Meditators Collapse Quantum Systems In A Groundbreaking Study

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By
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Is this peer reviewed evidence that human consciousness can modify quantum states at distance?

I am not an expert in these matters... but I have to admit that the discussion of the paper is quite something: *Cumulatively, these experiments suggest that mind–matter interactions occur in a broad range of physical target systems. Observed effects tend to be small in absolute magnitude and are* ***not trivially easy to repeat on demand****, but* ***high variance*** *and concomitant* ***difficulties in replication*** *are to be expected because all of these studies necessarily involved focused human attention or intention.* – nico May 11 '15 at 11:19

When it comes comes to quantum physics, it's very common for researchers to come across information and results that leave them baffled, or simply don't comply with the known laws of physics. The result is often more questions than answers — and that's okay.

"We chose to examine a phenomenon which is impossible, *absolutely* impossible, to explain in any classical way, and which has in it the heart of quantum mechanics. In reality, it contains the *only* mystery."

– Richard Feynman, a Nobel laureate of the twentieth century (from Dean Radin's *Entangled Minds: Extrasensory Experiences In A Quantum Reality*)

In many instances, some results can go against the long-held and ingrained belief systems of many who hold prominent positions within modern day academia. The idea that that we live in a "spiritual" universe, for example, has been criticized heavily by mainstream academics.

Richard Conn Henry, a professor in the Henry A. Rowland Department of Physics and Astronomy at John Hopkins University, explains this problem well:

> ***Physicists shy from the truth because the truth is so alien to everyday physics. A common way to evade the mental Universe is to invoke 'decoherence' — the notion that 'the physical environment' is sufficient to create reality, independent of the human mind. Yet the idea that any irreversible act of amplification is necessary to collapse the wave function is known to be wrong: in 'Renninger-type' experiments, the wave function is collapsed simply by your human mind seeing nothing. The Universe is entirely mental. . . . The world is quantum mechanical: we must learn to perceive it as such. . . .The Universe is immaterial — mental and spiritual.*** *(source)(source)*

Perhaps this is why most of the founding fathers of quantum physics all shared the same belief, that consciousness is fundamental, that it precedes material reality, not the other way around. Perhaps this is also why more than 20 Nobel prizewinnersand a large number of eminent minds have supported what seems to be the next step for quantum physics, which, in my opinion, is parapsychology.

Here is a great study published in the journal *Frontiers of Neuroscience* titled "A call for an open, informed study of all aspects of consciousness" that explores this thoroughly.

"The day science begins to study non-physical phenomena, it will make more progress in one decade than in all the previous centuries of its existence."

– Nikola Tesla

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The Quantum Double Slit and What Consciousness Did to It

The quantum double slit experiment sheds light on what's known as the the quantum measurement problem. The quantum double slit experiment involves a physical system, as well as a measuring apparatus, which does an observation of the system.

In this experiment, tiny bits of matter (photons, electrons, or any atomic-sized object) are shot towards a screen that has two slits in it. On the other side of the screen, a high tech video camera records where each photon lands. When scientists close one slit, the camera will show us an expected pattern, as seen in the video below. But when both slits are opened, an "interference pattern" emerges — they begin to act like waves. This doesn't mean that atomic objects are observed as a wave (even though it recently has been observed as a wave); they just act that way. It means that each photon individually goes through both slits at the same time and interferes with itself, but it also goes through one slit, and it goes through the other. Furthermore, it goes through neither of them. The single piece of matter becomes a "wave" of potentials, expressing itself in the form of multiple possibilities, and this is why we get the interference pattern.

How can a single piece of matter exist and express itself in multiple states, without any physical properties, until it is "measured" or "observed"? Furthermore, how does it choose which path, out of multiple possibilities, it will take?

This quantum uncertainty is defined as the ability, **"according to the quantum mechanic laws that govern subatomic affairs, of a particle like an electron to exist in a murky state of possibility — to be anywhere, everywhere or nowhere at all — until clicked into substantiality by a laboratory detector or an eyeball."**

Perhaps this is why most of the founding fathers of quantum physics all spoke of something outside of our physical realm that influences the system, factors associated with consciousness, like measurement, observation, and intention.

The Experiment and What Happened

A paper published in the peer-reviewed journal *Physics Essays* explains how this experiment has been used multiple times to explore the role of consciousness in shaping the nature of physical reality.

It was published by Dr. Dean Radin, who you will see in the lecture below. He's the chief scientist at the Institute of Noetic Sciences.
He produced incredible results: Human intention, via meditators, was able to actually collapse the quantum wave function. The meditators were the "observer" in this case.

In fact, as Radin points out in his lecture, a "5 sigma" result was able to give CERN the Nobel Prize in 2013 for finding the Higgs particle (which turned out not to be Higgs after all). In this study, they also received a 5 sigma result when testing meditators against non-meditators in collapsing the quantum wave function. This means that mental activity, the human mind, attention, intention, which are a few labels under the umbrella of consciousness, compelled physical matter to act in a certain way.

"Observations not only disturb what has to be measured, they produce it. . . . We compel [the electron] to assume a definite position. . . . We ourselves produce the results of the measurement."

When it comes to the study of human consciousness, results like these remind me of a study published by a statistics professor at UC Irvine more than a decade ago. It showed parapsychological experiments have produced much stronger results than those showing a daily dose of aspirin helps prevent a heart attack. It also showed that these results are much stronger than the research behind various drugs like antiplatelets, for example. Despite these findings, psi experiments are only marginally acknowledged and not even known in the general "scientific" community, despite the fact that the evidence for psi is stronger than for the effectiveness of popular pharmaceutical drugs!
Perhaps that's why the U.S. government ran a program examining psi for more than two decades, and is probably still doing so.
Related CE Article: Cancelled TED Talk: Physicist Contracted By The CIA Shares Everything He Knows About ESP

There exist external observers which cannot be treated within quantum mechanics, namely human (and perhaps **animal**) minds, which perform measurements on the brain causing **wave function collapse**.

I read of a backwards causation experiment where humans changed a random number of left- and right-eared headphone clicks by intent, but it only worked if the prerecorded data had not been viewed by anyone. Anyone human, that is.

Scientific Study Shows Meditators Collapsing Quantum Systems At A Distance

Published
4 years ago
on
May 1, 2014

Numerous scientists over many years have studied the role of consciousness and how it can directly influence our physical material world, and a lot of research has been published clearly demonstrating that consciousness and what we perceive to be our physical material world are directly intertwined. I will provide more examples of this toward the end of the article, but for now we are going to take a look at one.

We've written about it numerous times. Called the quantum double slit experiment, it's a great example of how consciousness can affect our physical material world. A paper published in the peer-reviewed journal *Physics Essays* explains how this experiment has been used multiple times to explore the role of consciousness in shaping the nature of physical reality.
The experiment uses a double-slit optical system to test the possible role of consciousness in the collapse of the quantum wave-function. Scientists predicted the ratio of the interference pattern's double slit spectral power to its single slit spectral power would decrease when attention was focused onto the double slit as compared to away from it. The study found that factors associated with consciousness **significantly** correlated in predicted ways with perturbations in the double slit interference pattern.
"Observations not only disturb what has to be measured, they produce it. . . . We compel [the electron] to assume a definite position. . . . We ourselves produce the results of measurement."
A number of experiments were conducted to measure perturbations in the wave function. In the first experiment, participants were instructed to direct their attention toward the double-slit apparatus or to withdraw their attention away and onto another task. At certain times, a computerized voice instructed them, saying "Please influence the beam now" when they were to focus on it and "You may now relax" when they were to look at something else. This first experiment was modestly designed in accordance with the consciousness collapse hypothesis (perturbations in the double slit interference pattern).

The second experiment was conducted at a Zen Buddhist temple, which was a great place to recruit meditators for the experiment. This time:

> *For audio feedback, during attention-away periods the computer played a soft, continuous drone tone, and during attention-toward periods it played a musical note that changed pitch to reflect the real-time value of R. Participants were instructed to*

> *direct their attention toward the double-slit device as in the initial study. If they were successful, then the double-slit spectral power was predicted to decline, and in turn the pitch of the musical note would also decline.*

This test finished after 19 participants engaged in 31 sessions. At the Institute of Noetic Sciences (IONS) laboratory, 3 meditators contributed 11 sessions and 4 non-meditators contributed 7 sessions. At the Zen Buddhist temple, 12 meditators contributed 13 sessions. The tests were supervised, and a double-slit apparatus was presented.

This experiment provided more evidence, and in the IONS laboratory the meditators showed "superior performance" as compared to the non-meditators.

A third experiment was then conducted, using 33 sessions where 6 meditators contributed to 22 sessions and 7 non-meditators contributed to 11 sessions. The 22 meditator sessions resulted in "a significant decline" in the ration of the interference pattern. The meditators here had "an especially strong statistical effect." This experiment clearly supported the hypothesis.

In the fourth experiment, 31 people contributed 51 sessions, and the experimental effect size observed in this study was three times greater than that observed in the first four experiments.

The study goes on, and consistently outlines a number of factors associated with consciousness (I focused on the ones using meditation, but there are more in the study) to collapse the quantum wave function, or interfere with its pattern.

"The study found that factors associated with consciousness significantly correlated in predicted ways with perturbations in the double slit interference pattern."
Below is a visual demonstration of the quantum double slit experiment.

This experiment is one out of many that prove consciousness and our physical material world are intertwined. We recently published a study titled "10 Scientific Studies That Prove Consciousness Can Alter Our Physical Material World," which you can read here

"A fundamental conclusion of new physics also acknowledges that the observer creates the reality. As observers, we are personally involved with the creation of our own reality. Physicists are being forced to admit that the universe is a "mental" construction. Pioneering physicist Sir James Jeans wrote: "The stream of knowledge is heading toward a non-mechanical reality; the universe begins to look more like a great thought than like a great machine. Mind no longer appears to be an accidental intruder into the realm of matter, we ought rather hail it as the creator and governor of the realm of matter. Get over it, and accept the inarguable conclusion. The universe is immaterial-mental and spiritual."

— R.C. Henry ("The Mental Universe" ; *Nature* 436:29, 2005.)

Science is quickly catching up to ancient wisdom. Changing our world requires action, yes, but that action must come from a place of peace, love, cooperation, and understanding. Who is to say that meditation, and directing intention toward what we would like to change, is not the base of action? If you change within, manifestation without will begin to unfold, and that's exactly what's happening on our planet right now. If our hearts are in the right place, and our intentions are pure, we will be provided with the necessary opportunities using action to implement change. This is why the role of consciousness, and recognition of its role, is so important. It plays a large factor in creating global change on a mass scale.

“No problem can be solved from the same level of consciousness that created it.”
– Albert Einstein

Sources:
http://deanradin.com/evidence/Radin2012doubleslit.pdf

Groundbreaking Research Shows Conscious Intention Directly Affects Quantum States; Scientific Basis for Mind of Over Matter?

Dean Radin, Ph.D.

Dean Radin, Ph.D. and Chief Scientist of IONS, the **Institute for Noetic Sciences**, recently introduced the results of a series of experiments that may provide the missing link between consciousness and matter, turning the tables on materialism and asserting consciousness as a fundamental component of reality itself. Using a variation of the famous double-slit experiment, he and his team hypothesized that the conscious intent of a human mind might be able to collapse a quantum wave function without direct interaction. Simply by concentrating they postulated, meditation might be able to affect and influence quantum particles – the smallest components of matter that form our physical universe..

Initial experiments used participants 2 meters away from the device. Alternating between asking participants to concentrate on the apparatus, then removing their attention showed astounding results. Fearing that temperature differences or other variables might have influenced the test, they offered the experiment to participants online. Using several thousand robotic control sessions to ensure that a determination could be made for the factor of human consciousness, the results were likewise astounding, with initial trial results of greater than 5 sigma.

Dr. Radin’s video from the April 2016 conference introducing the results from this experiment is **available online through the IONS channel**. I highly recommend watching the video in its

entirety to get a full understanding of the experiment results, research protocols, variables, controls and the results from other labs and researchers who have replicated these results.

If you are new to quantum mechanics, the double-slit experiment and how consciousness has been at the center of controversy in quantum mechanics since Einstein's heyday, please keep reading and watch the video embedded at the end instead. I promise that the full weight of these experiments will have a more profound impact if you have a true understanding of the implications.

Why is the study of consciousness important for the question of life after death?

Consciousness is at the center of the life or death question. The survival hypothesis, which is the scientific name for the belief that consciousness can survive death, is predicated on the belief that the mind – the self-aware part of us – is not dependent on the physical biology of the brain for its functioning. Although the evidence for life after death is overwhelming, scientific proof of life after death must be testable, repeatable and somewhat cogent with our current scientific thinking.

Current science is overrun with a reductionist materialistic reasoning. In this paradigm, consciousness is a quirk of our biology, contained safely within our brains and completely separate from the objective physical world outside. The arrogantly named 'pure sciences' such as physics, chemistry and biology regard consciousness as some philosophical backwater, completely irrelevant to the job of understanding the 'real universe' which, according to them, can and would function just as well without consciousness at all.

Neuroscience, for their part, have attempted to take a stab at consciousness. Armed with materialist thinking, neuroscientists have spent decades sawing into human brains to try to determine what part of our biology creates this highly unusual conscious awareness and the feeling of having the personal free-will to direct our own actions. In fact, most scientists – following the materialism regime – must admit that any assumption of free-will is an illusion. If the entire universe is based on the immovable laws of physics and chemistry, then our minds – and thus our idea of free will and personal agency – must be directed first by biology. This means that every action you take wasn't decided on by an independent mind making decisions, but by a collection of neurons destined to follow a pre-determined set of instructions based on an innumerable set of chemical and electromagnetic variables. Blinded by reductionism, neuroscience persists in attempting to reduce the action of consciousness to the physical laws that govern matter.

In his book *Science Set Free* Dr. Rupert Sheldrake admonishes the use of studying the components of a system in order to understand how a system works.

"Attempting to explain organisms in terms of their chemical constituents is rather like trying to understand a computer by grinding it up and analyzing its component elements, such as copper, germanium and silicon…In this process of reduction, the structure and the programmed activity of the computer vanishes, and chemical analysis will never reveal the circuit diagrams; no amount of mathematical modelling of interactions between its atomic constituents will reveal the computer's programs or the purposes they fulfilled"

Conversely, dualists are proponents of the theory that mind does not equal brain but instead is a separate, non-physical component of reality. Dualists often put forward the idea that the brain is instead like a radio or television; a receiver and interface for information. In this way, consciousness is like a field that is 'picked up' by our brain, and translated into physical action. The components of a

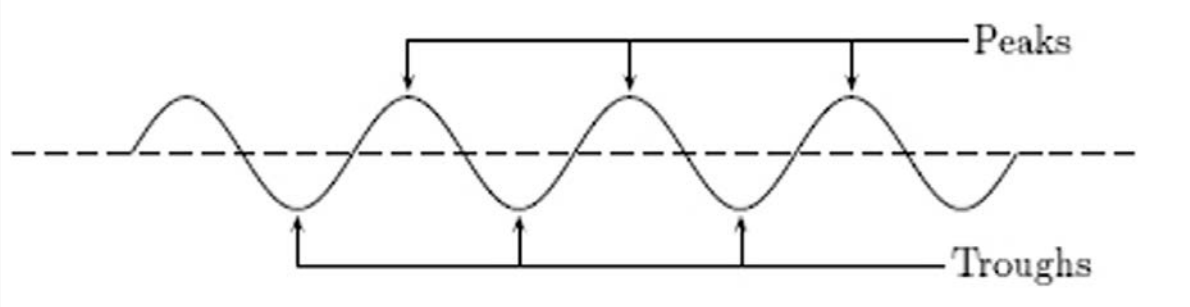
radio don't originate the broadcast, it simply transmits the pre-existing radio waves in a way that humans can hear and understand. In response, materialists will use the famous **Phineas Gage** incident as an example that personality is affected by damage to the physical brain. While certainly damage to the brain does seem to affect consciousness, a broken radio will similarly affect transmission of a radio signal, while leaving the original electromagnetic wave undamaged.

What both dualists and materialists have in common, however, is their lack of scientific proof in either case. We simply don't have any real understanding – beyond suppositions and hypotheses – that can give us clue about how consciousness arises and its relationship to the brain. Without a testable and repeatable hypothesis, scientific proof of life after death is remote at best.

What is the double-slit experiment, and why is it important?

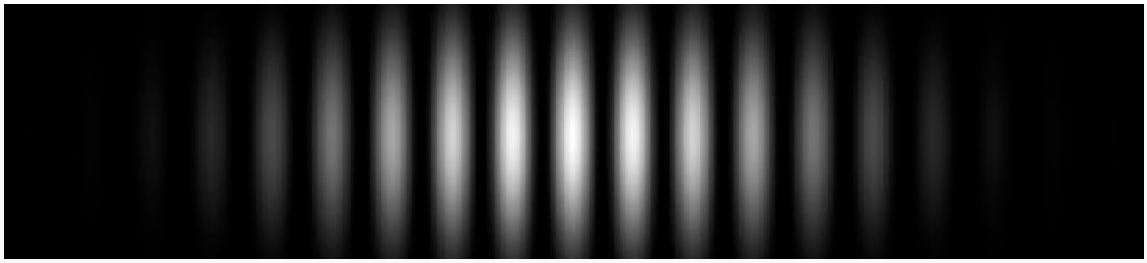
In order to understand why Dr. Radin's research and experimental results are so important to both science and metaphysics, one must understand a little bit about quantum mechanics and the history of the double-slit experiment. Before you groan and roll your eyes, consider how Einstein and his cohorts felt when a rather simple experiment undermined centuries of Newtonian thinking and instead cast our previously comfortable and predictive reality into a paradigm that Einstein himself called 'spooky'.

In 1905, Albert Einstein discovered that light acts as both a particle and a wave. This duality was highly mysterious to the emerging breed of quantum physicists because our world was anticipated to be concrete, definite and predictable. Matter was solid, reacting according to Newtonian physics. Sound and light were known to act like waves, just as waves on the ocean do – with peaks and troughs. Until Einstein's discovery, matter and light had separate and distinct properties and were expected to behave in certain ways.



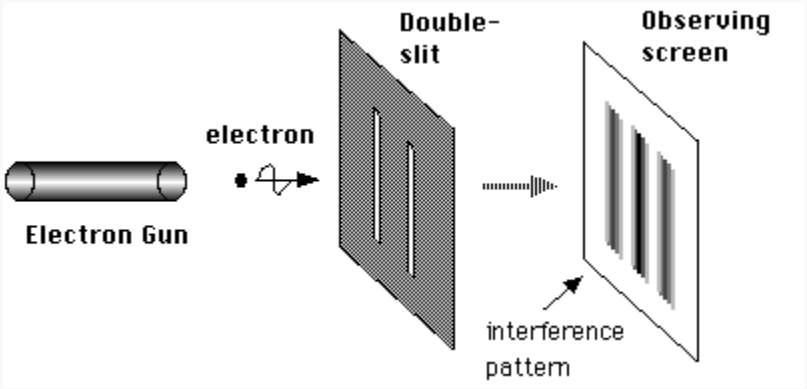
Waves, for example, follow a very specific pattern of peaks and troughs. Peaks can combine together to make even bigger peaks, and troughs can combine with other troughs to make even lower troughs. This feature of waves occurs wherever waves happen – in the ocean, in the ripples of a pond, and in light waves.

If you were to record where these peaks and troughs hit on a detector board, the pattern of lines that would appear would be a series of stripes called 'an interference pattern'. When a scientist sees this pattern, they know that they are looking at the property of a wave.



An interference pattern caused by waves

This is exactly what Thomas Young thought when he created the double-slit experiment in the early 1800's. The design of Young's experiment was simple: a beam of light is directed at a board with two vertical slits, and a detector board on the other side records the pattern of the wave as it hits the board. The wave pattern that resulted erroneously confirmed the idea that light was a wave until experimentalists rebooted the experiment in the 1920's to study this new particle-wave duality.



A Basic Double-Slit Experiment Design

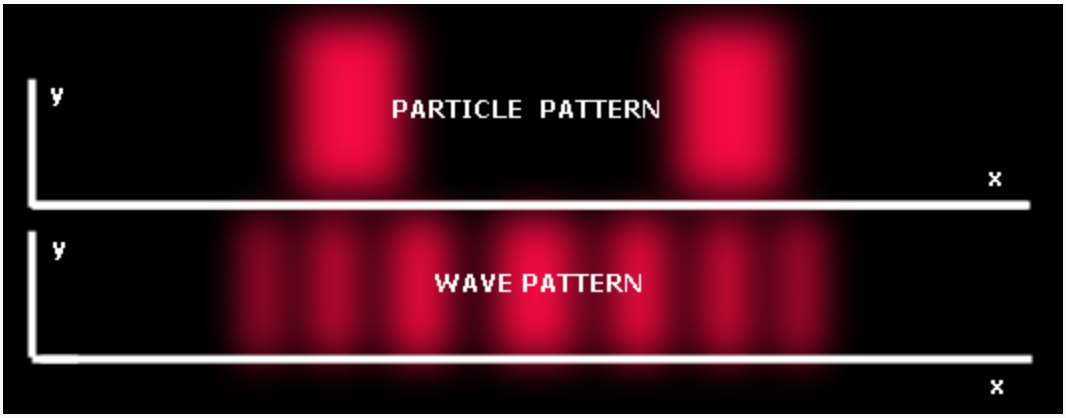
What happened next divided the physics word and turned science on its head, overturning centuries of classical Newtonian thought and putting the venerable Albert Einstein squarely on the wrong side of scientific progress. The stunning result of the double-slit experiment irrevocably altered our understanding of reality in ways that we are still coming to terms with.

Want to see a video about it? ***Watch an except from Nova's Fabric of the Universe with Brian Green explaining the double slit experiment.***

Here's what happened:

The experimentalists already knew that light through the double-slit experiment would appear in a light-wave pattern. When they decided to measure the particles to see which of the two vertical slits they went through, the outcome of the experiment changed radically. As soon as they 'looked' to measure the location and speed, the particles started acting like, well.. little balls of matter.

Although particles such as protons or electrons are not really 'little balls of matter', for our purposes, we can think of them this way to make visualizing this easier. When the photons were being measured, they went through one slit or the other as expected but instead of making the wave-like interference pattern, they made a pattern like two vertical lines. This is similar to what you'd expect if you were throwing baseballs through two vertical slits in a wall.



The patterns associated with light acting like particles versus when acting like a wave

Okay, so what?

Well, further testing showed that this peculiarity wasn't just limited to photons. The same thing happened when using electrons, protons, even atoms as large as buckyballs, which is a gigantic collection of 60 carbon atoms.

Now scientists are a tough bunch. They don't like the unknown, and it seemed like every time they tried to measure the location of a particle in this wave-like feature, the particle would collapse into the pattern of going through only one slit at a time and making the particle-like pattern as in the image above.

Thinking that the result was due to a mass of electrons trying to go through the slits, experimentalists tried the experiment again by shooting one electron at a time through the double-slits. We might expect that it would choose to go through either one slit or the other, or simply bounce back. After all, electrons are matter and should behave just like baseballs would.

Shockingly, even single electrons displayed this wave-like behavior. How could a single electron – which is a particle – display a wave-like pattern? More over, how could one electron appear in areas such as directly behind the middle of the two slits or way off to the side? Shouldn't single electrons being shot through two vertical slits only make two vertical lines on the detector wall behind it?

German physicist Werner Heisenberg realized that we aren't simply looking at a physical result, but a probabilistic one. The electron has a certain chance of hitting the detector in one of many places but it doesn't 'choose' it's final resting place until it is forced to by measurement.

This strange quantum behavior is described by *Heisnberg's uncertainty principle*. Each individual particle exists in a superposition – a probabilistic state of being everywhere and nowhere at once. As with the earlier experiment, the act of measurement – the act of pinning down the exact location and speed of the particle seemed to 'force' it to pick a spot and lose that probabilistic wave-like behavior.

The fabric of reality is fuzzy. We can only calculate the odds of a particle being in a particular place at one time. If we don't persist in trying to measure the particle's location or speed, it will resume its wave-like behavior and appear in places that would be impossible if the particle was truly going through one slit at a time, for example behind the center of the two slits.

Undeterred, later scientists designed “Delayed Choice” experiments that they hoped would solve this mystery once and for all. Since any amount of measuring, interacting with, or watching the particles caused them to lose their wave-like pattern, they decided to put a detector after the vertical slits in order to see which slit the particle ‘decided’ to go through. They only measured *after* the particle had ‘made its choice’. The single electron is expected to reach the double-slits as a probabilistic wave, but when the measurement device is turned on directly after exiting the slits, the experimenters should have been able to detect the change to the particle state and discover which slit it must have gone through.

The result was even more mind-blowing. Even though the particle wasn’t being measured or observed as it was going through the slits, the action of measuring the particle afterwards cause the particle to seemingly *go back in time* and enter the slits as with particle-like behavior.

Frustrated scientists notwithstanding, quantum physicists had to admit that at the smallest levels of known reality, our universe is not objective or predictable. Reality is a big question mark until something or someone interacts with it. Matter, which is made up of quantum particles, can’t exist in a definite state unless the wave function is collapsed, thus prompting Albert Einstein’s sardonic statement: “I like to think the moon is there even if I am not looking at it.”

Although some early physicists claimed that consciousness itself was affecting this freaky quantum behavior, others including Einstein wrote it off as metaphysical nonsense. It was claimed that somehow the act of measurement itself with a detector or apparatus was destructive to the wave-function, like knocking billiard balls off a pool table with a sharp poke from the cue.

By now, this issue was called ‘The Measurement Problem” and spoiler: it still hasn’t been solved. Scientists have gone to great lengths to avoid implicating consciousness in particle-wave collapse. One of the more bombastic theories is called the *many-worlds interpretation*. This suggests that there is no wave-collapse, simply a brand-new nearly identical universe is created every time the particle settles into a position. All other positions are likewise a reality in a different universe. Of course, this means that an infinite number of universes are willed into being as soon as any particle moves from a probabilistic position to a definite state but the lack of any way to test this theory means that many scientists regard this as more science fiction than science. Conversely, string theory, the new kid on the quantum physics circuit, attempts to solve this mystery with added dimensions; 11 to be precise. Although I find both the many worlds and string theories to be fascinating, it becomes an exercise in frustration when any theory involving consciousness is quickly relegated to the status of ‘woo’, and yet perfectly intelligent scientists can speak of 11 unobservable and untestable dimensions with a straight face.

Dr. Robert Lanza sums up this point perfectly in his book *Biocentrism*:

“When science tries to resolve a theory’s conflicts by adding and subtracting dimensions to the universe like houses on a Monopoly board, dimensions unknown to our senses and for which not a shred of evidence exists, we need to take a time-out and examine our dogmas.”

Science will agree that any interaction with quantum particles will collapse the wave function but it has been thus difficult to remove the act of conscious observation from the measurement problem. Even if scientists believe that consciousness has nothing to do with the destructive interaction with quantum particles, it still takes a conscious person to observe the data. Even if using remote

detectors to view the results hours later, we can't be sure the particles didn't wait to collapse at the moment a conscious person observed the results.

Before we analyze Dr. Radin's results and why it is so groundbreaking, its important to understand the implications. Why are scientists so reticent to implicate consciousness? Material science is based on objective forces in our universe that obey strict laws of behavior. Were consciousness proven to exist, it would imply a force unknown to science and it has shades of religiosity that scientists recoil from like vampires from the sun. Similarly, if consciousness were proven to affect matter at the most basic level all of materialist science would collapse. Everything that we've surmised about the material universe would need to be revamped starting with consciousness as the base of reality, not simply as a quirky epiphenomenon secured in the brain and safely disposed of at death.

Furthermore, even the ability for a conscious human being to objectively observe the universe would be called into question. If the consciousness of a scientist can not only collapse a wave-function, but influence it to collapse in a particular way then we would never claim an objective measurement again. Consciousness would be the one variable we could never control for.

Dr. Dean Radin's Experiment and Results

If you have read this far, you should now be able to follow Dr. Dean Radin's IONS conference presentation and understand the full impact of his results. The video is embedded below, or **linked here**.

Dr. Radin's experiment begins with the classic double-slit setup. Using a laser, detector, double-slit board and camera, his research team was able to capture the probabilistic wave-interference pattern of undisturbed protons. A computer recorded the interference pattern being created moment by moment.

Dr. Radin then added a series of conscious observers. Without interacting with the system at all (no destructive measurement), he asked the participants to imagine affecting the test. Radin used a feedback tone and imagery to give the observers something to concentrate on. If the tone got louder, they were having a larger anomalous effect on test. The observation period was interchanged with rest periods. Interestingly, Radin made a distinction between people who regularly meditated and those who didn't.

In the initial trials, the meditators produced significant results with the non-meditators falling slightly around chance. When combined, however, the results were still striking.

Suspicious of his results, Radin expanded the experiment online, carefully controlling for several dozen variables, such as vibration, temperature, time, cycles, etc. The results of 5,000 human and 7,000 robotic trials showed similar and statistically significant results. Although the effect is small, it is consistent and repeatable.

The results insinuate that human consciousness can affect the very fabric of reality with no proximity limitation. From anywhere in the world, a person's intentions can collapse a particle wave function into a definite state. More even than simply affecting the wave-function, Radin's research shows something like a quantum zeno effect; it 'steers' the quantum collapse.

So maybe the moon really isn't there until we look at it?

Radin is the consummate scientist. Although his methods and protocol has been independently verified, he is unwilling to draw any definite conclusions until more labs have replicated his study. At the time of this writing, another lab is in process of replicating the experiment. Although the scientist didn't want to reveal his name (likely due to the academic shaming associated with research of this sort), his initial results showed something on the range of "oh my God!", as Radin explains in the video. As expected, materialist science continues to ignore research such as Radin's and others. Aside from the fear of academic suicide, there is a very real insecurity of losing the objective reality afforded by material science.

Although Radin's research is one of the most direct applications of the interpretation that consciousness affects matter, the idea is not new. The aforementioned Dr. Robert Lanza is scientist famous for stem-cell research. Called one of the world's top three living scientists, he took the unusual and courageous step of publishing his 'theory of everything' called Biocentrism in 2009. In it, he posits that the basis of the universe is consciousness.

"The animal observer creates reality and not the other way around"

Dr. Lanza uses the measurement problem as a basis of this theory and illustrates is with this mind-bending analogy:

"Take the seemingly undeniable logic that your kitchen is always there, its contents assuming all their familiar forms, shapes and colors, whether you or not your are in it. At night, you click off the light, walk through the door, and leave for the bed-room. Of course it's there, unseen, all through the night. Right? But consider: the refrigerator, stove, and everything else are composed of a shimmering swarm of matter/energy. Quantum theory..tells us that not a single one of those subatomic particles actually exists in a definite place. Rather, they merely exist as a range of possibilities that are manifest. In the presence of an observer – that is, when you go back into get a drink of water – each one's wave function collapses and it assumes an actual position, a physical reality. Until then, it's merely a swarm of possibilities…So while you may think that the kitchen as you remember it was 'there' in your absence, the reality is that nothing remotely resembling what you can imagine could be present when a consciousness is not interacting"

What Dr. Lanza is suggesting based on 85 years of quantum mechanical research is, entirely, that the moon does not exist when we are not looking at it. Dr. Radin's research contributes to this notion by showing a definite statistical anomaly when consciousness is directed to influence quantum states.

