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Does Schrödinger's Cat Paradigm apply to forensic evidence? A Critical Interdisciplinary Review

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Abstract: Erwin Schrödinger is a scientist who stands out with his work in quantum mechanics. The legendary Schrödinger's Cat continues to be popular in today's scientific world. This famous cat describes on a quantum basis a reality that is accepted in quantum reality, but which we cannot practically observe in the macroscopic world.
Schrödinger's experiment was created in which we cannot tell whether the cat is dead or alive until the box lid is opened. Therefore, if we do not open the lid, the probability of the cat being dead or alive will be 50%. The "superposition state" of the cat ends with an observational measurement.
Being aware of the evidence in the position of silent witnesses at the crime scene will reveal many truths. This awareness should be based primarily on observation. This observation is like understanding the book's main idea by reading the summary on the back page. It can be considered a logical measure of the suitability of the evidence. This measure can only be formed with the results obtained by good observation and analysis.
In short, the effective use of systematic crime scene investigation is the basis of reaching an understanding of evidence with high evidential power. But at the heart of these two important activities is awareness of good observation. It should not be forgotten that the difference between the seeing eye and the looking eye is that the seeing eye knows what it is looking for.

Keywords: *Schrödinger's cat, forensic evidence, superposition state, observation.*

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Schrödinger'in Kedisi Paradigması Adli Kanıtlara Uygulanabilir mi? Disiplinlerarası Eleştirel Bir İnceleme

Ercan Seyhan

Öz: Erwin Schrödinger kuantum mekaniği alanında yaptığı çalışmalarla öne çıkan önemli bir bilim insanıdır. Efsanevi Schrödinger'in Kedisi ise günümüz bilim dünyasında hem fen bilimlerinde hem de sosyal bilimlerde popüler olmaya devam etmektedir. Bu ünlü kedi kuantum gerçeğinde kabul gören ancak bizlerin makroskopik dünya gerçeğinde pratik olarak pek de gözlemleyemediğimiz bir gerçeği kuantum temelinde anlatmaktadır.
Schrödinger'in deneyi, kutunun kapağı açılana kadar kedinin ölü mü yoksa canlı mı olduğunu anlayamadığımız bir deney olarak yaratıldı. Dolayısıyla eğer kapağı açmazsak, kedinin ölü ya da diri olma olasılığı %50 olacaktır. Kedinin "süperpozisyon durumu" gözlemsel bir ölçümle sona erer.
Olay yerindeki sessiz tanıklar konumundaki delillerin farkında olmak birçok gerçeğin ortaya çıkmasını sağlayacaktır. Bu farkındalık öncelikle gözleme dayanmalıdır. Bu gözlem, kitabın ana fikrini arka sayfadaki özeti okuyarak anlamaya benzer. Kanıtın uygunluğunun mantıksal bir ölçüsü olarak kabul edilebilir. Bu ölçü ancak iyi bir gözlem ve analiz ile elde edilen sonuçlarla oluşturulabilir.
Kısacası, sistematik olay yeri incelemesinin etkin kullanımı, kanıt gücü yüksek bir delil anlayışına ulaşmanın temelini oluşturmaktadır. Ancak bu iki önemli faaliyetin temelinde iyi gözlem yapma bilinci yatmaktadır. Unutulmamalıdır ki gören göz ile bakan göz arasındaki fark şudur: Gören göz ne aradığını bilir.

Anahtar Kelimeler: *Schrödinger'in Kedisi, adli kanıt, süperpozisyon durumu, gözlem.*

Introduction

Crime scene investigation is accepted as a technical practice. This stage can directly affect the scientificity, reliability, and acceptability of the evidence. The main objective of crime scene investigation is to protect the crime scene, detect, record, and collect the evidence, and send it to forensic science laboratories (Inman&Rudin, 2001).

Forensic scientists may agree that forensic work is based on five main pillars. These are Locard's principles of "every contact leaves a trace"; classification and identification; individualization; liaison and restructuring. Although this paradigm continues to be valid in many forensic science applications, there is often individualization, especially in evidence that is only physically compared and matched. On the other hand, in evidence that requires physicochemical examination, restructuring may not be necessary. In short, although these paradigms are instructive, they cannot be applied together for each piece of evidence (Ribaux et al., 2003).

