Observing Schrödinger's Cat
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draft May 3, 2020

Abstract: Understanding E. Schrödinger's 1935 tongue-in-cheek thought experiment requires calibrating his observer to the time units of the measurement result. Calibration, a metrology process, defines the units of a measurement result. Without such a definition any measurement is confusing.

Keywords: Schrödinger's Cat; measurement; calibration; accuracy

The following is all the information Schrödinger provided on his thought experiment.[1] "One can even set up quite ridiculous cases. A cat is penned up in a steel chamber, along with the 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 it happens, the counter tube discharges and through a relay releases a hammer which shatters a small flask of hydrocyanic acid. If one has left this entire system to itself for an hour, one would say that the cat still lives *if* meanwhile no atom has decayed. The first atomic decay would have poisoned it. The ψ function of the entire system would express this by having in it the living and dead cat (pardon the expression) mixed or smeared out in equal parts."

Schrödinger's experiment first appears to contrast two distributions, the probabilistic time distribution of an atom's state and a cat's binary state (alive or dead) by correlating two observations (measurements): an atom's decay and a cat's death. In fact, by virtue of the apparatus the actual time of each cat's death is a fixed time after the time of an atom's decay. Schrödinger proposed the mean time of each of these equal but shifted distributions is one hour. With a mean time of one hour the maximum extent of every cat's actual time of death distribution is estimated to be 2 hours.

Next, Schrödinger proposed one observation of the cat's state by a human at one hour. This is a one time observation of a third distribution, the observed state of one cat over time. This may be compared with the actual cat's state (second distribution). This comparison is more interesting as it describes a measurement of a cat's state.

The third distribution of each cat's observed time of death is correlated both to the actual time of death and to how often does the human observe the cat (i.e., the time-between-observations). In Schrödinger's experiment this time-between-observations is given as one hour. Then the precision of this one observation is +/- one hour relative to every cat's actual time of death (about a 2 hour span). This may suggest that the distribution of the actual time of each cat's death, fixed by the atom's decay, is the same as the distribution of the precision of the measurement observation (2 hours). This is confusing.

The accuracy (variation to the reference) of each observation is adjusted by calibration which correlates the measuring apparatus intervals (in this experiment, the time-between-observations) to a time reference (e.g., one second). A reference is a non-local intermediate required to maintain Euler's quantity ratios (see note 2).[2]

When the times proposed (both one hour) are applied, the third distribution of the time-between-observations is uncorrelated to the first distribution of the atom's decay time. This occurs because the precision +/- one hour, of the time-between-observations, is close to as wide as the atom's decay distribution (2 hours). This thought experiment, as presented, is two equal but time shifted distributions of the atom's decay and cat's death (one ψ function) and one uncorrelated observation (a different function). However, this experiment has drawn interest for 85 years because of what occurs when the human's time-between-observations are a distribution, not a single observation at one hour.

The first human observation of a dead cat after an observation of life is measured in time from the beginning of the experiment (alive cat). These observations of the time of death identify that the distribution over multiple experiments is correlated with the ψ function of an atom's probabilities and that the state of each cat is binary. The actual time of death and the observed time of death are different. Because the observed time of death is also correlated to the time-between-observations and the time reference defined.

The observer (or measuring apparatus) counts the number of times the cat is examined. These observations result in a sequence of alive states ended by one dead state during the 2 hour maximum time to complete one experiment. Counting this sequence of alive observation generates a magnitude, but not a measurement correlated to a time reference. Such a measurement requires defining and controlling the time-between-observations, which requires the calibration of the observer/measuring apparatus to a time reference.

As example in Schrödinger's experiment, calibration would be setting and maintaining the time-between-observations to 10s (s = second, the time reference or unit). Then the maximum variation of the observed time of death relative to the actual time of death is +/-10s (i.e., accuracy). Applying calibration, a count of the time periods between observations, which were uncorrelated to each other, becomes a sum of multiple time-between-observations each correlated to a time reference.[3]

Calibration is required to observe accurately a cat's time of death (i.e., a measurement). Schrödinger was incorrect, there is one ψ function of the actual cat's state and another function which includes calibration, of the observed cat's state. The states of life and death are not mixed.

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[1] E. Schrödinger, "The Present Situation in Quantum Mechanics". First published in German in Naturwissenschaften 23, 1935. This translation (J. D. Trimmer) first appeared in the *Proceedings of the American Philosophical Society*, 124, 323–38 (1980).

[2] L. Euler, *Elements of Algebra*, Chapter I, Article I, #3. Third edition, Longman, Hurst, Rees, Orme and Co., London England, 1822. "It is not possible to determine or measure one quantity other than by assuming that another quantity of the same type is known and determining the ratio between the quantity being measured and that quantity".

[3] K. Krechmer, Relative Measurement Theory, The unification of experimental and theoretical measurements, *Measurement*, Volume 116, February 2018, pages 77-82.
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