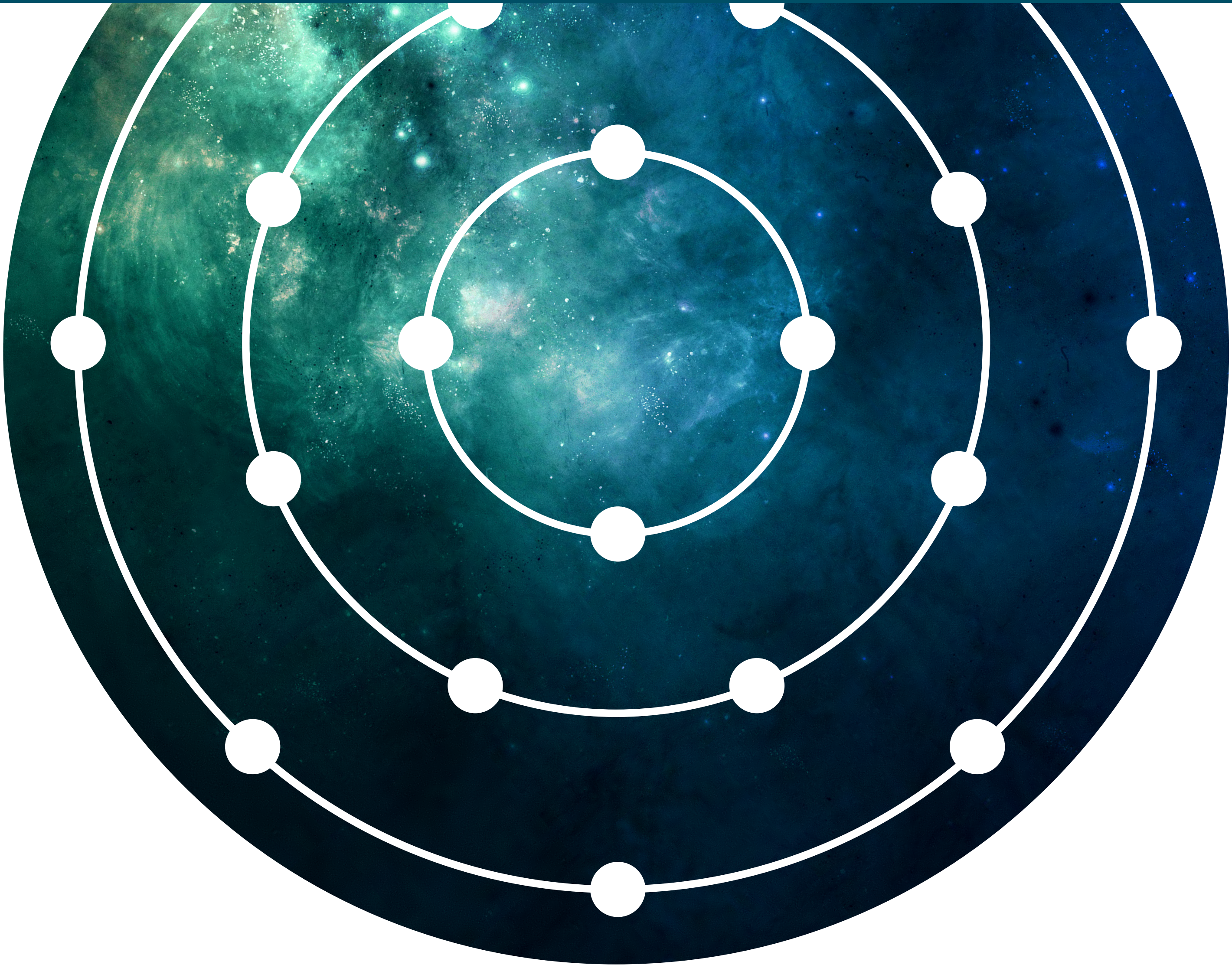

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The *Journal of Anomalous Experience and Cognition (JAEX)* provides a forum for the rigorous, multidisciplinary study of anomalous experience and cognition. Anomalous experience refers to unusual but not necessarily pathological experiences, such as mystical and out-of-body experiences. They can be spontaneous or induced and have life-changing effects. Anomalous cognition refers to rigorous multidisciplinary research that seeks to improve our understanding of psycho-physical interrelations. It includes the hypotheses that organisms can be affected by spatially or temporally distant stimuli -unmediated by the senses or reason- and that intentions can directly affect physical systems, as well as related attitudes, beliefs, and other variables.

For additional information see **https://journals.lub.lu.se/jaex**

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Editorial

Introducing the *Journal of Anomalous Experience and Cognition* (JAEX)

Etzel Cardeña, Lund University

If you have published anything in an academic journal, your email is probably inundated with unctuous invitations to have your earth-shattering contribution published in the next issue of a journal whose title is almost the same as that of an established journal. These invitations are almost invariably written in poor English and, reading the small print, require that you send money for an almost instantaneous acceptance. It does not take a Sherlock Holmes to conclude that these are predatory attempts to exchange money for a minimal to non-existent peer-review. If you have done anything that can stand scrutiny, you can easily dismiss all of these "invitations." However, even some genuine journals are little more than business propositions for those at the top who use the work by writers and reviewers to pay for their salaries, not to mention journals that list under their criteria for acceptance that the paper not deal with "pseudoscience," without further clarification, allowing them to reject any piece they may disagree with, even if appropriately conducted, and persecute those who challenge them (Beall, 2017; Cardeña, 2015).

This leaves a considerably smaller group of journals that have professional and ethical standards and remain open to challenging publications, and a *much* smaller list of journals that may deal with the topics of JAEX (anomalous experience and cognition). Historically, during its initial years at the end of the 19th century, the Society for Psychical Research covered the whole gamut of anomalous experiences and cognition, but soon areas such as hypnosis and dissociation detached themselves from association with their disreputable cousin, psi phenomena, a state of affairs that the just departed Carlos Alvarado questioned in many publications (e.g., Alvarado, 1989; see a special section of tributes in this issue).

The taboo against publishing research on anomalous experiences in mainstream journals and books went the way of disco music at the turn of the 21st century (e.g.,

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Cardeña et al., 2000; Lommel et al., 2001), but not the one against works on anomalous cognition (Cardeña, 2015). Furthermore, specific anomalous experiences and anomalous cognition in general have remained in their particular niches, typically according to discipline (e.g., psychology, anthropology, parapsychology), and the product of this balkanization of discourse has produced isolated enclaves that would benefit enormously from knowledge of each other, as the paper in this issue by Tressoldi and Storm suggests. It is not only that aspects of anomalous experiences and cognition seem to overlap, but that even the study of anomalous experiences/alterations of consciousness would benefit from comparing commonalities and differences across them, such as those produced by psychedelics and near-death experiences. And, of course, different disciplines offer varying worthy perspectives that would benefit from a common basis of knowledge (cf. Cardeña & Winkelman, 2011).

The *Journal of Anomalous Experience and Cognition* is launched as a forum for the presentation of new findings and theories, and the cross-fertilization across related topics and disciplines, while maintaining rigorous peer-reviewing standards and opening the results to all interested parties without any cost (i. e., it is a free, open access journal, based in a prestigious university, and with an authoritative editorial board). It thus joins the resistance against the increased monetarization and insularity of academic knowledge, while maintaining its independence from any organization's particular interests or biases (although the Parapsychology Foundation, to our delight, agreed to be JAEX's nominal publisher, it does not interfere with any editorial or financial decisions), unlike some of the niche journals.

This first issue includes an impressive array of papers, this time focused on anomalous cognition. Besides five research studies (including two exchanges between authors and reviewers), it contains tributes to the indefatigable historian and researcher Carlos Alvarado, book reviews, and a bibliography of recent publications.

If you are a researcher, theoretician, historian, humanist, or artist seriously interested in anomalous experiences and/or cognition, you need not look further for a journal that will welcome your submission. And if you are just a reader interested in areas of human functioning that have so far been mostly been neglected, you are equally welcome!

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Psychophysical Interactions with Entangled Photons: Five Exploratory Experiments.[1 2 3]

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Abstract : *Objective*: Four laboratory studies and an online experiment explored psychophysical (mind-matter) interactions with quantum entangled photons. *Method*: Entanglement correlation strength measured in real-time was presented via a graph or dynamic images displayed on a computer monitor or web browser. Participants were tasked with mentally influencing that metric. *Results*: A statistically significant increase in entanglement strength was obtained in experimental conditions across the four lab studies ($p < 0.02$), with particularly strong results observed in three studies conducted at the Institute of Noetic Sciences ($p < 0.0002$). Modestly significant results ($p < 0.05$) were observed in a high-quality subset of entanglement samples in an online experiment. Control experiments using the same equipment and protocols, but without observers present, showed results consistent with chance expectation in both the lab and online studies. *Conclusion*: These outcomes suggest that the fidelity of entangled states and the nonlocal resource they entail may be mutable in systems that include conscious awareness. This is potentially of interest for quantum information technologies such as quantum computation, encryption, key distribution, and teleportation. The results are also relevant for interpretations of quantum theory, especially

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3 The acting editor was David Marcusson-Clavertz, Ph. D.

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if future studies show that entanglement strength can be mentally modulated above the Tsirelson Bound – the mathematical upper limit predicted by quantum theory. Such an outcome would suggest that quantum theory in its present form does not hold when physical systems interact with certain mental states. The results of these exploratory experiments justify continued investigation of entangled photons as targets of mind-matter interaction.

Keywords: mind-matter interaction, quantum entanglement, neutral monism, consciousness, psi, psychokinesis, quantum information technologies

Highlights:

- Mind-matter interaction experiments involving pairs of entangled photons as the "matter" side of the interaction were conducted in the laboratory and online.
- Preliminary evidence suggests that entanglement correlation strength can be mentally modulated.
- This suggests it is feasible to test if entanglement can be mentally modulated above the Tsirelson Bound, the mathematical upper limit of entanglement according to quantum theory.
- If future studies confirm these results, then quantum information technologies (computing, communication, teleportation, etc.) may be vulnerable to mental influence.

Over the last century, research has progressively strengthened the empirical evidence for telepathy, clairvoyance, precognition, and other psychic or "psi" phenomena, while expanding the variety of situations and protocols under which they can be observed and studied. Nearly 20 meta-analyses of classes of psi phenomena support the conclusion that effects observed in controlled laboratory conditions are far beyond chance expectation and are not adequately explained by methodological problems or biases attributable to analytical or publication procedures (Cardeña, 2018; Tressoldi & Storm, 2021). Publication of topical reviews and meta-analytic reports in mainstream journals has broadened awareness of the research results – and provoked lively exchanges – and this has fostered a more informed and nuanced view of psi in some quarters of the scientific community (Mossbridge & Radin, 2018; Schooler et al., 2018). In our view, as the collective evidence becomes more persuasive the focus of scientific inquiry will continue to shift from establishing evidence to gathering psi data that will be useful for theory-building. Research on these well-documented forms of anomalous cognition and influence hold considerable promise for advancing scientific knowledge precisely because they expose the limits of our current understanding of Nature. However, along with that promise are unique challenges to experimental investigation.

Amassing evidentiary support for psi is challenging because the conditions for eliciting and enhancing these phenomena are not well understood. Research to help elucidate these conditions is complex because it aims to reveal the psychological, physiological, neurological, and environmental correlates of psi performance. Although such "process-oriented" research is laborious, in principle it is no more challenging than any other form of research on unusual states of consciousness (Corneille & Luke, 2021; Correa et al., 2022). Much can be learned about the conditions for producing psi effects without directly confronting questions about its fundamental mechanisms or its implications for physics, consciousness, and the mind-matter relation.

However, in contrast to process-oriented research, experiments to advance our understanding about the underlying nature of psi will need to address more central questions. They include: 1) How do psi phenomena fit in with existing theories of physics? 2) What are the implications of these phenomena for our conception of mind and consciousness? 3) What does psi imply for the mind-matter relation?, and 4) What inferences should be drawn about the nature of causality and temporality? These questions are challenging to frame experimentally because each domain is an active area of inquiry in its own right, with its attendant uncertainties and controversies, for example in quantum physics (Chiribella & Spekkens, 2015), consciousness studies (Velmans, 2017), the mind-matter relation (Stubenberg, 2018), and causality (Mendoza-Martínez et al., 2019; Sheehan, 2006; Svozil, 2018).

In addition, the nature of psi uniquely complicates experimentation. These effects appear to violate everyday constraints of space and time, so it is not possible given our current understanding to determine with certainty whence or even *when* psi effects originate. Time-reversed psi effects are well documented (Mossbridge & Radin, 2018), and many studies have shown that clairvoyance operates over far distances and under conditions in which participants are sequestered in high quality isolation chambers with full electromagnetic shielding (Schwartz, 2015). Hence, it is difficult to know with certainty if effects are associated with the designated participants or with someone else (e.g., the experimenter), or if they occur at times outside of the planned experimental sessions (e.g., when the data are observed). In view of these uncertainties, most psi studies take a practical approach and are analyzed under the assumption that effects do occur within the experimental sessions and are produced by the designated participants.[4] This is a practical position that we adopt in presenting the experiments discussed here.

Theoretical progress will entail a reckoning with physics, which in turn requires data that inform us about the physical nature of psi effects. However, because the locus of psi is often ambiguous it is difficult to know if such effects should be sought solely within the cognitive processes of participants, within the systems that are targets of intention, or some combination thereof. That is, many laboratory psi protocols are designed to correlate an intentional mental action or state with a target that is ultimately linked to the outcome of a random event, such as the toss of a die or the output of a truly random number generator (RNG). It has been long recognized that such effects can be alternately interpreted as either anomalous cognition or as anomalous influence (Schmidt, 1987). For instance, correctly guessing a symbol on a hidden card might result from a precognitive glimpse of the future when the card is revealed, or as a mind-matter interaction (also called psychokinetic or PK) influence on the random process used to select that card. Even if the ambiguity can be resolved in favor of PK, data will still be useful for theory to the extent that it carries detailed information on processes that connect to fundamentals of physical theory. Advances in psi research have often been driven by novel experimental paradigms. Examples include the ganzfeld telepathy experiment, physiological measures of presentiment, and micro-PK studies using RNGs (chapters 15, 17 and 20, respectively, in Cardeña et al., 2015).

Following that tradition, in this paper we report on a novel design using entangled photons as a target system and we highlight how this kind of experiment may help inform the interface between psi and physics. Photonic entanglement presents not only a simple and extensively studied system within physics, but one that is deeply connected to the essence of quantum mechanics, the most successful theory of physics to date. As Erwin Schrödinger once wrote: "I would not call [entanglement] *one* but rather *the* characteristic trait of quantum mechanics, the one that enforces its entire departure from classical lines of thought" (Schrödinger, 1935, p. 555). If the 20th century conclusion from physics was that Nature is quantum, the conclusion from the first decades of the 21st century is that the essence of quantum nature is revealed through properties of entanglement (Brunner et al., 2014). Accordingly, data that in-

4 There is some evidence for psi-like effects that can be attributed to the experimenter rather than the participants (Kennedy, 1976). But there are also experiments that show fairly constant effect sizes independent of the investigators and also show differences among selected and non-selected participants. The prime example is the highly successful ganzfeld telepathy experiment, which has been reported by some four dozen different principal investigators (Tressoldi & Storm, 2021). Similar results have also been observed in the extensive database of micro-psychokinetic experiments (Varvoglis & Bancel, 2015).

form us on how psi may interact with entangled states can potentially provide new information for theories both of psi and physics.

Another motivation for our proposal is that psi effects and physical entanglement both exhibit unexplained connections between parts of a system that in turn give rise to influences that are called *nonlocal.* These notions are well-defined within quantum theory and are descriptive for psi effects, and it will be important to determine whether these parallels are merely coincidental or point to a fundamental aspect of the mind-matter relation. For example, neutral monism is the philosophical proposition that reality consists of an inextricable relationship between mind and matter (Stubenberg, 2018). Proponents of this view state that the ability to know a thing (mind), and the thing that can be objectively known (matter), are not truly separate and that both mind and matter are fundamental aspects of a holistic reality, akin to two sides of the same coin. Neutral monism thus suggests that mind is intimately related to foundational concepts in physics, including space and time. This is apropos because recent theories about the structure and existence of spacetime are related to the phenomenon of quantum entanglement (Musser, 2018). Thus, if mental states can be shown to modulate measures of entanglement, then that may inform what has traditionally been considered a purely philosophical position. The possibility of leveraging entanglement to inform propositions about the mind-matter relation is therefore a principal motivation for introducing the psi-entanglement experimental paradigm.