It's hardly needed to be said that most of science recoils at the notion that we do not exist in a separate objective reality. To put consciousness at the center of reality with any sort of causal connection means that the universe only exists because we perceive it. They complain of solipsism, and the many unanswered questions that would then arise. 'What consciousness was around to will the big bang into existence?', they cry. The only logical answer for many is God, and that's where the conversation screeches to a dead halt.

Certainly more time will be needed to the scientific community to agree on a testable and repeatable basis for this theory. Bleeding-edge experiments from Dr. Radin and others are only just beginning to cut the binds of the reductionist and materialistic attitude that is still pervasive in academia. A

hopeful future including an expanded role of consciousness would make life after death studies less repugnant to science and certainly less imbued with religious overtones.

For afterlife researchers, any research that supports the idea that consciousness can affect the material world shows that consciousness is mind apart from brain, possibly interacting with but not dependent on biology. Although it doesn't directly prove that life after death exists, it does suggest that our consciousness may not be an illusory product of the brain. Quantum consciousness studies such as Radin's and other quantum mind proponents such as Henry Stapp, David Bohm, Stuart Hameroff and Roger Penrose could be a crucial step closer to understanding phenomena like near-death experiences, death-bed visions and past-life recall.

Until then, we can still put this theory into practice in our every day lives. From Phineas Quimby's Law of Attraction to Jane Robert/Seth's 'You create your own reality', to popularized versions of the idea such as 'The Secret' and 'The Vortex', philosophy, spirituality and the new-age genre has long accepted this notion with open arms. We may not have the ability to teleport or spontaneously upgrade our cars with the power of collapsing the wave-function of particles, but we can use our intentions to make good in our lives.

Remember always that your thoughts have power; they can set up circumstances for our success or our demise, hurt or help others and lead us into journeys of enlightenment or toil. One day we may have the scientific proof that our consciousness literally creates the universe around us. Until then all we can do is concentrate on making our little corner of the world just a little better.

Recommended Reading:

Sheldrake, Rupert, Ph.D.. 2013. ***Science Set Free(US)/The Science Delusion(UK): Ten Paths to New Discovery.*** ISBN 13: 978-0770436728.

Lanza, Robert, Ph.D. 2009. ***Biocentrism: How life and Consciousness are the Keys to Understanding the True Nature of the Universe.*** ISBN 13: 978-1935251743

Radin, Dean, Ph.D. 2009. ***Entangled Minds: Extrasensory Experiences in a Quantum Reality.*** ISBN 13: 978-1416516774

The Astonishing Link Between Quantum Physics & The Human Mind

22.9.2017
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Health, Lifestyle, Uncategorized

The connection between human consciousness, or factors associated with human consciousness such as intention, thoughts, feelings, and emotions, and the physical realm is fascinating. This is precisely why nearly all of the founding fathers of quantum physics were

so preoccupied with learning more about consciousness, and "non-material" science in general. The theoretical physicist who originated quantum theory, Max Planck, for instance, regarded "consciousness as fundamental" and matter as "derivative from consciousness." Eugene Wigner, another famous theoretical physicist and mathematician, also emphasized how "it was not possible to formulate the laws of quantum mechanics in a fully consistent way without reference to consciousness.

Fast forward to today, and we now have strong empirical evidence showing that the mind does indeed influence matter, both at the subatomic quantum scale, and at scales consistent with classical physics. Although many mainstream physicists would disagree, many wouldn't, and don't.

The classic example to illustrate how factors associated with consciousness are directly linked with the physical world comes from the "double slit experiment." A paper published in the peer-reviewed journal *Physics Essays* by Dean Radin, PhD, explains how this experiment has been used multiple times to explore the role of consciousness in shaping the nature of physical reality.

The paper showed that meditators were able to collapse quantum systems at a distance through intention alone.

The meditators were the "observer" in this case.

In fact, as Radin points out in his lecture, a "5 sigma" result was able to give CERN the Nobel Prize in 2013 for finding the Higgs particle (which turned out not to be Higgs after all). In this study, they also received a 5 sigma result when testing meditators against non-meditators in collapsing the quantum wave function. This means that mental activity, the human mind, attention, and intention, which are a few labels under the umbrella of consciousness, compelled physical matter to act in a certain way.

"Observations not only disturb what has to be measured, they produce it. . . . We compel [the electron] to assume a definite position. . . . We ourselves produce the results of the measurement."

Radin's work is a great place to start if you're curious about this, and probably one of the most well-researched and knowledgable scientists in the field.

He's published two groundbreaking books that deal with this phenomenon, something Einstein referred to as "spooky action at a distance." Action at a distance is the idea that physical systems can be moved, changed, or influenced without being physically touched by anything else. It refers to the nonlocal interaction of objects that are separated in space. See his works:

The Conscious Universe: The Scientific Truth of Psychic Phenomena
Entangled Minds: Extrasensory Experiences in a Quantum Reality

In fact, quantum entanglement was just achieved in space, as illustrated by a fairly recent study published in the journal *Science* that showed how scientists were able to produce entangled photons on a satellite orbiting 300 miles above the planet. They beamed the particles into two different ground-based labs that were 750 miles apart, all without losing the particles' strange linkage. You can read more about that here.

For a selected list of downloadable peer-reviewed journal articles reporting studies of psychic phenomena, mostly published in the 21st century, you can click here.

"Despite the unrivaled empirical success of quantum theory, the very suggestion that it may be literally true as a description of nature is still greeted with cynicism, incomprehension and even anger."

– (T. Folger, “Quantum Shmantum”; Discover 22:37-43, 2001)

The truth is, the current scientific worldview is heavily predicated on assumptions that are associated with classical physics, assumptions that have turned into scientific dogma, despite the fact that, at the end of the nineteenth century, physicists discovered empirical phenomena that could not be explained by classical physics. This led to the development, during the 1920s and early 1930s, of a revolutionary new branch of physics called quantum mechanics (QM).

“QM has questioned the material foundations of the world by showing that atoms and subatomic particles are not really solid objects—they do not exist with certainty at definite spatial locations and definite times. Most importantly, QM explicitly introduced the mind into its basic conceptual structure since it was found that particles being observed and the observer—the physicist and the method used for observation—are linked. According to one interpretation of QM, this phenomenon implies that the consciousness of the observer is vital to the existence of the physical events being observed, and that mental events can affect the physical world. The results of recent experiments support this interpretation. These results suggest that the physical world is no longer the primary or sole component of reality, and that it cannot be fully understood without making reference to the mind.”

– From the Manifesto For a Post-Materialist Science

The astonishing link between quantum physics and the human mind

September 27 2017

The connection between human consciousness, or factors associated with human consciousness such as intention, thoughts, feelings, and emotions, and the physical realm is fascinating.

This is precisely why nearly all of the founding fathers of quantum physics were so preoccupied with learning more about consciousness, and "non-material" science in general. The theoretical physicist who originated quantum theory, Max Planck, for instance, regarded "consciousness as fundamental" and matter as "derivative from consciousness." Eugene Wigner, another famous theoretical physicist and mathematician, also emphasized how "it was not possible to formulate the laws of quantum mechanics in a fully consistent way without reference to consciousness."

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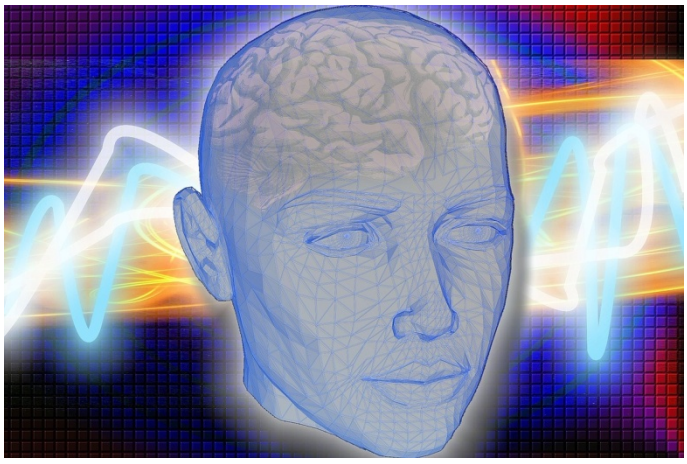

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It's Not Just at the Quantum Scale Where We See Mind/Matter Interaction

The Manifesto linked above also says:

Studies of the so-called "psi phenomena" indicate that we can sometimes receive meaningful information without the use of ordinary senses, and in ways that transcend the habitual space and time constraints. Furthermore, psi research demonstrates that we can mentally influence—at a distance—physical devices and living organisms (including other human beings). Psi research also shows that distant minds may behave in ways that are nonlocally correlated, i.e. the correlations between distant minds are hypothesized to be unmediated (they are not linked to any known energetic signal), unmitigated (they do not degrade with increasing distance), and immediate (they appear to be simultaneous). These events are so common that they cannot be viewed as anomalous nor as exceptions to natural laws, but as indications of the need for a broader explanatory framework that cannot be predicated exclusively on materialism.

As an avid researcher of non-material science, I find it odd that these phenomena are still so heavily ridiculed, yet have been studied and demonstrated at the highest levels of government, with successful results, for decades.

Physicist Russel Targ, the co-founder of a 23-year long government research program known as Stargate, recently gave a TED talk called "Everything I Know About ESP," which was then cancelled.

Stargate included successful examples of telepathy, clairvoyance, precognition, remote viewing, and more. As the research points out:

To summarize, over the years the back-and-forth criticism of protocols, refinement of methods, and successful replication of this type of remote viewing in independent laboratories (Bisaha & Dunne, 1979; Dunne & Bisaha, 1979; Jahn, 1982; and Jahn & Dunne, 1986), has yielded considerable scientific evidence for the reality of the phenomenon. Adding to the strength of these results was the discovery that a growing number of individuals could be found to demonstrate high-quality remote viewing, often to their own surprise, such as the talented Hella Hammid.

Individuals were able to identify objects in hidden locations in great distances, and there are several examples in the declassified literature.

Declassified documents also show that that the CIA kept tabs on other country's developments with regards to individuals who could work with or break the mind/matter barrier. This document, titled **"Research into Paranormal Ability To Break Through Spatial Barriers"** is one such example.

It states, "**A total of 50 experiments in the ability to break through of spatial obstacles were conducted. . . . Of the 50 experiments, 25 were successful, 17 were videotaped and high speed photography were used in 6,"** and goes into more detail about these individuals.

The point is, there are no shortage of individuals who are able to do this, as well as mainstream scientific examinations under strict protocols where mind has been shown to influence matter at all levels, not just the quantum level.

This is precisely why the American Institutes for Research concluded:

The statistical results of the studies examined are far beyond what is expected by chance. Arguments that these results could be due to methodological flaws in the experiments are soundly refuted. Effects of similar magnitude to those found in government-sponsored research at SRI and SAIC have been replicated at a number of laboratories across the world. Such consistency cannot be readily explained by claims of flaws or fraud.

Even as far back as 1985, a report prepared by the Army Research Institute disclosed that "the data reviewed in this report constitute genuine scientific anomalies for which no one has an adequate explanation for."

Another "proof," for lack of a better term, is the mind-body connection. The results in this area are just as strong as those in the "hard sciences."

In 1999, a statistics professor at UC Irvine published a paper showing that parapsychological experiments have produced much stronger results than those showing a daily dose of aspirin helps prevent a heart attack.

The placebo effect is another great example. As reported in Scientific American:

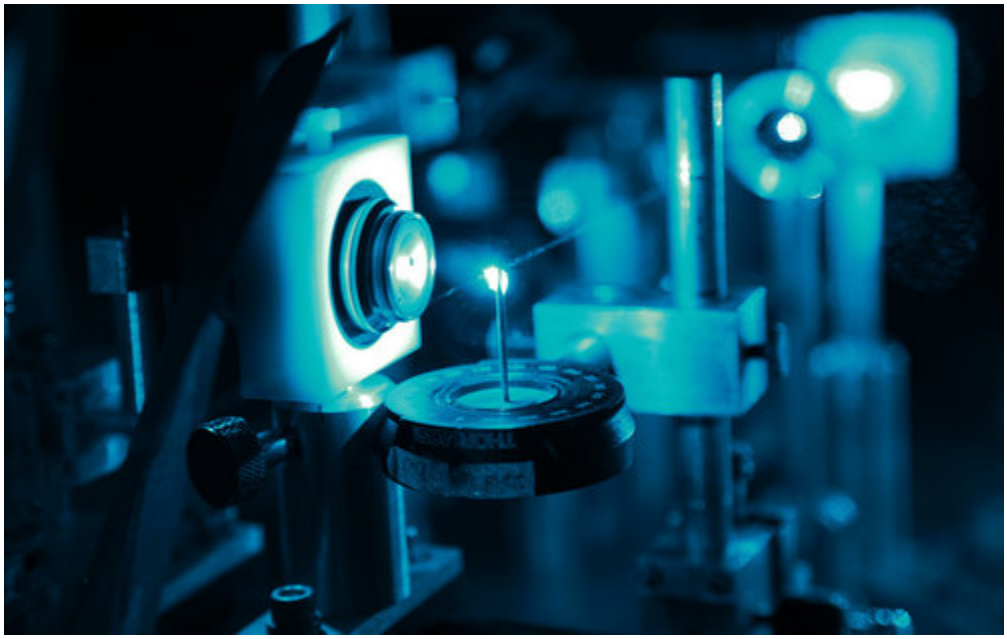
As neuroscientist Fabrizio Benedetti, one of the pioneers of placebo research, puts it, there isn't just one placebo effect but many. Placebo painkillers can trigger the release of natural pain-relieving chemicals called endorphins. Patients with Parkinson's disease respond to placebos with a flood of dopamine. Fake oxygen, given to someone at altitude, has been shown to cut levels of neurotransmitters called prostaglandins (which dilate blood vessels, among other things, and are responsible for many of the symptoms of altitude sickness).

The effectiveness of placebo has been proven time and time again, such as this Baylor School of Medicine study, published in the New England Journal of Medicine in 2002. It looked at surgery for patients with severe and debilitating knee pain. Many surgeons know there is no placebo effect in surgery, or so most of them believe. The patients were divided into three groups. The surgeons shaved the damaged cartilage in the knee of one group. For the second group they flushed out the knee joint, removing all of the material believed to be causing inflammation. Both of these processes are the standard surgeries for people who have severely arthritic knees. The third group received a "fake" surgery; the patients were only sedated and tricked into believing they had had the knee surgery. Doctors simply made the incisions and splashed salt water on the knee as they would in normal surgery. They then sewed up the incisions like the real thing and the process was complete. All three then groups went through the same rehab process, with astonishing results: The placebo group improved just as much as the other two groups who had surgery.

As you can see, the link between the human mind and quantum physics is quite strong.

Strange Link between Mind and Quantum Physics Confirmed by New Experiments

August 30, 2017



If you follow current research in consciousness studies you've probably heard about an extraordinary series of experiments conducted by Dean Radin Ph.D. and his colleagues at the Institute of Noetic Sciences.

These experiments, presented in the video below, suggest that human attention *alone* can reliably affect the wave distribution of photons traveling through an array.

The problem was that the effect had not yet been replicated by independent scientists. That was, until now.

Radin and his colleagues used a number of different experimental paradigms to explore the effect in various ways. They found that, even under highly controlled conditions, this strange mind over matter effect persisted.

Perhaps the most interesting finding was that certain individuals proved to be significantly more successful at influencing the photons' behaviour. The unique factor in these individuals was that almost all of them were highly experienced in either meditation or some kind of attentional training.

Since Radin presented these findings at the Science of Consciousness conference they have gained quite a bit of attention. They seem to suggest that mind is continuous with the world in a way that poses a serious challenge to the assumption that mind/consciousness is insignificant to the structure of reality.

The only problem was that the effect had not yet been replicated by independent scientists. That was, until now.

In recently published experiments, conducted by the physicist Gabriel Guerrer Ph.D. at the University of São Paulo, the apparent mind over matter effect has been observed once again, and with similarly high statistical significance.

Just as observed previously by Radin and his colleagues, Guerrer also found that participants are able reduce the wave distribution of photons in a double-slit system, simply by directing their attention towards it.

According to Guerrer, this effect points to
"a not yet mapped form of interaction between a conscious agent and a physical system"

Does Consciousness cause collapse

Conclusion:

In conclusion, the 'consciousness causes quantum collapse' hypothesis – at least when combined with modern neuroscience – is a viable theory of physical and mental reality, which offers a clear research program and distinctive experimental predictions. It proposes a solution to the measurement problem by defining when and where collapse occurs. And it provides a place for consciousness in nature by giving consciousness a causal role. Developing this theory may well enable us to answer even deeper questions; questions such as why consciousness causes collapse and why consciousness exists at all.

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Kelvin McQueen did his PhD at Australian National University, under the supervision of David Chalmers. He is now Assistant Professor of Philosophy at Chapman University in California.

New Research Shows Consciousness Affects Reality

JULY 4, 2016

A new scientific experiment made by Dean Radin Ph.D, by using a variation of the classic double-slit experiment, shown at the **Science of Consciousness Conference in Tuscon 2016 (Arizona)**, shows that consciousness indeed affects matter, therefore reality, no matter the distance between the observer and the apparatus.
After the first double-slit experiment, for many years scientists were debating over a enormously significant matter that has to do with consciousness and its relation to quantum mechanics. A significant number of very respected scientists from previous years came to the conclusion that consciousness indeed plays a crucial role in quantum mechanics and its measurement, meaning that consciousness has a direct impact on physical properties of matter, therefore the reality around each observer. Other scientists argued that something like that cannot happen, though saying that without actual research procedures, and relative ignorance.

Proving them wrong, consciousness does affect reality after all

A few years ago, Dean Radin Ph.D, at the **Institute of Noetic Sciences**, started a new experiment by using a variation of the classic double-slit experiment in various ways, where a simple observation by different people throughout the world effectively and significantly reduced the wave-pattern of particles in almost all of the cases, no matter the distance at all, **proving that there is indeed a clear relation of consciousness with reality**.

Study: Consciousness and the double-slit interference pattern: Six experiments
Study: Psychophysical interactions with a double-slit interference pattern

The great news is that the audience of the conference consisted of the most respected scientists and philosophers living today. Eventually we are getting closer to finding out and acknowledging that the role of consciousness is greater than the ignorance of a few, in a scale that's unimaginably enormous. Enjoy the video!

Video source: Institute of Noetic Sciences : IONS

Important news (August 24, 2017):

The above study has been independently replicated by Gabriel Guerrer, a physicist and former researcher at CERN. (link: https://osf.io/zsgwp/download)

The new paper from Gabriel Guerrer reports a **6.37 sigma replication**, which means **extremely significant**.
The following is the abstract of the new replicated paper:

Motivated by a series of reported experiments and their controversial results, the present work investigated if volunteers could causally affect an optical double-slit system through mental efforts alone. The participants task alternated between intending the increase of the (real-time feedback informed) amount of light diffracted through a specific single slit and relaxing any intention effort. The 160 data sessions contributed by 127 volunteers ***revealed a statistically significant 6.37 sigma difference between the measurements performed in the intention versus the relax conditions*** *($p=1.89\times10^{-10}, \, es= 0.50 \pm 0.08$), while the 160 control sessions conducted without any present observer resulted in statistically equivalent samples ($z=-0.04, \, p=0.97, \, es=0.00 \pm 0.08$).*

The results couldn't be simply explained by environmental factors, hence supporting the previously claimed existence of a not yet mapped form of interaction between a conscious agent and a physical system.

Groundbreaking Research Shows Conscious Intention Directly Affects Quantum States; Scientific Basis for Mind of Over Matter?

Dean Radin, Ph.D.

Dean Radin, Ph.D. and Chief Scientist of IONS, the **Institute for Noetic Sciences**, recently introduced the results of a series of experiments that may provide the missing link between consciousness and matter, turning the tables on materialism and asserting consciousness as a fundamental component of reality itself. Using a variation of the famous double-slit experiment, he and his team hypothesized that the conscious intent of a human mind might be able to collapse a quantum wave function without direct interaction. Simply by concentrating they postulated, meditation might be able to affect and influence quantum particles – the smallest components of matter that form our physical universe..

Initial experiments used participants 2 meters away from the device. Alternating between asking participants to concentrate on the apparatus, then removing their attention showed astounding results. Fearing that temperature differences or other variables might have influenced the test, they offered the experiment to participants online. Using several thousand robotic control sessions to ensure that a determination could be made for the factor of human consciousness, the results were likewise astounding, with initial trial results of greater than 5 sigma.

Dr. Radin's video from the April 2016 conference introducing the results from this experiment is **available online through the IONS channel**. I highly recommend watching the video in its entirety to get a full understanding of the experiment results, research protocols, variables, controls and the results from other labs and researchers who have replicated these results.

If you are new to quantum mechanics, the double-slit experiment and how consciousness has been at the center of controversy in quantum mechanics since Einstein's heyday, please keep reading and watch the video embedded at the end instead. I promise that the full weight of these experiments will have a more profound impact if you have a true understanding of the implications.

Why is the study of consciousness important for the question of life after death?

Consciousness is at the center of the life or death question. The survival hypothesis, which is the scientific name for the belief that consciousness can survive death, is predicated on the belief that the mind – the self-aware part of us – is not dependent on the physical biology of the brain for its functioning. Although the evidence for life after death is overwhelming, scientific proof of life after death must be testable, repeatable and somewhat cogent with our current scientific thinking.

Current science is overrun with a reductionist materialistic reasoning. In this paradigm, consciousness is a quirk of our biology, contained safely within our brains and completely separate from the objective physical world outside. The arrogantly named 'pure sciences' such as physics, chemistry and biology regard consciousness as some philosophical backwater, completely irrelevant to the job of understanding the 'real universe' which, according to them, can and would function just as well without consciousness at all.

Neuroscience, for their part, have attempted to take a stab at consciousness. Armed with materialist thinking, neuroscientists have spent decades sawing into human brains to try to determine what part of our biology creates this highly unusual conscious awareness and the feeling of having the personal free-will to direct our own actions. In fact, most scientists – following the materialism regime – must admit that any assumption of free-will is an illusion. If the entire universe is based on the immovable laws of physics and chemistry, then our minds – and thus our idea of free will and personal agency – must be directed first by biology. This means that every action you take wasn't decided on by an independent mind making decisions, but by a collection of neurons destined to follow a pre-determined set of instructions based on an innumerable set of chemical and electromagnetic variables. Blinded by reductionism, neuroscience persists in attempting to reduce the action of consciousness to the physical laws that govern matter.

In his book *Science Set Free* Dr. Rupert Sheldrake admonishes the use of studying the components of a system in order to understand how a system works.

"Attempting to explain organisms in terms of their chemical constituents is rather like trying to understand a computer by grinding it up and analyzing its component elements, such as copper, germanium and silicon…In this process of reduction, the structure and the programmed activity of the computer vanishes, and chemical analysis will never reveal the circuit diagrams; no amount of mathematical modeling of interactions between its atomic constituents will reveal the computer's programs or the purposes they fulfilled"

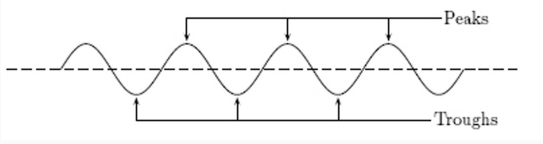
Conversely, dualists are proponents of the theory that mind does not equal brain but instead is a separate, non-physical component of reality. Dualists often put forward the idea that the brain is instead like a radio or television; a receiver and interface for information. In this way, consciousness is like a field that is 'picked up' by our brain, and translated into physical action. The components of a radio don't originate the broadcast, it simply transmits the pre-existing radio waves in a way that humans can hear and understand. In response, materialists will use the famous **Phineas Gage** incident as an example that personality is affected by damage to the physical brain. While certainly damage to the brain does seem to affect consciousness, a broken radio will similarly affect transmission of a radio signal, while leaving the original electromagnetic wave undamaged.

What both dualists and materialists have in common, however, is their lack of scientific proof in either case. We simply don't have any real understanding – beyond suppositions and hypotheses – that can give us clue about how consciousness arises and its relationship to the brain. Without a testable and repeatable hypothesis, scientific proof of life after death is remote at best.

What is the double-slit experiment, and why is it important?

In order to understand why Dr. Radin's research and experimental results are so important to both science and metaphysics, one must understand a little bit about quantum mechanics and the history of the double-slit experiment. Before you groan and roll your eyes, consider how Einstein and his cohorts felt when a rather simple experiment undermined centuries of Newtonian thinking and instead cast our previously comfortable and predictive reality into a paradigm that Einstein himself called 'spooky'.

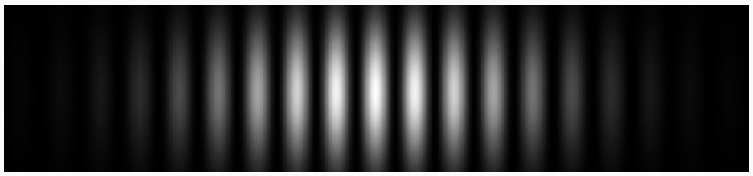
In 1905, Albert Einstein discovered that light acts as both a particle and a wave. This duality was highly mysterious to the emerging breed of quantum physicists because our world was anticipated to be concrete, definite and predictable. Matter was solid, reacting according to Newtonian physics. Sound and light were known to act like waves, just as waves on the ocean do – with peaks and troughs. Until Einstein's discovery, matter and light had separate and distinct properties and were expected to behave in certain ways.



Waves, for example, follow a very specific pattern of peaks and troughs. Peaks can combine together to make even bigger peaks, and troughs can combine with other

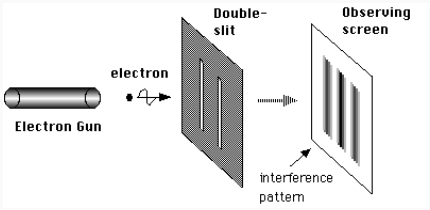
troughs to make even lower troughs. This feature of waves occurs wherever waves happen – in the ocean, in the ripples of a pond, and in light waves.

If you were to record where these peaks and troughs hit on a detector board, the pattern of lines that would appear would be a series of stripes called 'an interference pattern'. When a scientist sees this pattern, they know that they are looking at the property of a wave.



An interference pattern caused by waves

This is exactly what Thomas Young thought when he created the double-slit experiment in the early 1800's. The design of Young's experiment was simple: a beam of light is directed at a board with two vertical slits, and a detector board on the other side records the pattern of the wave as it hits the board. The wave pattern that resulted erroneously confirmed the idea that light was a wave until experimentalists rebooted the experiment in the 1920's to study this new particle-wave duality.



A Basic Double-Slit Experiment Design

What happened next divided the physics word and turned science on its head, overturning centuries of classical Newtonian thought and putting the venerable Albert Einstein squarely on the wrong side of scientific progress. The stunning result of the double-slit experiment irrevocably altered our understanding of reality in ways that we are still coming to terms with.

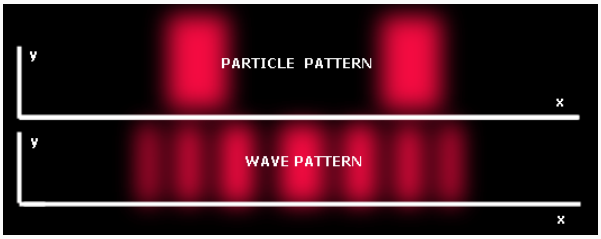
Want to see a video about it? ***Watch an except from Nova's Fabric of the Universe with Brian Green explaining the double slit experiment.***

Here's what happened:

The experimentalists already knew that light through the double-slit experiment would appear in a light-wave pattern. When they decided to measure the particles to see which of the two vertical slits they went through, the outcome of the experiment

changed radically. As soon as they 'looked' to measure the location and speed, the particles started acting like, well.. little balls of matter.

Although particles such as protons or electrons are not really 'little balls of matter', for our purposes, we can think of them this way to make visualizing this easier. When the photons were being measured, they went through one slit or the other as expected but instead of making the wave-like interference pattern, they made a pattern like two vertical lines. This is similar to what you'd expect if you were throwing baseballs through two vertical slits in a wall.



The patterns associated with light acting like particles versus when acting like a wave

Okay, so what?

Well, further testing showed that this peculiarity wasn't just limited to photons. The same thing happened when using electrons, protons, even atoms as large as buckyballs, which is a gigantic collection of 60 carbon atoms.

Now scientists are a tough bunch. They don't like the unknown, and it seemed like every time they tried to measure the location of a particle in this wave-like feature, the particle would collapse into the pattern of going through only one slit at a time and making the particle-like pattern as in the image above.

Thinking that the result was due to a mass of electrons trying to go through the slits, experimentalists tried the experiment again by shooting one electron at a time through the double-slits. We might expect that it would choose to go through either one slit or the other, or simply bounce back. After all, electrons are matter and should behave just like baseballs would.

Shockingly, even single electrons displayed this wave-like behavior. How could a single electron – which is a particle – display a wave-like pattern? Moreover, how could one electron appear in areas such as directly behind the middle of the two slits or way off to the side? Shouldn't single electrons being shot through two vertical slits only make two vertical lines on the detector wall behind it?

German physicist Werner Heisenberg realized that we aren't simply looking at a physical result, but a probabilistic one. The electron has a certain chance of hitting the

detector in one of many places but it doesn't 'choose' it's final resting place until it is forced to by measurement.

This strange quantum behavior is described by *Heisnberg's uncertainty principle*. Each individual particle exists in a superposition – a probabilistic state of being everywhere and nowhere at once. As with the earlier experiment, the act of measurement – the act of pinning down the exact location and speed of the particle seemed to 'force' it to pick a spot and lose that probabilistic wave-like behavior.

The fabric of reality is fuzzy. We can only calculate the odds of a particle being in a particular place at one time. If we don't persist in trying to measure the particle's location or speed, it will resume its wave-like behavior and appear in places that would be impossible if the particle was truly going through one slit at a time, for example behind the center of the two slits.

Undeterred, later scientists designed "Delayed Choice" experiments that they hoped would solve this mystery once and for all. Since any amount of measuring, interacting with, or watching the particles caused them to lose their wave-like pattern, they decided to put a detector after the vertical slits in order to see which slit the particle 'decided' to go through. They only measured *after* the particle had 'made its choice'. The single electron is expected to reach the double-slits as a probabilistic wave, but when the measurement device is turned on directly after exiting the slits, the experimenters should have been able to detect the change to the particle state and discover which slit it must have gone through.

The result was even more mind-blowing. Even though the particle wasn't being measured or observed as it was going through the slits, the action of measuring the particle afterwards cause the particle to seemingly *go back in time* and enter the slits as with particle-like behavior.

Frustrated scientists notwithstanding, quantum physicists had to admit that at the smallest levels of known reality, our universe is not objective or predictable. Reality is a big question mark until something or someone interacts with it. Matter, which is made up of quantum particles, can't exist in a definite state unless the wave function is collapsed, thus prompting Albert Einstein's sardonic statement: "I like to think the moon is there even if I am not looking at it."

