agree with her statement. As the cat is falling really fast, in a matter of less than one second it crashes on the surface, splashes and scatters. "Oh my God, the cat is dead!" howls the kid and all the family and all the experimentalists that are watching the outcome of the experiment agree with his statement. Now, we shall begin an analysis frame-by-frame of the film starting at the moment when the distance between the cat's snout and the surface is about 1 cm. An analysis frame-by-frame will show several nasty situations. For example we shall see the deformation and splashing of the skin and meat of the snout, the progressive breaking and scattering of the jaw, the scattering of one or more teeth, bones and pieces of bones, etc. We left to the reader's imagination the composition of the whole process. Probably at the end of it we could be able to identify the cat's tail, few teeth and may be some extremities (this experiment can be also used as a source of inspiration for the puzzle of Tibbles the cat, see [56]). The fundamental question is this one: what is the first frame in which the statement "the cat is dead" is true? A short meditation on this issue strongly suggests that we are obliged to introduce a (debatable) definition of death. For example, we can consider the cat as dead when the electrical activity in its brain ceases (like in humans). With this definition it is only a matter of time to find the last frame in which the cat's brain has enough integrity to produce a normal electric activity. But this choice presents some problems. Somebody may argue that surely in this frame the cat is dead but in several previous frames the cat is half destroyed (a cat falling from the sky with the tail pointing to Earth presents a slightly more complicated scenario). Moreover, we can theoretically do some surgery on a cat and leave only those parts allowing a normal electric activity and declare that this is also a cat (this surgery remembers me when Plato defined man as an animal, biped and featherless, and was applauded. The great Diogenes plucked a fowl and brought it into the lecture room with the words, "here is Plato's man", [57]). But let us keep aside these problems and let us examine the "dead cat" from another point of view. Starting from the moment that we accept that "the cat is dead" a decomposition process starts that finalizes when all ions, atoms, molecules, macromolecules, etc. composing the cat passed to the Earth and/or to the sky (this is a simplified view). An immediate question arises: when a dead cat stops to be a dead cat? One second after dying for example? Or one hour after dying? The answer is important to build $I_{core}^{dead}(\text{cat})$, that must be time-independent. The time-dependence is obligatory because if we try to circumvent this requirement by choosing a very short time interval, we face the problem of knowing and naming the kinds of objects existing after this time interval: scattered cats, splashed cats, decomposing cats, etc. An observer that saw the cat falling from the sky and remained there until the cat disappeared after decomposing may answer that the cat was dead about ten days (a rough estimation). Another observer that passed ten minutes after the cat's destruction may state "there is a dead cat". A third observer passing two days after may state "there is a smelly decomposing cat" (that contains implicitly the statement "the cat is dead"). A fourth observer arriving twelve days after the gedanken experiment may ask: "what is this dark stain on that surface?" (He is not able to recognize a dead cat at that moment), etc. These "objects" have not a common $I_{core}^{dead}(\text{cat})$. Truly the extension of $I_{core}^{dead}(\text{cat})$ is zero. This is because a dead cat is only semantically defined as existing.

The main conclusion of this short analysis is that a *dead cat* is merely an idea treated as if it were a concrete and real physical entity. Therefore one of the statements of the problem, i.e. the existence of dead cats, is not true. Then, from the formal point of view, the problem posed by Schrödinger is not *well-conceived*. This implies that the problem is not *well-formulated*. The inevitable conclusion is that Schrödinger's cat problem does not belong to the class of scientific problems [55]. As such, the use in his *gedanken experiment* of the expression *dead cat* is simply an abuse of daily language. This abuse corresponds to the fallacy of misplaced concreteness. It is interesting to note that, after presenting this fallacy, Schrödinger never returned to it [58].

Other examples do not employ microscopic devices. For example, let us consider a certain cat and a chamber. The first experiment consists in putting a certain cat inside a box with enough food and water. We close the chamber and wait one month. After this time we cannot state that the cat is still a cat or that it ceased to be a cat. May be it is alive or may be it died for any reason. The only way to know the answer is by opening the chamber and wait until a cat (or another thing) appears in our field of consciousness. This problem is related to the question: is the moon there when nobody looks? Another example is this one. Given that sunlight employs 8.3 minutes to reach the Earth from the surface of the Sun it would be silly to propose a wave function of the Sun as a linear combination of the wave function of an intact Sun and a destroyed Sun.

THE COLLAPSE OF THE ROLE OF CONSCIOUSNESS IN THE COLLAPSE OF THE WAVE FUNCTION

It was Wigner who first speculated that the von Neumann collapse of the wave function occurred by an act of consciousness in the human brain (Part B, Vol. 6 of [59]). This conscious-induced collapse seems to explain well the Schrödinger's cat paradox: after opening the chamber which contains the cat we see it dead or alive because conscious observation collapsed the wave function of the corresponding opposite quantum state. If conscious observation is essential to collapse the wave-function, then the destiny of the cat is not fixed until an observer opens the chamber. Alternatively, if conscious observation is not necessary, then the cat is either dead or alive before the chamber is opened. After our analysis we feel that this interpretation collapsed.

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