These broader motivations notwithstanding, we turn now to our experiment, which is a concrete example of how the paradigm can be used to address a fundamental question of physics and its relation to psi. The experiment measures photonic entanglement correlations and seeks to determine if a psi effort can modulate the strength of entanglement. A positive result would have practical ramifications because technologies based on quantum entanglement, such as quantum cryptography, rely on the constancy of entanglement measures. Psychic interference with entanglement might compromise these technologies, which are currently considered inviolable. But the experiment also lays the ground for a far-reaching test of quantum physics.

It is well-known that entanglement correlations have an upper limit and are strictly bounded by the mathematics of quantum theory (that limit is called the Tsirelson Bound; Cuffaro, 2018)). What this mathematically-determined bound suggests about the nature of physical reality is not entirely clear, but it is known that "super-quantum" theories with stronger correlations are conceivable. The important question for psi, then, is whether psi modulations of entanglement strength can exceed the Tsirelson Bound (TB). If it can, that would have profound implications for both psi and physics (this topic is revisited in the Discussion, later). Thus, an immediate goal of the current work is to determine then if a future psi-TB experiment is feasible.

All of these considerations hinge on a resolution of the locus problem: the ability to ascertain if a psi effect truly corresponds to a change in entanglement strength. That is, controls must determine that an effect is neither an artifact of a PK influence on some part of the experimental apparatus (e.g., the detector efficiency, or mirror alignment), nor due to clairvoyant or precognitive selection of an uncontrolled experimental parameter. Each of these artifactual possibilities can be considered a "loophole" that undermines inferences about psi-induced entanglement modulation. A strong motivation for introducing the psi-entanglement paradigm is that it holds a unique potential for closing, or at least for controlling, these PK loopholes. An indication of how this can work is considered later in the Discussion.

This paper presents four laboratory studies and a similar experiment carried out via the Internet. The goal of these preliminary studies was three-fold: (a) demonstrate a suitable protocol for studying psi effects on entangled photons; (b) explore appropriate methods of analyzing the data; and (c) formulate a measure of effect size to assess the feasibility of the psi-TB experiment.

Method: Laboratory Experiments

Equipment

These experiments used a commercial optical system that generates entangled polarization states in pairs of photons (quED, qutools.com, Munich, Germany). The entanglement quantity, denoted as **S**, is an algebraic combination of measurements first proposed by Clauser, Horne, Shimony, and Holt (Clauser et al. (1969), henceforth CHSH). The CHSH **S**-value has become the standard measure of entanglement in paired systems with two-valued measurements (2-qubit entangled states), as is the case for entangled photon polarizations. Its formalism, adapted from Bell's inequality condition for local causality, delineates when correlations imply nonlocal behavior.

In the CHSH scenario, a value of **S** ≤ 2 indicates that the correlations between pairs of photons are behaving in a locally causal manner. In this case, the observed correlations could be explained by a common cause acting on the two photons (a so-called local hidden variable explanation). A correlation strength **S** > 2 indicates

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that the entangled photons exhibit nonlocal correlations, i.e., pairs of photons are exhibiting correlations that are stronger than any form encountered in classical physics (meaning, constrained exclusively to local interactions). That **S** can be greater than 2 has been repeatedly verified to very high degrees of confidence, and that establishes nonlocality as an empirical fact of nature (Aspect et al., 1982; Bub, 2019).

It can also be shown that the mathematics of quantum theory imposes an upper bound, i.e., $\mathbf{S} \leq 2\sqrt{2}$. This is dubbed the Tsirelson Bound, named after mathematician Boris Tsirelson who first calculated this value (Cuffaro, 2018). This value delimits quantum correlations from hypothetical "super-quantum" correlations that, if shown to exist, would conflict with the mathematical predictions of quantum theory as currently understood. The photon pairs produced by the quED apparatus in our experiments operated in the regime $2 < \mathbf{S} \leq 2\sqrt{2}$, which assured that the photons, the "matter" side of these mind-matter interaction experiments, were indeed nonlocally correlated.

The quED apparatus generated entangled photons by passing a blue laser beam through a nonlinear crystal (beta barium borate), which in turn produced pairs of red photons by the process of spontaneous down-conversion. The strength of entanglement, **S**, was determined by measuring correlations between the photon pairs at different photon polarizations. To achieve this, each photon of a pair of photons was directed by a mirror to a separate, stepper-motor controlled, polarizing filter. The stepper-motors were programmed to cycle repeatedly through a sequence of 16 pairs of polarizer angles, pausing one second for data accumulation at each setting. Photons passing through the polarizers were then carried via fiber optics to a photon coincidence counter, which recorded the number of detected pairs. The resulting counts for the 16 settings were then combined by software to output a value for **S.**

At each polarization setting, the quED transmitted the coincidence counts via TCP-IP on a local area network (LAN) to a remote computer for real-time data processing and generation of display feedback. Each sample of **S** was thus based on coincidence counts from 16 consecutive pairs of polarization measurements, and the value of **S** was updated each time the polarization settings changed.[5] For these studies, we placed the quED in a room with no one present in that room while experimental or control runs were underway. Figure 1 shows a typical sequence of **S** values obtained over some 800 samples.

5 Considered as a time series, the S-values were thus autocorrelated with a dependency that decreased linearly from 1 to zero over the course of 16 lags.

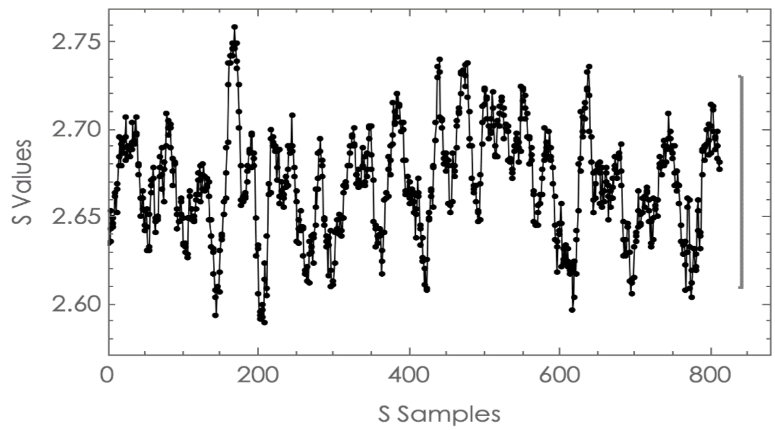

Figure 1. Example of continuously updated S values returned by the quED system. Note that there are autocorrelations in these samples because each value of S is calculated based on a sequence of 16 coincidence counts. The solid bar on the right side shows the 95% confidence interval of S based on Poisson counting statistics.

Procedure

Laboratory experiment 1 (January 2017), experiment 2 (February 2017), and experiment 3 (February 2017) were performed by the first author (DR) at the Institute of Noetic Sciences (IONS) in Petaluma, California. Laboratory experiment 4 (August 2017) was an independent collaboration conducted by the second author (PAB) at the Institut Métapsychique International (IMI) in Paris, which used a separate quED system. That study was carried out at the Dechen Chöling retreat center near Limoges, France. All three authors had experienced positive outcomes in previous psi experiments, and as a result they expected that the hypotheses proposed in these studies might be supported. However, because entangled photons had not been used in previous mind-matter interaction studies, their expectations were limited to simply being open to the possibility of observing positive outcomes. Similarly, most of the participants in the laboratory studies were probably open to the same possibility, but no systematic efforts were taken to assess their expectations or prior beliefs.

The general scheme was to compare entanglement **S** values under two participant conditions: a "concentrate" condition in which participants were invited to observe a real-time **S** value feedback signal and mentally intend for the signal to increase; and a "relax" condition in which feedback was absent and participants were invited to relax and withdraw any intention or attention directed toward the experiment. One possible way to implement this protocol was through a single long period of each attention condition per session and participant. This would have had the advantage of allowing participants an extended time to adapt and settle into each condition. Another possibility was to alternate between brief periods of each condition within a session. This was less relaxing for participants and made for more complicated analyses, but it had the advantage of effectively cancelling slow drifts due to variations in laser output or changes in the alignment of the sensitive nonlinear optics. Because slight drifting of the **S** value was occasionally observed in test runs, it was deemed prudent to adopt the alternation scheme for all experiments.

Experiments

In Experiment 1, the controlling computer and the participants were located inside a double steel-walled electromagnetically (EM) shielded chamber (Series 81 Solid Cell chamber, ETS-Lindgren Cedar Park, TX, USA). The quED was in an adjacent room about 5 meters away from the chamber. Because the EM shielded room was electrically sealed, to get the **S** samples from the quED into the computer inside the chamber, (a) a translator was used to convert TCP-IP data carried by a CAT-5 cable (from the quED) into an optical fiber, (b) the fiber was passed through a small data port in the chamber wall, (c) data were converted back into CAT-5, and then (d) the cable was connected to the computer.

In Experiments 2 and 3, the quED was in the same location but the **S** samples were sent via a LAN to a computer in an office in another building about 100 meters away. Experiment 4 did not use an isolation chamber but was otherwise configured similarly to Experiment 1. The quED was operated at half-power (25 mA) to conserve the laser in the IONS experiments, and at 35 mA in the IMI experiment. This resulted in about 1,000 and 2,000 entangled photon pairs per second, respectively. The online experiment is described separately, below.

The IONS configuration used a Windows PC running a custom Matlab (version 2014b, Mathworks, Newton, MA) script that received the **S** data and presented participants with instructions and displays to provide graphical and/or audio feedback about the **S**-values. The IMI experiment used an Apple Mac mini running OSX.

Protocol

The experimental protocols and informed consent forms, which were read and signed by all participants, were approved by the IONS' Institutional Review Board (IRB number RADD-2019_01r072719) and by the IMI's *Comité Ethique.*

In Experiment 1, IONS staff who had previously participated in mind-matter interaction experiments were recruited. They included three adult men (including DR) and four adult women. Two of the women ran two sessions each, and DR ran a total of 4 sessions. One at a time, each person entered the shielded chamber and was invited to sit in front of the computer that received the **S** samples. The experimenter (DR) then described the nature of the task. Next to the computer was an electric candle controlled by an Arduino microcontroller. When the participant was ready to begin, the experimental session was initiated by the experimenter, whereupon a recorded voice played by the computer welcomed the participant. Sessions began with a one-minute rest period, during which 32 S samples were collected without feedback. This took place in near blackout conditions and with no sound. Then, in an alternating fashion, a recorded voice announced the attentional conditions to be adopted by the participant.

First, a voice spoke the phrase *get ready,* during which 5 **S** samples were collected without any feedback to the participant. Then the computer announced, *now please concentrate,* whereupon the next 24 **S** samples received were presented in graphical form and by varying the illumination level of an electric candle and the volume of a droning tone. Following that epoch, the recorded voice announced, *now please relax,* whereupon the electric candle automatically dimmed to a uniform low level, the drone tone was silenced, and 24 more **S** samples were silently recorded (and no feedback provided). After 15 repetitions of this *get ready-concentrate-relax* sequence, the session ended. During a session, participants were asked to prepare to focus their attention during the *get ready* epochs, to focus their attention toward the system while holding the intention to make the candle illumination level and droning volume increase during *concentrate* epochs, and to withdraw their attention and intention during *relax* epochs.

Each sample took about 1.5 seconds to collect: 1 second of acquisition time by the photon coincidence counter and 0.5 seconds for the stepper-motors to position the polarization analyzers. Data transmission and computer processing time added about 10 milliseconds for each sample. A typical session, consisting of 15 *get ready, concentrate,* and *relax epochs,* was thus completed in 20-25 minutes (see Table 1).

In Experiment 2, the same alternating epoch protocol was used, except the feedback for each epoch was randomly selected by the computer to either accurately reflect the S value or to reverse it. That is, for reversed feedback (during *concentrate* epochs) the graph, volume of the droning tone and rise in illumination of the electric candle both varied inversely with the value of **S**. As in experiment 1, during *relax* and *get ready* epochs, no feedback was provided.

The purpose of the reversed feedback condition was to test if the hypothesized effect was due to the act of attention alone, or if the modulation of entanglement strength alternated with the specific direction of mental intention (as mediated through the feedback signal). Participants were blinded to the feedback mode, which ensured a uniform participant experience and avoided confounds (such as unconscious preferences) that may arise when asking people to consciously adopt opposing intentions. A hypothesis that is consistent with the proposal that psi effects correlate with intention states is that the direction of **S**-value deviations would correspond to the (masked) feedback mode. Experiment 3 was similar to Experiment 2, except that all of the **S** feedback was uniformly reversed in all sessions. In addition, this and Experiment 2 involved only one participant (DR).

Experiment 4 was similar to Experiment 1, with three modifications: 1) the electric candle was replaced by a video animation of a glowing ball in a starry space whose luminosity and size varied with the real-time **S** value, 2) the concentrate period was set to 32 **S**-value updates instead of 24, and 3) of the 16 volunteers, 13 had never participated in a psi experiment, and 3 had on a single occasion. They included 10 adult women and 6 adult men. Ages ranged from 31 to 76, with a median of 58.5 years and a standard deviation of 13.2 years. The participants were recruited from attendees at a 10-day Buddhist group retreat after being invited through a public announcement. Participants were then greeted at a private home next to the retreat center for the scheduled sessions where the experimenter (PAB) welcomed them, explained the general purpose of the experiment, and introduced the equipment and the psi task. Participants were left alone in a darkened room with the feedback screen. The experimenter initiated the session start remotely and returned after the session ended to informally debrief participants about their experience and thank them for their participation.

There were three attentional instructions assigned to the participant: *get ready, concentrate,* and *relax,* as described above. A trial was the smallest period of data accumulation, corresponding to a single record of data used to generate an **S** value. Trial data records provided by the quED included the coincidence photon counts, the orientations of polarization filters, the feedback mode, and other experimental parameters. Recall that the **S** value was calculated from the trial's coincidence counts combined with counts from the previous 15 trials. A run was comprised of the three successive conditions, in the order *get ready, concentrate,* and *relax*. These assignments were announced to the participant by recorded audio at the start of each condition. Each run lasted about one minute and was comprised of either 53 or 61 trials (IONS and IMI, respectively). Finally, a session was a period of automated data accumulation with a preset number of runs. Sessions typically lasted about 20 minutes and were conducted with a single participant (or for control sessions, no participants).

Table 1.

Session Parameters for the 4 Experiments

	IONS_1	IONS_2	IONS_3	IMI
Total Sessions	12	10	9	16
Total Runs	180	154	144	192
Runs/Session	15	16*	16	12
Trials/Session	827	880*	880	780
Trials/Condition	5-24-24	5-24-24	5-24-24	5-32-24
Feedback mode	Forward	Random per Run	Reverse	Forward
Participants	7	1	1	16
Trial duration	2 sec	1.4 sec	1.4 sec	1.3 sec
Session duration	27 min	20 min	20 min	16 min
Control Sessions	12	10	118	18
Control Runs	180	160	1876	364

* One session in Experiment 2 consisted of 10 runs and 540 trials.

The overall prediction was that **S**-values associated with *concentrate* epochs would differ from **S**-values of *relax* epochs. The prediction was based on the hypothesis that intentional mental effort can directly influence entanglement, which in turn implies that different efforts would produce different **S**-values. A natural construction for statistical testing is the numerical difference in **S**-values for trials of different conditions. In particular, and while recalling that sessions comprise periodic cycles (runs) of *get ready-concentrate-relax* conditions, we take the difference for trials separated by half a run length. This difference, ΔS, is calculated for all runs in a session or group of sessions. ΔS is thus the average difference in entanglement strength between a fixed point in a canonical run and the paired value half a run cycle away.

Values for ΔS are indexed by the fiducial position which we term the *lag index*. For convenience, the position of the last *concentrate* trial of the first run is assigned lag=0 and $\Delta S_{l=0}$ is thus the **S**-value difference of all last trials[6] of the *concentrate* and *relax*

6 To be precise, at lag = 0, **ΔS** is the difference of the last ***concentrate*** trials with the 3rd ***get ready*** trials (that is, 3 trials after the last trial of the ***relax*** epochs). The small offset is due to the brief ***get ready*** epochs which add 5 trials to the full run length.