Although some early physicists claimed that consciousness itself was affecting this freaky quantum behavior, others including Einstein wrote it off as metaphysical nonsense. It was claimed that somehow the act of measurement itself with a detector or apparatus was destructive to the wave-function, like knocking billiard balls off a pool table with a sharp poke from the cue.

By now, this issue was called ‘The Measurement Problem” and spoiler: it still hasn’t been solved. Scientists have gone to great lengths to avoid implicating consciousness in particle-wave collapse. One of the more bombastic theories is called the *many-worlds interpretation*. This suggests that there is no wave-collapse, simply a brand-new nearly identical universe is created every time the particle settles into a position. All other positions are likewise a reality in a different universe. Of course, this means that an infinite number of universes are willed into being as soon as any particle moves from a probabilistic position to a definite state but the lack of any way to test this theory means that many scientists regard this as more science fiction than science. Conversely, string theory, the new kid on the quantum physics circuit, attempts to solve this mystery with added dimensions; 11 to be precise. Although I find both the many worlds and string theories to be fascinating, it becomes an exercise in frustration when any theory involving consciousness is quickly relegated to the status of ‘woo’, and yet perfectly intelligent scientists can speak of 11 unobservable and un-testable dimensions with a straight face.

Dr. Robert Lanza sums up this point perfectly in his book *Biocentrism*:

“When science tries to resolve a theory’s conflicts by adding and subtracting dimensions to the universe like houses on a Monopoly board, dimensions unknown to our senses and for which not a shred of evidence exists, we need to take a time-out and examine our dogmas.”

Science will agree that any interaction with quantum particles will collapse the wave function but it has been thus difficult to remove the act of conscious observation from the measurement problem. Even if scientists believe that consciousness has nothing to do with the destructive interaction with quantum particles, it still takes a conscious person to observe the data. Even if using remote detectors to view the results hours later, we can’t be sure the particles didn’t wait to collapse at the moment a conscious person observed the results.

Before we analyze Dr. Radin’s results and why it is so groundbreaking, its important to understand the implications. Why are scientists so reticent to implicate consciousness? Material science is based on objective forces in our universe that obey strict laws of behavior. Were consciousness proven to exist, it would imply a force unknown to science and it has shades of religiosity that scientists recoil from like vampires from the sun. Similarly, if consciousness were proven to affect matter at the most basic level all of materialist science would collapse. Everything that we’ve surmised about the material universe would need to be revamped starting with consciousness as the base of reality, not simply as a quirky epiphenomenon secured in the brain and safely disposed of at death.

Furthermore, even the ability for a conscious human being to objectively observe the universe would be called into question. If the consciousness of a scientist can not only collapse a wave-function, but influence it to collapse in a particular way then we would never claim an objective measurement again. Consciousness would be the one variable we could never control for.

Dr. Dean Radin's Experiment and Results:

If you have read this far, you should now be able to follow Dr. Dean Radin's IONS conference presentation and understand the full impact of his results. The video is embedded below, or **linked here**.

Dr. Radin's experiment begins with the classic double-slit setup. Using a laser, detector, double-slit board and camera, his research team was able to capture the probabilistic wave-interference pattern of undisturbed protons. A computer recorded the interference pattern being created moment by moment.

Dr. Radin then added a series of conscious observers. Without interacting with the system at all (no destructive measurement), he asked the participants to imagine affecting the test. Radin used a feedback tone and imagery to give the observers something to concentrate on. If the tone got louder, they were having a larger anomalous effect on test. The observation period was interchanged with rest periods. Interestingly, Radin made a distinction between people who regularly meditated and those who didn't.

In the initial trials, the meditators produced significant results with the non-meditators falling slightly around chance. When combined, however, the results were still striking.

Suspicious of his results, Radin expanded the experiment online, carefully controlling for several dozen variables, such as vibration, temperature, time, cycles, etc. The results of 5,000 human and 7,000 robotic trials showed similar and statistically significant results. Although the effect is small, it is consistent and repeatable.

The results insinuate that human consciousness can affect the very fabric of reality with no proximity limitation. From anywhere in the world, a person's intentions can collapse a particle wave function into a definite state. More even than simply affecting the wave-function, Radin's research shows something like a quantum zeno effect; it 'steers' the quantum collapse.

So maybe the moon really isn't there until we look at it?

Radin is the consummate scientist. Although his methods and protocol has been independently verified, he is unwilling to draw any definite conclusions until more labs have replicated his study.

At the time of this writing, another lab is in process of replicating the experiment. Although the scientist didn't want to reveal his name (likely due to the academic shaming associated with research of this sort), his initial results showed something on the range of "oh my God!", as Radin explains in the video. As expected, materialist science continues to ignore research such as Radin's and others. Aside from the fear of academic suicide, there is a very real insecurity of losing the objective reality afforded by material science.

Although Radin's research is one of the most direct applications of the interpretation that consciousness affects matter, the idea is not new. The aforementioned Dr. Robert Lanza is scientist famous for stem-cell research. Called one of the world's top three living scientists, he took the unusual and courageous step of publishing his 'theory of everything' called Biocentrism in 2009. In it, he posits that the basis of the universe is consciousness.

"The animal observer creates reality and not the other way around"

Dr. Lanza uses the measurement problem as a basis of this theory and illustrates is with this mind-bending analogy:

"Take the seemingly undeniable logic that your kitchen is always there, its contents assuming all their familiar forms, shapes and colors, whether you are in it or not. At night, you click off the light, walk through the door, and leave for the bed-room. Of course it's there, unseen, all through the night. Right? But consider: the refrigerator, stove, and everything else are composed of a shimmering swarm of matter/energy. Quantum theory..tells us that not a single one of those subatomic particles actually exists in a definite place. Rather, they merely exist as a range of possibilities that are manifest. In the presence of an observer – that is, when you go back into get a drink of water – each one's wave function collapses and it assumes an actual position, a physical reality. Until then, it's merely a swarm of possibilities…So while you may think that the kitchen as you remember it was 'there' in your absence, the reality is that nothing remotely resembling what you can imagine could be present when a consciousness is not interacting"

What Dr. Lanza is suggesting based on 85 years of quantum mechanical research is, entirely, that the moon does not exist when we are not looking at it. Dr. Radin's research contributes to this notion by showing a definite statistical anomaly when consciousness is directed to influence quantum states.

It's hardly needed to be said that most of science recoils at the notion that we do not exist in a separate objective reality. To put consciousness at the center of reality with any sort of causal connection means that the universe only exists because we perceive it. They complain of solipsism, and the many unanswered questions that would then arise. 'What consciousness was around to will the big bang into existence?', they cry. The only logical answer for many is God, and that's where the conversation screeches to a dead halt.

Certainly more time will be needed to the scientific community to agree on a testable and repeatable basis for this theory. Bleeding-edge experiments from Dr. Radin and others are only just beginning to cut the binds of the reductionist and materialistic attitude that is still pervasive in academia. A hopeful future including an expanded role of consciousness would make life after death studies less repugnant to science and certainly less imbued with religious overtones.

For afterlife researchers, any research that supports the idea that consciousness can affect the material world shows that consciousness is mind apart from brain, possibly interacting with but not dependent on biology. Although it doesn't directly prove that life after death exists, it does suggest that our consciousness may not be an illusory product of the brain. Quantum consciousness studies such as Radin's and other quantum mind proponents such as Henry Stapp, David Bohm, Stuart Hameroff and Roger Penrose could be a crucial step closer to understanding phenomena like near-death experiences, death-bed visions and past-life recall.

Until then, we can still put this theory into practice in our everyday lives. From Phineas Quimby's Law of Attraction to Jane Robert/Seth's 'You create your own reality', to popularized versions of the idea such as 'The Secret' and 'The Vortex', philosophy, spirituality and the new-age genre has long accepted this notion with open arms. We may not have the ability to teleport or spontaneously upgrade our cars with the power of collapsing the wave-function of particles, but we can use our intentions to make good in our lives.

Remember always that your thoughts have power; they can set up circumstances for our success or our demise, hurt or help others and lead us into journeys of enlightenment or toil. One day we may have the scientific proof that our consciousness literally creates the universe around us. Until then all we can do is concentrate on making our little corner of the world just a little better.

09/26/2011 05:18 pm ET **Updated** Nov 26, 2011

Can Our Brain Waves Affect Our Physical Reality?

By [Peter Baksa]

So, what is thought and how does it connect up with quantum mechanics?

Your brain is comprised of a tight network of nerve cells, all interacting with one another and generating an overall electrical field. This electric field is detectable with standard medical equipment. Your brain waves are simply the superposition of the multitude of electrical states being formed by your nervous system.

Not only your brain, but your entire body has an electric field. Anywhere there's a nerve cell, there's electricity. It's just concentrated the greatest around your head because that's where the bulk of your nerve cells are. Any time you've felt the shock of static electricity, or used a touch-sensitive screen, you've proven that you have an electric field.

So, nothing mysterious about that part.

Being an electric field, all those overlying electric wave patterns that comprise your brain waves are governed by the same equations governing the electromagnetic spectrum, light, particles and everything else in the universe. The light seen coming from a star and the energy of your mind are one and the same type.

Your thoughts are formed in this electric field. The measurable perturbations and disturbances in the brain's overall electric field are your actual thoughts racing through your mind. As you read this article, the thoughts you are thinking of, the words your mind is processing, are all electrical impulses that can be measured if you had a few wires hooked up between your head and a machine. So thoughts are energy, the same as everything else.

That means they are governed by the rules of quantum mechanics and Schrödinger's wave equations as well. All those same weird things about quantum mechanics that describe how an electron or photon behave, apply to you and your thoughts as well. The particle-wave duality, the uncertainty principle, and of course, entanglement.

This implies that, like any other set of particles or source of energy, we are entangled with everything we've ever encountered, the environment around us and the rest of the universe through the zero point field. We'd mentioned that consciousness is the key to making the mysteries of quantum mechanics work in past articles — well, this is how it happens.

The one difference between us and a photon is that we can think, we are conscious. As such, we can choose which of the possibilities before us to collapse our wave function into. But more than that, since we are entangled with our environment we can thus affect that as well and influence the randomness, just as it can influence us.

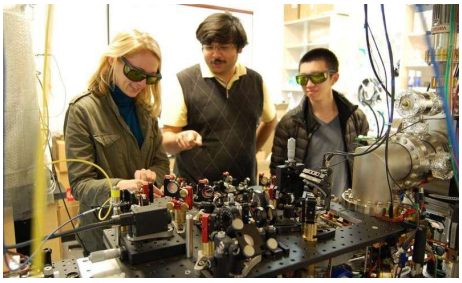
Since we are conscious, we can choose what part of the randomness around us to be affected by, and how we in turn would like to affect it. It is through the property of entanglement that we can affect change in our environment. Our minds are transceivers, able to receive and send signals into the “quantum soup” of the zero point field by way of the highly coherent frequencies of our thoughts.

The higher the frequency of our thought/brain wave, the higher our consciousness. The level of our consciousness is what makes our reality what it is and what it will continue to be. If you are seeking change, set an intention, declare a path (align your behaviors with your desire), then detach and allow the universe to handle the details.

- Quantum Physics
- October 23, 2015

'Zeno effect' verified—atoms won't move while you watch

October 23, 2015 by Bill Steele, Cornell University



Graduate students Airlia Shaffer, Yogesh Patil and Harry Cheung work in the Ultracold Lab of Mukund Vengalattore, assistant professor of physics.

One of the oddest predictions of quantum theory – that a system can't change while you're watching it – has been confirmed in an experiment by Cornell physicists. Their work opens the door to a fundamentally new method to control and manipulate the quantum states of atoms and could lead to new kinds of sensors.

The experiments were performed in the Utracold Lab of Mukund Vengalattore, assistant professor of physics, who has established Cornell's first program to study the physics of materials cooled to temperatures as low as .000000001 degree above absolute zero. The work is described in the Oct. 2 issue of the journal *Physical Review Letters*

Graduate students Yogesh Patil and Srivatsan K. Chakram created and cooled a gas of about a billion Rubidium atoms inside a vacuum chamber and suspended the mass between laser beams. In that state the atoms arrange in an orderly lattice just as they would in a crystalline solid. But at such low temperatures, the atoms can "tunnel" from place to place in the lattice. The famous Heisenberg uncertainty principle says that the position and velocity of a particle interact. Temperature is a measure of a particle's motion. Under extreme cold velocity is almost zero, so there is a lot of flexibility in position; when you observe them, atoms are as likely to be in one place in the lattice as another.

The researchers demonstrated that they were able to suppress quantum tunneling merely by observing the atoms. This so-called "Quantum Zeno effect", named for a Greek philosopher, derives from a proposal in 1977 by E. C. George Sudarshan and Baidyanath Misra at the University of Texas, Austin,, who pointed out that the weird nature of quantum measurements allows, in principle, for a quantum system to be "frozen" by repeated measurements.

Previous experiments have demonstrated the Zeno Effect with the "spins" of subatomic particles. "This is the first observation of the Quantum Zeno effect by real space measurement of atomic motion," Vengalattore said. "Also, due to the high degree of control we've been able to demonstrate in our experiments, we can gradually 'tune' the manner in which we observe these atoms. Using this tuning, we've also been able to demonstrate an effect called 'emergent classicality' in this quantum system." Quantum effects fade, and atoms begin to behave as expected under classical physics.

The researchers observed the atoms under a microscope by illuminating them with a separate imaging laser. A light microscope can't see individual atoms, but the imaging laser causes them to fluoresce, and the microscope captured the flashes of light. When the imaging laser was off, or turned on only dimly, the atoms tunneled freely. But as the imaging beam was made brighter and measurements made more frequently, the tunneling reduced dramatically.

"This gives us an unprecedented tool to control a quantum system, perhaps even atom by atom," said Patil, lead author of the paper. Atoms in this state are extremely sensitive to outside forces, l he noted, so this work could lead to the development of new kinds of sensors.

The experiments were made possible by the group's invention of a novel imaging technique that made it possible to observe ultracold atoms while leaving them in the same quantum state. "It took a lot of dedication from these students and it has been amazing to see these experiments be so successful," Vengalattore said. "We now have the unique ability to control quantum dynamics purely by observation."

The popular press has drawn a parallel of this work with the "weeping angels" depicted in the Dr. Who television series – alien creatures who look like statues and can't move as long as you're looking at them. There may be some sense to that. In the quantum world, the folk wisdom really is true: "A watched pot never boils."

Read more at: https://phys.org/news/2015-10-zeno-effect-verifiedatoms-wont.html#jCp

Consciousness-related interactions in a double-slit optical system

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March 9, 2018

Abstract

Motivated by a series of reported experiments and their controversial results, the present work investigated if volunteers could causally affect an optical double-slit system by mental efforts alone. The participants' task in the experimental sessions alternated between intending an increase in the (real-time feedback-informed) amount of light diffracted through a specific single slit versus relaxing their intentional effort. In total, 240 sessions contributed by 171 volunteers were recorded. The first 160 sessions were collected in an exploratory mode, and those data revealed statistically significant differences between the intention and relax conditions. The analysis method and variables of interest derived from the exploratory sessions were then pre-registered for the subsequent 80 formal sessions. The formal experiments, based on a directional hypothesis, were not statistically significant. A post hoc meta-analysis based on a bi-directional hypothesis, and applied to the same data, resulted in a 2.75 sigma outcome ($p = 6.02 \times 10^{-3}$; $es = 0.31 \pm 0.22$ 95% CI). Directional and bi-directional analyses applied to an equal number of control sessions, all conducted without observers present, resulted in uniformly non-significant outcomes. Analysis of environmental factors did not reveal any artifactual sources that might have produced the significant bi-directional effect. While the pre-registered analysis did not support the existence of the investigated phenomenon, the post hoc findings warrant further investigation to formally test the bi-directional hypothesis.

1 Introduction

One of the hardest problems still unsolved by modern science concerns the nature of consciousness and its relationship to matter [1]. The millennial old debate, currently addressed by the philosophy of mind, proceeds by asking if there are more fundamental aspects to reality, what are their properties, and how do they interact.

The first time physicists seriously considered the possibility of a role for consciousness within their discipline coincided with the development of quantum mechanics in the 20$^{\text{th}}$ century. In particular, the question of how the superposition state is reduced to a definite observed state, known as the quantum measurement problem, led some scientists [2–4] to associate such abrupt transitions with an increase in subjective knowledge. According to that interpretation, the conscious agent played an essential role in promoting the state reduction when gaining information by interacting with the experimental apparatus.

The question evolved into a controversial philosophical and theoretical debate [5–11] where the majority today denies the necessity of any "extra-physical" consciousness ingredient in quantum physics [12]. Data in support of the leading view is found in "which-path" experiments, reported and discussed by [13]. Those experiments reveal that a sufficient condition for a superposition state collapse is the availability of "which-path" information, even when theoretically

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obtainable but not effectively measured. The examples provided in [13] lead to the conclusion that information reaching human consciousness is not a mandatory step for state reduction.

Although a strong role for human consciousness in the quantum measurement problem may be ruled out, a weaker but theoretically highly significant role can be investigated; if the right conditions are met, can consciousness influence the collapse of the superposition state? Or, more generally, is there any sort of interaction between consciousness-related mental states and quantum systems?

Experimental efforts to address the above questions date back to the 1970's with the use of random number generators. These devices use quantum effects such as radioactive decay and tunneling to produce truly random binary numbers. In those studies, participants tried to directionally bias the 0 or 1 outcomes from 50/50 chance through their mental intention, usually being informed in real time about the measured values. Two major meta-analyses [14, 15] have reported statistical evidence for the anomalous correlation between conscious intention and the output of random number generators. The results revealed a *goal-oriented* characteristic, where the increase in 0 or 1 coincides with the participant's intended aim. Although significant, [15] concluded that the effect could be more simply explained as an artifact attributable to non-significant unpublished studies. That interpretation was argued as insufficient by the authors of the first meta-analysis [16].

A double-slit system as a target in a similar experimental protocol was first used by [17]. In the standard double-slit system if partial which-path information is obtained by any means, one expects a reduction in the interference component [18]. That study investigated the fringe visibility (a measure of the interference component) variation according to the participant's intention. Two experiments were presented, one supporting the interaction hypothesis and the other conforming to chance expectations.

Of particular interest to the present work are the double-slit experiment series [19–22] presented by Dean Radin and his collaborators. Those results are remarkable in the sense that many of the pre-planned experiments resulted in statistically significant evidence supporting the investigated interaction. Their findings, across the work series, claim that the observed effects: a) globally support the *mind-matter interaction* hypothesis, i.e. the causal effect of the participant's intention in the optical system; b) cannot be explained as procedural or analytical artifacts, as the control sessions (without participants present) resulted in no significant differences between the intention-present and intention-absent epochs; c) are stronger for participants with contemplative practices training, e.g. meditation; d) show a positive correlation to the participant's score obtained in an absorption questionnaire [23], which measures the degree of immersion that one can reach when performing a task; e) show a positive correlation to α-band desynchronization, a marker of a shift in attention as measured by an electroencephalogram; f) are retro-causal, i.e. obtainable even when the participant views previously recorded data that was not observed by any participant or the experimenter prior to the session; g) do not depend on distance, occurring even when the participant tries to exert influence on a distant optical system while receiving the feedback information about the state of the interference pattern streamed over the internet. As a result, the effect sizes obtained do not appear to decline with distance.

Inspired by Radin et al's challenges to the present scientific world view, the current experiment tried to replicate their first four findings using a similar protocol and a modified setup/analysis as described below.

2 Methods

2.1 Equipment

A semiconductor laser diode L (DL-3148-023, single mode $\lambda = 635$ nm, transverse magnetic polarization; Sanyo) is powered through a feedback driver circuit to maintain a constant 3 mW light output power. To minimize temperature fluctuations, the laser diode is mounted on a metal structure covered with styrofoam. No lenses or neutral density filters are employed.

As depicted in Fig. (1), the laser light passes through two slits DS etched in a metal foil (10 μm width each, centrally-separated by 200 μm; Lenox Laser). The resulting interference pattern is recorded at 10 Hz by a CCD camera C (FL3-GE-13S2M-C, 1288 x 964 pixel, 3.75 μm pixel size, 47% quantum efficiency at $\lambda = 635$ nm, 12-bit ADC; FLIR) running at room temperature with a heat sink attached to its top. An internal 1 mm width protective glass is removed from the camera to minimize refraction distortions.

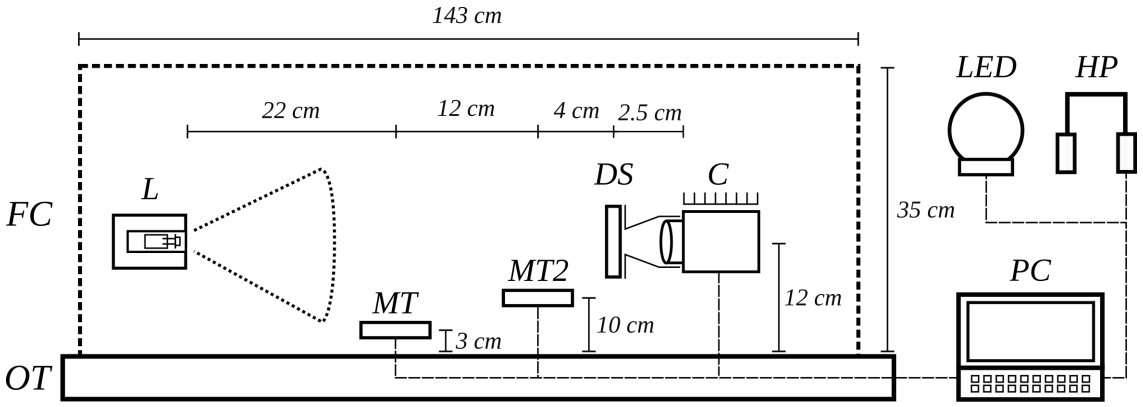

Figure 1: Experiment schematic side view. The distance of 2.5 cm represents the separation between the double-slit and the camera wall. The distance to the camera sensor is found with a fit procedure described in Section 2.6.

A 3D-printed hollow piece is used to connect the camera to the double-slit. One end is firmly attached to the camera's barrel and the other to a circular metallic piece that holds the double-slit foil. The plastic material color chosen is black to block light influences other than from the laser.

Concurrent with the CCD frame, temperature and magnetic field measurements are obtained using: a) an LM35 temperature sensor (0.5°C accuracy; Texas Instruments) coupled to the laser metal structure; b) an LM35 sensor placed between the laser and the double-slit for measuring room temperature ; c) an HMC5883L magnetometer (0.73 milli-gauss resolution, 12-bit ADC; Honeywell) placed close to the previous temperature sensor; d) an Arduino UNO microcontroller used to digitally read the sensors information. The whole system is presented as MT in Fig. (1).

Starting at experiment 4, additional temperature and magnetic field measurements were obtained by the $MT2$ system consisting of: a) an LM35 temperature sensor coupled to the CCD heat dissipater; b) an HMC2003 magnetometer (0.04 milli-gauss analog resolution; Honeywell) placed close to the double-slit; c) a 4 channel 16-bit ADC (ADS1115; Texas Instruments); d) an Arduino UNO microcontroller.

The described components rest on a passively damped optical table OT (SmartTable UT; Newport) and are situated inside a grounded Faraday cage FC (tombak alloy, 82% copper and 18% zinc). The experiment is controlled by a 2 GHz dual-core notebook computer PC running a custom program developed in python language. Two devices are used to provide real-time feedback for the participants: noise canceling headphones HP (QuietComfort 25; Bose) and an Arduino controlled 3W LED placed inside a translucent glass sphere. The LED is composed of red, green, and blue color components that can be combined to produce a wide range of colors.

A grounded uninterruptible power supply (Back-UPS 2200; APC) is used to feed the computer, the CCD camera and the laser power supply (MPS-3005; Minipa, Brazil) delivering 3.3 V DC to the driver circuit. The Arduino microcontrollers are powered through the *PC* USB port. To ensure stable analog-to-digital (ADC) readings (concerning reference voltage variations), the following measures are taken at MT: a) the LM35 readings are obtained by the microcontroller 10-bit ADC using the regulated internal 1.1V reference; b) The HMC5883L magnetometer is connected to a power regulated circuit module. At $MT2$, the LM35 and the HMC2003 are read by the ADS1115 ADC, which uses a regulated internal voltage reference.

2.2 Data acquisition

The python software controlling the experiment has its execution split into a two thread design. The first thread $T1$ is a 10 frames per second loop responsible for simultaneously triggering the sensors readings and collecting the data output within each 100 ms window. The second thread $T2$ represents the experiment flow, informing the participant about their current task, providing feedback depending on the current experimental condition, and performing data storage. As the program starts, $T1$ is set to continuously acquire data while $T2$ is in standby mode waiting for the command to start an experimental session. As a session starts, data arrays are sequentially filled with the sensors information captured by $T1$. As the session ends, the data arrays are sent to hard-disk storage while $T1$ continues its loop and $T2$ returns to standby mode.

The CCD camera is configured to acquire frames using a 25 ms exposure time. Gain increase, auto-exposure and all post-processing filters (e.g. gamma, sharpness, brightness) are disabled. Each frame is initially obtained in a 1264 x per 256 z (centrally aligned) pixel window. Next, for every x, the 256 z values are summed, and the result is right bit shifted by 4 units. This oversampling technique, physically viable according to the z-axis system symmetry, is used to increase the measurement resolution from 12 to 16 bits. The resulting 1264 x values, referred to as a "CCD frame" throughout this work, represent the stored information used for the real-time feedback and the posterior analysis. Additionally, the temperature of the camera's internal components is obtained from an on-board temperature sensor (0.5°C accuracy; 12-bit ADC). Figure 2 shows an example of a single frame obtained with the current experimental setup and the interference pattern measured, as well as its Fourier transform components.

The HMC5883L sensor is configured to 8 averaged measurements per sample, and its gain is set to 0.73 milli-gauss resolution. In MT all sensors are oversampled to reach 13-bit resolution (4 reads in HMC5883L and 64 in the LM35). In $MT2$ one single-ended ADS1115 reading (configured to a full scale-range of ± 4.096 V) is performed for each sensor, resulting in an effective 15-bit resolution.

A $n = 0, 1, \ldots, n_f$ frame session results in the following data: a) a three valued condition array $C[n]$ tagging each frame to the corresponding experimental state of intention, relax, or a state in-between; b) a run array $R[n]$ comprised of $0 \ldots 39$ integers uniquely identifying the intention/relax 300-frame blocks; c) a CCD frame array $I[n, i]$ with $i = 0, 1, \ldots, 1263$ and 16-bit integer values; d) the temperature arrays $T_C[n]$, $T_L[n]$ and $T_R[n]$ (32-bit floating point values) corresponding respectively to the on-board CCD camera, the laser and the room temperature sensors; e) the three-direction magnetic field arrays $M_x[n]$, $M_y[n]$, $M_z[n]$ (32-bit floating-point values) obtained by the MT system sensor; f) from experiment 4 forward, the 32-bit float arrays corresponding to the CCD external temperature $T2_C[n]$ and magnetic field components $M2_x[n]$, $M2_y[n]$, $M2_z[n]$, obtained from the $MT2$ system sensors.

2.3 Procedure

To avoid potential warm-up artifacts and ensure thermal equilibrium, the following measures are taken 2 hours before each day's first session: a) laser diode and environmental sensors are turned on. In order to accelerate the CCD camera warm-up curve, it is powered on throughout

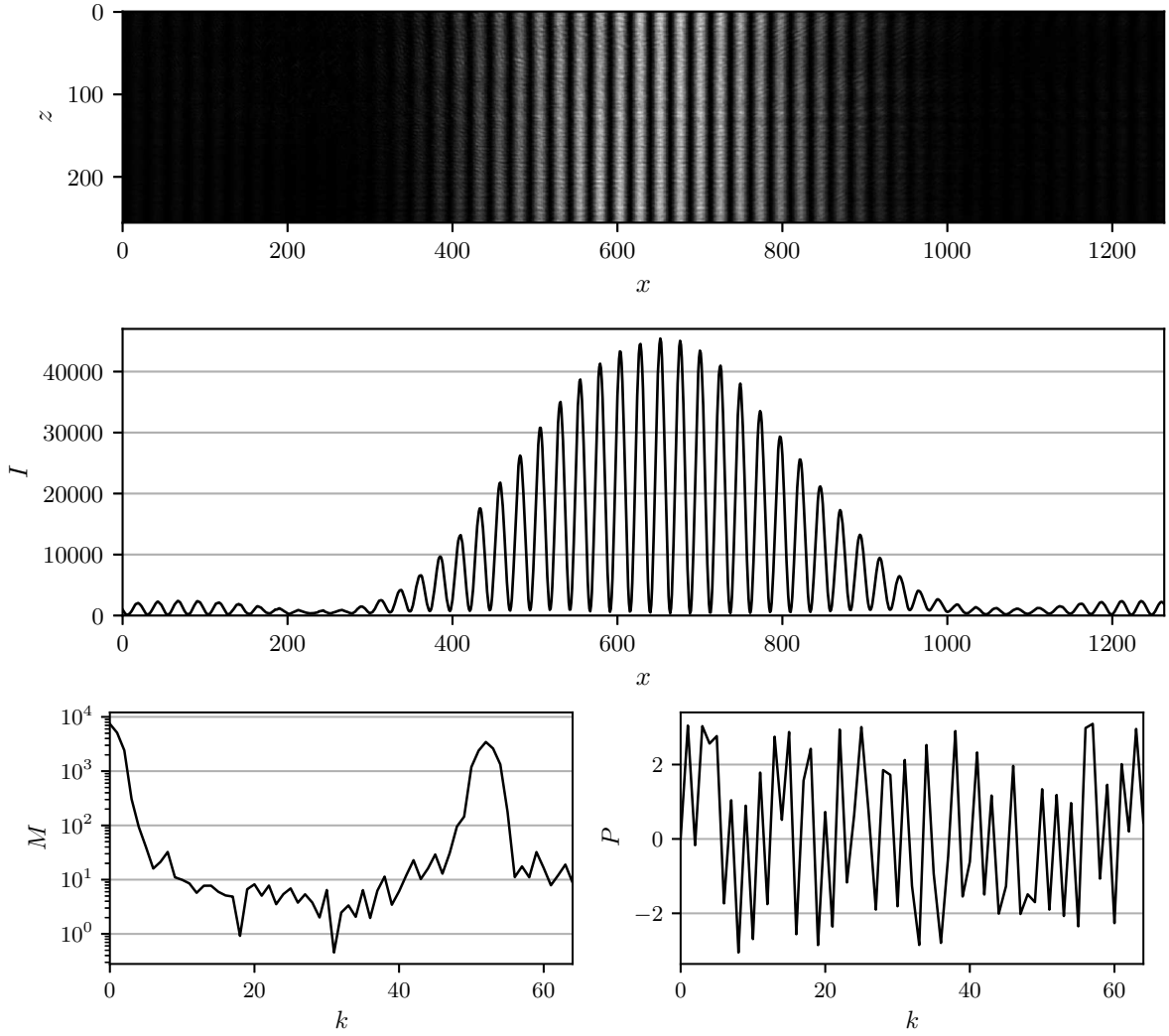

Figure 2: CCD frame information. Single raw-CCD frame showing the interference pattern measured (white representing the pixel brightness); 16-bit oversampled one-dimensional I projection in analog digital units (the maximum value corresponds to 69% of the illumination capacity); and the log-scale M magnitude and P phase components of the respective Fast Fourier Transform.

the entire experimental block to maintain its internal temperature even when in standby mode; b) the data acquisition software is started. Until the day's last session, the sensors will be uninterruptedly read at 10 Hz; c) lights and air conditioning in the experimental room are switched off.