Erwin Schrödinger is an important scientist who stands out with his work in quantum mechanics. The legendary Schrödinger's Cat continues to be popular and has been the subject of many scientific articles written today (Bhaumik, 2017). This cat, which is both alive and dead at the same time, is now famous not only in the scientific platform but also in social life. It is frequently referenced in quantum physics articles and has bestowed a "cat state" reputation as a term that began to be used in quantum measurements. This term is used for the metaphor known as superposition in quantum physics. However, with the social and numerical scientific interpretations of the cat's melodramatic character and the meaning value it carries, it has suddenly gained a solid place in literature, television, movies, cartoons, and video games (Monroe et al., 1996).

This symbolic superposition entity is a paradigm for us to understand the coexistence of the real relationship that exists between quantum and classical understanding. In short, the cat case tries to show that two different states occurring on a microscopic scale are valid simultaneously for a single particle. However, in the macroscopic world, this superposition state lasts until the observer opens the box. In other words, when the box is opened and the situation inside is observed, the cat situation deteriorates and turns into a single situation (Schrödinger, 1935).

The Foundation of Knowledge in Forensic Sciences: Evidence

Evidence is transferred to reports by forensic scientists. Applied analytical laboratory techniques have the greatest share in this knowledge formation (Houck, 1999). The main purpose of laboratory analysis is nothing but the individualization of the evidence. Which is the attachment of evidence to a place, time, person, or event. In this association, statistics has great importance in determining the accuracy and precision of the information. Forensic laboratories present their examination results with a certain scientific precision threshold level given in statistical values at certain intervals (Cleland, 2001).

Edmund Locard's principle that every contact leaves a trace emphasizes that mutual interaction and transfer will take place through the contact of any two things, even if the result is small or cannot be detected at first glance (Locard, 1939). What results from this transfer is valuable data. We can characterize and describe these data with proxy data that are frequently used in paleoclimatology (Mann, 2002). In forensic science, we can say that proxy data source is evidence. If the evidence is not collected and subjected to laboratory examination, no suggestion can be made within a certain uncertainty value range to reveal the truth (Cleland, 2001).

Human activities certainly leave an imprint. If a person commits a crime, he/she leaves behind something that was not there before, or when he first arrives at the scene, he takes something that is not on him and leaves. This formulation coincides with the following view put forward by Paul Kirk about the Locard Principle (Locard,1939):

> *"Whether the suspect consciously or unconsciously steps, touches, or leaves something of himself behind, he leaves behind a silent witness who will testify against him, too. It can be not only fingerprints or shoe prints, but also hair, fibers, a piece of broken glass, tool marks, paint on the wall he rubbed, blood, and semen he left on the scene. These and more are silent witnesses on the scene. It is clear that evidence never forgets; is not confused by excitement, and continues to be at the scene. Because physical evidence is a reality. He does not lie to himself. He does not hide if he is at the scene. However, human error can delay its discovery and degrade its value through misinterpretation."*

Scientists accept that every object in the universe has significant and measurable differences, but they are not the same, no matter how similar they may seem. The principle of dissimilarity, which states that nothing in nature can be the same, expresses originality. It is impossible to compare an object with all other similar ones. Therefore, it is hardly possible to test this assumption directly with all other analogies. The indirect confirmation test of this hypothesis depends on the examiner's analytical ability. Forensic scientists are constantly working on techniques for proving the uniqueness of objects. However, it is a fact that forensic science disciplines, which conduct more comparative research, require distinctive application and selective principles. This principle is accuracy and precision in measurement (Chang&Goldsby, 2014).

Scientific methods are applied to monitoring changes in all science fields. This method is a systematic research approach. The results obtained from the research can be qualitative values obtained by observing the system in general, or they can be quantitative values, that is, numerical values obtained by different measurements. After the experiments are completed and the results are recorded, the second step in the scientific method is the interpretation and evaluation of the observations. The researcher creates a hypothesis based on the data or explains a series of observations based on the experimental results. New experiments are created as possible to check the validity of the hypothesis. After collecting a sufficient amount of data, this information is summarized as a law (Chang&Goldsby, 2014). In science, a law is an appropriate verbal or mathematical expression that expresses the relationship between events and is always valid under the same conditions.

After many experimental studies, hypotheses are validated and turned into theories. The theory explains a decisive principle regarding any event and/or the laws underlying that event. The accuracy and precision of the values obtained in each hypothesis, theory, or law constitute the basis of quality and reliability. Accuracy and precision are two concepts that ensure the soundness and reliability of investigations in forensic sciences (Inman&Rudin, 2001).