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epochs, respectively, across all runs and sessions. Calculating ΔSl for successive lags returns a vector, **ΔS**, and for the analyses presented here, **ΔS** extended to a lag = 500 is the basis for statistical tests of a psi entanglement effect. To avoid overcomplicating the description here, further details of this value's construction are provided in the Appendix, but two observations allow for the formulation of hypothesis tests.

First, under the Null hypothesis, each ΔS_l is a random variable with mean zero and variance determined by the Poisson statistics of the trials' total photon counts. This property was used to devise Monte Carlo simulations to estimate the test statistics' null distributions. Second, by construction **ΔS** oscillates with a dominant Fourier period equal to the number of trials in a run, which we call L (e.g., see Appendix C and Figure A.1). Therefore, for null data, regression fits of **ΔS** to a Cosine function with period L (i.e., an oscillation) will return fitted amplitudes related to the Poisson variance and phases specific to the dataset.

We wished to formulate hypotheses about deviations in **ΔS** when a psi effect was present, but because the experiment had no precedent it was not clear what type of deviations to test. Too specific a test risks missing the effect while overly broad tests generally have low power. Our solution was to combine a set of three tests of increasing specificity. For each test statistic, a *p*-value was determined by comparison with its Monte Carlo null distribution. The *p*-values were then Log-summed to create a Fisher chi-squared statistic for which an overall *p*-value was determined by Monte Carlo comparison (described in more detail in Appendix D). The final Fisher *p*-value was then used to test for the effect's significance (with alpha of 0.05).

The three test statistics were as follows: The first took the maximum deviation of **ΔS**, $\mathbf{\Delta S}_{max} = \max\{|\Delta S_l|\}$, which was the broadest application of the general hypothesis as stated above. The second test statistic was $\mathbf{A}_{Fit}$, the fitted Cosine amplitude with period L. This test was more specific than the first because its power would increase if an effect was distributed smoothly across runs. The third test was for the Cosine *phase*. It adds the specificity that effects would closely follow the alternating conditions of *concentrate* and *relax* across all runs and participants. In this case it was expected that the phase would lock into a value related to the lag where the effects were strongest. A naïve guess would set the phase locking to lag = 0. However, for reasons described in more detail in Appendix B, we used lag = 2.5 as the expected value of the Cosine fit phase. As with the other tests, this third test compared the measured phase with its distribution under the Null hypothesis (estimated by Monte Carlo simulation) to return a *p* value. A fourth hypothesis stated that the psi effect would be of opposite sign when the feedback mode was reversed. These hypotheses are listed in formal terms below (see the Appendix for more details).

Hypothesis 1: $\Delta S_{max} > 0$

ΔS_{max}, the maximum unsigned difference in **S** values during *concentrate* vs. *relax* epochs, will exceed the 95% confidence interval of its Monte Carlo Null distribution.

Hypothesis 2: $A_{Expt} > A_{Null}$

The **ΔS** vector is fit to

$$\Delta S_L = A * Cos\left(\frac{2\pi}{L_R} L - \phi\right),$$

where **A** is the positive Fourier coefficient, ϕ the phase, and $2\pi/L_R$ is the run frequency. The hypothesis states that the fitted parameter **A**, which models the oscillation of the **S** signal that is expected if **S** is indeed modulated by intention, will exceed the 95% CI of its Monte Carlo Null distribution.

*Hypothesis 3: Phase locking of **ΔS**.*

This is similar to Hypothesis 2, but more specific in that it predicts that the oscillation is also *in phase,* with a small lag, with the alternating attentional conditions.

3a) The 95% CI of the fit parameter ϕ will include the maximum at lag = 2.5.

3b) The standard deviation of the fit parameter ϕ will exceed the 95% CI of its Monte Carlo Null distribution. The latter is determined by a bootstrap re-sampling of the Monte Carlo data (see Appendix for details).

*Hypothesis 4: **ΔS** will correspond to the feedback mode.*

For this hypothesis, analyses of H1, H2 and H3 were carried out separately on the two types of feedback (forward and reverse). The hypothesis was that the difference between data subsets will be significant at the 5% level for at least one of the three hypothesis tests.

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Results

Across all experimental data, the results of hypothesis tests 1-3 yielded p-values of 0.045, 0.090 and 0.043, respectively. Combining these tests (while accounting for test dependencies, as noted below) yielded an overall $p = 0.017$. The feedback hypothesis, H4, was not supported, and all tests on control data were insignificant. A summary of the test results is shown in Table 2.

A stark difference was observed between the IONS and IMI datasets, which were acquired separately, under quite different conditions, and with distinct participant pools and environmental settings. The IMI data produced nonsignificant results on all measures, whereas the IONS data were strongly significant on tests 1-3 and independently provided evidence for an anomalous effect on photon entanglement strength. These tests are described in more detail below, with an emphasis on the significant results of the IONS data. Figure 2 provides a graphical overview of the tests, showing the **ΔS** lag curve, its extremum (per H1), a cosine amplitude fit (H2), and an "**S**-value Condition Coefficients" curve which models the effect (per H3). See the Appendix A, B, C for details about these measures.

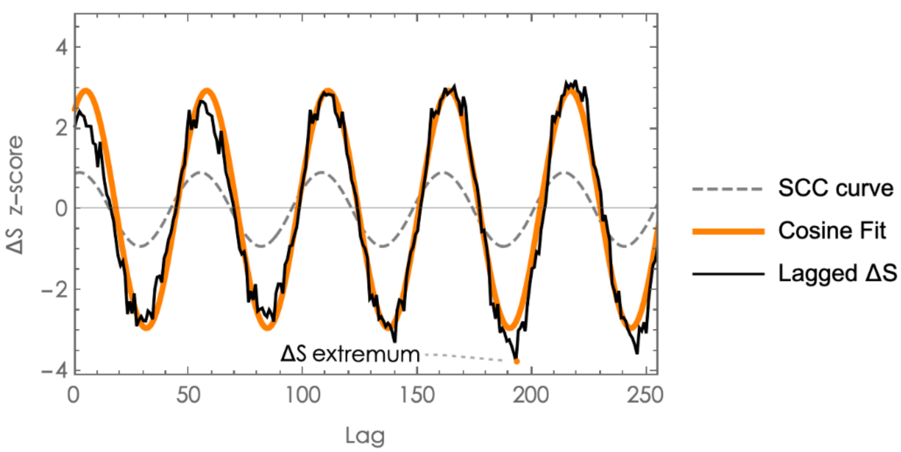

Figure 2. A portion of the ΔS lag curve for all IONS data (black trace), as compared to a cosine fit with free parameters of amplitude and phase (orange curve), and a **S**-value Condition Coefficients (SCC) curve (dotted line). The horizontal axis is the trial lag factor and the vertical axis gives the ΔS standard deviation from zero (i.e., the z-score). The ΔS extremum of H1 is also indicated.

Table 2

One-tailed P-Values for Tests of H1, H2, H3 and for a Composite Chi-squared Statistic (Fchi), which Combines the Three Values

	Session *p*-values			
	H1	H2	H3	Fchi
IONS	0.014	0.003	0.008	<0.0002
IMI	0.54	0.54	0.41	0.58
All Data	0.09	0.045	0.043	<0.017
	Control *p*-values			
IONS	0.80	0.91	0.66	0.95
IMI	0.31	0.65	0.20	0.37
All Data	0.88	0.56	0.35	0.79

Note: The *p*-values were estimated by Monte Carlo simulations performed separately for the IONS and IMI datasets. The independent IONS and IMI *p*-values were combined using a weighted Stouffer *Z* (inverse normal) procedure to yield global *p*-values for the entire experiment for each hypothesis as well as the combination Fchi. These tests indicate a clear effect in the IONS data and no effect in the IMI data.

Hypothesis 1: $\Delta S_{max} > 0$

The maximum deviation from zero (as a *z*-score) was extracted (for IONS data this was z = -3.77 at lag 193; *see* Figure 2). The absolute value of the extremum was then compared to its Null distribution, as determined by Monte Carlo simulation. This yielded a *p*-value estimate of *p* = 0.014 for the IONS data. An identical analysis of the IONS control data yielded *p* = 0.80.

Hypothesis 2: $\mathbf{A}_{Expt} > A_{Null}$.

The **ΔS** curve was fit to a cosine function (Figure 2) with free phase parameter and fixed period equivalent to that of the 53-trial experimental run length, L_R. The co-

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sine amplitude was compared to its Null distribution, as determined by Monte Carlo simulation. The *p*-value estimate was *p* = 0.003, while control data yielded *p* = 0.91. To assure that the optimal fit to **ΔS** did indeed occur at a cosine period of L_R, the analysis was repeated with cosine periodicities ranging from 20 to 90 lags. It was confirmed that the Fourier amplitude was maximized at a cosine periodicity set to the run length, L_R (Figure 3).

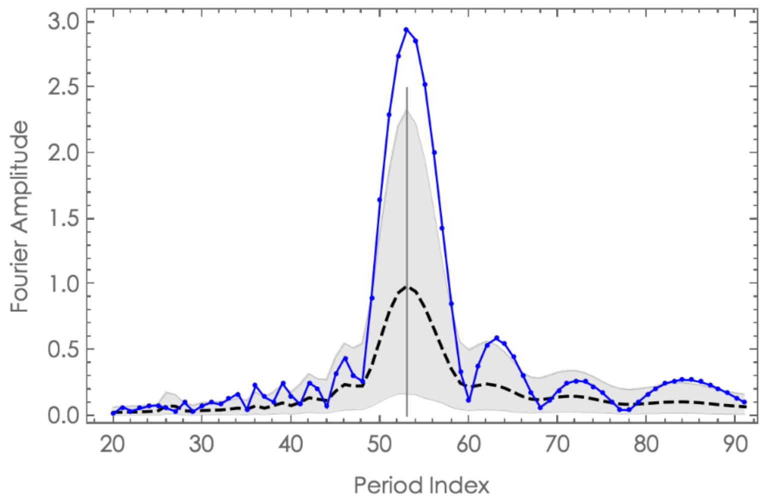

Figure 3. Positive cosine amplitude determined from fits to the **ΔS** lag curve for cosine periodicities ranging from 20 to 90 lags. The peak amplitude occurred at index 53, corresponding to the actual run periodicity. The blue trace is the fitted amplitudes from the IONS data, and the gray envelope is the 95% Confidence Interval (CI) of the Null distribution as determined by Monte Carlo simulations. The dashed line shows the Null mean values of amplitude fits, indicating that even for no effect, null data will produce a maximum at lag 53 for this analysis. The 95% CI is relative to the mean, however, and the amplitude fit to the data far exceeds that range.

Hypothesis 3: Phase locking of ***ΔS***

Phase locking was tested by first determining that the fitted phase agreed with the model value of lag = 2.5, and then testing for a reduced variance of the phase. The reasoning was that an anomalous effect that alternates with the intentional condition ought to lock the fitted phase to the model (see Appendix), thereby reducing the variability of the phase when fit to the data. Alternately, data that happened to yield a false positive result for H1 and H2 would not necessarily exhibit phase locking.

The fitted phase and its standard error (in lags) were 4.74 ± 2.86. The model maximum, at lag 2.5, was within a standard deviation of the phase parameter. The data and the model were thus aligned to within statistical error. To determine phase-locking, the standard deviation of the fitted phase was compared to its Null distribution obtained from bootstrap resampling of the Monte Carlo surrogate data. Further details are in the Appendix. This procedure resulted in p = 0.008 for the phase locking. The same analysis for control data was p = 0.56.

Combined results across Hypotheses and datasets

For the IONS and IMI datasets, we combined dependent *p-values from Hypotheses 1-3 using a modification of Fisher*'s method. Results from the independent IONS and IMI datasets were combined using a weighted Stouffer Z. The Fisher Chi Square combination of *p*-values, *Fchi, was given as the sum of the p-value logarithms*:

$$Fchi = -2 \times \sum_{i=1}^{N=3} Log[P_i]$$

Fisher's method assumes that the quantity *Fchi distributes as* χ^2 *with 2N degrees of freedom for independent* P_i. However, the three hypothesis tests were not independent, thus an empirical distribution for *Fchi* was determined via Monte Carlo simulation, which incorporated all dependencies into the cumulative distribution function. Using this technique, a combined *p*-value for the IONS data was $p < 0.00021$, and for the control data, p = 0.95 (Figure 4).

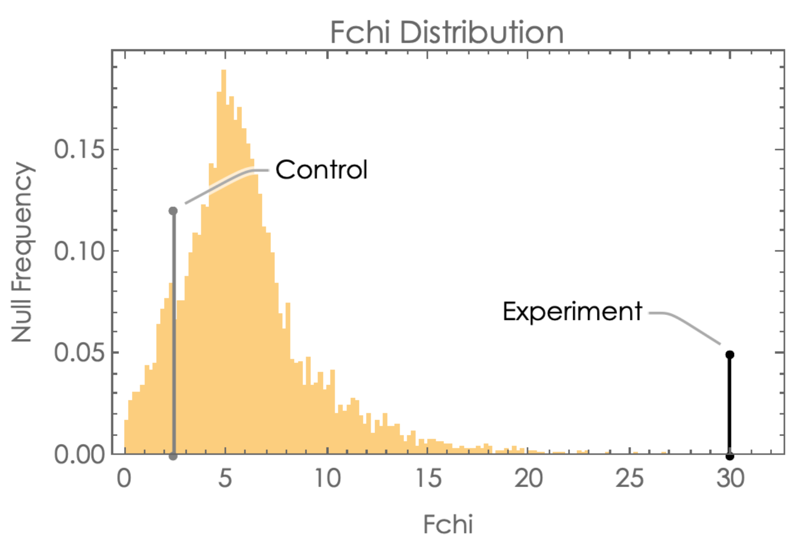

Figure 4. The Null ***Fchi*** distribution from combining ***p***-values of tests for H1, H2 and H3. The ***Fchi*** values for session and control experimental data are indicated. The session ***Fchi*** exceeds the largest value of the Monte Carlo distribution, thus the overall ***p***-value estimate depended on the number of repetitions of the Monte Carlo and a more accurate ***p***-value estimate may well be smaller.

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*Hypothesis 4: **ΔS** changes sign with feedback mode*

A comparison of feedback modes was performed for the corresponding subsets of the IONS data (IMI data were collected only for the Forward feedback mode). It was found that **ΔS** deviated in the direction of increased entanglement for both feedback modes, and that the deviations were independently significant at the 0.05 level under the combined tests of H1-H3 (see Table 3). Tests of the difference between the two feedback modes were not significant. The hypothesis H4, that directed intention would correlate with the sign of the effect, was therefore not supported.

Note that the calculation of the **ΔS** lag curve required that the data maintain a regular cycling of polarizer settings throughout each session. Consequently, feedback subsets from experiment 2 were not included in the test of Hypothesis 4 because the feedback mode in that study was randomly assigned from run to run and extracting data by feedback disrupted the continuous ordering of the polarizer settings. The tests of *Fchi* presented here thus compared data from experiments 1 versus 3, where the feedback mode was fixed for the duration of each session.

Table 3

Results of Testing Hypothesis 4 among the IONS Experiments

	Session Data			
	$\Delta S \cdot 10^{-3}$	**$Z_{\Delta S}$**	***Fchi***	***Fchi p*-value**
All IONS	5.7 (2.4)	2.43	29.9	<0.00021
IONS Forward	5.0 (2.9)	1.71	17.0	0.01
IONS Reverse	7.8 (5.1)	1.54	13.4	0.04
Fwd - Reverse	-3.3 (5.8)	-0.56	6.6 (4.7)	0.15

	Control Data			
	$\Delta S \cdot 10^{-3}$	$Z_{\Delta S}$	*Fchi*	***Fchi p*-value**
All IONS	1.8 (1.4)	1.22	2.4	0.89
IONS Forward	3.5 (3.2)	1.10	1.1	0.97
IONS Reverse	0.1 (1.7)	0.04	2.6	0.88
Fwd - Reverse	2.7 (2.9)	0.95	1.5 (4.7)	0.69

Note; Table entries for the values of **ΔS** at lag L = 2 and the corresponding standard deviations from zero ($Z_{\Delta S}$) were calculated from data of all three IONS experiments. The *Fchi* values and corresponding *p*-values for the IONS Forward and Reverse modes were calculated from experiments 1 and 3 only.