As the participant arrives at their scheduled time they sign an informed consent form describing the nature of the experiment. Next, they read a one-page text describing the task to be performed, and clarify any queries that they might have. Moving to the experimental room, the participant is briefly familiarized with the apparatus and the feedback devices. They sit in a chair about 3 m from the optical system, and are asked to remain seated and quiet during the entire session. They are then asked to put on the noise-canceling headphones. The experimenter switches the lights off, starts the session data acquisition, leaves the room, and waits for the session end in a nearby room. Shortly thereafter, over headphones, the participant hears a recorded message welcoming them, followed by guided instruction to take three deep

breaths. The recording then announces the beginning of each test condition.

The volunteer's task alternates between two different conditions: *intention* and *relax*. In the first, they are asked to concentrate on the intention to increase the magnitude of the provided real-time feedback. The feedback system is designed to inform the participant about instantaneous variations in the amount of light crossing through a specific single-slit. By intending the feedback magnitude increase, the participant is indirectly attempting to enhance the number of photons passing through the feedback-targeted single-slit. During the relax condition, the participant stops receiving the feedback information, and is asked to temporarily cease any intention toward the experimental system.

Intention runs are announced with the phrase "prepare yourself", followed by a 3-second silent delay, and then "... now, concentrate". The delay is included to facilitate the transition between an attention-away to an attention-toward mental state. Relax runs are announced with the phrase "now, relax". After the relax run ends, a random extra interval between 0 and 5 seconds is added to the in-between interval in order to decouple the measurements from possible periodic oscillations.

A single experimental session consists of 40 runs of alternating intention and relax conditions, with each run lasting 30 s. Each session lasts about 28 minutes, and yields approximately 16,800 sensor data frames, of which 6,000 are obtained in the intention condition and 6,000 in the relax condition. The in-between data is comprised of the frames obtained during the welcome and the instructions playback, the 0-5 s random windows, and the additional 100 s collected after the last relax run. The tail data are important to absorb the polynomial-fit border artifacts.

After the session's end, the participant meets the experimenter in the next room. An automatic timer triggers a *control session* that starts 10 minutes later, running on the exact same computer code but with no person present in the experimental room. Before the control session start the experimenter ensures that the experimental room lights are off, and places the headphones on the chair. The same feedback LED colors and the same decoupling time delays of the previous participant session are used.

Considering the subjective nature of the task, the participants are requested to rely on their personal understanding of how they are to perform the task. However, two general guidelines are provided: a) they should try to avoid getting physically tired, thus acting in a present but detached way; b) they shouldn't expect to be able to exert absolute control on the feedback response. Given the random characteristics of the measurement the feedback is supposed to, under the null hypothesis, show unpredictable behavior. They are informed that their influence, if genuine, could be too small to be perceived. This information is important to help participants avoid any frustration during the session, and to promote a balanced state where, independent of the current feedback magnitude, the participant sustains a uniform intent.

During the sessions, the experimenter had no access to the current condition nor consciously tried to mentally influence the result. The data analysis was performed only at the end each pre-planned experimental block. Experimental sessions were scheduled on weekdays after 6 pm and on Saturdays after 2 pm, and were separated by intervals of an hour and a half, usually allowing a maximum of three sessions during weekdays, and four on Saturdays.

The research was approved by the Comite de etica em pesquisa com seres humanos from Instituto de psicologia da Universidade de Sao Paulo, identifyied by CAAE 58223516.1.0000.5561.

2.4 Hypothesis

By intending the increase in the feedback magnitude, the participants are indirectly attempting to change the amount of light crossing each slit. In a standard double-slit experiment, the only way to causally promote such variation is by introducing into one of the slits some physical agent to interact with the light. The proposed study extends the standard experiment by adding an extra component: a participant (also denominated as conscious agent) trying to mentally interact with the experimental system and influence the slits light intensity. According to the

present scientific consensus, the agents must play a passive role, i.e. they shouldn't be able to modify the measured interference pattern with their introspective intentional efforts. Hence the null and the alternative hypothesis being tested are

$$H_0 : (\mu_I - \mu_R) = 0 \quad ; \quad H_1 : (\mu_I - \mu_R) \neq 0, \tag{1}$$

where μ_I stands for the mean of measurements performed under the intention epochs, and μ_R stands for the same in relax (intention absent) epochs. As a consequence of H_1, all probabilities reported throughout the study are two-tailed.

2.5 Participants

Participant recruiting looked for subjects interested in the investigated phenomena and who, based on some regular practice, showed a propensity for absorptive skills. This was motivated by Radin et al's correlation results, and favored meditators, mediums, holistic therapists, psychonauts, artists, martial artists, and athletes. Besides those groups, the recruiting included individuals who, by their curiosity and openness, were highly motivated to take part in the experiment.

The first invitations were sent to a list of experimenter's acquaintances who met the above-mentioned group inclusion criteria. Then, some who took part in the experiment were asked to nominate new potential participants from their own acquaintances, thus implementing a snowball sampling. The biased sample presented no obstacle as the main question concerned the existence of the investigated phenomenon, regardless of effect size distortions caused by a supposedly privileged group. In particular, in an experiment where attention is a crucial ingredient, it's convenient to select volunteers who, by their interest and motivation, are more likely to perform the experimental task with an increased level of commitment.

After their selection, the recruited volunteers filled out an online form about their personal practices and their beliefs and experiences regarding anomalous phenomena. The form also included a Portuguese translated version of the Tellegen absorption scale [23]. On the session days, before and after the experimental task, the participants filled out a questionnaire examining their current psychological state. A discussion of the correlations obtained between the questionnaires and scales with the experimental results lies outside the scope of the present work, and will be left for a future publication.

Across the experiment, no tests prior to the planned sessions were performed in order to pre-select the candidates. However, 29% of the sessions consisted of returning participants re-invited because of their previously obtained high z-scores.

2.6 Double-slit optical system

The double-slit system geometry is presented in Fig. (3). After traveling 38 cm the diverging laser beam reaches the double-slit region as a monochromatic plane wave of λ wavelength. The wavefront is then diffracted by the two rectangular apertures with respective widths of s_1 and s_2, which are separated by a d length. The distance from slit j center to an x point in the camera sensor is given by $r_j = \sqrt{y^2 + x_j^2}$, where $j = 1, 2$; $x_1 = (x - x_0) + (s_1 + d)/2$; $x_2 = (x - x_0) - (s_2 + d)/2$; and x_0 is the centrally-symmetric position between both slits.

According to the scalar diffraction theory [24, p. 75], the wavefield strength U at a point x can be expressed as a superposition of spherical waves emanating from every point within the diffraction aperture. The Huygens-Fresnel principle (as predicted by the first Rayleigh-Sommerfeld solution) followed by a Fraunhofer approximation results in the following intensity

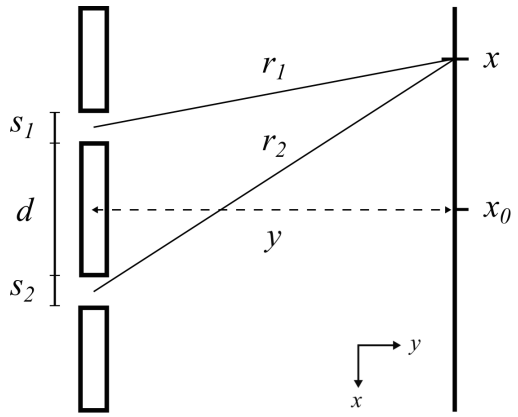

Figure 3: Top view of the double-slit system geometry. The double-slit xz plane is placed at a fixed y distance from the camera sensor xz plane.

after a single slit j:

$$U_j(x) = U_j^0 \, \exp\left\{ i \left[\theta_j + \frac{2\pi\, y}{\lambda} + \frac{\pi}{\lambda\, y}\, x_j^2(x) \right] \right\} \frac{\sin \beta_j(x)}{\beta_j(x)}, \tag{2}$$

$$\beta_j(x) = \frac{\pi}{\lambda\, y}\, s_j\, x_j(x),$$

where U_j^0 represents the total field strength emanating from the slit, and the phase θ_j translates a possible small rotation of the slit plane over the z axis. The measured light intensity I in the CCD sensor plane is given by the two-slit field superposition $\left|1/\sqrt{2}\, U_1 + 1/\sqrt{2}\, U_2\right|^2$, and in more detail to:

$$I(x) = \frac{1}{2}\, I_1(x) + \frac{1}{2}\, I_2(x) + \cos\left\{ \frac{\pi}{\lambda\, y}\, \left[x_2^2(x) - x_1^2(x) \right] + \theta_r \right\} \sqrt{I_1(x)\, I_2(x)} + DC, \tag{3}$$

$$I_j(x) = U_j(x)\, U_j^*(x),$$

where $\theta_r = \theta_2 - \theta_1$, and DC represent the dark current noise in the camera CCD. The first and the second terms are the *diffraction* components, and the third term is the interference component. All components together form an *interference pattern*, as exemplified in Fig. (2).

A least-square curve fitting procedure using Eq. (3) is applied to extract the physical parameters of the experimental setup. The data sample used consists of 100 CCD frames (equally time-spaced) obtained from each of the 60 control sessions formed by the first experiment. For practical purposes Eq. (3) is rewritten: $(U_1^0)^2$ is factored out from the three first members and $U_r = U_2^0/U_1^0$ is introduced in the next two; the x value is converted to a discrete set using the relationship $x = (i - i_0)\, \Delta p$, where $i = 0, \ldots, 1263$ and Δp is the pixel size. The extracted parameters are shown in Tab. (1).

2.7 Model

A theoretical model is developed to identify the experimental signatures arising from a legitimate mind-matter interaction. The interaction dynamics are modeled by a binary choice $c = \pm 1$, an intensity $0 \leq \psi \leq 1$, and a phase difference $-\pi < \phi \leq \pi$. The three degrees of freedom are considered functions of the conscious agent's subjective state. The extended interference pattern equation accommodating the supposed interaction is then given by:

$$I(x, c, \psi, \phi) = \left| \sqrt{\frac{1 + c\,\psi}{2}}\, U_1(x) + \sqrt{\frac{1 - c\,\psi}{2}}\, e^{i\,\phi}\, U_2(x) \right|^2 + DC, \tag{4}$$

par	mean	std	unit
y	30.458	0.017	mm
s_1	12.56	0.11	μm
s_2	12.18	0.16	μm
U_1^0	157	2	mm
DC	374	42	–
U_r	0.940	0.022	–
θ_r	-0.102	0.041	–
d	200	–	μm
λ	635	–	nm
Δp	3.75	–	μm
i_0	652	–	–

Table 1: Parameters mean values and standard deviations obtained in the fitting procedure of the 6,000 CCD frames. No std indicates a parameter that was fixed during the fitting procedure.

where global conservation of the light intensity is ensured as the sum of the two coefficients squared norm equals one. In more detail:

$$I(x,c,\psi,\phi) = \frac{1+c\,\psi}{2}\,I_1(x) + \frac{1-c\,\psi}{2}\,I_2(x) + \\ +\sqrt{1-\psi^2}\,\cos\left\{\frac{\pi}{\lambda\,y}\,\left[x_2^2(x)-x_1^2(x)\right]+\theta_r+\phi\right\}\sqrt{I_1(x)\,I_2(x)}+DC. \tag{5}$$

Inspecting Eq. (5) one learns that a ψ action would increase the amount of light diffracted through a specific single slit while decreasing the amount through the other. The binary c choice expresses the specific slit to be light-enhanced: $c=1$ meaning slit 1 and $c=-1$ meaning slit 2. For a non-zero ψ, the interference term decreases independently from c. A ϕ action would shift the interference term to the left/right depending on its sign.

Although it's possible to work with the time-domain pattern, the information extraction using fitting procedures requires intensive computations. Facing this technical challenge, it's convenient to Fourier transform the light intensity (operation denoted as $\mathcal{F}\{I\}$) using fast algorithms, and search for interaction signatures in the k frequency domain.

The next question to be addressed concerns the effect of $\psi\phi$-perturbations in the interference pattern and its translation into the magnitude and phase Fourier components. For a given double-slit system geometry, what are the magnitude and phase k-values that are more sensitive to the investigated $\psi\phi$-influences? The answer to this question will lead to the most efficient strategy for probing the interaction existence. The following component differences are adopted as a metric to characterize the signal associated with $\psi\phi$-perturbations:

$$\Delta M(k) = M_{\rm int}(k) - M_{\rm rlx}(k) \quad ; \quad \Delta P(k) = \frac{P_{\rm int}(k) - P_{\rm rlx}(k)}{M_{\rm rlx}(k)}, \tag{6}$$

where $\mathcal{F}\{I(x,c,\psi,\phi)\} = M_{\rm int}\exp(i\,P_{\rm int})$ represents the $\psi\phi$-influenced information supposedly obtained in intention conditions, and $\mathcal{F}\{I(x,0,0,0)\} = M_{\rm rlx}\exp(i\,P_{\rm rlx})$ represents the $\psi\phi$-absent information from relax conditions. The phase difference is divided by the associated magnitude to correctly represent the variation inertia – it's easier to change the phase of smaller magnitude k-values. Using the fit-extracted physical parameters from Tab. (1) and Eqs. 5–6, the $\psi\phi$-interacting versus non-interacting differences are numerically evaluated and presented in Fig. (4).

The difference extrema are used to guide the construction of variables of interest sensitive to $\psi\phi$-action. For example, a variable can be designed as the area of the magnitude component

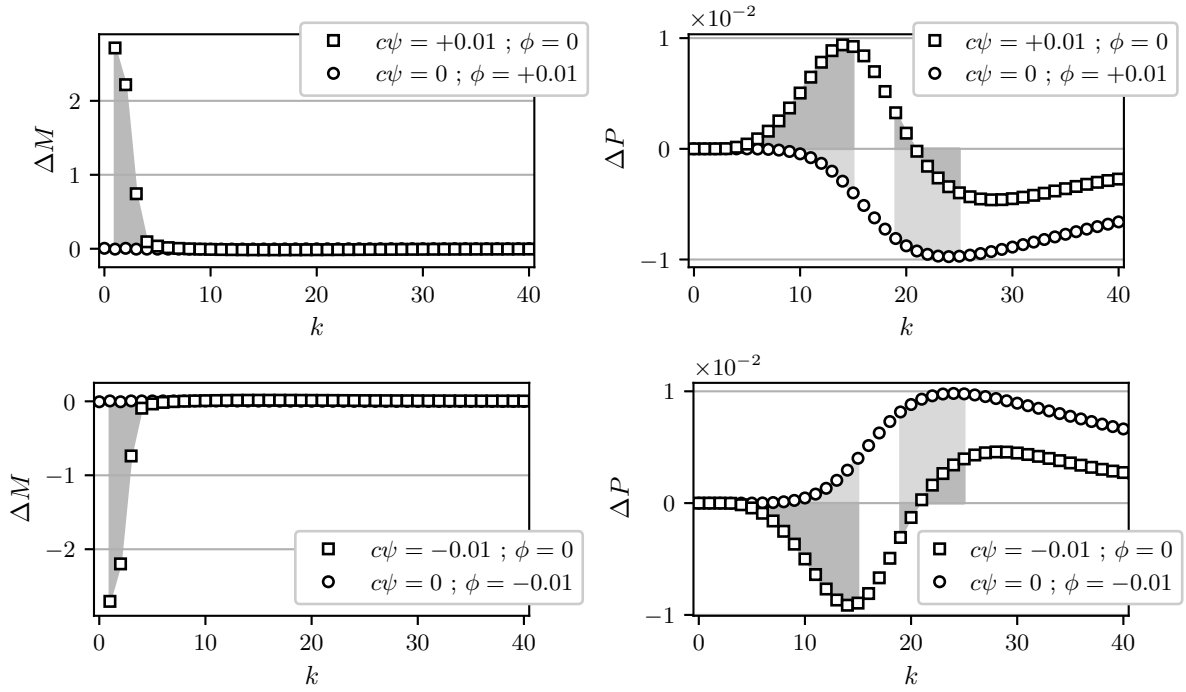

Figure 4: Magnitude and phase difference signatures for different values of c, ψ and ϕ. The magnitude shaded region represents the area explored in the real-time feedback, while the phase shaded areas represent the two chosen k-windows for building the V_1 and V_2 variables of interest used in the analysis. The differences sign inversion resulting from a c sign inversion allows one to discriminate between the increase or decrease in the light intensity diffracted through a specific slit.

evaluated between the $k = 1 \ldots 4$ window. In this way, a CCD frame is translated into a single real number that should increase when the first slit diffraction intensity increases, or decrease when the second slit diffraction intensity increases. The standard score sign obtained by a statistical test comparing the mean of the variables obtained in intention and relax conditions will then reveal the enhanced single-slit. It's important to note that the discrimination between $c = +1$ and $c = -1$ depends on $I_1(x)$ and $I_2(x)$ having slightly different shapes. Conversely, the phase component does not depend on geometrical asymmetries in the slits to allow a discrimination of the enhanced single-slit. Those arguments are demonstrated in the Supporting Information (SI) Section Appendix S1.

While the magnitude is insensitive to ϕ variations, the phase difference reveals a first $k < 17$ region dominated by a $c\psi$ action and a second $k > 17$ region dominated by ϕ contributions. Those two phase regions are represented throughout this study by variables respectively denoted as V_1 and V_2.

2.8 Real-time feedback

The feedback system is designed to inform the participant about instantaneous variations in the amount of light crossing through a specific single-slit. This is accomplished by obtaining this information on the fly, and then transforming it into a feedback magnitude as a real number ranging from 0 to 1 used to modulate the feedback devices intensity. While a feedback magnitude of 0.5 means that no variation is taking place, a value between 0.5 and 1 means an increase in the amount of light passing through the target slit, and a value between 0 and 0.5 means a decrease in the same quantity.

The participant is in sensory contact with two feedback devices: noise-canceling headphones

playing a richly harmonic droning tone and the colorful light produced by a LED shining through translucent glass. As the feedback magnitude increases, the LED light shines more brightly in the dark experimental room, and is accompanied by a corresponding increase in the tone volume. The feedback light colors are randomly picked for each of the 20 intention runs from a pool of 8 different pre-defined colors. During the data collection, the following method is used to calculate and inform the feedback magnitude. At every frame:

1. A fast Fourier transform is applied to the CCD frame, and the magnitude component is used to calculate the experiment-specific feedback variable of interest. The variables definitions are presented in Section 3.2.

2. Two sliding window vectors are updated with the variable value, storing respectively the last 30 and 150 frame values.

3. A Mann-Whitney U test is applied to the two samples. The resulting z-score is used to calculate a one-tailed probability p. The hypothesis being tested (fixed for each experiment) is interpreted as the last 3-second variable mean being significantly greater, or less, than the last 15-second variable mean.

4. The feedback magnitude is obtained as $F = 1 - p$, and F is set to a minimal value of 0.1 if below this threshold.

5. To avoid sudden changes that may disrupt the participant's concentration, the mean of the last 20 F values is calculated to F_m.

6. If the current frame is associated with an intention condition, the F_m value is used to instantly modulate the light and volume intensity of the feedback devices. Alternately, if the experiment is in the relax condition, no information about the experiment state is given to the participant; the feedback light remains off, and the sound is kept at a fixed 0.3 intensity. As a result, the feedback light is turned on only during intention runs, while the feedback volume is kept on during the whole session, being only modulated during intention runs and kept at a fixed 0.3 intensity during relax and during the recorded conditions announcements.

The feedback mechanism simplifies the task description, serving as an interface between the conscious agent and the physical process dynamics. Without it, the task instructions might sound rather abstract, causing mental wandering and distractions during the experiment. To simplify, the participants are instructed to always intend the increase of the feedback magnitude during the intention runs. The information about the favored slit is kept blind to the participant, but they are informed that a magnitude increase is linked to a physical variation, so by focusing on the feedback, they are indirectly interacting (or attempting to interact) with the light crossing the apparatus. As a secondary role, the feedback is used to arouse the participants' motivation in the hopes that they will eventually experience some sort of correlation between the presented intensities and their subjective state, thereby reinforcing their attention and intention toward the experimental system.

2.9 Analysis

The CCD frames recorded during each experimental session are processed and transformed into variables of interest according to the following steps (see Section 2.2 for the variables definitions):

1. For every n frame, the CCD frame array $I[n, i]$ is transformed by a fast Fourier algorithm, and decomposed into magnitude $M[n, k]$ and phase $P[n, k]$ polar components, where $k = 0, 1, \ldots, 631$.

2. For every k, the phase is unwrapped along the n frames to $P_u[n,k]$ in order to remove misleading 2π discontinuities caused by the $-\pi$ to π constraint.

3. For every k, the standard deviation of $P_u[n,k]$ along the n frames is computed to $s_P[k]$.

4. A variable of interest is obtained as $V_\alpha[n] = \sum_{k=l}^{h} P_u[n,k]$, for every k between l and h that satisfies the $s_P[k] < 0.5$ relationship. In the case of a non-satisfying condition, the given k is left out of the sum, not contributing to the variable in that particular session – this cut is described in more detail in SI Section Appendix S2. The V_α variable is optionally followed by the notation $\langle l - h \rangle$ to specify its lower and higher k-window bounds.

5. Additionally, compound variables can be obtained as e.g. $V_{12}[n] = +V_1[n]\langle 5 - 15\rangle - V_2[n]\langle 19 - 25\rangle$.

Using a procedure referred to as *differential analysis*, a nonparametric bootstrap test is applied to the variables of interest in order to test the equality hypothesis between the intention and relax sample means. The difference of the intention and relax variable's mean values is initially computed using the original conditions array. Then, the test repeatedly shifts the condition array to a random frame position in order to find the statistical distribution of the intention/relax differences. For each session and variable, a standard z-score is obtained with the following steps:

6. An 8^{th} order polynomial is least-square fitted to the variable $V[n]$. The residual difference between the variable and the polynomial is obtained as $V_d[n]$. This nonlinear detrending procedure is made in order to rule out the variable dependency in slowly changing environmental conditions, e.g. room temperature.

7. The run array $R[n]$ is used to identify the first frame n_s of the first attention run, as well as the last frame n_e of the last relax run. To avoid artifacts in the variable extremities caused by the polynomial fitting procedure, the variable V_d is trimmed in the range $n_s - 300$ to $n_e + 300$, being then denoted as $V_d[n_t]$, where $n_t = 0, 1, \ldots, n_e - n_s + 600$.

8. The condition array $C[n]$ is trimmed in the same interval (described in the previous item) to $C[n_t]$, and then used to split the variable $V_d[n_t]$ into two arrays: $V_I[m]$ and $V_R[m]$ with $m = 0, 1, \ldots, 5999$ values respectively recorded during intention and relax conditions.

9. $V_I[m]$ and $V_R[m]$ means are calculated to μ_I and μ_R. The two-sample mean difference is denoted as $\Delta\mu = \mu_I - \mu_R$. The null hypothesis is $\mu_I = \mu_R$, while $\mu_I \neq \mu_R$ stands for the alternative hypothesis.

10. A pseudorandom number r between 0 and n_t length is drawn using a Mersenne Twister algorithm. $C[n_t]$ is copied and circularly shifted by r units, resulting in $C_r[n_t] = C[n_t - r]$. The procedure described in items 8 and 9 is then applied to C_r, resulting in the mean difference $\Delta\mu_r$.

11. The previous item procedure is repeated 5,000 times, filling a vector with $\overline{\Delta\mu_r}$ mean and $\sigma_{\mu r}$ standard deviation.

12. The standard score concerning the intention-relax sample mean difference is obtained as $z = (\Delta\mu - \overline{\Delta\mu_r})/\sigma_{\mu r}$.

Figure 5 presents an example of a V_{12} compound variable obtained in a participant session. The top plot shows the variable (black line) obtained by following steps 1–5, and the associated best fitting 8^{th} order polynomial (white line). The bottom plot displays the variable residual (black line) as described in step 6, and (for illustrative purposes) the residual average obtained

through a 300-frame window Savitzky-Golay filter (white line). Both data samples are trimmed as described in step 7, and show the condition data described in step 8 – dark gray bars represent intention and light gray bars represent relax condition frames.

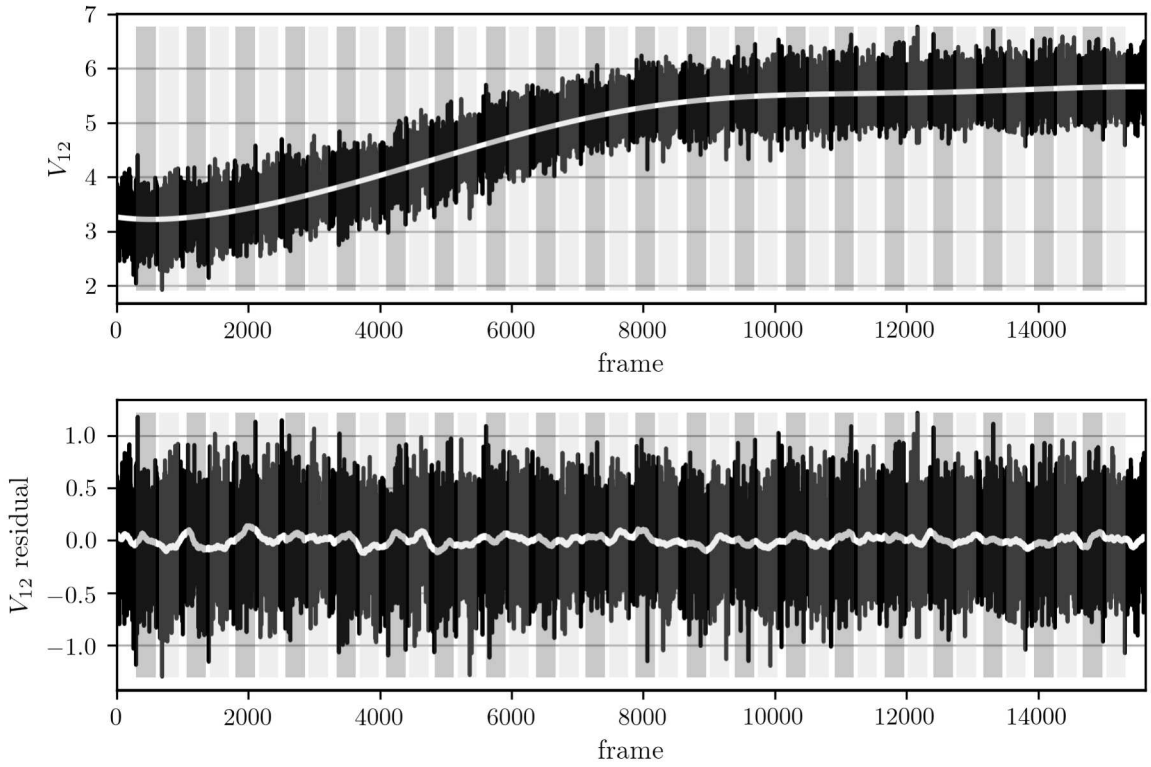

Figure 5: Variable of interest example. This particular session composed V_{12} as $V_1\langle 5-15\rangle - V_2\langle 19-25\rangle$, and resulted in a $z = 1.65$ score for this variable.

For an experiment consisting of N sessions, a global z-score for a given variable is obtained by combining individual session results in a Stouffer's $z = \sum_{i=1}^{N} z_i/\sqrt{N}$. The effect size is then calculated by $es = z/\sqrt{N}$, with $\sigma = 1/\sqrt{N}$ standard error.

3 Results

3.1 Study design

Compared with previous efforts to probe the phenomenon using random number generators (RNG), the double-slit (DS) system has the advantage of providing interference information across a spatial dimension rather than providing binary outcomes. Having more information available makes it more potentially sensitive to the investigated $\psi\phi$-interaction. However, the richness comes at the cost of requiring a more complex analysis to extract the relevant information.

While in an RNG experiment the null hypothesis is precisely defined as the 0/1 data conforming to the associated binomial distributions, the solution in a DS experiment is far more complex. It starts with two questions: what is the variable of interest most sensitive to the investigated interaction, and what is the most appropriate statistical test to evaluate the differences between the intention and relax conditions? Concerning the use of Fourier-transformed variables, it's not possible to simply mirror the definitions used in a different experimental arrangement as, by numerical inspection, one finds that the meaningful model predicted $\psi\phi$ k-windows are sensitive to small variations in the geometry parameters such as the double-slit distance from the camera sensor.

Adding to the complexity, the investigated interaction is supposed to display a goal-oriented aspect according to the reported RNG meta-analyses literature. This means that the degrees of freedom c, ψ and ϕ should vary in a specific way to fulfill the participant intention of a feedback magnitude increase. As a consequence of this plasticity, the collected data should itself depend on the provided feedback characteristics, and stronger results may be obtained by providing more reliable real-time information about the slits intensity variations. Conversely, providing meaningless feedback could render participant data statistically equivalent to the controls. At early stages, one finds a paradoxical situation: sensitive information should be presented to the participants at the same time that a posterior data analysis (with enough statistical power) is required in order to define the relevant variables.

Facing those challenges, it's clear that starting a DS experiment with a pre-defined analysis is a good recipe for obtaining non-significant differences between the intention and relax conditions, or, a false negative result if the investigated effect is genuine. Thus, for every novel setup, it's necessary to start the experiment in an exploratory fashion. At the same time, the more the researcher explores the analysis degrees of freedom, the more likely this will create false-positive results. To balance this delicate equation, the final analysis variables used in this study are obtained by an optimizing procedure applied to partial data. The optimized analysis is then uniformly applied to the remaining datasets. Two optimization scenarios are considered: the variables that maximize the intention/relax differences in the participant, and those in the control data. Finally, to investigate whether the results can be explained by over-tuning, additional experiments are proposed with a pre-planned analysis using the same optimized method.

For completeness' sake, it's important to state that the theoretical model presented in Section 2.7 was not available prior to the data collection. The variables initially used were based on the magnitude component of the Fourier transform, and were analyzed using a different method than the one presented in Section 2.9. After finishing the experiments 1-5 data collection, the analysis method was improved by the introduction of polynomial non-linear detrending – a more meaningful approach than the previously used linear detrending. However, a global analysis applying the new method to the same magnitude variables turned into a non-significant result. This led the experimenter to consult the digital signal processing literature, finding that the initial estimate of magnitude-based variables wasn't optimally effective since "much of the information about the shape of the time domain waveform is contained in the phase, rather than the magnitude" [25, p. 192]. The Fourier magnitude component is more appropriately used when dealing with an oscillating variable collected across time, while for the spatially-distributed interference pattern, the waveform shape is more relevant than its particular frequency spectrum. This understanding guided the model development, and led to the use of phase variables. As this finding occurred after the $N = 160$ series, the experimenter didn't have the opportunity to test the feedback with the same phase variables used in the final analysis.

