[... ] the scientist subconsciously, almost inadvertently, simplifies his problem of understanding Nature by disregarding or cutting out of the picture to be constructed himself, his own personality, the subject of cognizance.
One can even set up quite ridiculous cases. A cat is penned up in a steel chamber, along with the following device [...] in a Geiger counter, there is a tiny bit of radioactive substance, so small, that perhaps in the course of the 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 that 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 psi-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.
"The Copenhagen interpretation of quantum mechanics implies that after a while, the cat is simultaneously alive and dead."

Rüdiger Schack  Royal Holloway, University of London
QBism and the Greeks, or how to interpret quantum mechanics
Schrödinger’s Cat

Compare Schrödinger:

The psi-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.

with Wikipedia:

The Copenhagen interpretation of quantum mechanics implies that after a while, the cat is simultaneously alive and dead.
Psi-function, $|\psi\rangle$ (or wave function, or quantum state)

$|\psi\rangle$ determines probabilities

The psi-function for a physical system encodes, via the Born rule, the outcome probabilities for arbitrary measurements on the system.
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$|\psi\rangle$ is equivalent to a probability distribution

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Quantum mechanics is a theory of probabilities
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\[ |\psi\rangle = \frac{|\uparrow\rangle + |\downarrow\rangle}{\sqrt{2}} \]
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Standard interpretation: Wave function implies cat is both dead and alive

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→ Bruno de Finetti
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Probabilities of what?
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→ Nature and the Greeks
Heads or Tails

Tossing a “fair” coin, following *The Logic of Science* by E. T. Jaynes:

Observation 1
prob = 1/2 is not a property of the coin.

Observation 2
prob = 1/2 is not a joint property of coin and tossing mechanism.

Observation 3
Any probability assignment starts from a prior probability.
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- This is the theory of personalist Bayesian probability due to de Finetti, Ramsey, Savage, Jeffrey and others.
Dutch book (adapted from Wikipedia)

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Personalist Bayesian probability

**Definition**
To assign probability $p$ to an event $E$ means to regard as fair a bet on $E$ at the odds implied by $p$.

**In other words,**
I am happy to bet on $E$ at these odds or any more favourable odds, but not at less favourable odds.
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An agent’s probability assignments are called Dutch book coherent if they rule out the possibility of a Dutch book.
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An agent’s probability assignments are called *Dutch book coherent* if they rule out the possibility of a Dutch book.

**Theorem**

An agent’s probability assignments are Dutch book coherent if and only if they obey the standard probability rules.
Bayesian statistics in a nutshell

- Start from your prior probabilities (= prior belief), collect data to refine and update these, and use the updated “posterior” probabilities to make predictions.

Bayesian statistics is implied by Dutch-book coherence. Bayesian statistics has become mainstream in the last two decades due to powerful computers and new algorithms (in particular, MCMC). Bayesian statistics has been used by Nate Silver to predict the outcomes of recent US elections with spectacular success.
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QUANTUM STATES DO NOT EXIST
The abandonment of superstitious beliefs about the existence of Phlogiston, the Cosmic Ether, Absolute Space and Time . . . , or Fairies and Witches, was an essential step along the road to scientific thinking. Quantum states, too, if regarded as something endowed with some kind of objective existence, are no less a misleading misconception, an illusory attempt to exteriorize or materialize our actual probabilistic beliefs.
What is a quantum state? Whose quantum state?

- A quantum state (or psi-function) for a physical system is assigned by an agent (a user of quantum mechanics) and reflects his personal beliefs.
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Quantum mechanics provides rules for the agent to update his quantum state in the light of measurement data.
What about a quantum random number generator?
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An agent’s probabilities for 0 and 1 depend on the his prior quantum state for the device, i.e., on his prior belief.
Botched attempt at a Quantum Bayesian account of Schrödinger's Cat in Scientific American

Standard interpretation: Wave function implies cat is both dead and alive

Quantum Bayesianism: Wave function describes mental state only; cat is either dead or alive
Schrödinger’s Cat, revisited

**Schrödinger**

The psi-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.

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The psi-function expresses an agent’s beliefs about the outcomes of his measurements on the entire system, including his probabilities for finding the cat dead or alive.
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### So when did the cat die, exactly?

Rüdiger Schack, Royal Holloway, University of London  
QBism and the Greeks, or how to interpret quantum mechanics
### The thought experiment

Wigner leaves his friend in a closed lab with the box containing cat and radioactive substance. After one hour, the friend opens the box. After two hours, Wigner returns.

What should Wigner do? Either,

- he writes down a psi-function with "cat alive/friend happy" and "cat dead/friend sad" smeared out in equal parts. Before he opens the lab, the cat is neither dead nor alive.

Or,

- because his friend opened the box, Wigner reasons that the lab definitely contains either a sad friend and a dead cat, or a happy friend and a live cat. Therefore Wigner writes down equal probabilities for the two cases.
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Who is right, Wigner or his friend?

Wigner:
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His friend:
As soon as I open the box, after one hour, the cat is alive or dead.
Some attempts to resolve the paradox

- Bohmian Mechanics.
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They are both right.
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Copenhagen interpretation:
A measurement corresponds to a laboratory procedure.

QBism:
A measurement is any action an agent takes to elicit an experience.
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Split between classical macro-world and quantum micro-world.

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• So there is an outcome in the friend’s experience and none yet in Wigner’s. Of course their accounts differ.
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If Wigner goes on to ask his friend about her experience, then the disagreement is resolved the moment he receives her report, i.e. when it enters his own experience.
Botched attempt at a Quantum Bayesian account of Schrödinger’s Cat in Scientific American

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Asher Peres:

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**QBism puts the agent at the center**

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Schrödinger to Sommerfeld (1931):
Quantum mechanics forbids statements about what really exists — statements about the object. It deals only with the object-subject relation. Even though this holds, after all, for any description of nature, it evidently holds in quantum mechanics in a much more radical sense.
Conclusion (QBism and the Greeks)

- Everything any of us knows about the world is constructed out of his or her individual private experience.
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• Hence it can be unwise to rely on a picture of the physical world from which personal experience has been explicitly excluded, as it has been from physical science since the ancient Greeks.

• The recognition that science has a subject as well as an object liberates us from the grip of an ancient Greek maneuver that worked for over two millennia, but tripped us up in the 20th century. QBism restores the subject-object balance and thus clears up the obscurities and ambiguities of the interpretation of quantum mechanics.