Effect sizes and power estimates

The data from the IONS experiments allowed us to estimate the experimental effect size (ES) and to examine the experiment's power under scenarios of different effect sizes (refer to Appendices D and F for more details). We employed a mean-difference type ES, which is defined[7] as ES = $\Delta S_{lag2.5}/4$ and employs the value of **ΔS** at the lag 2.5. An estimate of ES from the experiment was thus obtained by the measured value, $\Delta S_{lag2.5} = 0.00575 \pm 0.0024$ divided by 4, whereby $ES_{Exp} \approx 0.0014$. With ES_{Exp} as input, the Monte Carlo simulations return $ES_{MC} = 0.00566$, which confirms that a simple Monte Carlo model with ES as input captures the main effect we measured.

The Monte Carlo model uses a constant effect, neglecting any inter-session or inter-run variability. Despite this simplification, the model nevertheless allows for useful power estimations of the various tests and analyses we have presented. A summary plot is shown in Figure 5. The estimates show that the *Fchi* statistics, which include H3, give a substantial power increase over the tests taken individually or in pairs without H3. Although Figure 5 also shows that a simple test of **ΔS** at lag = 2 has the highest power, the test assumes no variability among sessions and runs, as well as prior knowledge of the optimal lag for testing. None of these conditions are likely to hold in a real experiment. Thus, for real data on a new experiment, we expect that the *Fchi* test that we developed and used for analysis would have the highest power among the approaches outlined.

7 The factor of 1/4 is not fundamental and was merely a consequence of how the analyses were constructed; other, equivalent algorithms could have used a different scale factor.

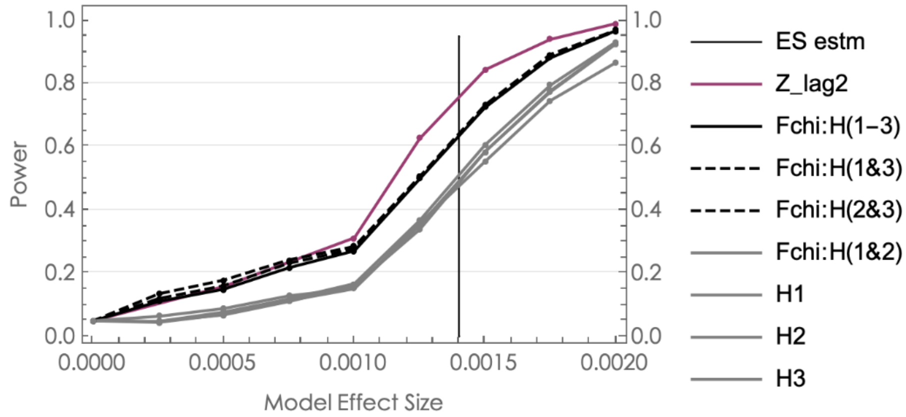

Figure 5. Power estimates for hypothesis tests and combinations of tests, as estimated by constant effect Monte Carlo simulations. The horizontal axis is the model effect size, as described in the text, and the vertical axis is the statistical power for significance at an alpha level of 0.05. The Fchi power curves refer to combinations of hypothesis tests, H1, H2 and H3. Combined tests that include the phase variance tests of H3 have higher powers than any of the tests individually, or combined tests without H3. Z_lag2 is the power of the **ΔS** z-score at lag = 2, for this model. The vertical bar indicates the estimated effect size of the experiment (an estimate of the uncertainty is ~0.0004 at one-sigma).

Method: Online Experiment

In this version of the experiment, **S** samples were sent over the Internet from the quED device located in the IONS laboratory to an Amazon cloud server (Figure 6). The experiment was programmed using a combination of PHP, Javascript, Ajax, and MySQL, and the web server was a Ubuntu Linux virtual machine hosted by Amazon. The server operated continuously and assigned each incoming **S** sample to either a *concentrate* or *relax* epoch, where each epoch was uniformly 24 samples in length. Each sample took an average of about 2 seconds to process, approximately 500 msec longer than in the laboratory tests, due to Internet transmission and server processing time. The two types of epochs automatically alternated after collecting 24 samples.

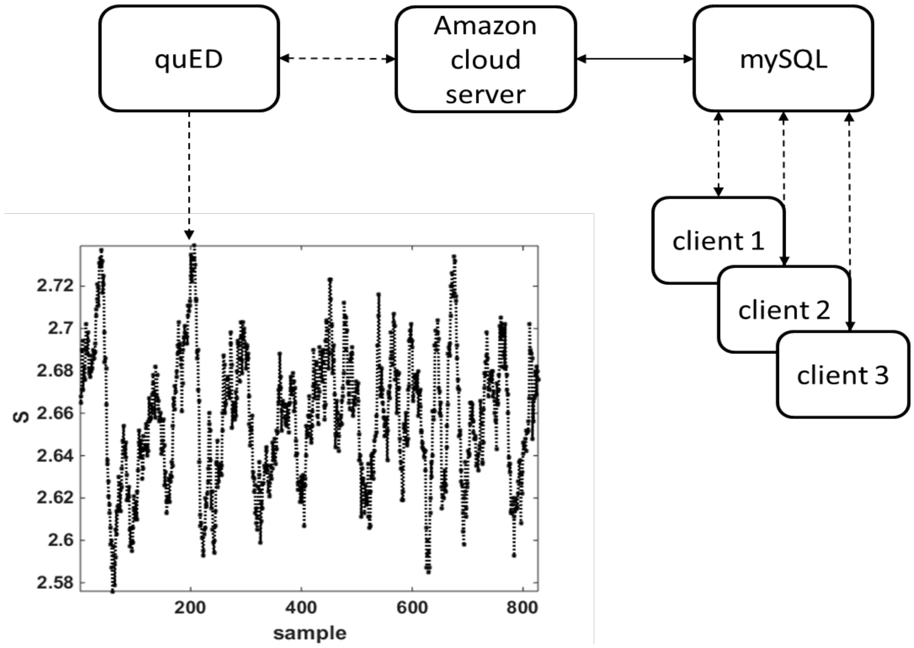

Figure 6. Online experiment infrastructure. All data, including the **S** samples and the attention assignments, were stored in a mySQL database. A SurveyMonkey.com questionnaire was used to collect information about the participants. User logins were handled via a Google login process, and user identities were anonymized via md5 encryption.

Procedure

When a user navigated to the website *entangledphotons.us*, the browser led the participant through a login process to create a unique ID and then presented options for two types of feedback displays. One was a graph similar to that used in the laboratory experiments; the other was a "bubble cloud" display that looked like a collection of randomly bouncing colored bubbles. The feedback provided in both displays was accurate in the sense that an increase in **S** was reflected by a line in the chart going up, or by the randomly moving bubble cloud coalescing into a pleasing toroid shape. Besides the visual feedback, a whistling wind sound was also played, in which the pitch of the wind corresponded to the height displayed in the graph or to the degree of bubble coalescence.

As in the laboratory studies, during *concentrate* epochs the feedback was displayed and during relax epochs the feedback display was removed and replaced by a grey rectangle. Unlike in the laboratory studies, there was no *get ready* condition.

If the web server failed to receive an **S** value from the quED within a few seconds, to avoid freezing the feedback display the server automatically switched to a pseudorandom number generator to produce "pseudo-S samples" generated uniformly

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at random between the values 2.1 and 2.3. These pseudo-samples were noted in the database, but the feedback presented to the participants was not altered to allow the website to continually remain active. When the quED failed, the device was manually reset to continue to generate entangled photons.

Because the data from the quED were automatically sent to a database on the Amazon cloud server, by design this allowed many people to participate in the experiment at the same time. That is, the same feedback display under the same attention condition could be viewed on many web browsers. This provided a way to explore the effects of multiple people attempting to simultaneously influence the entangled photons. When no observers were engaged with the system, the quED data continued to generate **S** samples and send them to the database, providing an ongoing no-observation control condition.

A candidate participant clicking on a button in their browser to start the experiment was taken as a positive consent to participate in the study. The instructions were to mentally attend to the feedback with intention to increase entanglement strength during the *concentrate* epochs, and to withdraw attention and intention during the *relax* epochs.

Analysis

The analytical methods used to evaluate the data produced in the online experiment differed from the methods used in the laboratory studies for two reasons. First, by design multiple people could conduct the study at the same time, so besides examining overall results, the data could be examined separately for none (the control condition), one, two, or more simultaneous participants. Second, the quED device was not designed to operate continuously for long periods of time, so the quality of photon entanglement began to degrade over time. The change in **S** values and occasional failure of the quED system required several preprocessing steps to transform the recorded data into useable samples.

Figure 7 shows the full set of data recorded in this experiment. Samples in the range 2.1 ≤ **S** ≤ 2.3 were generated by the pseudorandom algorithm. Each such sample was marked in the database to distinguish it from an **S** value. A second type of sample was noise, identified as values below 2.1 or above 2.83 (the Tsirelson Bound). This occurred when **S** values were either not transferred correctly to the cloud server, or when spurious values were generated by the quED. A third category was valid **S** samples.

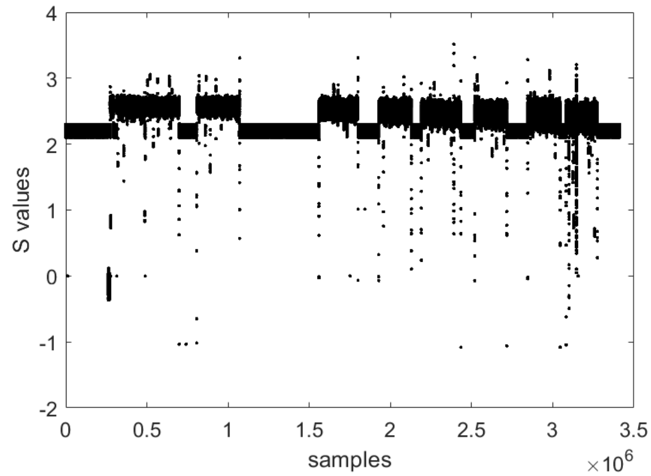

Figure 7. All collected samples in the online experiment. Values between 2.3 and 2.8 represented valid entanglement **S** measures. Values between 2.1 and 2.3 were pseudorandomly simulated samples, and outliers were quED or transmission artifacts. All pseudorandom and artifactual samples were excluded from subsequent analyses.

Figure 8 (top left) shows the data remaining after extracting the pseudo-**S** samples. To remove outliers, the remaining data were linearly detrended to remove long-term drift (Matlab function *detrend*) and then an outlier removal function (Matlab function *rmoutliers*) was applied with a sliding median window 10,000 samples in length. This function identifies outliers as median absolute deviations greater than 3, based on the local median in the sliding window. These two procedures resulted in Figure 8 (top right). The final pre-processing step removed nonlinear periodicities present in the outlier-removed data. To do this, a second order Savitzky-Golay filter was applied to the data (Matlab function *smooth*, with option *sgolay* and window length 97, i.e., four epochs of 24 samples each plus 1, the latter because the filter window length is required to be odd), and then the resulting smoothed curve was subtracted from the outlier-removed data. This resulted in the data shown in Figure 8 (bottom left).

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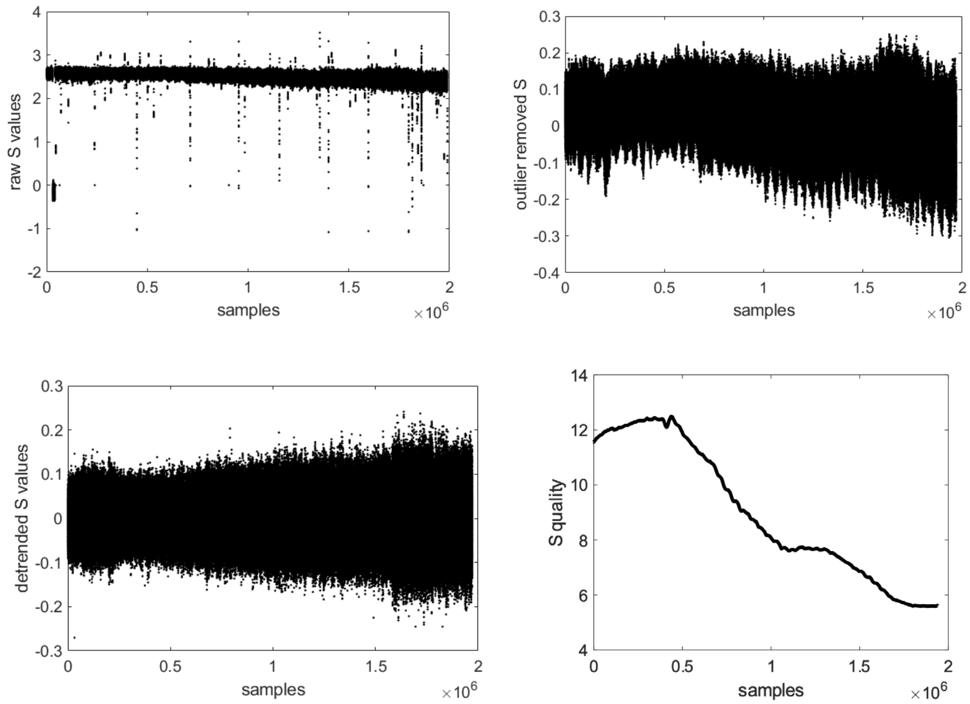

Figure 8. Top left: All **S** samples collected from the quED. Top right: After linear detrending and outlier removal. Lower left: After removal of nonlinearities with a Savitzky-Golay filter. Lower right: Photon pair entanglement quality in terms of number of sigma above classical correlations.

The increase in variance of the **S** residuals (call these $\mathbf{S}_R$), which is visually evident in Figure 8 (lower left), was due to two reasons: (1) cumulative minor misalignments of the quED optics, which were in turn caused by vibrations in the polarization filters as they were rotated, and by diurnal variations in ambient temperature, and (2) degradation of electronic components in the laser's power control circuit, which reduced the laser's illumination intensity and eventually brought the experiment to an end when a key component completely failed. The consequence of this increase in variance was that the quality of the entanglement correlations progressively degraded. For the first 500,000 samples, the observed value of **S** exceeded the CHSH value for a classical correlation by about 12 sigma (Figure 8, lower right, calculated as sigma = $(\mu_s - 2)/\sigma_s$). After 500,000 samples, entanglement quality systematically decreased, dropping to about 6 sigma by the end of the experiment. That end point was still far above the threshold for classical correlations, but because of the clear decrease in entanglement quality, the first 500,000 samples were analyzed separately from the remaining samples.

To evaluate the results of the experiment, each completed concentrate and relax epoch (each with 24 contiguous **S** values) was identified, and then the median of the last 8 $\mathbf{S}_R$ samples in each epoch was determined. The statistical difference in the resulting medians was evaluated using a t-test at lag 0, this process was repeated up to lag +10, and then the False Discovery Rate (FDR) algorithm was applied to the resulting 11 tests (Benjamini & Hochberg, 1995).

This procedure was applied to the first 500,000 $\mathbf{S}_R$ samples for one or more users and then compared to the same measures for zero users, which acted as a control. Then the same procedure was applied to the remaining samples. A similar analysis was then conducted for just one user, two simultaneous users, and so on, up to the maximum number of users contributing at least 20 completed *concentrate* and 20 *relax* epochs.

Results

The online experiment ran continuously for three months (April through June 2017). During that time, 1.97 million **S** samples were successfully received from the quED system. Of those, 228,000 **S** samples were observed by one or more participants and 1.8 million were not observed. Over 750 people participated from around the world.

Analysis of the first 500,000 samples for one or more participants identified 125,413 observed samples and 374,587 unobserved samples. Of the former, approximately 3,000 completed epochs were identified in the *concentrate* and *relax* conditions. We say "approximately" because the number of samples in the two conditions differed slightly. This occurred because in the process of removing outliers it was no longer guaranteed that a completed *relax* epoch would always follow a completed *concentrate* epoch. Likewise, when the data were lagged the attention conditions changed the boundaries of the epochs. Thus, for some epochs that had 24 contiguous samples at 0 lag, when the condition boundaries were shifted, they might no longer have had 24 contiguous samples. Any incomplete epochs were excluded from further analysis.