For the exploratory experiments, 127 volunteers contributed 160 experimental sessions resulting in five experimental blocks labeled 1 to 5, with each having a pre-planned number of participants. The data collection followed the procedure described in Section 2.3, and occurred over a timespan of 9 months starting in October 2016. Data for experiments 4 and 5 were collected during a 40-session block that alternated each day between exp. 4 and exp. 5.

In an experiment labeled 0, 30 sessions were recorded following the same procedure used in experiments 1-5, the only difference being that a 150 W lamp replaced a person during the participant sessions. The lamp was placed in the participant chair inside a black cardboard cylinder, and was turned off before the control session started.

In the formal experiments labeled 6–9, 44 new volunteers, plus 26 that took part in the previous experiments contributed 80 experimental sessions. The analysis methodology pre-registered in [26, 27] was the same used in the exploratory experiments. Data for experiments 6 and 7 were collected during a 40-session block that alternated each day between exp. 6 and exp.

7. The same occurred for experiments 8 and 9. The two experimental blocks were separated by a three week period. The $N = 80$ data collection occurred over a timespan of 2 months starting in October 2017.

3.2 Feedback configuration

As described in Section 2.8, the feedback configuration consists of two experimenter choices: a variable of interest and a binary single-tailed test hypothesis. By fixing these choices the experimenter defines the binary c, while the participant (blind to the c definition) accounts for the $\psi\phi$-action.

In experiment 5, the feedback variable was built using the log-transformed M magnitude component of the Fourier transform, and defined as the area across the $k = 1 \dots 4$ range. The feedback hypothesis (represented by the $>$ symbol) tested an increase of the variable's mean in the short 3 s window, as compared to the 15 s one. The larger the variable mean increase, the lower the p probability obtained from the single-tailed test, hence the larger the F. The instantaneous F increase in this experiment is expected to reflect a positive $c\psi$ effect, as revealed in Fig. (4), i.e. an increase in the diffraction power through slit 1. In experiment 4, the feedback was configured with the same variable but the opposite $<$ test hypothesis. In this case, an F increase is related to an increase in the number of photons crossing the second slit.

The definitions used in each experiment are shown in Tab. (2). The use of different feedback variables in experiments 0–5 reflects the learning curve of the author as the study evolved. Although different variables have been explored, they all use the first two to five magnitude k wavenumbers, the most sensitive magnitude region for a supposed ψ action. The first experiment used a ratio mathematically defined as $\sum_{k=49}^{55} M[n,k] / \sum_{k=1}^{4} M[n,k]$, and represented as M $\langle 49-55 \rangle$ / $\langle 1-4 \rangle$. The nominators used in experiments 0–3 have much smaller predicted variations as compared with the denominators. Thus, the denominators dominate the variable change in the case of a ψ action, implying an inversion in the first three experiments between the test hypothesis and the enhanced slit: an increase in slit 1 (2) diffraction power with the feedback $<$ ($>$) hypothesis.

exp.	FV	FH	FS
0	M $\langle 49-55 \rangle$ / $\langle 1-4 \rangle$	$<$	1
1	M $\langle 49-55 \rangle$ / $\langle 1-4 \rangle$	$<$	1
2	M $\langle 5-9 \rangle$ / $\langle 1-5 \rangle$	$>$	2
2	P $\langle 5-9 \rangle$ / $\langle 1-5 \rangle$	$>$	1
3	M $\langle 3-10 \rangle$ / $\langle 1-2 \rangle$	$>$	2
4	$\log M$ $\langle 1-4 \rangle$	$<$	2
5	$\log M$ $\langle 1-4 \rangle$	$>$	1
6	$\log M$ $\langle 1-4 \rangle$	$<$	2
7	$\log M$ $\langle 1-4 \rangle$	$>$	1
8	$\log M$ $\langle 1-4 \rangle$	$<$	2
9	$\log M$ $\langle 1-4 \rangle$	$>$	1

Table 2: Feedback configuration. Variable of interest (FV) and one-tailed test hypothesis (FH), followed by the feedback-favored slit (FS).

Concerning the evolution of the feedback variables, in experiment 1 the variable nominator was associated with the magnitude peak seen in Fig. (2). This focus on the waviness region initially investigated a possible state reduction induced by the observers. In this case a decrease was expected as a consequence of the increase in particle-like photons. Afterwards, the developed model revealed a predicted small $\sqrt{1-\psi^2}$ variation linked to the slits intensity mod-

ulation. In experiment 2, an extra feedback variable with the same magnitude k-window was added using the phase component. Examining the phase difference in Fig. (4), it's possible to see that the nominator dominates in this case, indicating that the diffraction favored slit 1, while the magnitude variable favored slit 2. The z-score resulting from the phase and the magnitude variables variation test were combined to calculate the feedback magnitude, leading to a contradictory slit enhancement. In contrast, the phase variable unequivocally favored a negative ϕ action and an increase in V_2.

The specific combination of the feedback variable and the feedback hypothesis implies in a feedback-favored slit for each experiment. As shown in Section 2.7, switching from $c = +1$ to $c = -1$ causes a differential sign inversion in the V_1 variable. As a consequence (in a genuine $\psi\phi$-interaction scenario), the V_1 differential analysis is expected to result in opposite z-score signs when applied to experiments with opposite feedback-favored slits. Thus, an analysis composition rule is pre-defined: when combining the V_1 z-scores from different experiments within a Stouffer's sum, the z signs must be inverted between experiments with opposite feedback-favored slits.

For the variable V_2, no particular differential sign was intentionally favored in the experiments, as the magnitude variables used in the feedback are insensitive to ϕ variations. The analysis composition rule, in this case, could not be pre-defined. The exception is exp. 2, where a positive z was favored by the feedback system.

3.3 Variables' optimization

The variables of interest used in the analysis are built using the Fourier transform phase component. The differences shown in Fig. (4) are a good starting point for understanding the regions in the frequency domain sensitive to each investigated degree of freedom ψ and ϕ, however to effectively define the k-windows which maximize the supposed signal-over-noise relationship, an optimization technique was devised according to the following rules:

1. The 60 participant and 60 control sessions from experiment 1 are used to obtain the optimal k-window parameters that define the variables of interest. Those datasets are exclusively used for optimization purposes, not contributing to the final result analysis.

2. Two variables are prospected, V_1 and V_2, corresponding respectively to the ψ and ϕ degrees of freedom. Each variable is defined by a phase sum over a k-window with l lower and h higher bounds. The notation $V\langle l - h\rangle$ is adopted to express the variables k-range.

3. Diverse combinations of l and h values are explored; the procedure described in Section 2.9 is used to obtain a $V\langle l - h\rangle$ variable, and test it within a differential analysis. Therefore, each (l, h) pair yields a $N = 60$ global z-score representing the differences in variables between the intention and relax conditions. This procedure is equally applied in the participant and in the control data, resulting in two z-score two-dimensional surfaces.

4. The variables explored satisfy the condition of being composed of 5 or more k-values. This requirement ensures more restrictive variables, as the larger the window length, the less likely it is to produce same-direction phase variations by pure chance. If the phase variations in the k-window are a product of noise, they should be composed of positive and negative variations that cancel out when summed.

5. A comparison test is used to find the (l, h) parameters associated with extreme values in the z-score surfaces. Two scenarios are considered, the $V_{1,2}$ variables that maximize the z-score absolute value in the participant data, and the $\Lambda_{1,2}$ variables associated with the extreme z-scores in the control data. These scenarios are respectively referred to throughout the study as *default* and *reverse*.

Figure 6 shows the z-score surfaces resulting from the optimization procedure. The optimal variables found for the default scenario are $V_1\langle 5-15\rangle$ and $V_2\langle 19-25\rangle$, while the variables that optimize the reverse scenario are $\Lambda_1\langle 7-18\rangle$ and $\Lambda_2\langle 21-36\rangle$.

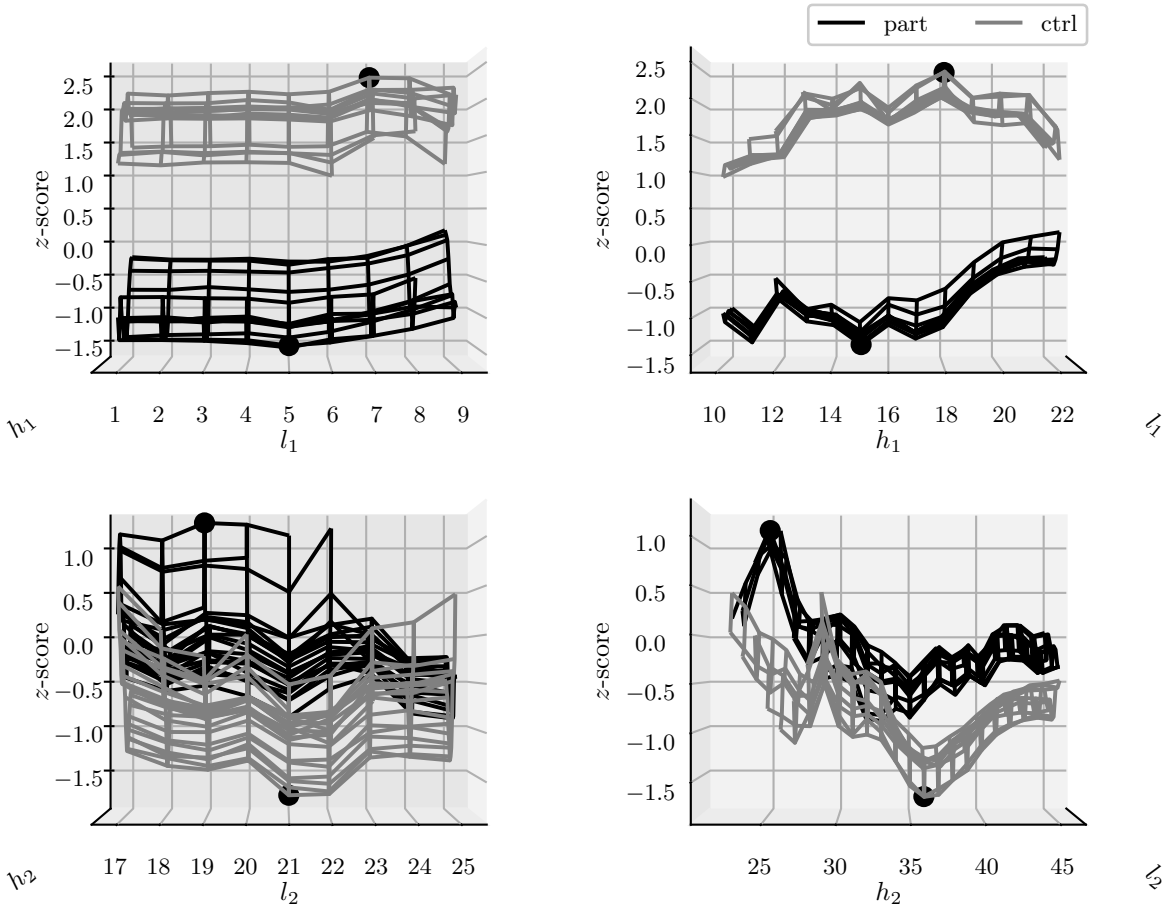

Figure 6: Variables' optimization results. Top: l and h projections of the same participant and control z-score surfaces obtained for prospecting V_1 and Λ_1. Bottom: the same for prospecting V_2 and Λ_2. Black dots mark the extreme values found for each surface.

3.4 Exploratory experiments

The next step consists of uniformly applying the intention/relax differential procedure described in Section 2.9 to the experiments 2–5 data. Table 3 summarizes the statistical results obtained in the default scenario. Based on the pre-defined composition rule discussed in Section 3.2, an exp. 2–5 Stouffer z-score is obtained for V_1 by reversing the z-sign between exps. 2–4 and exp. 5, revealing a significant 3.43 sigma result for the participant data, and $z = 0.49$ for the controls. For V_2, an exp. 2–5 global z-score is obtained by reversing the exps. 3-5 z sign, revealing a significant 2.80 sigma result for the participant data, and $z = -0.20$ for the controls.

Compound variables V_{12} are obtained by combining V_1 and V_2 in a constructive way while respecting the sign composition rules. For experiments 4 and 5, for example, the composition rules require opposite signs for V_1 and same negative signs for V_2. The compound variable is then obtained using a final-score positive sign convention, such that V_{12} for experiments 4 and 5 is respectively obtained as $+V_1 - V2$ and $-V_1 - V2$ (equally applied in participant and control sessions). The composition is applied to the variable's data before the differential analysis. This signal-amplifying technique benefits from correlated (or anti-correlated) variations in regions 1 and 2. The cumulative z-score plots for V_{12} presented in Fig. (7) reveal that the participant

		$V_1\ \langle 5-15\rangle$		$V_2\ \langle 19-25\rangle$		V_{12}				
exp.	N	z_p	z_c	z_p	z_c	comp.	z_p	z_c	es_p	es_c
0	30	0.54	-0.55	0.79	0.97	$+V_1+V_2$	0.85	0.21	0.15	0.04
1	60	-1.49	2.00	1.16	-0.58	$-V_1+V_2$	1.97	-1.25	0.25	-0.16
2	30	0.52	0.70	1.10	-0.33	$+V_1+V_2$	1.65	0.48	0.30	0.09
3	30	1.65	-0.15	-0.59	0.10	$+V_1-V_2$	2.07	-0.39	0.38	-0.07
4	20	1.85	-0.13	-1.32	0.87	$+V_1-V_2$	2.40	-0.76	0.54	-0.17
5	20	-3.15	-0.54	-2.87	-0.96	$-V_1-V_2$	3.50	1.44	0.78	0.32
2-5	100	3.43	0.49	2.80	-0.20		4.68	0.35	0.47	0.04

Table 3: Exploratory experiments' results in the default scenario. The participant (control) sessions Stouffer's z-score is denoted as z_p (z_c), while effect size is denoted as es_p (es_c).

effects are consistently obtained in a crescent fashion across the experimental sessions, rather than being caused by a few deviating sessions. The controls, in turn, show a $z = 0$ tendency.

Table 4 shows the statistical results obtained in the reverse scenario. In this variable's scenario, the exercise also consists of implementing sign-composition choices that maximize the control data z-scores. The signs used are shown in the comp. column of the results' table. Unlike with the standard scenario V_1 compositions, the reverse signs are not bound to any physical reasoning. An examination of the Λ_1 variable reveals that the significant z_c value obtained in the exp. 1 optimization is not consistently replicated in the remaining experiments. While the Λ_2 variable obtains a slightly significant 2.18 sigma global result in the controls, the Λ_{12} composition conforms to the null hypothesis.

		$\Lambda_1\ \langle 7-18\rangle$		$\Lambda_2\ \langle 21-36\rangle$		Λ_{12}				
exp.	N	z_p	z_c	z_p	z_c	comp.	z_p	z_c	es_p	es_c
0	30	0.85	-0.43	1.01	0.66	$-\Lambda_1+\Lambda_2$	0.40	0.67	0.07	0.12
1	60	-1.05	2.45	-0.68	-1.73	$+\Lambda_1-\Lambda_2$	-0.32	2.55	-0.04	0.33
2	30	0.93	-0.83	-1.08	-0.72	$-\Lambda_1-\Lambda_2$	-0.04	0.47	-0.01	0.08
3	30	0.46	-0.32	-1.79	1.36	$-\Lambda_1+\Lambda_2$	-1.92	1.29	-0.35	0.24
4	20	1.54	-0.48	-0.51	1.04	$-\Lambda_1+\Lambda_2$	-1.39	0.25	-0.31	0.06
5	20	-0.56	-0.88	-0.55	-1.29	$-\Lambda_1-\Lambda_2$	0.02	1.70	0.00	0.38
2-5	100	-1.20	1.24	-0.37	2.18		-1.68	1.84	-0.17	0.18

Table 4: Exploratory experiments' results in the reverse scenario. The participant (control) sessions Stouffer's z-score is denoted as z_p (z_c), while effect size is denoted as es_p (es_c).

The V_{12} effect sizes throughout the experiments can be seen in Fig. (8). The results for the standard scenario show statistically significant deviations in the participant sessions, and null effects in the controls. The reverse exercise fails to produce a globally significant result in the control sessions. Furthermore, it produces similar effect size magnitudes for the control and the participant data. The inability to obtain an artificial significant result in the control data by exploiting the optimization method and the variable composition provides evidence for a legitimate interaction in the participant data.

In experiment 0, the chosen signs for the compound variable V_{12} maximize z_p in an attempt to artificially produce a significant result. The null effect results obtained in this experiment dismiss a room-temperature increase as an evident artifact that could explain the participant results in exps. 1–5.

To study the $\psi\phi$-interaction homogeneity along the sessions duration, the variables' residuals and the condition arrays were divided in half before the differential analysis. In experiments

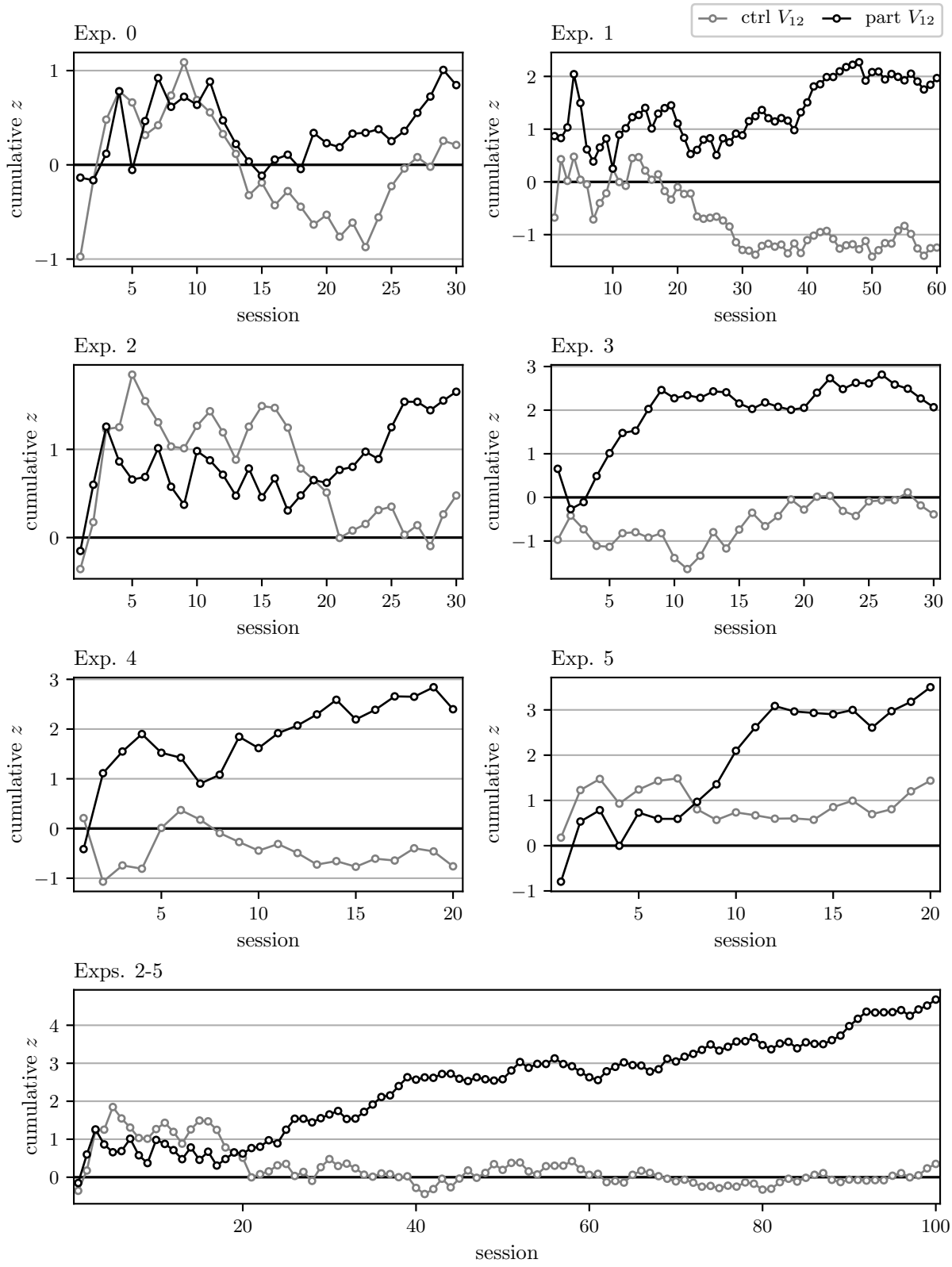

Figure 7: Cumulative z-score for the exploratory experiments in the default scenario. Cumulative plots are calculated as $\sum_{i=1}^{s} z_i/\sqrt{s}$, and given as a function of the session number s. The last points represent the values shown in Tab. (3). The bottommost plot reveals the Stouffer global result for the 100 sessions from experiments 2–5.

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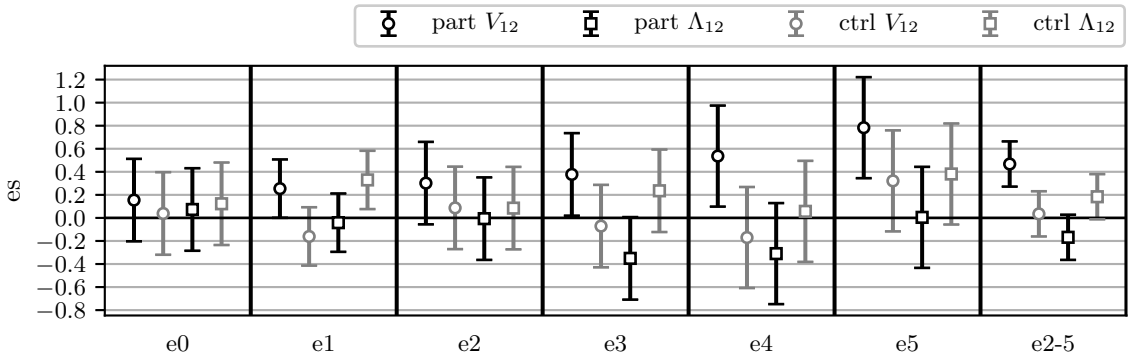

Figure 8: Effect sizes for the exploratory experiments. The error bars represent the 95% confidence interval, calculated as $1.96/\sqrt{N}$, where N is the experiment sessions number. Default and reverse scenarios are considered.

2–5, the first and second half data overall results for V_{12} are $z_p^{1st} = 2.61$, $z_p^{2nd} = 3.51$ for the participant sessions and $z_c^{1st} = 0.32$, $z_c^{2nd} = 0.10$ for the controls. Significant results for both halves in the participant sessions indicate a consistent $\psi\phi$-action across the time.

In experiment 3, two CCD frames were collected in the 100 ms window. The first was used to provide the real-time feedback and the second was simply stored – no effort was made to process it or to inform the participant of its variations. This design was used to investigate the supposed $\psi\phi$-interaction characteristics; whether it depends exclusively on some information reaching the conscious agent or can be better understood as a kind of field interaction that could reach the undisplayed frame. The second frame result for V_{12} is $z_p = 1.88$, $z_c = -0.65$, revealing a similar, but slightly smaller, participant result than that obtained with the first frame analysis, thus favoring the second hypothesis.

3.5 Formal experiments

When examining the exploratory results, in particular, the large effect sizes seen in exps. 4 and 5, important questions arise concerning the replicability of their results and the legitimacy of the chosen signs that compose the V_{12} variable. To investigate those issues, four new experiments were conducted.

Experiments 6 and 8 used the same feedback configuration as exp. 4; while exps. 7 and 9 mirrored exp. 5 feedback strategy. The same exps. 4 and 5 V_{12} sign composition rules were predefined: $V_{12} = +V_1 - V_2$ for exps. 6 and 8; and $V_{12} = -V_1 - V_2$ for exps. 7 and 9; where $V_1\langle 5-15\rangle$ and $V_2\langle 19-25\rangle$ followed the standard scenario definition. The pre-registered analysis method for obtaining each session/variable z-score was the same used in the exploratory experiments.

Table 5 summarizes the statistical results obtained for the intention/relax differential analysis. For V_1 and V_2, statistical significance is found in participant data from exps. 7 and 9. However, a sign inversion is seen in exps. 8 and 9 participant data. The cumulative z-score plots for V_{12} presented in Fig. (9), highlights the sign inversion between the two $N = 40$ blocks. While the combined exps. 8-9 is statistically significant, the global exp. 6-9 result, both in the participant and control data, conforms to the null hypothesis.

3.6 Post hoc meta-analysis

In retrospect, the directional hypothesis being tested in the formal experiments is tighter than the original motivation of the study. While the primary hypothesis was concerned with absolute differences between intention and relax epochs, the tests performed in the formal studies were implicitly merged with a secondary hypothesis that the z-signs would be strictly associated with

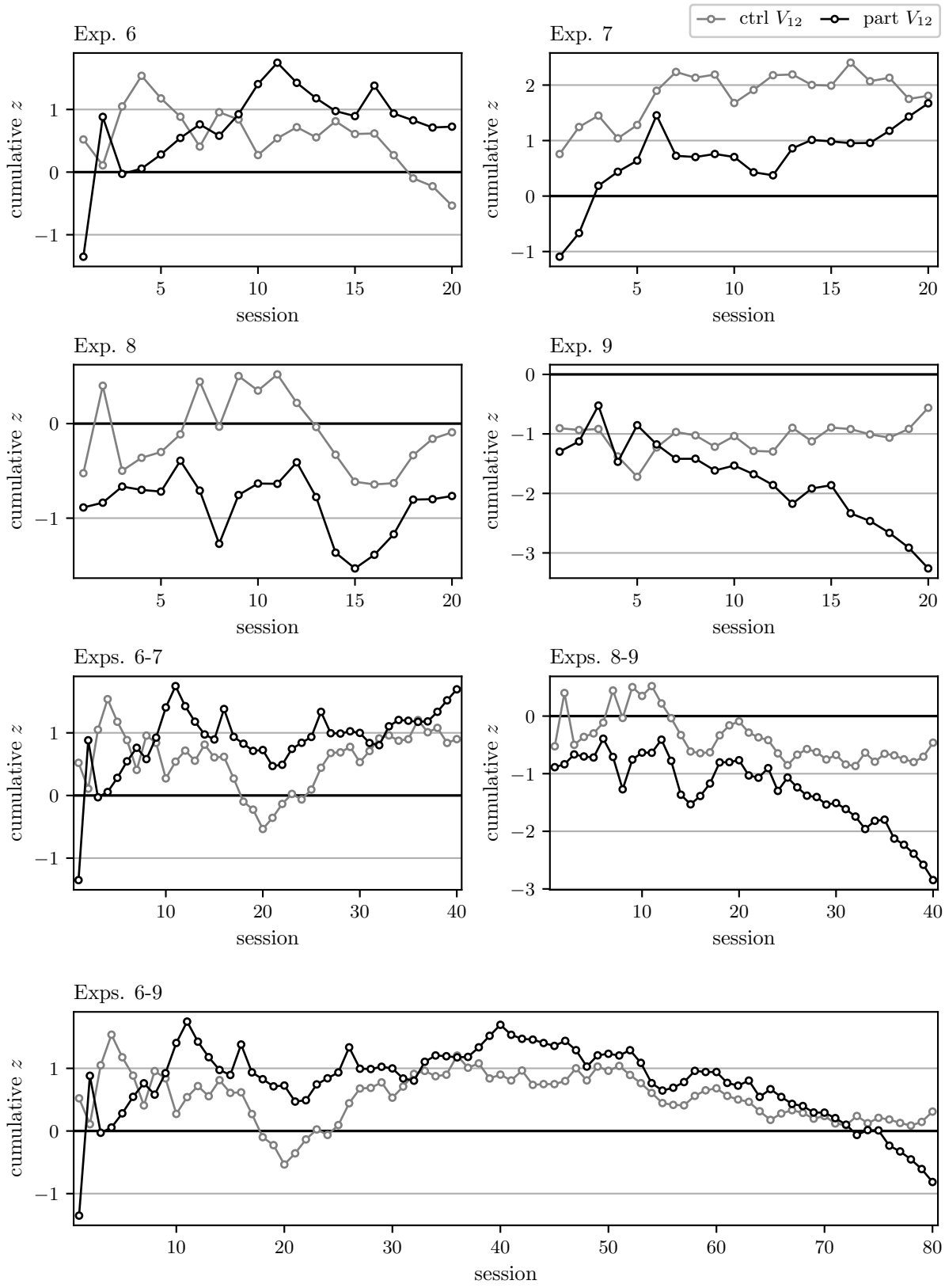

Figure 9: Cumulative z-score for the formal experiments. Cumulative plots are calculated as $\sum_{i=1}^{s} z_i/\sqrt{s}$, and given as a function of the session number s. The last points represent the values shown in Tab. (5). The bottommost plot reveals the global result for the 80 sessions from experiments 6–9.

		$V_1\ \langle 5-15\rangle$		$V_2\ \langle 19-25\rangle$		V_{12}				
exp.	N	z_p	z_c	z_p	z_c	comp.	z_p	z_c	es_p	es_c
6	20	-0.22	0.54	-0.22	1.71	$+V_1 - V_2$	0.73	-0.54	0.16	-0.12
7	20	-1.37	-0.57	-2.17	-1.34	$-V_1 - V_2$	1.67	1.81	0.37	0.40
8	20	-1.53	-0.87	-0.30	-0.41	$+V_1 - V_2$	-0.77	-0.09	-0.17	-0.02
9	20	2.23	-1.21	3.00	1.48	$-V_1 - V_2$	-3.26	-0.56	-0.73	-0.13
6-7	40	0.81	0.78	1.69	-0.27		1.69	0.90	0.27	0.14
8-9	40	-2.66	0.24	-1.91	-0.75		-2.85	-0.46	-0.45	-0.07
6-9	80	-1.31	0.72	-0.16	-0.72		-0.81	0.31	-0.09	0.03

Table 5: Formal experiments' results. The participant (control) sessions Stouffer's z-score is denoted as z_p (z_c), while effect size is denoted as es_p (es_c).

the feedback-favored slit. As a post hoc meta-analysis, the two hypotheses of difference and direction are decoupled into separate tests.

3.6.1 Difference test

The primary hypothesis is tested by applying Fisher's method to the experiments' results. According to this bi-directional method, the associated probabilities summed as $-2\sum^{N_e}\ln p_i$ follow a chi-squared distribution with $2N_e$ degrees of freedom, where N_e describes the number of experiments being combined. Unlike with the Stouffer's method, the z-sign plays no role since a two-tailed probability yields the same value for $+z$ and $-z$.

The results for the Fisher combination are shown in Tab. (6) and Fig. (10), where the combined probabilities are converted back to standard scores. Statistical significance is found in the participant data, where all the controls conform to the null hypothesis.

	$V_1\ \langle 5-15\rangle$				$V_2\ \langle 19-25\rangle$				V_{12}			
exps.	z_p	z_c	es_p	es_c	z_p	z_c	es_p	es_c	z_p	z_c	es_p	es_c
2-5	3.05	0.08	0.30	0.01	2.32	0.29	0.23	0.03	4.17	0.62	0.42	0.06
6-9	1.95	0.63	0.22	0.07	2.53	1.59	0.28	0.18	2.75	0.72	0.31	0.08

Table 6: Statistical results obtained with Fisher's method. N_e is respectively 4 and 4 for exps. 2-5 and 6-9.