For a scientist, accuracy and precision are completely different concepts. Accuracy refers to the closeness of measurements to the true value. Accuracy measures the closeness between a result and the true value. Precision describes the closeness between many results measured in the same way. Accuracy is expressed in terms of absolute error or relative error. Precision indicates the repeatability of measurements, that is, the closeness of results obtained in the same way. In general, the precision of a good measurement can be easily determined by repeating measurements with replicate samples (Chang&Goldsby, 2014).

Philosophy of Evidence in Forensic Sciences

Human beings naturally observe, measure, and make comparisons. However, the most important feature that distinguishes scientific measurement from others is objectivity. Because every observation or measurement may be subject to error at any time. So scientists want to know how much they can trust the measurement results. Determining the uncertainties and margins of error in the measurement approximately forms the basis of scientificity in measurement (Chang&Goldsby, 2014).

Measurement uncertainty is a quality indicator that is very important in the analytical sciences. Therefore, it is of great importance in terms of forensic sciences and evidence analysis. The outputs of the analysis are a measurement value (such as weight), what something is (such as a drug) or its characteristics (such as traces of a weapon on a hive), or similar results from other sub-disciplines (Atkins &Jones, 1997).

However, specifying the exact line among observations, evaluations, and analyses is very important in forensic science philosophy. While analysis is a measurement, observation, and evaluation are subjective evaluations. These are the techniques used in the forensic sciences sub-disciplines. If the same is obtained with other analysis methods, the measurements are objective.

In most of the procedures in the forensic sciences, comparison and matching take time. During this process, analytical results are taken and comparisons are made with each other. In forensic science, the difference between interpretation and evaluation is very clear. While interpretation is determining what something might be, evaluation is trying to determine what the interpreted thing means. While evaluating, it is triying to determine what the current sample matches and what this match might mean. In other words, the evidence interpretation is trying to evaluate the value of the proof in the event. So the deduction can be made. While there is a need for scientific knowledge in interpretation, evaluation, and analysis; information need continues to increase in intensity from interpretation to analysis at each stage. While analysis can usually be done by trained technicians with technical knowledge and skills; interpretation can only be done by those who have sufficient knowledge about the relevant discipline. Being able to interpret and evaluate the evidence needs to be efficient in both physical examination and instrumental analysis. Therefore, we can say that the product of the evaluation is an expert report.

A scientific approach to a problem consists of a series of scientific activities that include observation, measurement, hypothesis generation, and hypothesis testing. Observation can be performed without needing any measurement or can be based on a measurement. In both cases, the scientist can generate hypotheses and test the results. The source and cause of the effect are tried to be determined. Forensic scientists form and interpret hypotheses by deduction and induction. As the number of repetitions increases, the system's giving the same result will indicate that our hypothesis is correct and reliable. This principle constitutes the basis of the Bayesian Approach, which is frequently used in forensic science examinations and evaluations of evidence.

Sustainable Reliability-Objectivity/Impartiality

Forensic investigations are organized by a series of unit operations. While trying to reveal what happened at the crime scene, basic forensic science activities are carried out. These are the basic steps for reliable and objective forensic science applications (Kalia et al., 1997). The principles of divisibility and transferability of matter and other principles related to forensics are the basic rules for presenting evidence with scientific data. Identifying, individualizing, connecting, and restructuring the question "who? what? where? when? how?" while establishing the scientific link between evidence, crime, and criminal. Unit operations are the basis for the answers to the questions. These questions are event-based and are shown as the basic triangle of the victim, suspect, and evidence/witness, which are the interactive elements of the crime scene (Cook et al., 1998).

The unit operation that chemists often use can be applied in all forensic science disciplines. Although unit operation is a term developed by chemical engineers, it is applied to many science branches. They can also be defined as logical structures used for analysis and synthesis activities in science disciplines. The targeted aim is to provide reliability with sustainable quality assurance (Saks&Koehler, 2008).

The description is the operation sequence that provides a better understanding of an event. We cannot describe identification as just a perception. It is to understand the event fully and in detail. When a scientist wants to identify an object of interest, he makes physical and chemical measurements with a certain degree of precision. Many forensic techniques are based on comparing evidence with a standard sample. The applied test techniques are considered validated and accepted if they are reproducible, sensitive, and specific. Repeatability is that the standard sample always returns the same correct value. Sensitivity is the ability to accurately detect the unique characteristics of the material under investigation. The specificity is that the test technique gives accurate and precise results for a particular material. Individualization is the next step after identification. Evidence can be individualized immediately after classification. The general approach to individualization in forensic science is to determine accurately and precisely when comparing two evaluated materials for the general classification. Chemistry, physics, and logic determine the uniqueness of an object. However, in terms of forensic sciences, individualization is the determination of uniqueness after classification. In other words, comparisons are made on samples from the same origin classification. Liaison is to establish the connection between the source (evidence) and the target (the suspect). This inference is the phase of the transferred material's positive detection. Source and target are two relative concepts. Sometimes the transfer can be detected on both sides. The unit operates at this stage where hypotheses are compared and a decision is made. The hypothesized evidence probability is the probability of any contact between the target and the source (Kaye, 2010).