Comparison of the observed epochs indicated a significant increase in entanglement strength for lags 0 through 5 (after adjustment by FDR at $p < 0.05$, see Figure 9, left). For the unobserved samples, some 7,800 completed epochs were identified, and none of the lags were significant. In addition, the difference in entanglement strength between observed and unobserved samples was significant for lags 0 through 7 after FDR adjustment. The same analyses applied to the remaining 1.5 million samples, of which approximately 2,200 were observed epochs and 28,800 were unobserved epochs, were uniformly nonsignificant after FDR adjustment (Figure 9, right).

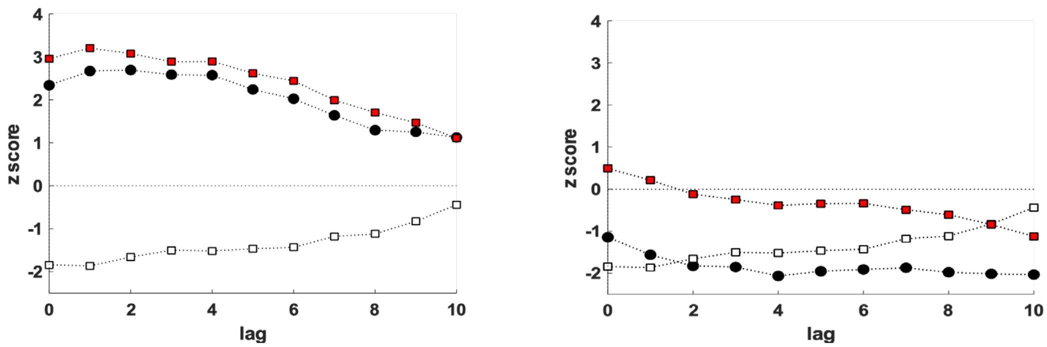

Figure 9. Black circles are results for observed data from lags 0 through 10, white squares are the same for unobserved data, and red squares are the difference between those two curves. Left graph: Analysis of first 500,000 samples recorded during high-quality entanglement. For observed data, lags 0 through 5 are significant after adjustment for False Discovery Rate; for unobserved data, no lags are significant. Right graph: Same analyses for the remaining 1.5 million samples. None of the results in either condition are significant.

Figure 10 shows the results by number of observers for the first 500,000 samples and for the remaining 1.5 million samples. These graphs are shown in terms of effect size rather than *z* scores because the number of epochs contributed by multiple participants differed, as indicated by the error bars. None of these results were significant after FDR adjustment, but there is a suggestion with the initial 500,000 samples that the more simultaneous participants, the larger the resulting effect size.

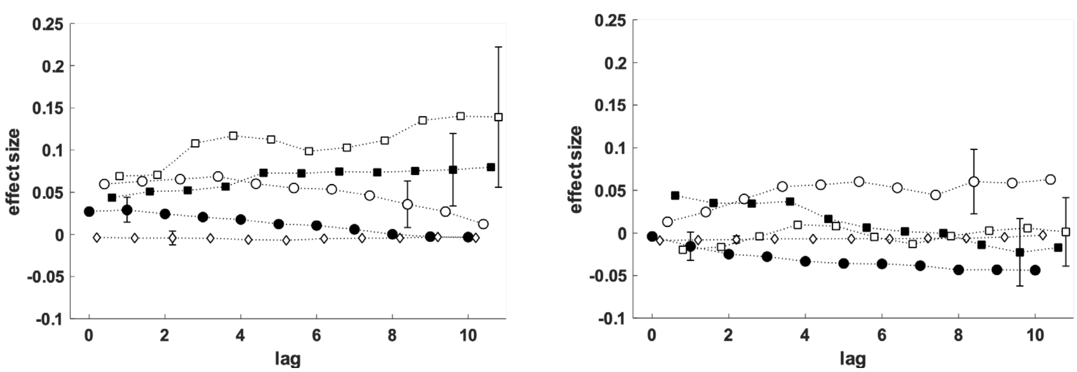

Figure 10. Black circles are experimental results in terms of effect size for one participant, white circles for two simultaneous participants, black squares for three, and white squares for four. Small diamonds represent effect size for no observers. Error bars are ± 1 sigma. Left graph: First 500,000 samples. Right graph: Remaining 1,471,589 samples.

Discussion

These studies probed correlations between directed mental attention and intention and entanglement strength in pairs of photons. To our knowledge, explorations of possible mental interactions with nonlocal forms of matter have not been previously reported. Accordingly, the results presented here should be considered preliminary. With that caveat in mind, the outcome for all four laboratory studies combined was determined to be $p < 0.02$, with the outcome for the three IONS experiments combined at $p < 0.0002$ (or possibly more significant, as this *p*-value was determined based on the number of repetitions used in the Monte Carlo procedure). Identical analyses applied to the IMI data, which were collected under different conditions and with a different participant population, did not attain significance. The online experiment produced indications of an effect on data with higher-quality entanglement, and those results may be elucidated in more detail in future analytical work.

Although nonlocality is well-established as a feature of the quantum realm, its relevance and application to the mind remains unclear. These experiments were a first step in exploring whether nonlocality might play a role in this regard or whether the seeming parallels between nonlocal mind (psi) and nonlocal matter are merely a coincidence. Should nonlocality turn out to be a common feature of both mental and quantum domains, it may provide a hint for approaches that attempt some kind of unification, such as that proposed by the philosophy of neutral monism. Progress along these lines will depend on the careful examination and subsequent extension of these first results.

A principal challenge in these studies was to devise a protocol that would accommodate unavoidable drifts in the measured strength of entanglement correlations, and the fact that the quED design required collecting coincidence counts across 16 consecutive trials to produce a single **S** value. The adopted protocol, using short, alternating epochs of *concentrate* and *relax* conditions, eliminated problems of drifts and offsets when comparing attentional conditions, but at the cost of including **S** values derived from data generated under a mix of conditions. The two analytical approaches we discussed handled this drawback by testing statistics as a function of the run lag.

The genesis of these analyses was as follows: The analysis of the online data was first devised and applied to those data and the laboratory data by DR, using a Matlab platform. The laboratory results indicated significance exceeding the $p = 0.05$ level. That analysis was then verified by PAB using new code on the Mathematica platform. At that point it became clear that an approach with more statistical power was possible, so PAB devised a new test combining three hypotheses. That procedure was developed and then applied to the data, as described herein. That analysis, however, could not be applied to the more complex online data. Consequently, we have reported the results of the first, simpler analysis for the online data, and a second, more detailed analysis, for the laboratory studies.

Future Studies

These results lay the ground for future confirmatory replications in which analyses can be specified before data collection. The studies described here provided the basis for effect size and power estimates, as well as a guide to upgrading the experimental design and apparatus. Improvements to consider are the use of more stable lasers and optics, which can alleviate problems of drifts and entanglement quality, and an augmented detection system employing beam splitters instead of mirrors and 4 or 8 coincidence detectors. This would permit calculation of **S** measurements in one or two steps, instead of 16, and allow for analyses that avoid **S**-values obtained under mixed attentional conditions.

A deficiency of the lab experiments, which became clear in hindsight, is that they did not collect baseline data immediately before and after each session. Baselines of 5 to 10 minutes immediately prior to and after data collection (with participants absent and without any adjustments to the apparatus) would be helpful in documenting the equipment's stability. This is an important feature to be included in future studies.

Challenges

Before turning to the novel implications of these experiments, we address several well-known issues in research involving psi phenomena. The first is the variability and difficulty in reproducing psi effects (Rao, 1985). Obtaining different results in seemingly comparable circumstances, as we found for the IONS and IMI lab studies, is not uncommon in this domain, or indeed in many other, more conventional experimental domains (Hudson, 2021). Discussions about a "reproducibility crisis" in science remain an ongoing challenge in identifying and firmly establishing all sorts of interesting effects, including psi (Guttinger, 2020).

Still, we expect that process-oriented research will continue to make progress. Two recognized factors for obtaining better results are the use of participants who are familiar with the nature of the task, and even better, who had performed well on previous studies. In addition, it is desirable to have a setting that allows for the participants to apply their full and relaxed attention to the experimental tasks. Although the

IONS experiments attempted to optimize these factors, this was not the case for the IMI study. The IMI experiment was conducted primarily with first-time participants who had limited time to settle into the experimental sessions because they were following the demanding schedule of a group meditation retreat. Another consideration was the relatively small size of the participant pool at IONS, which can impact the variability of effect sizes. The discrepancy in results is thus not inconsistent with previous experience and observations reported in the psi literature.

A second issue pertains to the problem of determining the locus of the effect, as alluded to at the beginning of the paper. Two competing interpretations of psi effects are the psychokinetic (PK) paradigm (Varvoglis & Bancel, 2015), and that of precognitive selection or Decision Augmentation Theory (May et al., 1995). Under PK, attention and/or intention are assumed to not only correlate with measured deviations in the behavior of the physical system, but to *cause* those changes. By contrast, precognitive selection posits that the participants' or investigators' intuition informs the fortuitous timing of data collection so as to take advantage of naturally occurring fluctuations in the data that "just happen to" favor confirmation of the hypothesis.

Both ideas assume the existence of anomalous psi effects, but with the selection paradigm the target system is not influenced at all, only a biased selection of data are extracted from an otherwise unperturbed system. The analyses we used in the experiments described here could not definitively distinguish between these two mechanisms and we would have detected the same statistical results in either case. However, because we are ultimately interested in inferences that might be drawn from a causal PK effect on entanglement, this was a limitation in the current experiment's design, which should be addressed in future studies.

Ways to potentially control for selection effects include reducing the degrees of freedom for when the experimenter or participant decides to start a session, collecting data before and after sessions, and randomizing session durations. These measures should be understood through modeling and folded into future protocols. Although the preliminary protocol reported here did not consider this design feature, the results do provide some peripheral support of the PK hypothesis because of the nonsignificant result of the feedback hypothesis, H4. A straightforward interpretation of the selection hypothesis would have predicted that the direction of observed effects and the method of feedback should agree, whereas there was no evidence of that in these data. We will be interested to see if this speculation is borne out by a future protocol that incorporates selection screening.

If such a protocol were devised, and the results were consistent with a PK effect, then it is still not certain that the results could be attributable only to a modulation of entanglement strength. Alternatives could include influences on elements of the optical apparatus, the electronics of the coincidence counter, or some other component of the experimental system. That is, a PK effect might take advantage of well-known weaknesses (loopholes) within the standard Bell-CHSH experiment (Yang & Zhang, 2021). Consequently, identifying and closing these loopholes will be necessary to strengthen evidence for a PK effect that specifically modulates entanglement. A full discussion of this issue is beyond the scope of this paper, but two possible avenues worth mentioning are: (a) to adapt solutions used to close standard loopholes in Bell experiments, particularly the so-called detection and measurement independence (free-choice) loopholes which can be viewed (under the psi hypothesis) as a hybrid of PK and selection; and (b) to explore other types of entanglement experiments, such as quantum steering or tripartite scenarios that might offer independent support for a true entanglement effect (Ruzbehani, 2021).

Implications

Assuming for the moment that the mind-modulated entanglement hypothesis is correct, several observations and potential inferences follow. Our results are the first to address quantum nonlocality directly as a potentially deep, albeit ill-defined connection between psi phenomena and quantum systems. That is, previous mind-matter interaction experiments have involved psi interactions with distant physical systems, but not physical systems known to have nonlocal properties. That includes previous experiments designed to test if focused attention and/or intention can modulate quantum-based randomness, such as electron tunneling phenomena in semiconductors (Jahn et al., 2007), and experiments testing whether psi perception can influence photon interference in a double-slit optical system (Radin et al., 2021).

A second observation is that, lacking evidence for intentional steering (as per H4), it may be that observed effects on entanglement strength are associated with mere attention alone. This would stand in contrast with the relevant literature on so-called goal-oriented psi effects, in particular the results of many micro-PK studies using truly random number generator outputs as targets (Bancel, 2017; Varvoglis & Bancel, 2015). Many of those studies conclude that intention “steered” the direction of the effect, contrary to what we observed in these experiments. What is less clear is whether those previous studies are explainable in terms of psi selection (May et al., 1995), or instead suggestive of PK (Dobyns, 2000). Finding that the distinction between intentional steering and the application of mere attention is associated with a PK/psi-selection dichotomy would be a useful advance that could influence theoretical models as well as advances in experimental design.

The measured increase in **ΔS** suggests that the quality of entanglement (and by extension its value as a nonlocal resource) is increased when coupled to attentional awareness. This is surprising because interactions with external systems generally cause entanglement to dissipate. There exist quantum information procedures for increasing the quality (fidelity) of entanglement, but these "distillation" protocols involve operations on multiple copies of entangled qubits (Ecker et al., 2021), and it is not obvious how that is relevant to coincidence measurements in single photon pairs, as measured in our experiments. Further investigations of quantum distillation might provide insights into how entanglement could be accessible to processes associated with mental states. Theoretical questions aside, it is important to note that *any process* that increases the fidelity of entangled states is of central interest in quantum information technologies such as computing, encryption, key distribution, and teleportation. That consideration alone provides a strong motivation for continued research.

The magnitude of the **ΔS** increase that we measured is also noteworthy. We found $\mathbf{\Delta S_{exp}} \approx 0.0057 \pm 0.0024$. The most refined attempts to date to approach the upper limit of quantum entanglement (the Tsirelson Bound) have reported values of $\mathbf{S_{TB}}$ - **S** as small as 0.0008 ± 0.0005 (Poh et al., 2015). The size of the positive modulations in **S** that we measured thus exceeds the gap between the Tsirelson Bound and the best reported **S**-values. Our exploratory experiments are thus successful in demonstrating that a test to see if mind can modulate entanglement beyond the Tsirelson Bound is a practicable goal. Such a test, if successful, would have deep implications. If the Tsirelson Bound is in fact a hard limit for psi-mediated entanglement, as it is for conventionally prepared quantum systems, it would indicate that psi phenomena obey quantum theory and suggest that theories of psi should be compatible with current physics, at least as far as information dynamics are concerned. However, if mental intention violates the Tsirelson Bound, it would imply that quantum theory provides an incomplete description of the world when systems incorporate certain mental phenomena. Such a test could empirically inform the metaphysical puzzle that seeks to discover the fundamental constituents of our world. In that case, a suitably devised test might be able to distinguish qualia as more fundamental than the qubit, or vice versa. In philosophical terms, this could be a test of idealism versus materialism, or it could offer guidance for the formulation of a "middle way," such as neutral monism.

As this discussion makes clear, there is much to do before such an experiment can be performed in a convincing manner. It is worth mentioning that it took nearly

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40 years to achieve a loophole-free demonstration of nonlocal Bell correlations.[8] The first step toward such a test in the present domain would require access to entanglement sources with improved stability and fidelity. Then it would be useful to design optical configurations with multiple coincidence detectors and fixed analyzers, as that would eliminate the need for stepping through the 16 polarization conditions, providing single-shot measurements of **S**. Such a set-up would provide further flexibility for designing comparisons between concentrate and relax periods, and would facilitate experiments to explore the key question of whether the underlying effect is better understood as PK or as selection. Equally important would be attracting interest from researchers in the quantum information community, who could supply much-needed advice on a range of subtle issues regarding entanglement. We hope that this paper will serve in that regard.

Replication Issues

On the psychological side of the hypothesized psychophysical effect, it is important to emphasize that the experiments described here, as well as possible future designs, are not simply physics experiments. It would be a mistake to assume that simply asking a person to focus their attention toward the physical apparatus will be sufficient to observe the effect. The phenomenon at issue here is more subtle, involving psychological attributes of the experimental set and setting, as well as tacit factors that have yet to be fully recognized or elaborated.

As already mentioned, among factors suspected to influence outcomes in previous psi experiments, there are obvious variables like the participant's level of comfort with the environment in which the test is conducted. In addition, the type and presentation of specific tasks involved, the nature of the feedback (if any), the outward attitudes of the experimenters (e.g., warm and enthusiastic versus cold and skeptical), and unconscious biases or concerns held by either participants or investigators, may also influence outcomes.

Another consideration is how best to match participants to a given experimental protocol. The assumption that all participants are equal is obviously an error, and psi research has shown that results are improved when some pre-selection of participants is adopted (Alexander et al., 1998; Ryzl, 1963). However, the strategies of par-

8 That is, experiments that simultaneously close the locality and detection loopholes. Very strong constraints have been put on the so-called free-choice (or, measurement independence) loophole. But this loophole cannot be closed completely. A demonstration of Bell nonlocality that simultaneously addresses all three has yet to be performed.

ticipant selection are more of an art than a science at this point, and as such it adds overhead to the experimental program.