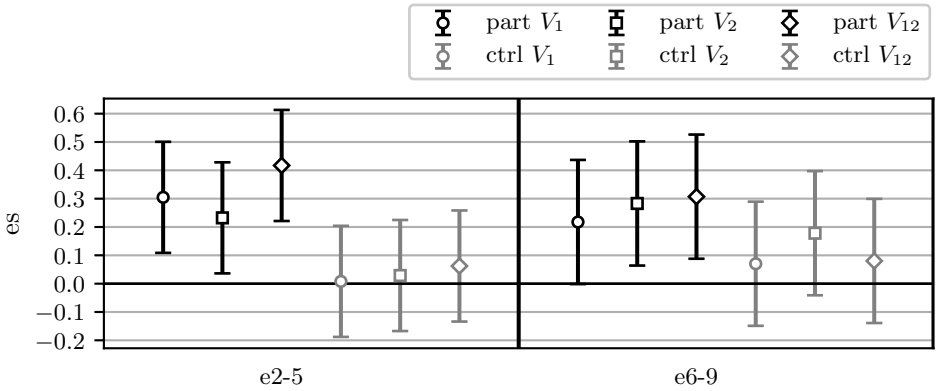

Figure 10: Effect sizes for experiments 2-5 and 6-9 combined with Fisher's method. The error bars represent the 95% confidence interval.

To achieve those results, the sessions' differential z-scores are first combined, as usual, into

each experiment's Stouffer z-score; then, the experiments' z-scores are combined using Fisher's method. According to the literature, "the Stouffer test statistics is sensitive to consistent, even if mild, departures from null hypothesis in separate studies, whereas the Fisher procedure is most sensitive to occasional, extreme departures" [28, p. 66]. As stated, the use of a Stouffer combination within an experiment is strategic, aiming to catch small but consistent intention/relax differences in the same direction. If the direction can be consistently predicted by the feedback-favored slit, that's a secondary question detailed below.

3.6.2 Direction test

Two tests are performed to study the relationship between the obtained z-score signs and the feedback-favored slit: binomial and correlation. Both analyses use the V_1 and V_2 z-scores obtained in exps. 4-9, since they all share the same feedback variable. Experiments 4,6,8 and 5,7,9 are considered separately due to their opposite feedback-favored slit. The tests results are shown in Tab. (7).

	V_1 binomial				V_2 binomial				V_1 & V_2 correlation			
exps.	n_p^+	n_c^+	p_p	p_c	n_p^+	n_c^+	p_p	p_c	r_p	r_c	p_p	p_c
4,6,8	26	27	0.25	0.37	27	31	0.37	0.70	-0.32	0.04	0.01	0.74
5,7,9	27	23	0.37	0.05	29	29	0.70	0.70	0.33	-0.09	0.01	0.50

Table 7: First two columns: binomial tests for the V_1 and V_2 z-score signs. Third column: correlation between V_1 and V_2 z-scores.

In the binomial analysis, the number of positive z-score sessions n^+ is statistically evaluated according to a binomial distribution of $N = 60$ and $p = 0.5$. For $N = 60$ sessions, a number of positive z outcomes between 23 and 37 is expected as statistical fluctuation (with $\alpha = 5\%$). As seen in the results table, no significant outcomes were found for any condition.

For the correlation analysis, the Pearson's r is obtained for the V_1 and V_2 differential z-scores. Statistical significance is found for the participant data, providing interesting evidence for the $\psi\phi$-interaction; in terms of absolute z-score value, both variables tend to result in values of correlated magnitude, while the values found in the control data are uncorrelated. The results also show that the correlation signs are inverted between the two experimental groups, confirming the legitimacy of having used the V_{12} sign compositions. As the scores are anti-correlated in exps. 4,6,8, the compound variable should follow the generic form of $V_{12} = \pm(V_1 - V_2)$; and since in exps. 5,7,9 the scores are correlated, the variable is generically expressed as $V_{12} = \pm(V_1 + V_2)$.

3.7 Environment variables

The differential analysis was also applied to the environment variables, and the resulting standard scores are presented in Tab. (8), where global scores are combined using Fisher's method. Two variables resulted in global statistical significance, the laser temperature T_L and the CCD external temperature $T2_C$. The latter one shows significance also for the control data, which is indicative of an artifact possibly related to analog-digital resolution and discrete temperature jumps.

To determine whether those two variables, or any other, could be associated with the differences measured in the $V_{1,2}$ variables of interest, the Pearson's r correlation was calculated between the 240 differential z-scores obtained for the $V_{1,2}$ variables and the 240 differential z-scores obtained for the environmental variables. The CCD internal temperature T_C vs V_1 was the only combination showing a statistically significant correlation in the participant data, with $r_p = -0.18$, $p_p = 0.005$; and $r_c = 0.04$, $p_c = 0.49$ for the controls.

	T_C		T_L		T_R		$\|M_x\|$		$\|M_y\|$		$\|M_z\|$	
exp.	z_p	z_c	z_p	z_c	z_p	z_c	z_p	z_c	z_p	z_c	z_p	z_c
0	-0.08	0.41	0.22	0.12	0.88	0.24	-1.19	-0.30	0.30	0.46	2.22	-0.67
1	1.17	-0.33	-0.25	0.53	-0.70	-0.23	0.91	0.43	-0.34	-0.09	0.07	0.16
2	-0.69	0.91	-1.21	1.49	1.03	0.12	0.19	-0.23	0.70	-0.10	-0.83	-1.36
3	-1.14	1.28	3.14	-0.21	-1.61	1.35	-0.59	-1.07	-2.12	0.71	2.43	-0.18
4	-0.73	0.03	-0.68	-0.22	-0.15	0.18	-0.05	1.26	-0.10	-0.04	0.70	-0.70
5	-0.11	0.44	0.20	-1.09	-1.15	0.34	-1.24	-1.10	-1.53	0.98	-1.15	-0.63
6	-0.92	0.68	-0.66	0.32	0.01	-0.34	0.69	-0.46	0.18	-0.94	-0.12	0.10
7	0.20	0.14	-2.53	-1.06	-0.24	-0.50	-1.73	0.32	0.04	0.04	0.35	-1.06
8	0.47	0.49	-1.85	-1.61	1.36	0.87	0.35	-1.04	0.60	0.09	-0.01	0.97
9	0.26	-0.55	-1.67	-1.85	-0.46	0.04	-0.30	1.46	0.03	2.05	0.99	-0.62
1-9	0.22	0.10	2.93	1.12	0.55	0.04	0.37	0.67	0.41	0.25	0.71	0.26

	$T2_C$		$\|M2_x\|$		$\|M2_y\|$		$\|M2_z\|$	
exp.	z_p	z_c	z_p	z_c	z_p	z_c	z_p	z_c
4	-1.25	0.98	0.39	-1.26	1.00	-1.32	0.08	-0.14
5	0.19	-0.58	0.60	-0.21	1.54	-0.67	0.27	0.67
6	-2.08	1.89	1.08	-0.69	0.12	-0.13	0.63	-0.86
7	2.16	2.37	0.05	1.23	0.73	0.71	0.14	0.44
8	3.57	2.87	-0.60	0.28	-0.10	-0.39	-0.54	-0.02
9	4.34	4.46	-0.49	-0.03	0.25	-0.08	-0.76	0.54
4-9	5.23	4.94	0.16	0.33	0.36	0.21	0.04	0.07

Table 8: Differential z-scores for the environmental variables throughout the experiments. To investigate magnitude variations, the magnetic field components were transformed into their absolute values before analysis. Global scores are obtained with Fisher's method.

No environmental variable resulted in both a global significant z-score and a significant correlation to the $V_{1,2}$ differential z-score. This excludes the trivial explanation of temperature or magnetic field variations in intention/relax conditions being the primary cause of the changes measured in the $V_{1,2}$ variables.

4 Discussion

The exploratory experiments testing a consciousness-related form of interaction with a double-slit system resulted in a highly significant difference between the intention and relax conditions. The subsequent formal experiments then tried to replicate these previous findings, failing to reach global significance. While one may feel compelled to straightforwardly interpret this result as the nonexistence of the investigated interaction, the following arguments challenge key aspects of this interpretation.

In the formal experiments, one may claim that some statistical fluctuations may have locally occurred in some experiments, but globally, and for a sufficiently large dataset, they converge to the expected null difference. This interpretation is challenged by the standard score magnitudes found in participant data as compared with the controls, as quantitatively revealed by the Fisher test performed in the post hoc analysis. One must have in mind that under the no-interaction scenario, participant and control data are understood as essentially equivalent.

A possible objection would be that the control and participant data cannot be equally

classified because of the participant's bodily presence in the experimental room; hence heat, vibrations, and electromagnetic radiation could explain the larger effect sizes. While the body may slightly affect the measurements, it must be noted that the variables have their trends corrected with an 8^{th} order polynomial, and that the measured effect translates to a consistent difference between the detrended values obtained in the 40 alternated intention and relax epochs.

With regard to the physical mechanisms that could influence the participant data, heat is a monitored quantity, and no sensor resulted in both a globally significant differential score and a significant correlation to the variables of interest. Also, in experiment 0 a lamp producing more heat than a human body replaced the participant, demonstrating that a temperature increase in the experimental room cannot account for the measured effects. Vibrations and electromagnetic influences were highly attenuated with the respective use of a vibration isolation table and a Faraday's cage. Even in the case of minor leakages, the oscillatory nature of vibration is more likely to introduce noise into the measurements than a direction-consistent variation that could mimic a signal; and if the participant can (according to their intention) modulate a electromagnetic emission that affects the double-slit system, that itself indicates a novel technology.

According to the no-interaction interpretation, one must claim that the exploratory experiments' results are due to data dredging. The first response to this view is related to the physical meaning of the variables of interest. The variables explored by the optimization technique are theoretically justified by the mathematical model predicting the $\psi\phi$-interaction signatures according to the system's measured geometry. This is also important as it restricts the number of possible combinations, as opposed to a variable not bound to any physical meaning.

As a further challenge to the data-dredging argument, one faces again the participant/control equivalence; if both datasets are equivalent, how likely is one to find such a big effect in only one of them while applying the exact same analysis to both? It is reasonable to ask if the results could be somehow inflated, but in the absence of a legitimate interaction, the inflation should equally affect both samples. The final challenge is empirical, and presented by the so-called reverse study where the author tried to deliberately hack the control data in order to artificially produce the largest possible intention/relax differences – a task which failed to produce a statistically significant global effect.

In contrast, the post hoc meta-analysis results may be indicative of an anomalous interaction. The word meta is emphasized in the sense that it simply implements a different way of combining the experiments' global scores, where all the session scores are unaltered. The intent of this post hoc analysis was to decouple the formally tested hypothesis into two different tests: of an absolute difference between intention/relax conditions, and of a causal relationship between the difference sign and the slit targeted in the feedback. The bi-directional analysis revealed significant intention/relax absolute deviations in the participant data, while the relationship between the feedback-favored slit and the $V_{1,2}$ variables was found in their mutual correlation value rather than in their absolute signs.

One challenge faced by the anomalous interaction interpretation is in terms of meaning; if one cannot control the effect sign obtained, what is happening within the underlying physical process? A possible argument for the inability to control the light-enhanced slit is based on the discrepancy between the variable used to provide feedback and the one used in the offline analysis. While the first variable is built using the Fourier magnitude component, the second uses the phase. This difference is attributable to the author's learning curve during the study, and can thus be avoided in future studies. A more speculative explanation points to some sort of global conservation law underlying the phenomenon; while local significant differences may occur, globally and across time they tend to cancel out. Knowing this, future studies can pre-register to combine the experiment's results using the Fisher method.

The main obstacle for the $\psi\phi$-interaction interpretation is its controversial nature – the interaction shouldn't exist according to the current scientific world view. Also, if the interaction

exists how could it have remained undetected given the technological breakthroughs of the last century? First, it's reasonable to expect a small cross-section; an effect so small that it would ordinarily go undetected, that needs a large dataset and proper amplification to be statistically detected in a controlled setting. Second, being a function of the conscious agent subjective condition, it may rely on a specific state of consciousness and sufficient skill, thus not being consistently achievable by anyone in any situation. In particular, if the effect happens to be catalyzed by states opposed to ordinarily prevailing rational faculties such as thinking and the use of language, a paradoxical situation may ensue; the more one tries to exert control, the less they cause the phenomenon. A third reason can be advanced as a consequence of the sociocultural process described by [29, Chap. 1] that led physicists to shift from philosophical interests to a more pragmatic approach in response to post-world war II military interests. While it was not uncommon for the founding fathers of quantum physics to discuss topics such as consciousness and mysticism, because of the post-war technological race, the interest in such topics not only became old-fashioned but something to be avoided while following a "serious" career path. As a result, the current consensus holds that consciousness is not necessary to describe the physical world, while not introducing consciousness per se in their experiments.

More experiments should then be carried to formally test Fisher's combination and clarify the interpretation of the present results. In such experiments the feedback variable should be similar to the one used in the final analysis, and the two methods for combining the experiments' results should be pre-registered – Stouffer and Fisher. This protocol will more precisely test the secondary hypothesis for the relationship between the feedback-enhanced slit and the sign of the differential scores, as well as the reproducibility of the bi-directional effects.

Also, improvements to the current double-slit setup can be achieved through strategies such as the use of a Peltier cooled CCD sensor to improve the signal-to-noise ratio in the interference pattern measurements, and by implementing a real-time detrending method to provide more reliable feedback information. As to the study design, it's recommended that the experiment begin in an exploratory mode, and move to formal studies when sufficient knowledge is gained from the apparatus. To further rule out the participant's bodily presence as a possible artifact source, a non-local version of the experiment can be performed with participants situated outside of the experimental room when they receive the real-time feedback. From the theoretical side, refinements in the interaction model can be sought in order to provide even sharper variable predictions.

5 Conclusion

The four pre-registered experiments combined resulted in a statistically null difference between the data collected in intention and relax conditions. A post hoc combination of the formal experiments' scores using sign independent statistics, however, provided statistically significant results favoring the existence of anomalous interactions between conscious agents and a physical system. Further studies are warranted to formally test the post hoc hypothesis.

6 Acknowledgements

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Supporting Information: Consciousness-related interactions in a double-slit optical system

Appendix S1 Interaction signature properties

This section explores how the interaction signatures described in Section 2.7 vary according to the sign of the c parameter. To begin, a generic complex sum is considered for $z_{1,2} = r_{1,2}\, e^{i\,\theta_{1,2}}$, where r and θ are real numbers. Their sum in polar coordinates is given by:

$$z_1 + z_2 = \sqrt{r_1^2 + r_2^2 + 2\,r_1 r_2\,\cos\left(\theta_2 - \theta_1\right)}\;\exp\left\{i\left[\theta_1 + \arctan\left(\frac{r_2\,\sin\left(\theta_2 - \theta_1\right)}{r_1 + r_2\,\cos\left(\theta_2 - \theta_1\right)}\right)\right]\right\}. \quad \text{(S1)}$$

From this equation, it's possible to conclude that the compound magnitude component is invariant to an $r_1 \leftrightarrow r_2$ exchange, while the compound phase is not.

In Section 2.7 the interaction signatures were obtained by a $\mathcal{F}$ Fourier transform applied to the interference pattern described in Eq. (5). According to its linearity property, this particular transformation can be seen as a sum of three complex numbers. Since the third term doesn't depend on c, only the first two are considered in a complex sum with M magnitude and P phase:

$$\frac{1 + c\psi}{2}\,\mathcal{F}\{I_1\}(k) + \frac{1 - c\psi}{2}\,\mathcal{F}\{I_2\}(k) = M(k, c, \psi)\;\exp\left[i\,P(k, c, \psi)\right]. \quad \text{(S2)}$$

The functions $I_1(x)$ and $I_2(x)$ represent the diffraction patterns produced by slits 1 and 2. While spatially separated, they can have the same Fourier-transform magnitudes if their shapes are identical. In such a scenario, it's possible to show that $M(-c) = M(c)$, i.e. the impossibility of discriminating the specific slit 1 or 2 associated with a ψ effect. The demonstration follows from using Eq. (S1) to obtain $M(k, c, \psi)$, and realizing that the $r_1 \leftrightarrow r_2$ exchange corresponds to a c sign inversion if the I_1 and I_2 magnitude components are identical.

Alternately, differences between I_1 and I_2 shapes can produce asymmetries that enable one to discriminate the specific slit 1 or 2 associated with a ψ effect. The shape differences can be caused by two conditions: a)$s_1 \neq s_2$, or, different slit widths; b) $U_r \neq 1$, or, a different amount of light crossing each slit. Condition b) is a consequence of a), but it can also be enhanced by small rotations of the double-slit plane. Both conditions are met for the current setup, as shown in Tab. (1). For $U_r < 1$, one finds that $M(-c) < M(c)$, and, consequently, $M(-c) - M(0) < 0$ while $M(c) - M(0) > 0$. The last two inequalities, that are an approximation to Eq. (6) describing the difference signatures, show that it's possible to obtain positive or negative magnitude differences for a respective slit 1 or 2 light intensity enhancement.

For the $P(k, c, \psi)$ phase component, no asymmetries are necessary to discriminate between $\pm c$. As previously shown, the compound phase is naturally asymmetric to an $r_1 \leftrightarrow r_2$ exchange. Thus even for identical magnitudes one obtains $P(-c) < P(c)$, and, consequently, the positive or negative differences for $\pm c$ shown in Fig. (4).

Appendix S2 Phase variable discontinuities

The method for transforming a CCD frame in a variable of interest was described in Section 2.9. The present section details the strategies for avoiding artificial discontinuities that may arise in the process.

When transforming a complex number from Cartesian to polar coordinates, the obtained phase angles are confined to a $-\pi \ldots \pi$ interval. If the phase value is close to $\pm\pi$, variation over time may consequently result in a 2π discontinuity. It's usually possible to detect and fix the jumps using an unwrap algorithm, as shown in Fig. (S1).

However, as shown in Fig. (S2), sometimes the algorithm fails in fixing the discontinuities. This occurs when the unwrap fails to detect a jump as a consequence of noise added to the

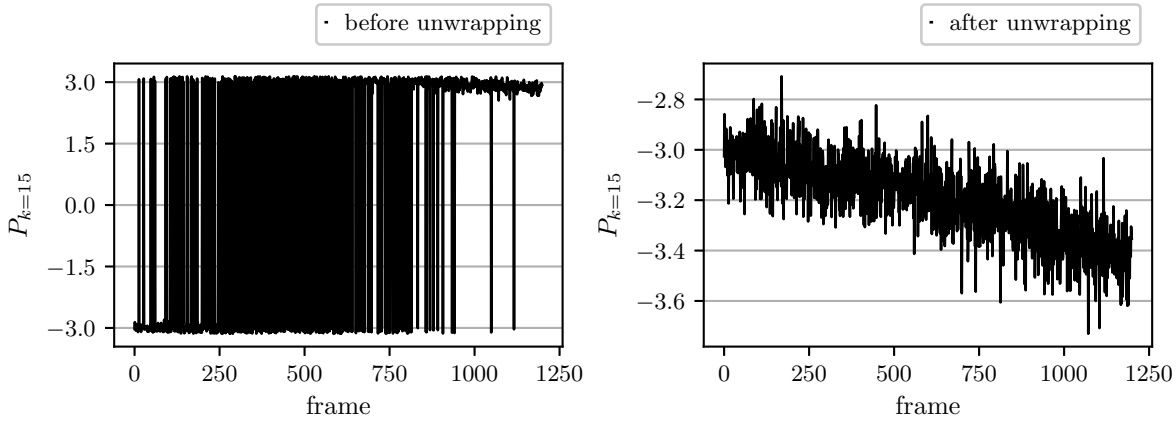

Figure S1: An example in the Fourier phase component at $k = 15$ where unwrapping successfully fixes the 2π discontinuities.

phase values. As discussed in the digital signal processing literature [25, p. 166], the smaller the magnitude associated with a certain k, the higher the phase noise. Thus, according to the magnitude values shown in Fig. (2), in the current setup one expects to find more unwrap-surviving discontinuities in k between 10 and 40, than in k between 1 and 9.

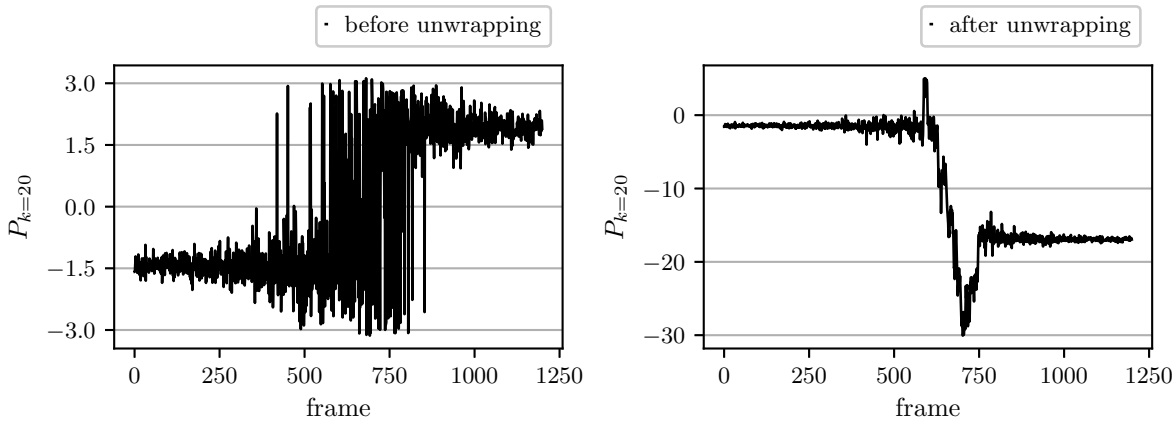

Figure S2: An example in the Fourier phase component at $k = 20$ where unwrapping fails to fix the 2π jumps, producing even larger discontinuities.

Discontinuities in the time series are bound to introduce artifacts in a differential analysis, and must therefore be avoided. When building the variable of interest, the standard deviation of the unwrapped phase is used as a criteria for the detection of discontinuities. If the phase's standard deviation associated with a given k is above a cut value, the phase component at the given k is not allowed to contribute in the phase sum that defines the variable of interest.

Figure S3 reveals the rate of phase rejection per session as a function of the k values used in variables $V_1\langle 5-15\rangle$ and $V_2\langle 19-25\rangle$. The 240 participant and 240 control sessions from experiments 1-9 are used for obtaining the graphs. As previously predicted, all rejection ratios are below 30%, and are higher for larger k values. Although the participant data show slightly higher rejection rates, the control and participant data reveal similar rejection shapes.

Phase discontinuities present a challenge for the use of phase variables in the feedback real-time environment. For example, if the feedback variable used is $V_1\langle 5-15\rangle$, and a unwrap-surviving discontinuity is detected at some point in the $k = 15$ component, then one reaches a dilemma; allowing this component to contribute to the next phase sum computations introduces discontinuities, but excluding the component does also.

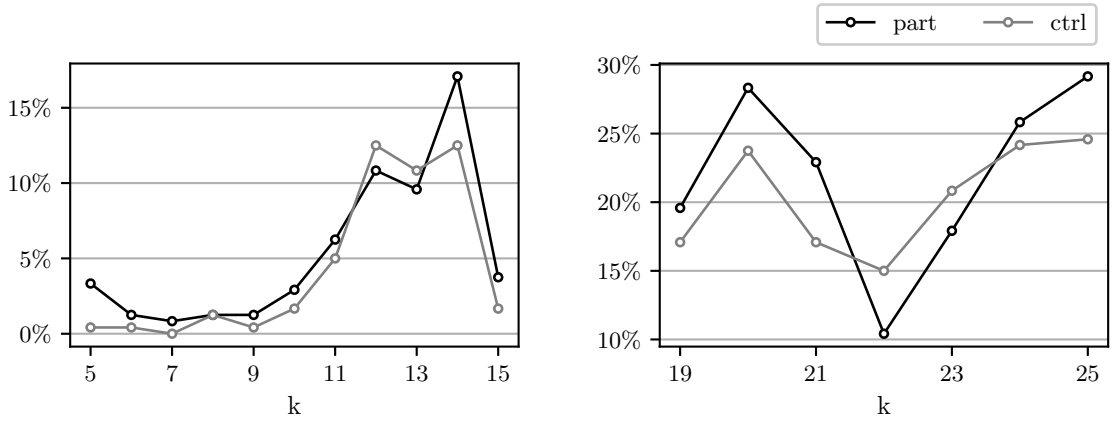

Figure S3: Phase discontinuity rejection per section for participant and control $N = 240$ data. The rejection is associated with standard deviation values larger than 0.5. Left (right) plot show the rejection for k-values associated with the V_1 (V_2) variable.

Consciousness-related interactions in a double-slit optical interferometer

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Abstract

Motivated by a series of reported experiments and their controversial results, the present work investigated if volunteers could causally affect an optical double-slit system through mental efforts alone. The participants task alternated between intending the increase of the (real-time feedback informed) amount of light diffracted through a specific single slit and relaxing any intention effort. The 160 data sessions contributed by 127 volunteers revealed a statistically significant 6.37 sigma difference between the measurements performed in the intention versus the relax conditions ($p = 1.89 \times 10^{-10}$, $es = 0.50 \pm 0.08$), while the 160 control sessions conducted without any present observer resulted in statistically equivalent samples ($z = -0.04$, $p = 0.97$, $es = 0.00 \pm 0.08$). The results couldn't be simply explained by environmental factors, hence supporting the previously claimed existence of a not yet mapped form of interaction between a conscious agent and a physical system.

1 Introduction

One of the hardest problems still unsolved by humanity concerns the nature of consciousness and its relationship to matter [1]. The millennial old debate, currently addressed by the philosophy of mind, proceeds asking if there's a more fundamental aspect to reality, what are their properties and how do they interact.

The first time physicists seriously considered the possibility of consciousness being a subject of their responsibility, coincided with the developments of quantum mechanics in the 20$^{\text{th}}$ century. In particular, the question on how the superposition state is reduced to a definite observed state, known as the quantum measurement problem, led some scientists [2–4] to associate such abrupt transitions with a subjective knowledge increase. According to that interpretation, the conscious agent played an essential role in promoting the state reduction when experimenting on the acquired information.

The question evolved into a controversial philosophical and theoretical debate [5–11] to the present-day, where the majority stands for the opposite view, denying the necessity of the "extra-physical" consciousness ingredient in quantum physics [12]. Data in support of the leading view is found in "which-path" experiments, reported and discussed by [13]. Those experiments reveal that a sufficient condition for a superposition state collapse is a "which-path" information availability, even when theoretically obtainable but not effectively measured. The provided counter-examples may lead to the conclusion that information reaching human consciousness is not a mandatory step for state reduction.

Although a strong role for human consciousness in the quantum measurement problem may be ruled out, still, a weaker but not less important role can be investigated: if the right conditions

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are met, can consciousness collapse the superposition state? Or, more generally, is there any sort of interaction between consciousness-related mental states and quantum systems?

The experimental efforts to address the above questions are dated back to the 70's with the use of random number generators. These devices explore quantum effects as radioactive decay and tunneling to produce truly random binary numbers. In those studies, participants tried to directionally bias the 0 or 1 outcomes through their mental intention, while (usually) being real-time informed about the measured values. Two major meta-analyses have been reported [14, 15], where both resulted in statistical evidence for the investigated goal-oriented interaction. Although significant, the latter concluded that the effect could be more simply explained by an artifact caused by non-significant unpublished studies, what was contested by the authors of the first meta-analysis [16].

The first use of a double-slit interferometer as a target in a similar experimental protocol is attributed to [17]. In the standard double-slit system if a partial which-path information is obtained through extra measurements, one expects as a consequence a reduction in the interference component [18]. The mentioned study investigated the fringe visibility (a measure of the interference component) variation according to the participant's intention. Two experiments were presented, one supporting the interaction hypothesis and the other conforming to chance expectations.

Of particular interest to the present work are the double-slit experiment series [19–22] presented by Dean Radin and his collaborators. Those results are remarkable in the sense that most of the pre-planned experiments resulted in statistically significant evidence supporting the investigated interaction. Their findings, across the work series, claim that the observed effects: a) globally support the *psychophysical* interaction hypothesis, i.e. the causal effect of participant's intention in the optical system (the mind-matter interaction nomenclature is also used); b) cannot be explained as procedural or analytical artifacts, as the control sessions (without participants present) resulted in no significant differences between the intention active and intention absent epochs; c) are stronger for participants with contemplative practices training, e.g. meditation; d) show a positive correlation to the participant's score obtained in the absorption questionnaire [23] measuring the degree of immersion that one can reach when performing a task; e) show a positive correlation to α desynchronization, a marker of increased attention measured by an electroencephalogram device; f) are retro-causal, i.e. obtainable even when the participant acts in previously recorded data that was kept unseen by any participant or the experimenter prior to the session; g) don't depend on distance, occurring even when the participant (not physically present in the experimental room) tries to exert their action on a distant real-time data collection, while receiving the feedback information streamed via the internet. As result, the effect sizes obtained doesn't display a significant correlation to the participant distance to the apparatus.

Inspired by Radin et al. challenging claims in the face of the present scientific world view, the current experiment tried to replicate their first four findings (a discussion concerning c) and d) results is outside the scope of the present work and will be left for a future publication) using a similar protocol and a modified setup/analysis as described below.

2 Results

2.1 Double-slit optical system

The double-slit system geometry is presented in Fig. (1). According to the experimental setup described in Section 4.1, after traveling 38 cm the diverging laser beam reaches the double-slit region (in a good approximation) as a monochromatic plane wave of λ wavelength. The wavefront is then diffracted by the two rectangular apertures with respective widths of s_1 and s_2, which are separated by a d length. The distance from slit j center to a x point in the

camera sensor is given by $r_j = \sqrt{y^2 + x_j^2}$, where: $j = 1, 2$; $x_1 = (x - x_0) + (s_1 + d)/2$; $x_2 = (x - x_0) - (s_2 + d)/2$; and x_0 is the centrally-symmetric position between both slits.

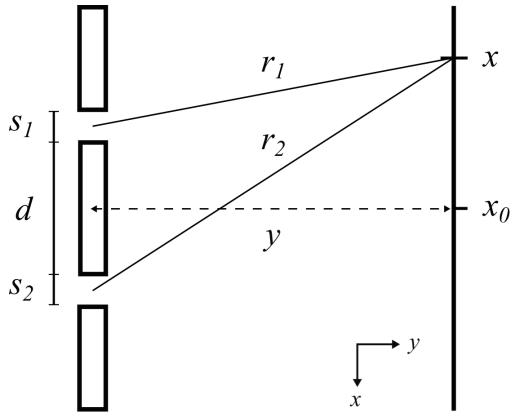

Figure 1: Top view of the double-slit system geometry. The double-slit xz plane is placed at a fixed y distance from the camera sensor xz plane.