Restructuring is linking the connections in time and space from the data obtained. At this stage, answers are sought to "where, how, and when". Evidence found at the crime scene can be used to reveal the situations that occurred before, during, and after the event. In other words, the evidence can answer the questions of "in what order the activity occurred" and "in what order of time it occurred" in the period of the event. Sometimes, claims can be confirmed or refuted by reconstructing only a part of the event. Reconstruction begins with a crime scene investigation. It continues with the identification, collection, and examination of evidence. It is supported by the records obtained at the crime scene and witness statements.

Restructuring is a unit operation consisting of a somewhat complex chain of operations. The deductive method is used in the basic thinking style. However, it also requires induction in the stages within itself. Common restructuring activities generally interested in are trace evidence transfers, blood pattern analysis, bullet path detection, fracture and crack analyses on materials, and post-fire and explosion crime scene structuring.

In general, changes occur because an effect creates physical signs and symptoms in the environment. These signs and symptoms can be observed, tested, measured, and recorded. In short, we can define restructuring as the determination of the chronological time sequence of the process in which the investigated event occurred.

Schrodinger's Cat Paradigm

The Schrödinger's Cat paradigm is an experiment in measurement. The "cat" in the Schrödinger experiment is placed in a steel box with a radioactive source that has a 50/50 probability of oscillation for a total of one hour. A cyanide capsule is placed inside the box, the activation of which depends on the emission of radiation by a separate mechanism and which will be broken by a hammer. If gamma-ray emission occurs inside the can, the sensor will activate, triggering the hammer that will break the cyanide capsule. In this case, the cat will die. But if the release does not occur, the poison capsule will not break and the cat will also live. In this experiment, we cannot tell whether the cat is dead or alive until the lid of the box is opened and observed (Schrödinger, 1935).

In the classical-quantum sense, this is the case when the cat is both dead and alive. From another point of view, if the radiation source in the experiment oscillates, it determines the cat's fate. In this case, it will be impossible for us to understand the condition of the cat unless we open the box lid. So, the probability of being dead or alive will be 50/50. This statistical probability is epistemic. In other words, decisions can be made based on information from observation (Gribbin, 1995).

If we see that the cat is dead, we will understand that gamma rays were released, the hammer broke the tube and the poison was released. That is, the cat was dead immediately after the gas release. If we see that the cat is alive, we will understand that there is no gamma emission, that the hammer did not break the tube, and that no poison release occurred. So the cat is still alive.

However, before the observation was made, Schrödinger focused on what would happen inside the box in a quantum sense. Before the lid was opened, it was assumed that the cat was in superposition, that is, both dead and alive.

Because the radioactive source oscillating probability is 50/50, the cat's death/survival rate was accepted as 50/50. Therefore, nothing definite can be said about the condition of the cat before making an observation. Whenever the lid is opened and observed, then the cat state collapses from the superposition to one of two possible states. So it is understood that he is dead or alive. The same is true for the radiation source. If the cat is dead, oscillation is made, if the cat is alive, there is no oscillation. In both cases, it is necessary to open the cover and observe (Everett, 1957). This cutting-edge uncertainty situation is based on the assumptions underlying the measurement process. Two propositions are valid before the observation. The first is the fact that this system state, which Schrödinger put forward, will constantly evolve and the cat will continue to be in superposition. The second is the fact that two possible sub-eigenstates of the superposition, namely “being alive” and “being dead”, will end with the observation. So, one of the 50/50 possibilities will deterministically come true and one of the possibilities will collapse.

Schrodinger’s Cat-Measurement and Probability

Although the idea of a cat in a superposition state in quantum thinking has been criticized by many physicists, it may not be a very strange concept on a quantum basis. So the cat is both dead and alive. However, this is based on the probabilities (Monroe et al., 1996).