With such a range of factors that might influence the outcome, developing replicable experimental protocols will likely take substantial resources. Our sense is that a long-term view is needed, one that can support a program of research that progressively addresses the full range of experimental and protocol issues outlined above. As this preliminary report suggests, such a program appears to be achievable, and it is certainly justified given the fundamental nature of the questions addressed. Data from these studies are available upon request from the first author.

Author Contributions

Dean Radin secured funding for this project, conducted three laboratory and online experiments, analyzed the data, and prepared the first draft of the manuscript. Peter Bancel conducted one lab study, confirmed the initial analyses, developed a more refined approach to analyze the laboratory studies, and contributed significantly to subsequent drafts of the manuscript. Arnaud Delorme designed and developed the computing infrastructure, the software used to collect the data from the quED, and reviewed the draft manuscript.

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Appendices

A. Calculation of S-values and ΔS

The following procedure generates an **S**-value for any combination of experimental sessions. Data trials are extracted using selection windows of 16 consecutive trials (one trial for each of the 16 analyzer combinations). Windows are placed at identical locations within runs, which assures that they have identical SCC assignments (see section C). The trials are then sorted by polarization setting and summed to the yield the total coincidence counts for each setting. For polarizers in the two wings[9], (**A, B**), of the experiment, and with orientations **a** and **b**, the correlation coefficient is given as :

$$E(\boldsymbol{a},\boldsymbol{b}) = \frac{N_{++}(\boldsymbol{a},\boldsymbol{b}) - N_{-+}(\boldsymbol{a},\boldsymbol{b}) - N_{+-}(\boldsymbol{a},\boldsymbol{b}) + N_{--}(\boldsymbol{a},\boldsymbol{b})}{N_{++}(\boldsymbol{a},\boldsymbol{b}) + N_{-+}(\boldsymbol{a},\boldsymbol{b}) + N_{+-}(\boldsymbol{a},\boldsymbol{b}) + N_{--}(\boldsymbol{a},\boldsymbol{b})}$$

where ± refers to a polarization analyzer setting parallel or perpendicular to orientations ***(a, b)***. The CHSH scenario measures correlations for two different polarizer orientations in each wing, A and B. With these orientations denoted as ***(a, a')*** and ***(b, b')***, the **S**-value is given by:

$$\mathbf{S}_{exp} = E\,(\boldsymbol{a},\boldsymbol{b}) - E\,(\boldsymbol{a},\boldsymbol{b'}) + E(\boldsymbol{a'},\boldsymbol{b}) + E\,(\boldsymbol{a'},\boldsymbol{b'})$$

The settings for our experiment are the CHSH settings that maximize **S**: (***a, a'***) = (0°, 45°) and (***b, b'***) = (22.5°, 67,5°). The standard deviation of S_{exp} can be derived with the assumption that the counting error for n counts is $\sigma_n = n$, whereby from propagation of errors, we have:

$$\sigma_S = \sqrt{\sum_{i=1}^{16} N_i \left(\frac{\partial S}{\partial N_i} \right)^2}$$

The differential values, **ΔS**, that are designated by the hypotheses are given by:

$$\Delta \mathbf{S} = \mathbf{S}_L - \mathbf{S}_{L+27}$$

where L is a lag, L=0 positions the selection window at the last of the *concentrate* trials, and L+27 is a lag shifted by half of a run-length from L (the lag is L+31 for IMI data). The value **ΔS** constitutes the effect size for our experiments. For our choice of a 16-trial window for TCC, SCC has its maximum at L = 2.5 for IONS data and L=6 for IMI data, so for the respective hypothesis tests L = (2.5, 6) is used. The lag of the SCC maximum is moderately sensitive to changes in the TCC window: ±2 trials in TCC window length produce a lag change in SCC of ± 1. Because $\mathbf{S}_L$ and $\mathbf{S}_{L+27}$ derive from nearly equivalent quantities of data, the standard error of **ΔS** is taken as:

9 The 'wings' are the flight paths of the two entangled photons. Each wing is similarly configured with a polarization analyzer, mirrors, and fiber optics that direct the photon to a coincidence detector.

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$$\sigma_{\Delta S} = \sigma_S \sqrt{2}$$

It is important to note that combining data from different sessions will not lead to accidental biases of **ΔS** because coincidence data from any given window at a lag L is always paired with nearby data in the same run at L+27. Any possible shifts in the baseline levels of **S**, which occur as the laser output and optical alignments change from session to session, will cancel out when the paired **S**-values at lags L and L+27 are subtracted. In addition, calibrations show that biases of **ΔS** due to drifts within a session are below the level of detectability for our data.

B. Fits of the ΔS Lag Curve

The **ΔS** lag curve is calculated from lags 0 to 503, as described in the text. The following values are calculated for each lag, L_m:

- The **S**-value of the 16-trial window terminating at L_m.
- The S-value of the window displaced by 1/2 a run, at lag $L_m + 27$ (for IONS data; the displacement is 31 for the IMI data).
- The difference of the two **S**-values, **ΔS**.
- The Poisson statistical errors of these 3 values.
- The number of (Poisson) standard deviations from zero of **ΔS** (the z-score).

The **ΔS** lag curve is then fit to the Cosine function,

$$\Delta S_L = A * Cos\left(\frac{2\pi}{L_R} L - \phi\right)$$

where the amplitude (taken as A≥0) and phase are free fit parameters, and L is the lag. The frequency $2\pi/L_R$ is fixed and corresponds to run lengths of 53 (61 for IMI data) lags for the IONS(IMI) data, taking a value of 0.118551 (0.103003). The fit is done using the NonlinearModelFit function of *Mathematica* (version 12.1). The test statistic for H1, **MaxZ**, is taken as the absolute value of the extremum of the **ΔS** lag curve. The values of **A** and ϕ are the best fit parameters to the curve.

C. Determination of Test Lag for Hypothesis 3

The overall prediction, based on the hypothesis that mind can directly influence aspects of distant material systems, was that deviations in **S**-values would be associated with the participants' intentional focus during the *concentrate* epochs as compared to the *relax* epochs. One complication for analysis was that the measurements of **S** were calculated over 16 consecutive trials, which meant that data from a previous instructional condition could overlap with the present condition. This in turn meant that the hypothetical mental influences on **S** would not appear instantaneously when the computer announced the next condition, but rather it would become increasingly evident with some time lag. This lag would affect how the **S**-value of a given trial should be associated with a given condition.

In addition, it was expected that participants would need time to cognitively "switch gears" when shifting their attention between successive conditions (Gopher et al., 1996). This too would affect how **S**-values and conditions should be associated because participants' effectiveness in focusing their attention might possibly change over the duration of each epoch as the session proceeded. Our approach toward addressing these issues was to construct an "**S**-value Condition Coefficient" **(**SCC). The SCC provided a way to analyze any collection of trials used to calculate **S** and to quantify the degree to which the data were expected to exhibit lagged "*concentrate*-like" *or* "*relax*-like" behavior. The construction of SCC is discussed below.

S-value Condition Coefficients (SCC)

A SCC coefficient is assigned to each trial. As a first step, a *Trial* Condition Coefficient (TCC) is constructed. The TCC quantifies the induction of a participant's momentary psi effort at the time of a trial. TCC is defined as the average of instructional conditions across a window of preceding trials. It thus represents the immediate history of intentional efforts and is motivated by the assumption that a brief time is needed for participants to adapt and "settle into" each condition. For example, a psi effect might increase over the duration of an instructional epoch because a participant has time to settle into the condition as trials proceed. A "history" window of 16 consecutive trials is used for TCC, which corresponds in these experiments to about 20 seconds. This corresponds to 3-4 slow breaths and is long enough for participants to process cognitively and to fully sense the change between conditions, yet it is shorter than the 24-trial epochs of each condition. By designating values of 0, 1 and -1 to the conditions *get ready, concentrate* and *relax*, the TCC obtains values between ± 1.

The construction of the **S**-value Condition Coefficient (SCC) is taken as the average of the TCCs over the 16-trial **S**-value calculation window. The SCC is thus a weighted average of the underlying condition parameters (-1,0,1) for the 31 trials preceding an **S**-value. The TCC and SCC for the experiments, and their relation to the run structure are shown in Figure A.1. Finally, the SCC for **ΔS** is simply the difference of two SCC's, lagged by 27 (or 31, for IMI data) trials[10].

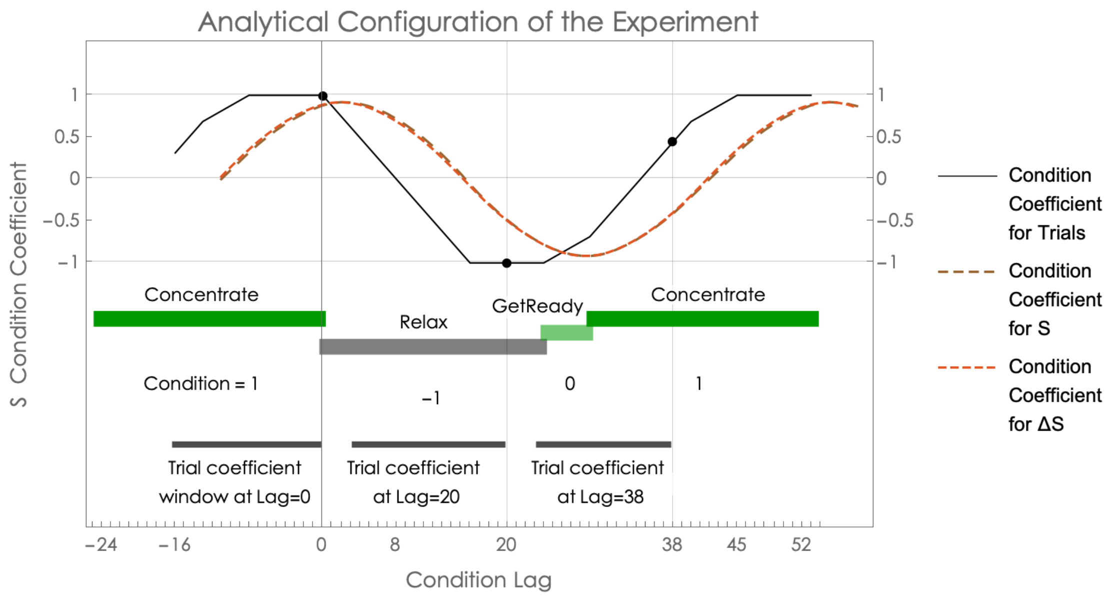

Figure A.1. Construction of **S** Condition Coefficients (SCC) for the experiment. The figure shows the value of condition parameters (0,1,-1), the Trial Condition Coefficient (TCC), and SCC within an experimental run. Trials are assigned lags with respect to lag = 0 for the last ***concentrate*** trial. The thick horizontal bars (in green and gray) indicate the position and durations of the ***get ready***, ***concentrate*** and ***relax*** instructions, relative to lag 0. Narrow horizontal bars (in black) are 16-trial selection windows for calculating **S**, TCC and SCC. They are positioned at lags 0, 20 and 38 in this example. These windows select which trials are used for calculations of **S**. The selected trial data may be coincidence counts when calculating **S**, the condition parameters when calculating TCC, or the TCCs when calculating SCC. All of these quantities are indexed by the window's lag. The TCC values for these windows are indicated by the black points on the TCC curve. The maximum of SCC occurs at lag = 2.5, which gives the lag positions for **S**-values to test hypotheses 1 and 3.

We note the following about lagged curves for **S, ΔS** and SCC. Because hypotheses 2 and 3 assume that an effect has a modulation period equal to the run length L_R, tests can be performed by fitting **ΔS** to a periodic function. Note that even if an effect is absent, lagged curves can be approximately cyclic with a period L_R. This is because

10 The 16-trial window for constructing SCC was dictated by the experimental setup and the CHSH calculation for **S**. However, the choice of a 16-trial window for the TCC was based on psychological considerations. Nevertheless, SCC is not too sensitive to the TCC window choice, and its period is the run length, regardless of that choice.

values of **ΔS** lagged modulo LR use subsets of the same data. That is, if the run length is LR, and if $\{\Delta S_n\}$ are taken at intervals $L + n \cdot L_R$, (n=1,2,...), then $\{\Delta S_n\}$ share subsets of the data for ΔS_0. Curves lagged up to L_R effectively show the evolution of **ΔS** over the course of an average run. For lags extending beyond L_R, the **ΔS** curve provides information on how the run profile changes during a session. Lagged curves are thus useful for determining the amplitude and phase of data structure relative to the run length, and for displaying the evolution of effects over the longer timescale of a full session.

D. Monte Carlo Estimations of Test *p*-values

The Null distribution of **MaxZ** for the test of H1 is built out of Monte Carlo calculations of the lag curve and the distribution of **A** is estimated from Cosine fits of the Monte Carlo lag curves. The surrogate data are generated as follows. For each experimental session, the average of coincidence counts at each polarization setting is calculated. This yields a matrix $\mathbf{M}_{ps}$ where **p** indexes the 16 polarization settings, and s indexes the session. $\mathbf{M}_{ps}$ thus reproduces the average levels of coincidence counts measured in the experiment, for all sessions and analyzer settings. To generate a surrogate Null dataset, the experimental coincidence counts for each trial are replaced with random variables drawn from Poisson distributions with mean parameters given by $\mathbf{M}_{ps}$. The result is a simulation under the assumption of the Null hypothesis, and with the same structure and count levels as the experimental data. Test statistic *p*-values are estimated by counting the fraction of test values calculated for the Monte Carlo surrogate datasets that exceed the experimental values, **MaxZ** and **A** (see Figure A.2). Distribution estimates typically used 4,000 Monte Carlo iterations.

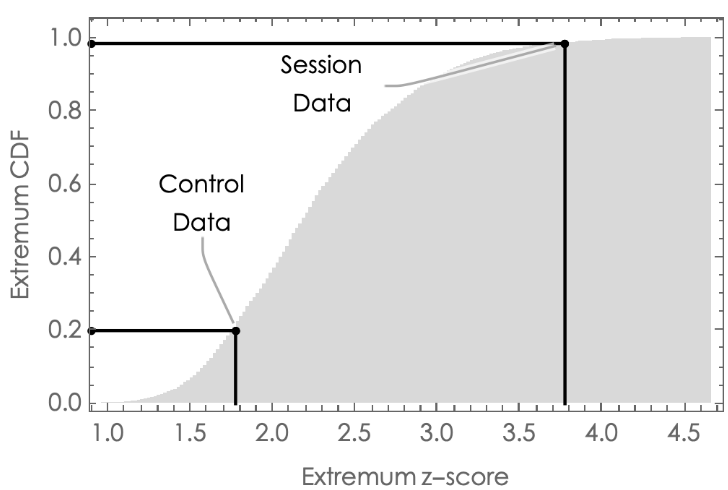

Figure A.2. The results and Monte Carlo CDF for the test of H1. The horizontal axis is the extremum z-score of the **ΔS** lag curve for 4000 Monte Carlo simulations. The vertical axis gives the cumulative probability.

The **p**-value of MaxZ for the IONS data is **p** = 0.003 (**p**-values for the extrema are 1-tailed and are given by 1-CDF).

The Cosine fits also yield a Null distribution for ϕ**.** However, since H3 tests both the value and the variability of this quantity, an estimate of the Null distribution of the standard deviation of ϕ is also needed. The distribution for σ_ϕ is estimated by a bootstrap analysis, as follows. From each surrogate Null dataset, a new dataset is generated by random sampling of the sessions, with replacement. A Cosine fit of the resampled data yields a new value for ϕ. The procedure is repeated on the initial surrogate 100 times and the standard deviation of the ϕ's is calculated. The estimated distribution of σ_ϕ is obtained by repeating the resampling analysis for each one of the (4000) surrogate Monte Carlo datasets (see Figure A.3). Note that grouped values of **MaxZ**, **A**, and σ_ϕ are identified with each individual Monte Carlo dataset. This will be important for treating dependencies among tests in the determination of the Null distribution of *Fchi,* the Fisher combination of *p*-values.