According to the scalar diffraction theory [24, p. 75], the wavefield strength U at a point x can be expressed as a superposition of U^0 intensity spherical waves emanating from every point within the diffraction aperture. The Huygens-Fresnel principle (as predicted by the first Rayleigh-Sommerfeld solution) followed by a Fraunhofer approximation, results in the following intensity after a single slit:

$$U_j(x) = -i\,U_j^0\,\frac{h\,s_j}{\lambda\,y}\,\exp\left\{i\,\left[\theta_j + k\,y + \frac{k}{2y}\,x_j^2(x)\right]\right\}\,\frac{\sin\beta_j(x)}{\beta_j(x)}, \qquad (1)$$

$$\beta_j(x) = \frac{k\,s_j}{2y}\,x_j(x),$$

where $k = 2\pi/\lambda$, h is the slit height and a θ_j phase is introduced to represent a possible small rotation of the slit plane over the z axis. The measured light intensity I in the CCD sensor plane is given by the two slit field superposition $\left|1/\sqrt{2}\,U_1 + 1/\sqrt{2}\,U_2\right|^2$, and in more detail to:

$$I(x) = \frac{1}{2}\,I_1(x) + \frac{1}{2}\,I_2(x) + \cos\left\{\frac{k}{2y}\,\left[x_2^2(x) - x_1^2(x)\right] + \theta_r\right\}\,\sqrt{I_1(x)\,I_2(x)} + DC, \qquad (2)$$

$$I_j(x) = U_j(x)\,U_j^*(x),$$

where $\theta_r = \theta_2 - \theta_1$, and DC represent the dark current noise in the camera CCD. The first and the second terms are the *diffraction* components and the third term is the *interference* component. All components together form an *interference pattern*, as exemplified in Fig. (6).

A least square curve fitting procedure using Eq. (2) is applied to extract the physical parameters of the experimental setup. The data sample used consists of 100 CCD frames (equally time spaced) obtained from each of the 130 control sessions formed by experiments 1, 3, 4 and 5 (experiment 2 was left out for providing slightly deviant values; for the experiment definitions see Section 2.3). For practical purposes Eq. (2) is rewritten: $h\,U_1^0$ is factored out from the three first members and $U_r = U_2^0/U_1^0$ is introduced in the next two; the x value is converted to a discrete set using the relationship $x = (i - i_0)\,\Delta p$, where $i = 0, \ldots, 1263$ and Δp is the pixel size. The extracted parameters are shown in Tab. (1).

2.2 Hypothesis

The complementarity principle in quantum mechanics states that one can observe either the wave or the particle properties of light, but not both simultaneously. In the double-slit experi-

par	mean	std	unit
y	30.447	0.022	mm
s_1	12.55	0.13	μm
s_2	12.13	0.17	μm
$h\,U_1^0$	241	3	mm
DC	360	40	–
U_r	0.963	0.017	–
θ_r	-0.065	0.054	–
d	200	–	μm
λ	635	–	nm
Δp	3.75	–	μm
i_0	652	–	–

Table 1: Parameters mean values and standard deviations (both resulting after outliers removal) obtained in the fitting procedure of the 13,000 CCD frames. No std indicates a parameter that was fixed during the fitting procedure.

ment, this fact is translated as: if one succeeds in measuring the path of each photon by being able to tell if it crossed through the left or the right slit, then the interference component should vanish. However, when a group of untracked photons form an interference pattern, it's still possible to measure the particle-like trajectory information, but a group average instead of the individual tracks. The fit procedure previously described managed to obtain this information by extracting U_r, the ratio between the amount of light crossing each slit.

In a standard double-slit experiment, the only way to cause controlled variations in U_r is by introducing into one of the slits some physical agent to interact with the light. The proposed study extends the standard experiment by adding an extra component: a participant (also denominated as *conscious agent*) trying to mentally interact with the light and influence the slits intensity ratio. According to the present scientific consensus, the agents must play a passive role, i.e. they shouldn't be able to modify the measured interference pattern with their introspective intentional efforts. However, motivated by the empirical evidence previously described, a theoretical model is developed to identify possible experimental signatures arising in the case of a legitimate psychophysical interaction.

The interaction dynamics is modeled by a binary choice $c = \pm 1$, an intensity $0 \leq \psi \leq 1$, and a phase difference $-\pi < \phi \leq \pi$ – all functions of the conscious agent subjective state. The extended interference pattern equation accommodating the supposed psychophysical interaction is then given by:

$$I(x, c, \psi, \phi) = \left| \sqrt{\frac{1 + c\,\psi}{2}}\, U_1(x) + \sqrt{\frac{1 - c\,\psi}{2}}\, e^{i\,\phi}\, U_2(x) \right|^2 + DC, \tag{3}$$

and in more detail:

$$I(x, c, \psi, \phi) = \frac{1 + c\,\psi}{2}\, I_1(x) + \frac{1 - c\,\psi}{2}\, I_2(x) + \tag{4}$$
$$+ \sqrt{1 - \psi^2}\, \cos\left\{ \frac{k}{2y}\, \left[x_2^2(x) - x_1^2(x) \right] + \theta_r + \phi \right\} \sqrt{I_1(x)\, I_2(x)} + DC.$$

Inspecting Eq. (4) one learns that a ψ action would increase the amount of light diffracted through a specific single slit while decreasing the amount in the other. The binary c choice expresses the specific slit to be enhanced: $c = 1$ meaning slit 1 and $c = -1$ meaning slit 2. For

a non-zero ψ, the interference term decreases independently from c. A ϕ action would shift the interference term to the left/right depending on its sign.

Although it's possible to work with the time domain pattern, the information extraction using fitting procedures requires intensive computations. Facing this technical challenge, it's convenient to Fourier transform the light intensity (operation denoted as $\mathcal{F}\{I\}$) using fast algorithms and searching for the interaction signatures in the k frequency domain. The following differences in the magnitude and phase components are adopted as a metric to characterize the most sensitive wavenumbers related to ψ and ϕ variations:

$$\Delta M(k) = M_{\text{int}}(k) - M_{\text{rlx}}(k) \quad ; \quad \Delta P(k) = P_{\text{int}}(k) - P_{\text{rlx}}(k), \tag{5}$$

where $\mathcal{F}\{I(x, c, \psi, \phi)\} = M_{\text{int}} \exp(i\, P_{\text{int}})$ and $\mathcal{F}\{I(x, 0, 0, 0)\} = M_{\text{rlx}} \exp(i\, P_{\text{rlx}})$. Using the fit extracted physical parameters from Tab. (1) and Eqs. 4–5, the $\psi\phi$-interacting versus the non-interacting differences are numerically evaluated and presented in Fig. (2).

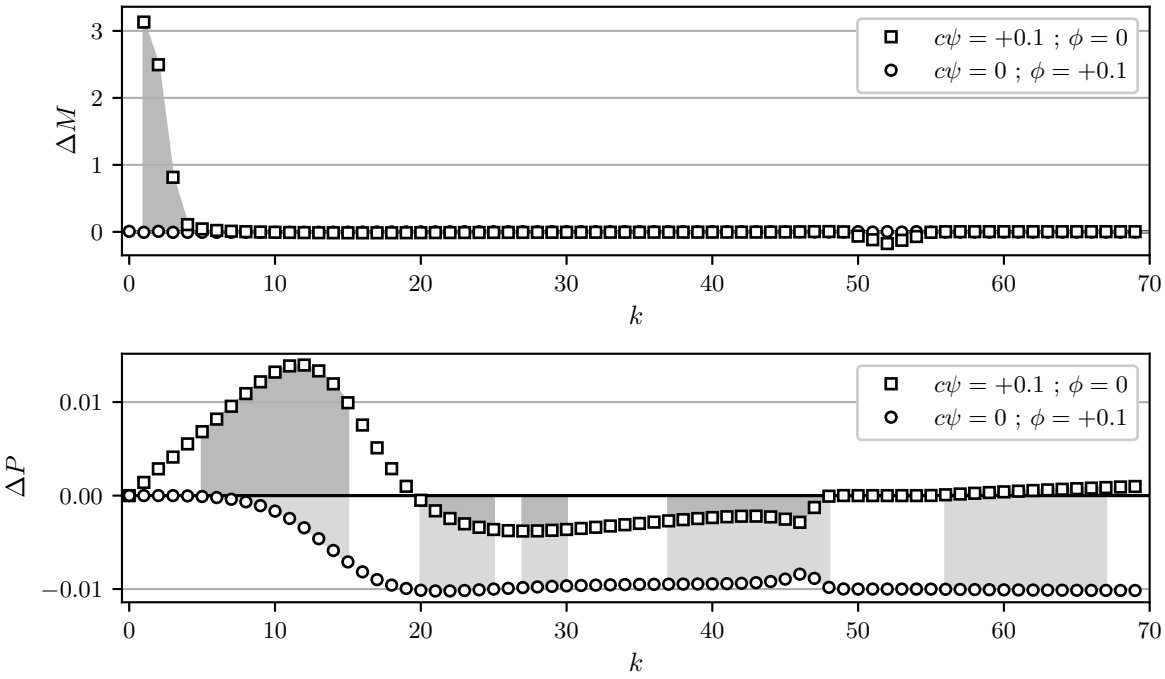

Figure 2: Magnitude and phase difference signatures for different values of c, ψ and ϕ. The magnitude shaded region represents the area explored in the real-time feedback, while the phase shaded areas represent the five chosen wavenumber regions for building the variables of interest used in the analysis. The difference curves in both plots possess an odd function symmetry regarding a c and ϕ sign inversion.

The difference signatures are used to guide the construction of variables of interest sensitive to $\psi\phi$-action. For example, a variable can be designed as the area of the magnitude component evaluated between $k = 1$ and 4. In this way, a CCD frame is translated into a single real number that should increase as ψ increases, and vice versa.

2.3 Experiments

Over a time span of 9 months starting in October 2016, 127 volunteers contributed to 160 experimental sessions following the procedure described in Section 4.3. The participant's task alternated between mentally intending the increase of light intensity crossing through a specific slit and interrupting the intention effort. Each participant session was followed by a control

session where no one was present in the experimental room. The data collection occurred across five experiments labeled from 1 to 5 with a pre-planned number of participants.

The first 20 sessions from experiment 1 were obtained in a pilot study. Using a 0.3 conservative estimative of the obtained effect size, an $\alpha = 0.05$ probability of making a Type I error, and a statistical power of 0.8, 120 sessions were calculated as a safe number for achieving this goal. This number was divided into three experiments testing different feedback configurations and later on extended to 160 to perform two additional experiments that tested a feedback test hypothesis inversion while using the same feedback variable and included more sensitive environmental measurements.

The variables of interest were built using the phase component obtained by the CCD frame Fourier transform. A higher sensibility is expected as "much of the information about the shape of the time domain waveform is contained in the (Fourier transform) phase, rather than the magnitude" [25, p. 192]. The variables k area ranges are defined through an interactive process: it starts with a model compatible k range suggestion and proceeds to analyze all the collected data with the bootstrap procedure described in Section 4.5. The initial k range is then slightly changed and the process repeated, each round resulting in a statistical score for the intention versus relax differences. The chosen k ranges are the ones revealing the higher Stouffer's z-scores for the participant data (denoted as z_p).

The optimal area ranges found for the phase variable in the current setup are: k running from 5 to 15, denoted as V_1 and followed by the notation $\langle 5-15 \rangle$ for expressing its range; V_2 $\langle 20-25 \rangle$; V_3 $\langle 27-30 \rangle$; V_4 $\langle 37-48 \rangle$; and V_5 $\langle 56-67 \rangle$. The variables are built following steps 1–5 from Section 4.5. The k removal rate per session as described in step 4 is around 6% for $V_{1,4,5}$ and 23% for $V_{2,3}$. The expected variations for the five variables in case of a $\psi\phi$-interaction are shown in Fig. (2).

		V_1 $\langle 5-15 \rangle$		V_2 $\langle 20-25 \rangle$		V_{12}				
exp.	N	z_p	z_c	z_p	z_c	comp.	z_p	z_c	es_p	es_c
0	30	0.51	-0.54	0.39	0.79	$V_1 + V_2$	0.35	0.10	0.06	0.02
1	60	-1.48	1.99	1.13	-0.32	$-V_1 + V_2$	2.13	-1.17	0.28	-0.15
2	30	0.51	0.73	1.11	-0.37	$V_1 + V_2$	1.73	0.70	0.32	0.13
3	30	1.65	-0.16	-0.94	0.27	$V_1 - V_2$	2.38	-0.43	0.43	-0.08
4	20	1.84	-0.12	-0.91	0.86	$V_1 - V_2$	2.24	-0.74	0.50	-0.17
5	20	-3.19	-0.56	-2.77	-0.97	$-V_1 - V_2$	3.48	1.39	0.78	0.31
1-5	160						**5.11**	**-0.37**	**0.40**	**-0.03**

		V_α			$V_{12\alpha}$				
exp.	N	α comp.	z_p	z_c	comp.	z_p	z_c	es_p	es_c
0	30	V_4 $\langle 37-48 \rangle$	-1.20	-0.50	$V_{12} - V_4$	0.70	0.37	0.13	0.07
1	60	V_3 $\langle 27-30 \rangle$	-1.38	-0.27	$V_{12} - V_3$	2.27	-0.89	0.29	-0.11
2	30	V_3 $\langle 27-30 \rangle$	-0.94	1.11	$V_{12} - V_3$	2.51	0.38	0.46	0.07
3	30	V_4 $\langle 37-48 \rangle$	3.17	-0.49	$V_{12} + V_4$	3.83	-0.14	0.70	-0.03
4	20	V_5 $\langle 56-67 \rangle$	2.70	1.09	$V_{12} + V_5$	2.98	-0.22	0.67	-0.05
5	20	V_4 $\langle 37-48 \rangle$	1.98	0.50	$V_{12} + V_4$	3.35	1.35	0.75	0.30
1-5	160					**6.37**	**-0.04**	**0.50**	**0.00**

Table 2: Statistical results obtained with the method described in Section 4.5. The participant (control) sessions Stouffer's z-score is denoted as z_p (z_c), while effect size is denoted as es_p (es_c). In experiment 0, the third variable selection and the compound variables sign definitions are such that it maximizes its z_p.

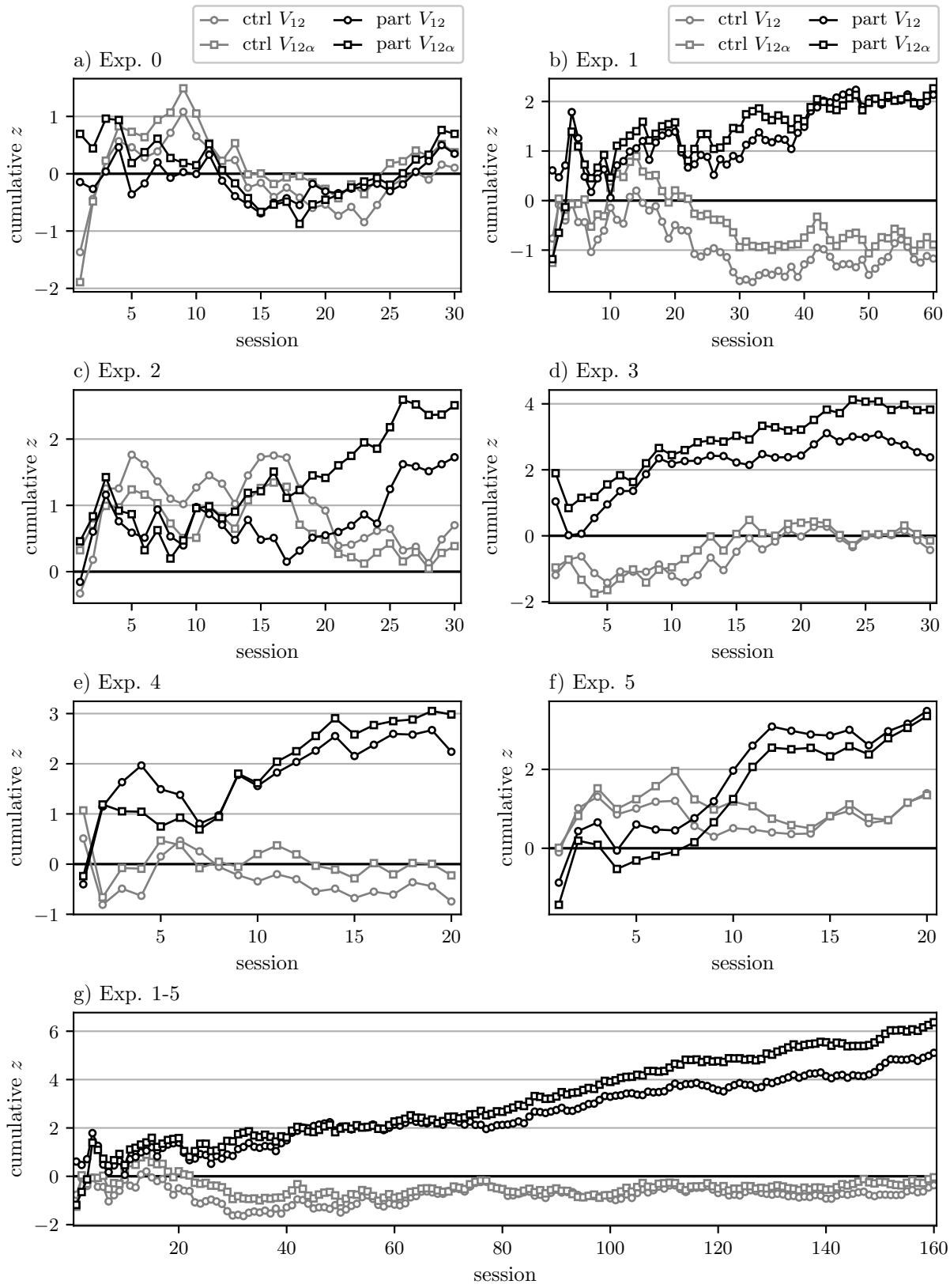

Figure 3: The cumulative z-score for each experiment calculated as $\sum_{i=1}^{s} z_i/\sqrt{s}$ and given as a function of the session number s. The last points represent the values shown in Tab. (2). Plot g) reveal the global result for the 160 sessions from experiments 1–5.

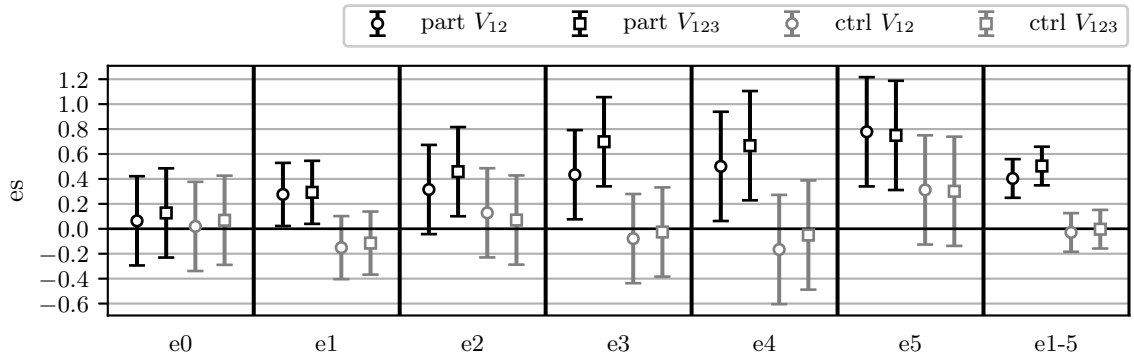

Figure 4: Effect size for all experiments. The error bars represent the 95% confidence level interval, calculated as $1.96/\sqrt{N}$, where N is the experiment sessions number.

Table 2 summarizes the statistical results obtained concerning the variables differences between the intention and relax conditions. The top table refers to the V_1 and V_2 variables used in all experiments and their composition V_{12}. The bottom table extends the compound variable to a third component, selected in each experiment for yielding the maximum z_p. The variable composition is a strategy used to enhance the signal-to-noise ratio: it increases the signal in the case of a correlated activity in the combined regions, and it washes out the noise in the case of no interaction. The different sign definitions used in the compound variables (equally applied in participant and control sessions) are understood as experiment specific relationships between the two $\psi\phi$ degrees of freedom, resulting from the distinct feedback strategies discussed in Section 2.5.

The overall results for experiments 1 to 5 consisting of z-score, associated two-tailed probability, number of positive resulting z-score sessions and effect size in the V_{12} variable are: $z_p = 5.11$, $p_p = 3.29 \times 10^{-7}$, $n_p^+ = 105$, $es_p = 0.40 \pm 0.08$ for the participant sessions and $z_c = -0.37$, $p_c = 0.71$, $n_c^+ = 79$, $es_c = -0.03 \pm 0.08$ for the controls. The overall results for the three component variable $V_{12\alpha}$ are: $z_p = 6.37$, $p_p = 1.89 \times 10^{-10}$, $n_p^+ = 112$, $es_p = 0.50 \pm 0.08$ and $z_c = -0.04$, $p_c = 0.97$, $n_c^+ = 78$, $es_c = 0.00 \pm 0.08$. The results show a significant deviation in the differential z-score obtained in the participant sessions and a null effect in the controls.

The cumulative z-scores presented in Fig. (3) reveal that the participant effects are consistently obtained in a crescent fashion across the experimental sessions, rather than being caused by a few deviating sessions. It also shows how the three variable composition (as compared to the two variable composition) enhances the z result in the participant sessions while approximating the controls to the null value. The effect sizes seen in Fig. (4) reveal a linear improvement for the V_{12} variable across the experiments and a general improvement for $V_{12\alpha}$ after experiment 2. The possible causes are discussed in Section 2.5.

In an experiment labeled as 0, 30 sessions were recorded following the exact same procedure of experiments 1-5, the only difference being a 150 W lamp replacing a person during the participant sessions. The lamp was placed in the participant chair inside a black cylindrical cardboard and was turned off before the control session started. The null effect results exclude a room temperature increase as an artifact source.

To study the $\psi\phi$-interaction homogeneity along the sessions duration, the variable residual and the condition data were sliced in half before the differential analysis. Considering experiments 1–5, the first and second half data overall results for V_{12} are $z_p^{1st} = 3.10$, $z_p^{2nd} = 3.32$ for the participant sessions and $z_c^{1st} = -0.84$, $z_c^{2nd} = 0.27$ for the controls. For $V_{12\alpha}$, it resulted in $z_p^{1st} = 5.20$, $z_p^{2nd} = 3.50$ and $z_c^{1st} = -0.65$, $z_c^{2nd} = -0.07$. The both halves significant results in the participant sessions indicate a consistent $\psi\phi$-action across the time.

In experiment 3, two CCD frames were collected in the 100 ms window. The first one

was used to provide the real-time feedback and the second one was simply stored – no effort was made to process it or to inform the participant of its variations. This design was used to investigate the supposed $\psi\phi$-interaction characteristics: if it depends exclusively on some information reaching the conscious agent or if it can be better understood as some sort of field interaction that could reach the undisplayed frame. The second frame result for V_{12} is $z_p = 2.08$, $z_c = -0.34$ and $z_p = 3.37$, $z_c = -0.44$ for V_{124}, revealing similar results to those obtained with the first frame analysis and thus favoring the second hypothesis.

The same differential analysis applied to the luminosity variable, i.e. the total amount of light reaching the CCD sensor, results in a $N = 160$ global $z_p = 1.17$ and $z_c = -0.75$, where none of the experiments showed a significant deviation. The $\psi\phi$-interaction can be seen as globally conserving the light intensity, while locally redistributing the intensities between the slits.

2.4 Environment variables

The differential analysis was applied to the environment variables (described in Section 4.2) and the resulting standard scores are presented in Tab. (3). The last three rows with A1, A2, and A3 experiments, represent three different sign composition strategies for obtaining the $N = 160$ global Stouffer's z-score: A1 corresponds to $[+1, +1, +1, +1, +1]$, where the first entry represents the value multiplied by the experiment 1 z-values, and so on for the next entries/experiments; A2 is motivated by the V_1 z-score signs, and corresponds to $[+1, -1, -1, -1, +1]$; A3 is motivated by the V_2 z-score signs, and corresponds to $[+1, +1, -1, -1, -1]$.

	T_C		T_L		T_R		$\lvert M_x\rvert$		$\lvert M_y\rvert$		$\lvert M_z\rvert$	
exp.	z_p	z_c	z_p	z_c	z_p	z_c	z_p	z_c	z_p	z_c	z_p	z_c
0	-0.08	0.41	0.22	0.12	0.88	0.24	-1.19	-0.30	0.30	0.46	**2.22**	-0.67
1	1.17	-0.33	-0.25	0.53	-0.70	-0.23	0.91	0.43	-0.34	-0.09	0.07	0.16
2	-0.69	0.91	-1.21	1.49	1.03	0.12	0.19	-0.23	0.70	-0.10	-0.83	-1.36
3	-1.14	1.28	**3.14**	-0.21	-1.61	1.35	-0.59	-1.07	**-2.12**	0.71	**2.43**	-0.18
4	-0.73	0.03	-0.68	-0.22	-0.15	0.18	-0.05	1.26	-0.10	-0.04	0.70	-0.70
5	-0.11	0.44	0.20	-1.09	-1.15	0.34	-1.24	-1.10	-1.53	0.98	-1.15	-0.63
A1	-0.37	0.91	0.52	0.41	-1.14	0.68	-0.07	-0.25	-1.40	0.54	0.58	-1.04
A2	1.73	-1.01	-0.68	-0.54	-0.53	-0.71	0.31	-0.01	-0.10	0.04	-1.30	0.79
A3	1.20	-0.53	-1.87	1.53	1.18	-0.86	1.35	0.57	1.59	-0.73	-1.21	0.06

Table 3: Differential z-score for the environmental variables across the experiments. Three different sign composition strategies (A1 to A3) were tested to obtain the global score. To investigate magnitude variations, the magnetic field components were transformed into their absolute values before analysis. Bold numbers represent the statistically significant scores.

Although experiment 3 resulted in three statistically significant values for the participant sessions, the effect was not consistently replicated across the experiments, such that no combination A1, A2, or A3 resulted in a global significant result. This excludes the trivial explanation of temperature or magnetic field variations in intention/relax conditions being the primary cause of the changes measured in the V variables.

The next step, was to check the Pearson's r correlation between the 160 differential z-scores obtained for the V variables of interest and the 160 differential z-scores obtained for the environmental variables. When looking at $V_{12\alpha}$, $|M_x|$ it's the only environment variable that shows a statistically significant correlation: $r_p = -0.24$, $p_p = 2.21 \times 10^{-3}$ for the participant sessions and $r_c = -0.05$, $p_c = 0.54$ for the controls. The V_{12} calculation showed a similar result $r_p = -0.21$, $p_p = 8.97 \times 10^{-3}$, $r_c = -0.04$, $p_c = 0.59$. For V_1, the significant correlation

appeared for T_C as $r_p = -0.17$, $p_p = 2.96 \times 10^{-2}$, $r_c = 0.00$, $p_c = 0.97$, while for V_2 appeared only for T_R as $r_p = 0.16$, $p_p = 4.91 \times 10^{-2}$, $r_c = -0.06$, $p_c = 0.45$.

The fact that the control sessions resulted in no correlations reinforces the previous argument of independence between the environment and the measured light variation. On the other hand, the significant correlations found in the participants sessions may be interpreted as some sort of physical signature resulting from the $\psi\phi$-interaction. To investigate the consistency of this claim, a second sensor system $MT2$ with a more sensitive magnetometer and a temperature sensor attached to the camera heat sink was added to experiments 4 and 5.

The same differential analysis was applied to the $MT2$ temperature $T2_C$ and magnetic field sensor variables $(M2_x, M2_y, M2_z)$, resulting in non-statistically significant single (and global) z-score for experiments 4 and 5. The 40 points correlation analysis resulted in a significant r comparing V_2 and $T2_C$ z-scores: $r_p = -0.42$, $p_p = 6.35 \times 10^{-3}$, $r_c = -0.12$, $p_c = 0.45$. Although the $MT2$ system failed to reproduce the $|M_x|$ correlation, it also displayed a negative significant correlation with the camera temperature, but in V_2 instead of V_1.

2.5 Feedback configuration

Finally, to investigate how different signs may have arisen from the different V variables across the experiments, it's necessary to understand how the real-time feedback was configured for each one. As described in Section 4.6, the feedback configuration consists of two experimenter choices: a variable of interest and a binary single-tailed test hypothesis. By fixing these choices the experimenter defines the binary c while the participant concentrates in the $\psi\phi$-action.

In experiment 5, the feedback variable was built using the log-transformed M magnitude component of the Fourier transform and defined as the area across the $k = 1$ to 4 range. The feedback hypothesis (represented by the $>$ symbol) tested an increase of the variable's mean in the short time 3 s window, as compared to the 15 s one. The larger the variable mean increase, the lower the p probability of the two-sample mean equality and hence, the larger F. The instantaneous F increase in this experiment is expected to reflect a positive $c\psi$ effect as revealed in Fig. (2), i.e. an increase in the diffraction power through slit 1. In experiment 4, the feedback is configured with the same variable but the opposite $<$ test hypothesis. In this case, an F increase is related to an enhancement in the number of photons crossing the second slit.

The definitions used in each experiment can be seen in Tab. (4). The use of different strategies for building the feedback variable over the progressing experiments translates into the learning curve of the author as the experiment evolved. Although different variables have been used, all of them explored the first two to five magnitude k wavenumbers, the most sensitive magnitude region concerning a supposed ψ action. The first experiments used a ratio, mathematically defined as $\sum_{k=49}^{55} M[n,k] / \sum_{k=1}^{4} M[n,k]$ and represented as $M\ \langle 49-55 \rangle\ /\ \langle 1-4 \rangle$ in the case of experiment 1. In practice, the nominators used in the experiments 0–3 have much smaller predicted variations as compared to the denominators. Thus, the denominators dominate the variable change in case of a ψ action, implying in an inversion between the test hypothesis and the enhanced slit: an increase in slit 2 diffraction power with the feedback $>$ hypothesis.

When analyzing the phase difference presented in Fig. (2), one finds that a $c\psi$ action is predicted to dominate the first 15 wavenumbers, while a ϕ action would be more evident from $k = 20$ onward. The V_1 z-score signal is then used to obtain from the experimental data the c value throughout the experiments. In experiments 4 and 5 for example, the same feedback variable was used but the test hypothesis inverted, resulting in inverted V_1 variable z sign in the two experiments. As shown in Tab. (4), the model predicted favored slits are maximally anti-correlated to the experimentally obtained (in experiments 1– 5). Although the negative correlation reveals a theoretical issue yet to be understood, the absolute interconnectivity of both indicate a successful single-slit enhancement control and the importance of the feedback during the data taking.

exp.	FV	FH	MS	ES
0	$M\ \langle 49-55\rangle\ /\ \langle 1-4\rangle$	$<$	1	1
1	$M\ \langle 49-55\rangle\ /\ \langle 1-4\rangle$	$<$	1	2
2	$M\ \langle 5-9\rangle\ /\ \langle 1-5\rangle$	$>$	2	1
3	$M\ \langle 3-10\rangle\ /\ \langle 1-2\rangle$	$>$	2	1
4	$\log M\ \langle 1-4\rangle$	$<$	2	1
5	$\log M\ \langle 1-4\rangle$	$>$	1	2

Table 4: Feedback configuration: variable of interest (FV) and one-tailed test hypothesis (FH); followed by the model predicted favored slit (MS) and the experimentally favored one (ES), obtained through a V_1 z-score sign inspection.