While evaluating the probability, some possibilities may coexist with the same ratio. Although this situation creates conceptual confusion, the problem to be emphasized is the determination of how these possibilities occur. So how and when did the possibilities become reality? What are the reasons for the possibilities to become reality?

By observation, the dichotomy of being dead/alive in Schrödinger’s Cat turns into being either dead or alive, and one of the possibilities turns into a reality. However, there is another statistical situation which is a case of randomness. In this experiment, Schrödinger assumed that a random radioactive release would kill the cat. Therefore, observation is impossible until the lid is opened. When the cover is closed and alpha particles are released; alpha particles reach the Geiger counter in time t, the hammer connected to an electrical circuit powered by a Geiger counter drops, the cyanide tube is broken by this hammer and the gas released into the box kills the cat.

However, the cat’s death is statistically random and it cannot be determined exactly when it died. Because it is not possible to determine when the oscillation will occur and which particle will activate the device. If we open the lid at time t, the statistical probability of particle oscillation, hence the death of the cat, will be 50%. If we open the lid in t/2 time, there will be a 25% chance that the cat is dead. However, if we open the lid later than t time, for example at 2t time, there will be a 25% chance that the cat is alive this time. Therefore, without observation, quantum can only provide us with statistical information, that is, probability information (Fine, 1993).

Schrödinger experimented by blending the quantum functions in the nuclear world with the realities of the macroworld. Although it continues to receive many criticisms today, new information continues to be produced/suggested with alpha particles and the Geiger counter. For example, with the recording devices added to the Geiger counter, the time of the oscillation can be recorded. The death of the cat can be monitored with a mechanical recording system, or the approximate time of death can be determined by an autopsy performed after the test results in the death of the cat. This will give us the approximate time of the gamma irradiation. In this case, it will be as if the cat's body recorded the event (Monroe et al., 1996).

This cat paradox produced is an experiment pointing to the use of physics solutions in the measurement problem. In the Shrödinger experiment, the superposition state, which occurs according to the presence or absence of radioactive particle emission in the microscopic environment, relates to a deterministic understanding of a cat being both dead and alive in the macroscopic environment, that is, the superposition state (Ghirardi et al., 1986).

In general, the universe records all kinds of information by observing itself. In other words, traces of every event continue to exist in the universe. Therefore, macro and micro environmental events can be revealed with good observation and measurement. The important point here is the issue of "being aware".

Conclusion: Schrödinger's Cat and Evidence

Schrödinger's experiment was created in which we cannot tell whether the cat is dead or alive until the box lid is opened. Therefore, if we do not open the lid, the probability of the cat being dead or alive will be 50%.

If we see that the cat is dead, we understand that the gamma has been released, the hammer has broken the tube and the poison has been released. So, the cat is dead immediately after the gas is released. If we see that the cat is alive, we will understand that there is no gamma emission, that the hammer did not break the tube, and that no poison release occurred. So, the cat is still alive. In short, the "superposition state" of the cat ends with an observational measurement.

Forensic science reveals the temporal and spatial relationship between people and places with events in the past. Evidence is a means of proof that provides for revealing certain facts from the past. It is very difficult to reach the truth without evidence. Being aware of the evidence in the position of silent witnesses at the crime scene will reveal many truths. This awareness should be based primarily on observation. This observation is like understanding the book's main idea by reading the summary on the back (Trimmer, 1980).

In Schrodinger's experiment, the silent witness is the cat. Until the lid is opened, it is both dead and alive in a quantum sense. The observer is in a serious dilemma until the lid is opened. In terms of forensic sciences, after the cover is opened, the condition of the cat also becomes evidence to indicate whether gamma-ray emission has been made or not. This state of the evidence, namely the superposition is a paradigm that is present at every stage associated with the evidence we have described throughout our article. Clarification of this position can be accepted as a situation that can continue until the first response, secure, detection, collection of evidence, and sending to the forensic laboratory for a scientific report of analytical examinations. In other words, evidence can become a real proof tool via observation and analytical examinations (Monroe et al., 1996).

The reliability of the evidence is directly proportional to the power of the proof. The power of proof can be considered a logical measure of the evidence's suitability for the purpose. This measure can only be formed by good observation and analysis.

In short, the effective use of systematic crime scene and analytical investigation methods is the of basis for understanding the evidential power. But at the heart of these two important activities is awareness of the evidence. This awareness is very important not to experience dichotomy about evidence at any stage in the forensic science process. It should not be forgotten that the difference between the seeing eye and the looking eye is that the seeing eye knows what it is looking for.

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