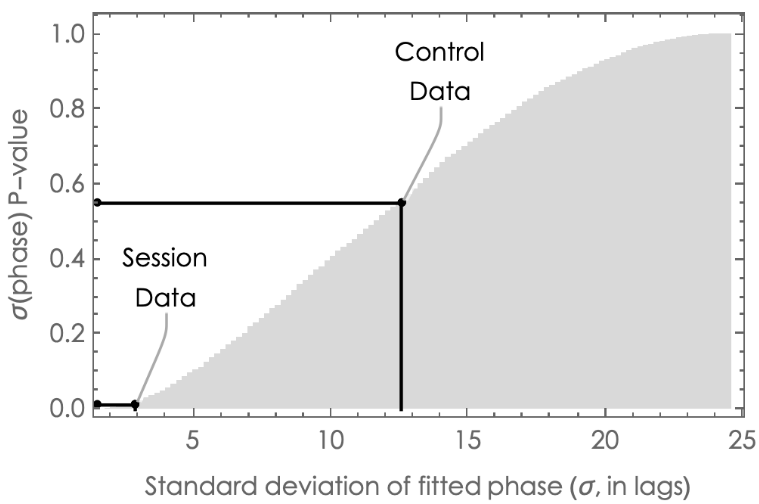

Figure A.3. The results and CDF for the test of H3. The horizontal axis is the bootstrapped standard deviation of the **ΔS** lag curve phase. The vertical axis gives the cumulative probability, which is equivalent to the **p**-value for this test; **p**-value = 0.013, one-tailed.

Determination of the σ_ϕ distribution increases calculation times by a factor of 100, but yields in return a significant increase in the power to detect an effect. In particular, it is sensitive to effects that lock to the periodicity of the SCC, the alternating instructional conditions of *concentrate* and *relax.* In this case, the locking will narrow the variance of ϕ, and one-sided tests for H3 predict a low value of σ_ϕ relative to the Null distribution. Figure A.4 shows the evolution of σ_ϕ as simulations include progressively stronger effects.

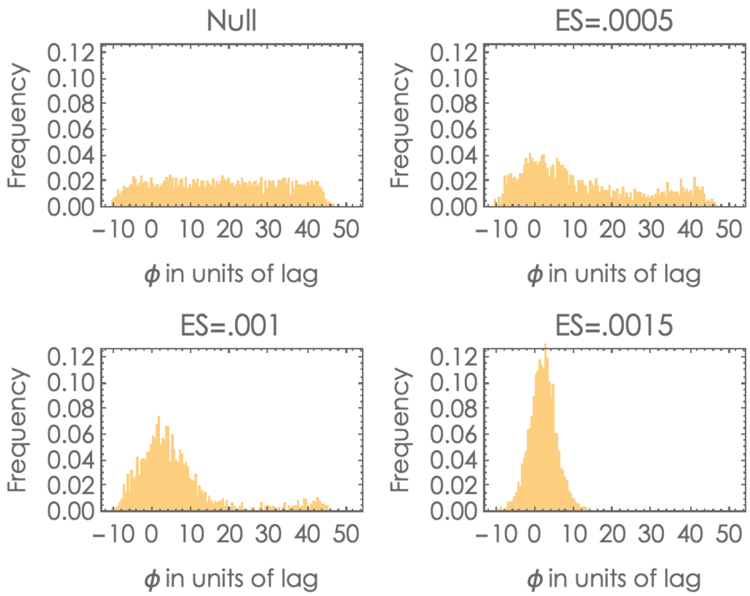

Figure A.4. Locking of the fit parameter ø under the presence of an effect as evidenced by the narrowing of its variability. The distribution of ø sharpens as a simulated psi effect with periodicity of the SCC is increased. The units of ES refer to relative differences of S-values under the ***concentrate*** and ***relax*** conditions. The IONS experiment yields an ES slightly smaller than 0.0015.

E. Methods for Combining *p*-values

The combined *p*-value for tests of H1-H3 are given by the *p*-value of Fisher's Chi Square, *Fchi*. The value is determined by comparison of *Fchi* with its Null distribution, as estimated by Monte Carlo simulation. The procedure compensates for any dependencies between the triples of *p*-values associated with **maxZ**, **A** and σ_ϕ. The statistics are, in fact, highly correlated (Spearman Ranks: **maxZ** and **A** ≈ 0.87; **maxZ** or **A** vs. σ_ϕ ≈ -0.45), so a Monte Carlo approach to *Fchi* is necessary. The Fchi value for the IONS session data is 29.9, which is higher than any value in the simulated distribution of 4000 Monte Carlo iterations. The control data yields an *Fchi* of 10.8. The corresponding P-value estimates are <0.00021 and 0.95, respectively. A histogram of the *Fchi* Null distribution is shown in Figure 4 in the text.

The weighted Stouffer Z to combine tests from the independent IONS and IMI datasets is given by:

$$Z = \frac{\sum_{i=1}^{N} w_i Z_i}{\sqrt{\sum_{i=1}^{N} w_i^2}}$$

where Z_i are normal scores inverted from the test *p*-values and the relative weights, w_i, are 1 and 0.845, respectively, for the IMI and IONS datasets. The weights are the square root of the ratio of total coincidence counts for the two datasets.

F. Comments on the Monte Carlo and Bootstrap Procedures

The analyses present estimated *p*-values of test statistics and these assume that simulations adequately represent the Null hypothesis. Given the complexity of the experiment, the data structure and the tests, some comments are in order to justify this assumption.

A modelling approach to surrogate Null data is likely to encounter mistaken assumptions or incorrect biases, so we adopted a bootstrap procedure using the experimental data to produce surrogate datasets by random sampling with replacement. There are several limitations on the sampling that must be considered. First, sampling on trials needs to respect the analyzer settings because indiscriminate sampling would erase the Bell correlations. Second, sessions have different average **S** levels, and this could conceivably produce accidental structure in analyses which *should not* be expunged from the surrogate datasets. Figure A.5, which shows independent **S**-values from 7 different sessions, demonstrates that the mean levels of the **S**-value varied considerably, as did the statistical noise in the measurements. However, fluctuations within a session were quite stable and generally lay within a 90%CI of the noise.

Thus, we chose to constrain the random sampling to be from within a session and to respect polarization settings. Two ways to achieve this are 1) adding Poisson counting errors to each trial and, 2) randomly sampling (with replacement) the exact trials within each session and within each subset of analyzer settings. The two procedures generate distributions of test statistics for H1-H3 that are nearly identical (see Figure A.6). Distributions generated from experimental and control data are in similar close agreement. However, the Poisson error method produces slightly less significant results at small p-values, and we have adopted this more conservative method in reporting our results.

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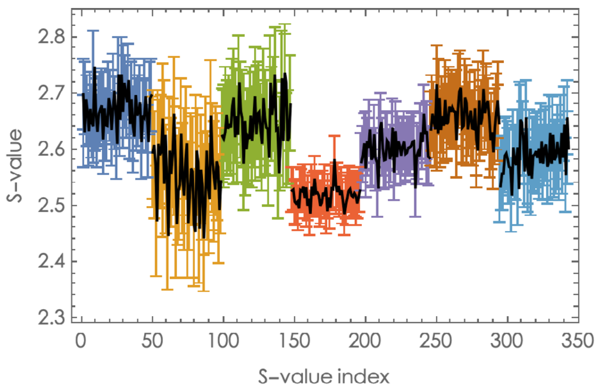

Figure A.5. Independent **S**-samples taken at 16-trial intervals for 7 IONS experimental sessions. The error bars are 90%CIs for each sample. Differences in errors indicate inverse differences in the flux of coincidence counts, likely due to the laser power level or quality of the optical alignment.

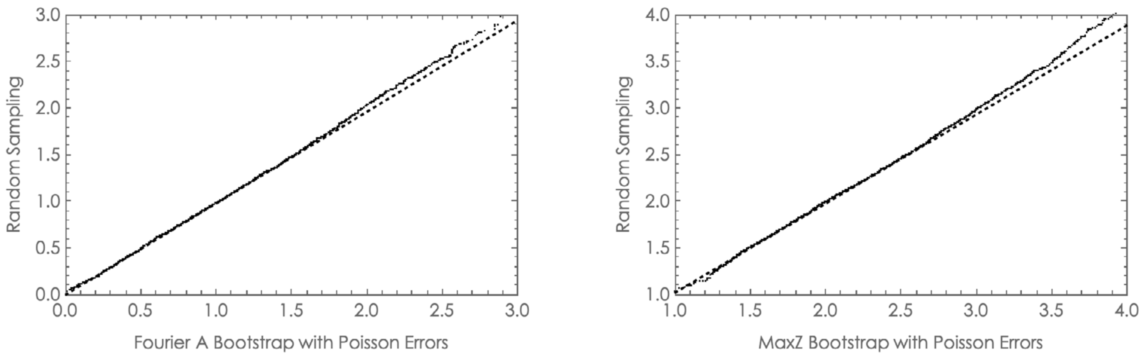

Figure A.6. Quantile-quantile plots of the distributions for **maxZ** and **A** comparing the two bootstrap methods. The random sampling method (vertical axis) is slightly more sensitive and produces more significant *p*-values at quantiles above ≈ 0.98 (corresponding to *p*-values smaller than 0.02).

For the Poisson error bootstrap, the average value of coincidence counts is tabulated for each setting of each session. The resulting 16xN matrix (where N is the number of sessions) is then used to generate a new Poisson random variable for each trial in the dataset, where the matrix element for the session and setting sets the trial's Poisson distribution parameter (i.e., the distribution mean).

A further step is needed to estimate the Null distribution of the fitted phase's variance. The procedure is essentially a bootstrap within a bootstrap and is performed as follows. First a surrogate dataset is generated using one of the methods above. The surrogate data are thus a concatenation of sessions, with the resamplings performed separately on each session. From the surrogate, the **ΔS** lag curve is generated, and the test statistics **maxZ, A** and ϕ are calculated. To estimate ϕ's standard error, σ_ϕ, a new dataset is generated by randomly sampling on the *sessions* (there are a total of 31 sessions in the three IONS experiments, for example). Statistics are calculated and the resampling on sessions is repeated (typically 100 to 200 times) to create a sample distribution of phases associated with each surrogate dataset. The phase standard error is then calculated and grouped with the values of the three test statistics for that surrogate dataset. The bootstrap thus generates four distributions for the four test statistics. The distributions are then used to transform the distribution values to *p*-values, and the logs of the grouped *p*-values for **maxZ, A** and σ_ϕ are summed to give the distribution of *Fchi.*

Anomalous Cognition: An Umbrella Review of the Meta-Analytic Evidence[1]

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Abstract: *Objective*: The aim of this study was to assess the results of all meta-analyses on anomalous cognition conducted between 1989 and 2021 in order to find moderators associated with greater effect sizes. *Method*: We included all meta-analyses of studies related to anomalous cognition published up to 2021. *Results*: Our dataset, accumulated over more than 80 years of investigation, refers to 11 meta-analyses related to six different states of consciousness. The evidence clearly shows that anomalous cognition seems possible and its effects can be enhanced by using a combination of some non-ordinary or altered states of consciousness (e.g., dreaming, ganzfeld, etc.), coupled with free-response procedures, or neurophysiological dependent variables. These conditions facilitate an alternative form of cognition seemingly unconstrained by the known biological characteristics of the sense organs and the brain. *Conclusion*: The accumulated evidence expands our understanding of the mind-brain relation and the nature of the human mind.

*Keywords***:** anomalous cognition; meta-analysis; free response; forced-choice; physiological responses; psi; ESP

Highlights

- State of consciousness and the type of response are strong moderators of the effect size magnitude.
- A modified state of consciousness with respect to the ordinary state, combined with a conscious free-response protocol, or a normal state of consciousness

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combined with an unconscious psychophysiological response protocol, are the best positive moderators.

The scientific study of the reality and characteristics of anomalous cognition (other terms used are anomalous perception, extrasensory perception, and nonlocal cognition)[22], unconstrained by the known biological characteristics of the sense organs and the brain, has employed quantitative techniques under controlled conditions, popularized in the English-speaking world by the pioneering work of Joseph Banks Rhine in the early 1930s at the Psychology Department of Duke University (Zingrone & Alvarado, 2015; Zingrone et al., 2015). After Rhine's first studies, many other investigators, mainly in USA and Europe, have continued this line of investigation by using a variety of methodological and experimental procedures in order to offer solid evidence of the existence of this type of cognition. This type of research was later referred to as "proof oriented."; later, research became more "process oriented" in order to discover the environmental, physiological, and mental factors (including personality traits) that might elicit and enhance (i.e., moderate) this type of cognition (Stanford, 1974).

With the accumulation of experimental studies, it has been deemed necessary to summarize quantitatively the results using appropriate statistical tools. Even though the term *meta-analysis* was coined in 1976 by the statistician Gene V. Glass (1976), the first meta-analysis *per se* dates back to 1940 (Pratt et al., 1940), and consisted of 145 reports on extra-sensory perception experiments published from 1882 to 1939. This meta-analysis also included an estimate of the required number of unpublished papers that would be required to reduce the overall significant effect to mere chance (referring to the publication bias problem). At that time, the statistical tools for the quantitative synthesis of the results were quite poor but, with the improvement of such tools, more sophisticated meta-analyses have been carried out by different authors.

Some five decades later, by way of a formal meta-analysis of forced-choice precognition studies (Honorton & Ferrari, 1989), evidence began to accumulate that suggested that an anomalous form of cognition seemed possible, primarily under controlled laboratory conditions. The forced-choice design is so named because the target-guess is "one of a limited range of possibilities which are known to [the participant] in advance" (Thalbourne, 2003, p. 44). Precognition is defined as "a form of extrasensory perception in which the target is some future event that cannot be deduced from normally known data in the present" (Thalbourne, 2003, p. 90). For the

2 The term ***nonlocal*** is used here as a description of the main characteristics of a type of cognition unconstrained by the spacetime construct used in physics, without any reference to other meanings deriving from other disciplines (e.g., quantum mechanics or quantum biology).

period 1935 to 1987, including a total of 309 studies (50,000 participants and approximately two million individual trials), there was a weak albeit significant effect size of 0.02, with 92 studies (30%) showing significant hitting ($p < .05$) (Honorton & Ferrari, 1989). Another forced-choice meta-analysis by Stanford and Stein (1994) reported an association between hypnosis and ESP, reporting that there was "cumulative ESP-test significance for hypnosis" (p. 235).

Steinkamp, Milton, and Morris (1998) also meta-analyzed forced-choice studies (from 1935-1997), but they compared clairvoyance with precognition in order to evaluate any difference between the two. Clairvoyance is defined as "paranormal acquisition of information concerning an object or contemporary physical event" (Thalbourne, 2003, p. 18). Steinkamp and colleagues hypothesized that clairvoyance studies would have a significantly higher effect size because precognition had an extra "calculational step," involving "real-time ESP" (clairvoyance) and then extrapolation from that information "to make an informed prediction about future events" (p. 193). Assessing 22 study-pairs with effectively similar procedures, effect sizes for both modalities were almost identical, with no significant difference between the two. They concluded that the burden of proof rested with those "who argue for a difference between effect sizes under real-time and future ESP" (p. 209).

Storm, Tressoldi, and Di Risio (2012) continued where Honorton and Ferrari (1989) left off on forced-choice ESP. For the period 1987 to 2010, they formed a homogeneous dataset of 72 studies that yielded a weak, but statistically significant mean effect size of 0.014. There was no evidence that these results were due to low-quality design or selective reporting. They noted a linear incline in effects indicating that effect sizes increased over that period.

Bem, Tressoldi, Rabeyron, and Duggan (2016) looked at the cumulative evidence related to so-called behavioral precognition in a normal state of consciousness. The main methodological characteristic of these studies was that participants were requested to predict future events randomly presented, using a forced-choice procedure. The overall effect size was .09, but the results showed that tasks requiring a fast response yielded a statistically significant effect size of 0.11. In contrast, those not requiring a fast response yielded an almost null effect of 0.03.

Turning to a different experimental design, Milton (1997) meta-analyzed 78 *free-response* studies published over the period 1964 to 1993 (these studies included remote viewing studies, in which the percipient "attempts to describe the surroundings of a geographically distant agent"; Thalbourne, 2003, p. 107; although an agent is not always used). In all studies, participants were in a normal (waking) state of consciousness, but the task requires a good control of mental information similar to that requested in some meditation practices, in order to distinguish between information related to the target and that deriving from inner mental activity. The term free response refers to “any test of ESP in which the range of possible targets is relatively unlimited and is unknown to the percipient” (Thalbourne, 2003, p. 44) and participants are requested to verbally describe without constraints their mental content (mentation) as it pertains to randomly preselected targets (usually photographs or video-clips), included among a set of decoys that are presented on-screen. Milton found a mean effect size of 0.16.