A question to be addressed concerns the effect size evolution throughout the experiments. In experiment 1, the variable nominator is associated to the peak seen in Fig. (6) M plot. It was initially imagined that the peak exclusively translated the waveness of the pattern. Afterwards, it was understood that it actually represents a convolution between the cosine waveness and the two slits diffraction term product, as a result of the Fourier convolution theorem applied to the third term of Eq. (4). The consequence for the feedback variable is a ratio between two similar information, thus blurring the variations caused by a possible $\psi\phi$-interaction. In experiment 2, an extra variable was built with the same k ranges but using the Fourier phase component. Examining the phase difference in Fig. (2), it's possible to see that the nominator dominates in this case, thus implying a slit 1 diffraction favor, while the magnitude variable favored slit 2. The z resulting from the phase and the magnitude variables were combined to calculate the feedback magnitude, leading to a contradictory slit enhancement request. In light of these arguments, it's possible to interpret the effect size increase throughout the experiments as resulting from better quality information being provided to the participant.

3 Discussion

The five experiments testing a consciousness-related form of interaction with a double-slit system resulted in a 6.37 sigma effect, successfully replicating the anomaly found by previous studies. In contrast, the control sessions conformed to the null hypothesis, showing that the obtained effect cannot be reduced to methodological or analytical artifacts. The effect neither can be explained by a temperature increase in the experimental room as shown by experiment 0 with a lamp producing more heat than a human body does. Experiment 0 also excluded possible artifacts caused by the participant/control sessions order. Care was taken in order to isolate the experiment from mechanical vibrations and electromagnetic waves, as well to monitor the magnetic field and the temperature over different places. The same differential analysis procedure resulted in no significant results for the monitored environmental variables, discarding those physical processes as the primary causal sources of the light measured intention/relax differences.

The participants intended the feedback magnitude increase, which in turn was linked to a specific feedback variable and a test hypothesis. The variable was built by taking into account a model which predicted the most sensitive wavenumber regions in the case of a legitimate interaction. With this method, the participants indirectly intended the increase in the amount of light crossing through a specific slit. The results indicate a flexible interplay between the two degrees of freedom ψ and ϕ to achieve the desired variation, revealing a goal-oriented characteristic for the $\psi\phi$-interaction. As the light luminosity is conserved, the interaction can be pictured as Maxwell's demon kind of influence, where intention plays the demon's role by "steering" some photons to the desired left/right slit.

The observed effect cannot be explained as the consequence of a measurement taking place in the participants conscious awareness. If that were the case, one should expect to see a decrease in the interference component followed by a 50/50 balanced slit intensity ratio. Differently, the results reveal a probability modulation enhancing the light passage through the desired slit. Thus the presented results don't provide a solution to the quantum measurement problem (a similar view is shared by [26] on commenting about Radin et al. conclusions). According to the experimental evidence, it is more reasonable to label the effect as an interaction adding complex numbers to the path amplitudes, which by interference leads to a change in the outcome probabilities. Instead of challenging the quantum mechanics framework and the traditional objective interpretations, the results are suggestive of a standard-model violation, pointing to the existence of a still to be elucidated fundamental force field.

A pertinent question to be addressed is: if such an effect really exists how could it have lasted consensually undetected in spite the technological breakthroughs of the last century? First, it's reasonable to expect a small cross-section; an effect too small it could go unperceived in people's daily lives, that needs proper amplification and a group of people to be statistically detected in a controlled setting. Second, by being a function of the conscious agent subjective condition, it may rely on a specific state of consciousness and an individual skill to promote it, thus not being consistently obtainable by anyone in any situation. In particular, if the effect happens to be catalyzed by states opposed to rational faculties such as thinking and the use of language, it may lead to a paradoxical situation: the more one tries to exert control in a pragmatic approach, the less they cause the phenomenon. The third reason can be argued as a consequence of the sociocultural process described by [27, Chap. 1] that led physicists to shift from philosophical interests to a more pragmatic approach motivated by post world war II military interests. While it was not uncommon to watch the quantum physics founding fathers discussing topics such as consciousness and mysticism, after the post-war technological race, the interest in such topics not only became old-fashioned but something to be avoided while following a "serious" career path. As a result, the current consensus defends that consciousness is not necessary to describe the physical world, while not introducing consciousness per se in their experiments.

Compared to the previous efforts to probe the phenomenon using random number generators, the double-slit system has the advantage of providing interference information across a spatial dimension as opposed to binary outcomes. Having more information available makes it more sensitive to the investigated $\psi\phi$-interaction. Moreover, as opposed to the usual random number generator physical processes, it allows final state interference, which allows the phase difference ϕ to play a role in the probability modulation. Regarding the double-slit variable of interest, the use of Fourier transformed variables is suggested in order to benefit from the full CCD frame instead of using the fringe visibility three pixels (the central maximum value and its adjacent minima).

Future improvements to the current double-slit setup can be achieved by focusing on strategies to improve the signal-to-noise ratio in the interference pattern measurements and to provide clearer feedback information. From the theoretical side, refinements in the interaction model can be sought in order to provide sharper variable predictions. Regarding the profound implications in the event that the observed effect is confirmed as a legitimate anomaly, replication efforts are highly advised.

4 Methods

4.1 Equipment

A semiconductor laser diode L (DL-3148-023, single mode $\lambda = 635$ nm, transverse magnetic polarization; Sanyo) is powered through a feedback driver circuit to maintain a constant 3 mW

light output power. To minimize temperature fluctuations, the laser diode is mounted on a metal structure covered with styrofoam.

As depicted in Fig. (5), the laser light passes through two slits DS etched in a metal foil (10 μm width each, centrally-separated by 200 μm; Lenox Laser). The resulting interference pattern is recorded at 10 Hz by a CCD camera C (FL3-GE-13S2M-C, 1288 x 964 pixel, 3.75 μm pixel size, 47% quantum efficiency at $\lambda = 635$ nm, 12-bit ADC; FLIR) running at room temperature with a heat sink attached to its top. An internal 1 mm width protective glass is removed from the camera to minimize refraction distortions.

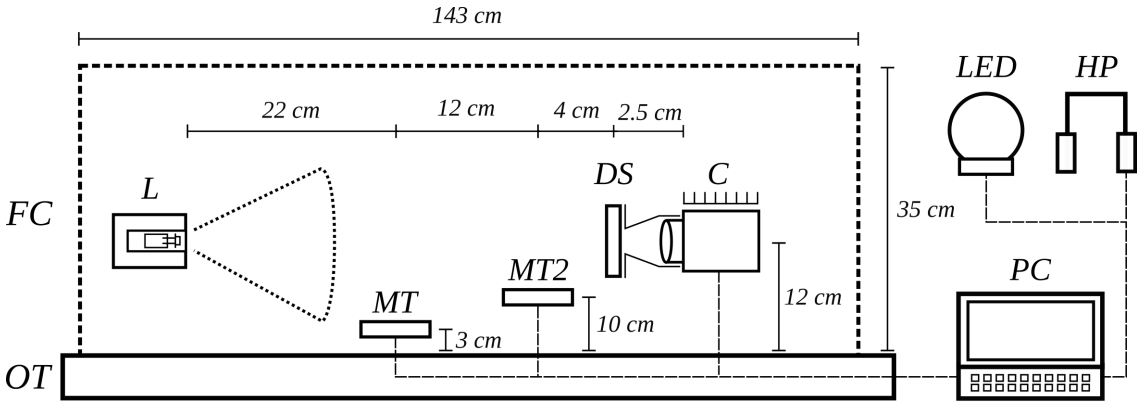

Figure 5: Experiment side view. The distance of 2.5 cm represents the separation between the double-slit and the camera wall. The distance to the camera sensor is found with a fit procedure described in Section 2.1.

A 3D-printed hollow piece is used to connect the camera to the double-slit. One extremity is firmly attached to the camera's barrel and the other to a circular metallic piece that holds the double slit foil. The plastic material color is chosen black to block light influences other than the laser.

Simultaneous to the CCD frame, temperature and magnetic field measurements are obtained using: a) an LM35 temperature sensor (0.5°C accuracy; Texas Instruments) coupled to the laser metal structure; b) an LM35 sensor placed between the laser and the double-slit for measuring room temperature ; c) an HMC5883L magnetometer (0.73 milli-gauss resolution, 12-bit ADC; Honeywell) placed close to the previous temperature sensor; d) an Arduino UNO microcontroller used to digitally read the sensors information. The whole system is presented as MT in Fig. (5).

In experiments 4 and 5, additional temperature and magnetic field measurements were obtained by the $MT2$ system consisting of: a) an LM35 temperature sensor coupled to the CCD heat dissipater; b) an HMC2003 magnetometer (0.04 milli-gauss analog resolution; Honeywell) placed close to the double-slit; c) a 4 channel 16-bit ADC (ADS1115; Texas Instruments); d) an Arduino UNO microcontroller.

The described equipments rest on a passively damped optical table OT (SmartTable UT; Newport) and inside a grounded Faraday cage FC (tombak alloy, 82% copper and 18% zinc). The experiment is controlled by a 2 GHz dual-core notebook computer PC running a custom program developed in python language. Two devices are used to provide real-time feedback for the participants: noise canceling headphones HP (QuietComfort 25; Bose) and an Arduino controlled 3W LED placed inside a spherical translucent glass. The LED is composed of three color components red, green, and blue that can be combined to produce a wide range of colors.

A grounded uninterruptible power supply (Back-UPS 2200; APC) is used to feed the computer, the CCD camera and the laser power supply (MPS-3005; Minipa, Brazil) delivering 3.3 V DC to the driver circuit. The Arduino microcontrollers are fed through the PC USB port. To ensure stable analog-to-digital (ADC) readings (concerning reference voltage variations), the following measures are taken in MT: a) the LM35 readings are obtained by the microcontroller

10-bit ADC using the regulated internal 1.1V reference; b) The HMC5883L magnetometer is connected to a power regulated circuit module. Regarding $MT2$, the LM35 and the HMC2003 are read by the ADS1115 ADC, which uses a regulated internal voltage reference.

4.2 Data acquisition

The python software controlling the experiment has its execution split into a two thread design: the first thread $T1$ is a 10 frame per second loop responsible for simultaneously triggering the sensors readings and collecting the data output within every 100 ms window; the second thread $T2$ represents the experiment flow, informing the participant about their current task, providing feedback depending on the current experimental condition, and performing data storage. As the program starts, $T1$ is set to continuously acquire data while $T2$ is in stand by mode waiting for the command to start an experimental session. As a session starts, data arrays are sequentially filled with the sensors information captured by $T1$. As the session ends, the data arrays are sent to hard-disk storage while $T1$ continues its loop and $T2$ returns to the stand by mode.

The CCD camera is configured to acquire frames using a 25 ms exposure time. Gain increase, auto-exposure and all post-processing filters (e.g. gamma, sharpness, brightness) are disabled. Each frame is initially obtained in a 1264 x per 256 z (centrally aligned) pixel window. Next, for every x, the 256 z values are summed and the result is right bit shifted by 4 units. This oversampling technique, physically viable according to the to z-axis system symmetry, is used to increase the measurement resolution from 12 to 16 bits. The resulting 1264 x values, referred to as a "CCD frame" throughout this work, represent the stored information used for the real-time feedback and the posterior analysis. Additionally, the temperature of the camera's internal components is obtained by an on-board temperature sensor (0.5°C accuracy; 12-bit ADC). Figure 6 shows an example of a single frame obtained with the current experimental setup and the interference pattern measured, as well its Fourier transform components (used for building the variables of interest described in Section 4.5).

The HMC5883L sensor is configured to 8 averaged measurements per sample and its gain is set to 0.73 milli-gauss resolution. In MT all the sensors are oversampled to reach 13-bit resolution (4 reads in HMC5883L and 64 in the LM35). In $MT2$ one single-ended ADS1115 reading (configured to a full scale-range of $\pm$ 4.096 V) is performed for each sensor resulting in an effective 15-bit resolution.

A $n = 0, 1, \ldots, n_f$ frame session results in the following data: a) a three valued condition array $C[n]$ tagging each frame to the corresponding experimental state – intention, relax, or a state in-between; b) a run array $R[n]$ filled with integers uniquely identifying the condition associated with each of the 300 frame blocks, where the blocks alternate between intention and relax conditions to a total of 40; c) a CCD frame array $U[n, i]$ with $i = 0, 1, \ldots, 1263$ and 16-bit integer values; d) the temperature arrays $T_C[n]$, $T_L[n]$ and $T_R[n]$ (32-bit floating point values) corresponding respectively to the CCD camera on-board, the laser and the room temperature sensors; e) the three direction magnetic field arrays $M_x[n]$, $M_y[n]$, $M_z[n]$ (32-bit floating point values) obtained by the MT system sensor; f) in experiments 4 and 5, the 32-bit float arrays corresponding to the CCD external temperature $T2_C[n]$ and magnetic field components $M2_x[n]$, $M2_y[n]$, $M2_z[n]$, obtained from the $MT2$ system sensors.

4.3 Procedure

To avoid potential warm-up artifacts and ensure thermal equilibrium, the following measures are taken 2 hours before every day's first session: a) laser diode and environmental sensors are turned on. In order to accelerate the CCD camera warm-up curve, it's kept power plugged in during the whole experimental block, since it maintains its internal temperature even when in stand by mode; b) the data acquisition software is started. Until the day's last session, the

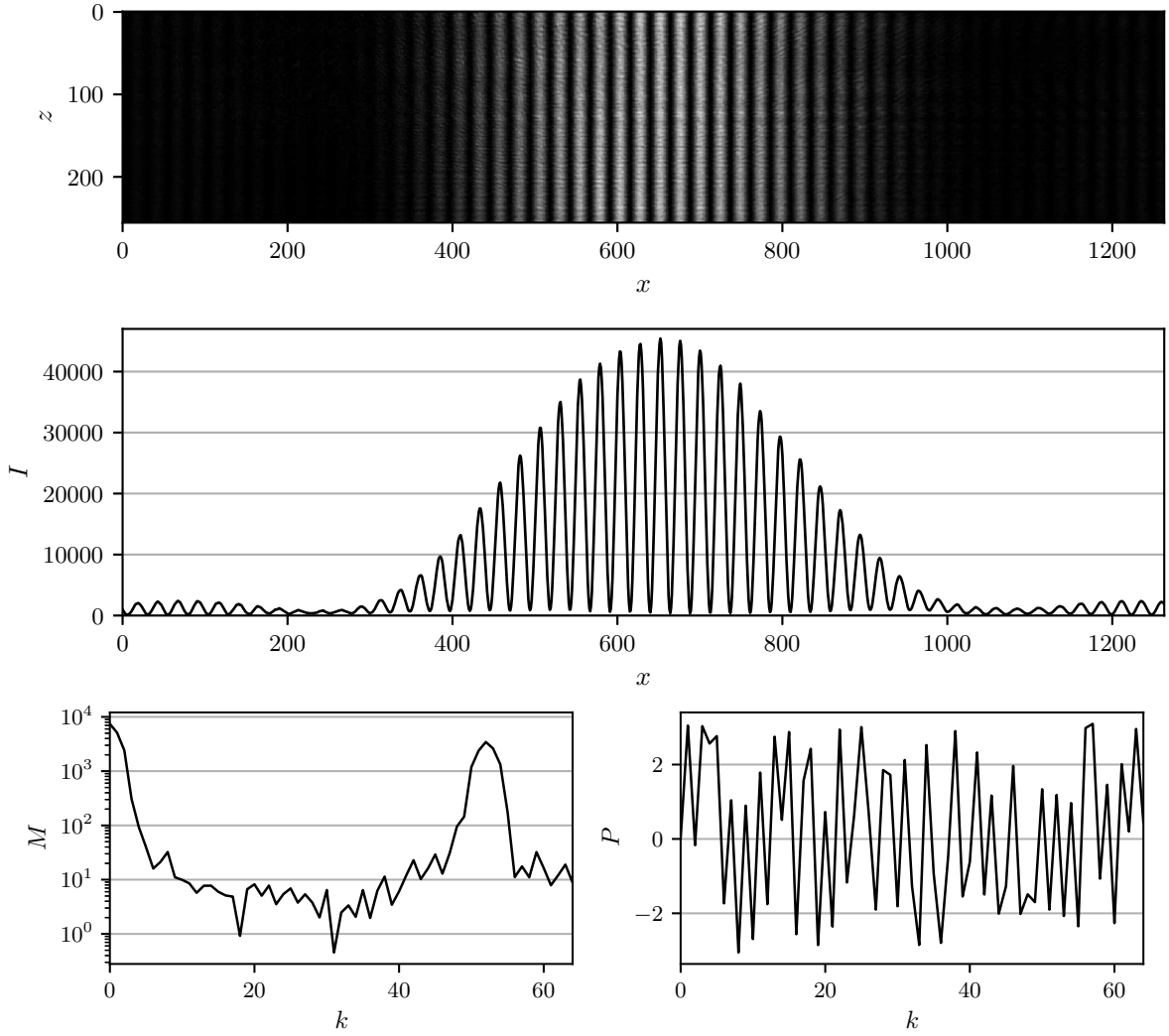

Figure 6: Single raw CCD frame showing the interference pattern measured (white color representing the pixel brightness); 16-bit oversampled one-dimensional I projection in analog digital units (the maximum value corresponds to 69% of the illumination capacity); and the log-scale M magnitude and P phase components of the respective Fast Fourier Transform.

sensors will be uninterruptedly read at 10 Hz; c) lights and air conditioning in the experimental room are switched off.

As the participant arrives at their scheduled time they fill out an informed consent form describing the nature of the experiment. Next, they read a one-page text with the task instructions to be performed. Moving to the experimental room, the participant is briefly presented with the apparatus and to the feedback devices. They sit in a chair about 3 m from the optical system, are asked to remain seated during the whole session and then to put on the noise-canceling headphones. The experimenter switches the lights off, starts the session data acquisition and leaves the room while waiting for the session end in a nearby room.

Shortly thereafter, the participant hears a headphone streamed recorded message welcoming them, followed by guided instruction to take three deep breaths. Then the recording announces the beginning of each test condition. The volunteer's task oscillates between two different situations: *intention* and *relax*. In the first, they are asked to concentrate on the intention to increase the magnitude of the provided real-time feedback (described in Section 4.6). During

the relax condition, the participant stops receiving the feedback information and is asked to temporarily cease any intention toward the experimental system. Intention runs are announced with the phrase "prepare yourself", followed by a 3-second silent delay, and then "... now, concentrate". The delay is included to allow the transition between an attention-away to an attention-toward mental state. Relax runs are announced with the phrase "now, relax". After the relax run ends, a random extra time between 0 and 5 seconds is added to the moment in-between to decouple the measurements from possible periodic oscillations.

After the session's end, the participant meets the experimenter in the next room. An automatic timer triggers a control session starting 10 minutes later, running on the exact same computer code but with no person present in the experimental room. The same decoupling time delays of the previous participant session are used.

Considering the subjective nature of the task, the participants are invited to call upon their own experiences to perform the task. However, two general guidelines are provided: they should try to avoid getting physically tired, thus acting in a present but detached way; b) they shouldn't expect to be able to exert absolute control on the feedback response. Given the random characteristics of the measurement, the feedback is supposed to show unpredictable behavior. They are informed that their influence (in really existent) could be too small to be perceived. This is important to avoid any frustration during the session and to promote a balanced state, where independent to the current feedback magnitude, the participant sustains an inflexible intent.

A single experimental session consists of 40 runs of alternating intention and relax conditions, each run lasting 30 s. Each session lasts around 28 minutes and yields approximately 16,800 sensor data frames, of which 6,000 are obtained in the intention condition and 6,000 in the relax condition. The in-between data is composed of the frames obtained during the welcome and the instructions playback, the 0-5 s random windows, and the extra 60 s collected after the last relax run. The tail data are important to absorb the polynomial fit border artifacts.

During the sessions, the experimenter had no access to the current condition nor tried to mentally influence the result. The data analysis was only performed at the end each pre-planned experimental block. Experimental sessions were scheduled on weekdays after 6 pm and on Saturdays after 2 pm, and were divided by intervals of an hour and a half, usually allowing a maximum of three (four) sessions during weekdays (Saturdays).

4.4 Participants

Participant recruiting looked for subjects interested in the investigated phenomena and that through some regular practice showed a propensity for absorptive skills. This was motivated by Radin et al. correlation results and favored meditators, mediums, holistic therapists, psychonauts, artists, martial artists, and athletes. Besides those groups, the recruiting included individuals who by their curiosity and openness were highly motivated in taking part in the experiment.

The first invitations were sent to a list of experimenter's acquaintances that met the above-mentioned group inclusion criteria. Then, some who took part in the experiment were asked to nominate new potential participants from their own acquaintances, thus implementing a snowball sampling. The biased sample offered no obstacle as the main question concerned the existence of the investigated phenomenon, regardless of effect size distortions caused by a supposedly privileged group. In particular, in an experiment which attention is a crucial ingredient, it's convenient to select volunteers who by their interest and motivation are more susceptible to perform the experimental task with an increased level of commitment.

After their selection, the recruited volunteers filled out an online form about their beliefs and experiences regarding anomalous phenomena, also including a Portuguese translated version of the Tellegen absorption scale [23]. On the session days, before and after the experimental task, they filled out a questionnaire examining their current psychological state. As previously

stated, a discussion concerning the correlations obtained between the questionnaires/scales and the experimental results are outside the scope of the present work and will be left for future publication.

Across the experiment, no tests prior to the planned sessions were performed in order to pre-select the candidates. However, 20% of the sessions consisted of returning participants re-invited by their previously obtained high z-scores.

4.5 Analysis

All the CCD frames recorded in each experimental session are processed and transformed into variables of interest according to the following steps (see Section 4.2 for the variables definitions):

1. For every n frame, the CCD frame array $U[n, i]$ is transformed by a fast Fourier algorithm and decomposed into magnitude $M[n, k]$ and phase $P[n, k]$ polar components, where $k = 0, 1, \ldots, 631$.

2. For every k, the phase is unwrapped along the n frames to $P_u[n, k]$ in a measure to remove misleading 2π discontinuities caused by the $-\pi$ to π constraint.

3. For every k, the standard deviation of $P_u[n, k]$ along the n frames is computed to $s_P[k]$.

4. A variable of interest is obtained as $V_\alpha[n] = \sum_{k=\beta}^{\gamma} P_u[n, k]$, for every k between β and γ that satisfies the $s_P[k] < 0.5$ relationship. In the case of a non-satisfying condition, the given k is left out of the sum, not contributing in that particular session to the variable. This cut is necessary to discard anomalous discontinuities that survives the unwrapping – behavior caused by the noisier P phase associated to small magnitude M values. The V_α variable is optionally followed by the notation $\langle \beta - \gamma \rangle$ to specify its area range.

5. Compound variables are built, e.g. $V_{124}[n] = V_1[n]\langle 5-15\rangle - V_2[n]\langle 20-25\rangle + V_4[n]\langle 37-48\rangle$. The specific choices concerning area ranges and sign compositions are discussed in sections 2.3 and 2.5.

A nonparametric bootstrap test is applied to the variables of interest to test the equality hypothesis between the intention and relax sample means, a procedure referred as *differential analysis*. For each session and variable, a standard z-score is obtained with the following steps:

6. An 8^{th} order polynomial is least-square fitted to the variable $V[n]$. The residual difference between the variable and the polynomial is obtained as $V_d[n]$. This nonlinear detrending procedure is made in order to rule out the variable dependency in slowly changing environmental conditions, e.g. room temperature.

7. The run array $R[n]$ is used to identify the first frame n_s of the first attention run, as well the last frame n_e of the last relax run. To avoid artifacts in the variable extremities caused by the polynomial fitting procedure, the variable V_d is trimmed in the range $n_s - 300$ to $n_e + 300$, being then denoted as $V_d[n_t]$, where $n_t = 0, 1, \ldots, n_e - n_s + 600$.

8. The condition array $C[n]$ is trimmed in the same interval (described in the previous item) to $C[n_t]$, and then is used to split the variable $V_d[n_t]$ into two arrays: $V_I[m]$ and $V_R[m]$ with $m = 0, 1, \ldots, 5999$ values respectively recorded during intention and relax conditions.

9. $V_I[m]$ and $V_R[m]$ means are calculated to μ_I and μ_R. The two-sample mean difference is denoted as $\Delta\mu = \mu_I - \mu_R$. The null hypothesis is $\mu_I = \mu_R$ while the alternative hypothesis stands for $\mu_I \neq \mu_R$.

10. A pseudorandom number r between 0 and n_t length is drawn using a Mersenne Twister algorithm. $C[n_t]$ is copied and circularly shifted by r units resulting in $C_r[n_t] = C[n_t - r]$. The procedure described in items 8 and 9 is applied to C_r, resulting in the mean difference $\Delta\mu_r$.

11. The previous item procedure is repeated 5,000 times, filling a vector with $\overline{\Delta\mu_r}$ mean and $\sigma_{\mu r}$ standard deviation.

12. The standard score concerning the intention-relax sample mean difference is obtained as $z = (\Delta\mu - \overline{\Delta\mu_r})/\sigma_{\mu r}$.

For an experiment block consisting of N sessions, a global z-score for a given variable is obtained by combining individual session results in a Stouffer's $z = \sum_{i=1}^{N} z_i/\sqrt{N}$. The effect size is then calculated by $es = z/\sqrt{N}$ with $\sigma = 1/\sqrt{N}$ standard error.

Figure 7 presents an example of a V_{124} compound variable obtained in a participant session from experiment 3. The first plot shows the variable (black line) obtained by following steps 1–5, and the associated best fitting 8^{th} order polynomial (white line). The second plot displays the variable residual (black line) as described in step 6, and (for didactical purposes) the residual average obtained through a 300 frame window SavitzkyGolay filter (white line). Both data samples are trimmed as described in step 7 and show the condition data described in step 8 – dark gray bars represent intention and light gray bars represent relax condition frames.

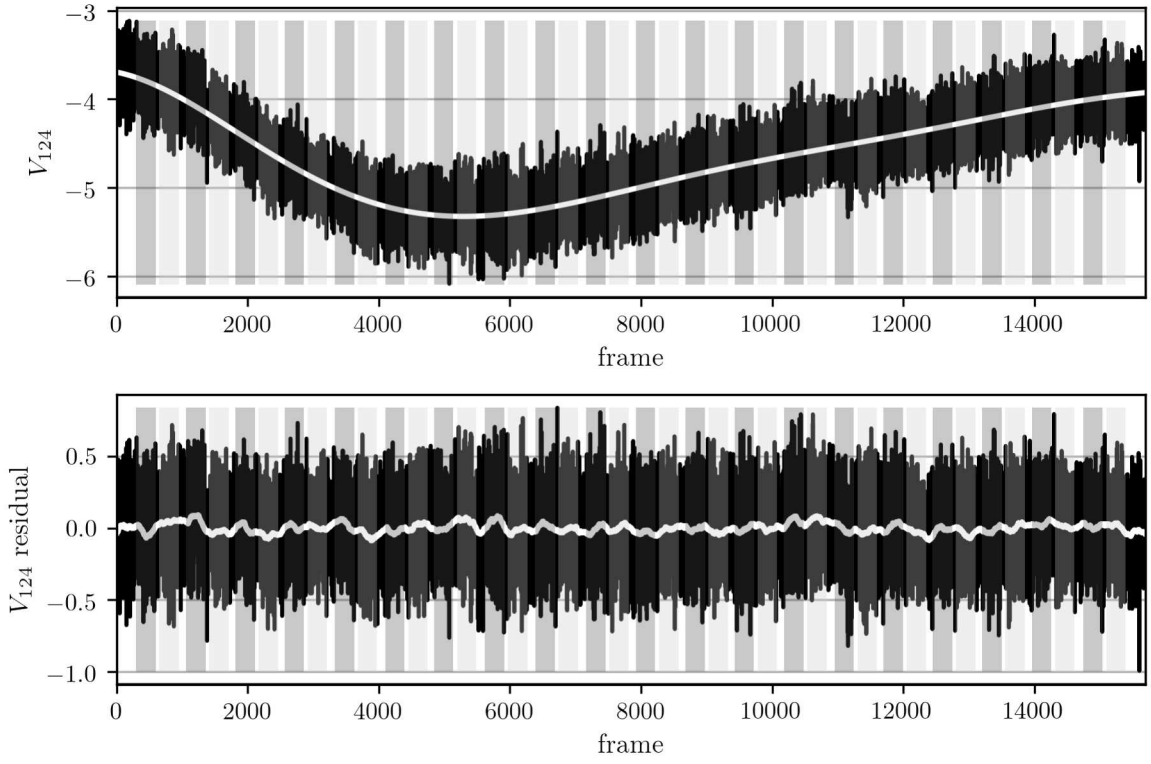

Figure 7: Variable of interest V_{124} and its residual for a participant session. This particular session resulted in a $z = 2.07$ score for this variable.

4.6 Real-time feedback

The feedback system is designed to inform the participant about variations in the two slits intensity ratio. This is accomplished by obtaining this information in real-time and then transforming it into a feedback magnitude, a real number ranging from 0 to 1 used to modulate the feedback devices intensity.

The participant is in sensory contact with two feedback devices: noise-canceling headphones playing a richly harmonic droning tone and the colorful light produced by a LED shining through translucent glass. As the feedback magnitude increases, the LED light shines more intensively in the dark experimental room, followed by the same increase in the tone volume. The feedback light colors are randomly picked for each of the 20 intention runs from a pool of 8 different pre-defined colors. During the data collection, the following method is used to calculate and inform the feedback magnitude. At every frame:

1. A fast Fourier transform is applied to the CCD frame and the magnitude component is used to calculate the (experiment specific) feedback variable of interest. For the experiment definitions see Section 2.5.

2. Two sliding window vectors are updated with the variable value, storing respectively the last 30 and 150 frame values.

3. A Mann-Whitney U test is applied to the two samples. The resulting z-score is used to calculate a one-tailed probability p. The hypothesis being tested (fixed for each experiment) is interpreted as the last 3-second variable mean being significantly greater (or less) than the last 15-second variable mean.

4. The feedback magnitude is obtained as $F = 1 - p$, and F is set to a minimal value of 0.1 if below this threshold.

5. If the current frame is associated with an intention condition, the F value is used to instantly modulate the light and volume intensity of the feedback devices. Transversely, if the experiment is in the relax condition, no information about the experiment state is given to the participant: the feedback light is kept off, and the sound is kept at a fixed $F = 0.3$ intensity. As a result, the feedback light is turned on only during intention runs, while the feedback volume is kept on during the whole session, being only modulated during intention runs and kept at a fixed 0.3 intensity during relax and during the recorded conditions announcements.

The feedback mechanism simplifies the task description, serving as an interface between the conscious agent and the physical process dynamics. Without it, the task instructions could sound rather abstract causing mental wondering and distractions during the experiment. To simplify, the participants are instructed to always intend the increase of the feedback magnitude during the intention runs. They are informed that a magnitude increase is linked to a physical variation, so by focusing on the feedback, they are indirectly interacting (or trying to) with the light crossing the apparatus. As a secondary role, the feedback is used to arouse the participants motivation as they eventually can experience some sort of correlation between the presented intensities and their subjective state, thus reinforcing their attention and intention towards the experimental system.

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