Dunne and Jahn (2003) presented a total of 653 formal trials conducted “over several phases of investigation” (p. 207) during a 25-year period. Percipients had to “describe verbally an unknown remote geographical target where an agent is, was, or will be situated at a prescribed time” (p. 209), thus classifying these trials as remote viewing. The authors reported a significant effect size of 0.21. Baptista, Derakhshani, and Tressoldi (2015) followed up with their meta-analysis including all studies available up to 2014, comprising the SRI, the SAIC (Utts, 1996), the Milton (1997), and the Dunne and Jahn (2003) databases, obtaining an overall effect size of 0.38.

Mossbridge, Tressoldi, and Utts (2012) ventured into new territory when they assessed unconscious physiological anticipation effects in their meta-analysis of 26 studies (for the period 1987 to 2010). This anticipatory effect is also referred to as *presentiment* (sensing an event before it occurs). The overall significant effect size was 0.21. Duggan and Tressoldi (2018) updated this study with 19 new studies from 2008 to 2018, with an overall weighted effect size of 0.28, thus replicating the findings of the Mossbridge et al. study.

Turning to dream-ESP (extra-sensory cognition tested during the dream state), Storm and colleagues (2017) found that two dream-ESP databases—studies from the Maimonides Dream Laboratory (MDL) and post-MDL studies—were not significantly different from each other in terms of mean effect size. The combined databases (N = 50) yielded a mean effect size of 0.20, and the authors concluded that dream content can be used to identify target materials correctly and more often than would be expected by chance.

Finally, we come to the ganzfeld design, which is a “special type of environment (or the technique for producing it) consisting of homogeneous, un-patterned sensory stimulation” to the eyes and ears of the participant who is usually in “a state of bodily comfort” (Thalbourne, 2003, p. 45). A number of investigators pioneered the technique in the 1970s (Braud et al.,1975; Honorton & Harper, 1974; Parker, 1975). The Ganzfeld technique can be used to test telepathy, as well as clairvoyance and precognition. Te-

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lepathy refers to the "paranormal acquisition of information concerning the thoughts, feelings or activity of another conscious being" (Thalbourne, 2003, p. 125).

In one of the earliest ganzfeld meta-analyses, Honorton (1985) found a hit rate of 38% in his database (*N* = 28), where 25% was expected by chance. Bem and Honorton (1994) conducted a second meta-analysis on ten computer-controlled autoganzfeld studies (in this design, targets are randomly-selected, presented, and scored). The hit rate did fall, but to a still significant 32%. Milton and Wiseman (1999) followed up with their assessment of 30 new studies (1987 to 1997), yielding a non-significant effect size of 0.013. However, an Exact Binomial test on trial counts produce a significant hit rate of 27% (Utts, 2008).

Storm, Tressoldi and Di Risio (2010) meta-analyzed a database of 29 ganzfeld studies (1997 to 2008) and found a significant effect size of 0.14. The most recent meta-analysis by Storm and Tressoldi (2020) covered studies from 2008 to 2018, with an effect size of 0.13. The most comprehensive study to date is by Tressoldi and Storm (2021b) as it pulls together all valid ganzfeld studies (*N* = 113) from 1974 to 2020, obtaining a statistically significant overall effect size of 0.09.

The main aims of this study are: (a) to assess the strength of evidence supporting the reality of anomalous cognition obtained from meta-analyses, and (b) to determine its moderators (i.e., the conditions that increase its efficiency).

Method

Search procedure

For the present study, we collected all available meta-analyses conducted up to 2021 published in English-language peer-reviewed journals. (As a matter of expediency, we also use the online study by Tressoldi and Storm (2021b)—for details, see next section.) This synthesis represents an update to 2021 of previous reviews presented by Tressoldi (2011) and more recently by Cardeña (2018). We searched the Google Scholar, PubMed, and Scopus databases with the keywords: "meta-analysis and ganzfeld" or "anomalous" or "extrasensory perception" or "clairvoyance" in the title.

Inclusion and Exclusion Criteria

All meta-analyses should include studies related to different but specific phenomena suggestive of anomalous (nonlocal, extrasensory) cognition. Studies included in the meta-analyses assessed here, used the following original inclusion criteria: appropriate randomization (using electronic equipment or random tables) of the target presentation; when appropriate, random target positioning during judgment (i.e., target was randomly placed in the presentation with decoys); masked response transcription or impossibility to know the target in advance; when appropriate, sensory shielding from sender (agent) and receiver (perceiver); when appropriate, target independently checked by a second judge; experimenters masked to target identity.

The 13 meta-analyses had to have been published in peer-reviewed English-language journals. Only ESP meta-analysis (i.e., telepathy, clairvoyance, and precognitive) were assessed, and they had to provide sufficient methodological and statistical information for the authors to prepare appropriate tables. We excluded older meta-analyses comprised of studies that were included in more recent meta-analyses. For example, all meta-analyses related to anomalous cognition in a ganzfeld condition before 2020 (e.g., Bem & Honorton, 1994; Milton & Wiseman, 1999b; Storm et al., 2010) were not included here because all studies in those meta-analyses were analysed in the Tressoldi and Storm (2021b) meta-analysis. We also excluded the Milton and Wiseman (1999a) meta-analysis because it was related to mass participation without any control over recruitment and motivation of participants who were requested to predict masked targets, similar to the lottery guessing tasks. A partial overlap with the studies included in Honorton and Ferrari (1989) is presented in Steinkamp, Milton, and Morris (1998) who included only the studies that combined both a clairvoyance and a precognition task.

The general methodology adopted in most of the studies included in the meta-analyses required participants to identify concealed or future targets that were generated randomly and presented in either a forced-choice or a free-response condition. Other studies do not record overt choices, but instead focus on neurophysiological responses (e.g., EEG, heart rate) prior to target presentation. The states of consciousness during these tasks range from ordinary (normal) to non-ordinary (altered or modified under conditions such as hypnosis, ganzfeld, etc.).

Results

Descriptive Statistics

Authors of the meta-analyses, number of studies included in each of them, the states of consciousness, response types, and overall effect sizes with corresponding with 95% confidence intervals (CIs), are presented in Table 1.

Table 1

Chronological Summary of Meta-Analyses on Anomalous Cognition

Meta-analysis	Authors	N Studies	State of consciousness	Response type	ES (± 95%CIs)
1.	Honorton & Ferrari (1989)	309	Normal	Forced-choice	.02±.009°
2.	Stanford & Stein (1994)	25	Hypnosis	Forced-choice	.524±.01a .048±.01t
	Stanford & Stein (1994)	25	Normal	Forced-choice	.505±.01a .01±.01t
3.	Steinkamp, Milton, & Morris (1998)	31	Normal	Forced-choice	.01±.00015°b .005±.0002°c
4.	Mossbridge et al. (2012)	26	Normal	Unconscious physiological anticipations	.21±.08°
5.	Storm et al. (2012)	72	Normal	Forced-choice	.014±.008°
6.	Baptista et al. (2015)	90	Remote Viewing	Overt free response	.38±.1°
7.	Bem et al. (2016)	61 (fast-thinking)	Normal	Forced-choice	.11±.03*
	Bem et al. (2016)	29 (slow-thinking)	Normal	Slow response	.03±.04*
8.	Storm et al. (2017)	14 (Maimonides) 36 (Non-Maimonides)	Dream	Overt free response	.33±.10° .14±.08°
9.	Duggan & Tressoldi (2018)	27	Normal	Unconscious physiological anticipations	.28±.10*
10.	Storm & Tressoldi (2020)	37	Mixed modified states of consciousness	Overt free response	.072±.05°
	Storm & Tressoldi (2020)	33	Normal	Overt free response	.027±.05°
11.	Tressoldi & Storm (2021b)	113	Ganzfeld	Overt free response	.09±.04*

*= Hedges's g, ° = z/√n or t/√n ; [a] = Proportion Index; transformed into z/√n; [b] = precognition whole database; [c] = clairvoyance whole database.

As reported on Table 1, we included a total of 11 suitable meta-analyses, reporting 16 overall effect sizes obtained from 928 studies. All effect sizes, but the Bem et al. (2016) related to slow responses, are significant. As to their type, apart from the use of a proportion index in Stanford and Stein (1994), all other effect sizes are conceptually but not mathematically equivalent because they are Cohens' d equivalent, either mean $z/\sqrt{n}$ or $t/\sqrt{n}$ (as normal approximations to the binomial test), or Hedges's g, with sizes ranging from $-\infty$ to $+\infty$ and none deriving from correlation effect sizes. The two proportion index effect sizes were transformed into $z/\sqrt{n}$ to compare them with the other effect sizes (see Table 1 and 4) applying Rosenthal and Rubin's (1989) formula. The effect sizes used measure how far the summary statistic (e.g., hit rate, mean) deviates from the null hypothesis value in terms of number of standard deviations; Hedges's g is used as a correction for potential small sample effects.

As presented in Table 1, the 11 meta-analyses cover anomalous cognition in six different states of consciousness from the normal state in a waking condition (i.e., non-altered stated of consciousness or non-ASC) to altered states of consciousness (ASC) such as the dream state, and three types of responses: (i) overt conscious free-response; (ii) overt conscious forced-choice; (iii) unconscious physiological measures.

In Figure 1, the effect sizes of all meta-analyses presented in Table 1 are shown in decreasing magnitude to enable a visual comparison of their differences.

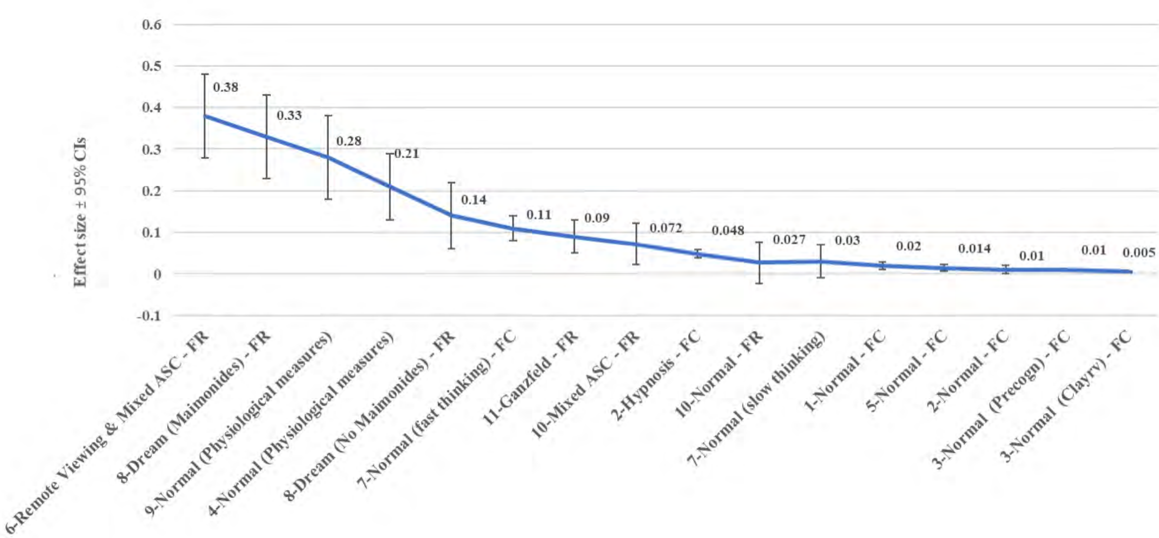

Figure 1. Effect sizes with corresponding 95% confidence intervals of the different meta-analyses presented in Table 1. The abscissa shows the meta-analysis number, the state of consciousness, and the type of response FR = Free Response, FC = Forced-Choice. The connecting line is provided for ease of comparison.

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Meta-Analyses Reporting Standards

In order to give an overall picture of the quality of all 11 meta-analyses, we checked whether four major meta-analysis reporting standards (MARS): studies selection criteria, effect size formulas, studies quality check, publication bias check, were followed as recommended by the APA (Appelbaum et al., 2018). Table 2 shows that most of the meta-analyses actually implemented these four standards before the publication of the MARS in 2018.

Table 2

Meta-Analysis Reporting Standard Checklist

Meta-analysis	**Studies selection criteria**	**Effect size formulas**	**Studies quality check**	**Publication bias check**
Honorton & Ferrari (1989)	✓	✓	✓	✓
Stanford & Stein (1994)	✓	✓	✓	☒
Steinkamp, Milton & Morris (1998)	✓	✓	✓	☒
Mossbridge et al. (2012)	✓	✓	✓	✓
Storm et al. (2012)	✓	✓	✓	✓
Baptista et al. (2015)	✓	✓	☒	✓
Bem et al. (2016)	✓	✓	✓	✓
Storm et al. (2017)	✓	✓	✓	✓
Duggan & Tressoldi (2018)	✓	✓	✓	✓
Storm & Tressoldi (2020)	✓	✓	✓	✓
Tressoldi & Storm (2021b)	✓	✓	✓	✓

Questionable Research Practices and Publication Bias

We can also test the methodological standards of meta-analyses by calculating the percentage of studies affected by so-called "questionable research practices" (QRP; Banks et al. 2016; John et al., 2012). The tacit aim of QRPs in the first place, is to obtain a statistically significant result. If we observe that in most meta-analyses a high percentage of studies did not reach significance, either the authors of the studies applied QRPs unsuccessfully, or might not have applied them at all. It is worth to point out that in psi, researchers have been urged for decades to submit and publish non-significant results, way before this happened in psychology and other disciplines (Wiseman et al., 2019).

In Table 3, in the 9 meta-analyses that reported the number of significant studies, it was a simple matter to calculate the percentages of non-significant studies which ranged from 54% to 81% , with one exception at 23%. Thus, it can be argued that the majority of authors of the studies included in most of the meta-analyses probably did not use QRPs, or used them unsuccessfully arguing against the argument that the results can be explained away by publication bias. The high failure rates, however, indicate the difficulties in detecting anomalous cognition, which has been a consistent characteristic in psi research. Our finding, however, is actually a defense of the phenomenon, as it is unlikely that experimenters deliberately aimed to produce a majority of non-significant findings just to perpetuate the myth of an unreliable anomalous form of cognition.

Table 3

Percentage of Studies that Did not Reach the Criterion of Statistical Significance

Meta-analysis	Source	Statistically nonsignificant studies (%)
1.	Honorton & Ferrari (1989)	70
2.	Stanford & Stein (1994)	NA
3.	Steinkamp, Milton & Morris (1998)	NA
4.	Mossbridge et al. (2012)	54
5.	Storm et al. (2012)	78
6.	Baptista et al. (2015)	23
7.	Bem et al. (2016)	79

8.	Storm et al. (2017)	73
9.	Duggan & Tressoldi (2018)	58
10.	Storm & Tressoldi (2020)	80
11.	Tressoldi & Storm (2021b)	81

Moderators Analyses

We now consider two possible moderators of anomalous cognition: State of consciousness and Response type. First, state of consciousness has been considered a key variable in parapsychology, this assumption is decades old and underpins the ganzfeld design (Parker, 1975; Cardeña & Marcusson-Clavertz, 2020). Second, as shown in Table 1, there are three response types (forced choice, free-response, and unconscious physiological anticipation). We see forced-choice, in both the normal and altered states of consciousness, as the least efficient strategy because the responses, manual or verbal, are consequently partially controlled by ordinary (local) cognitive activity. Free response would be the next best strategy, though it requires participants to filter out local mental activity, thus probably explaining why selected participants do better than naive (unselected) participants (see Storm & Tressoldi, 2020). Physiological anticipation, however, seems to be the best of the three options (confirmed by the two meta-analyses with the largest ESs; see Table 1, #4 & #9), arguably because the anomalous/nonlocal information bypasses conscious mental activity.

We considered whether it was possible to predict the overall effect size, taking into account the state of consciousness and the type of response as the main moderators. For each meta-analysis, we assigned a rank score from 1 to 2 according to the state of consciousness with these criteria: normal (waking) state of consciousness = 1; modified (altered) state of consciousness during the response = 2. Similarly, we assigned a rank score to the type of response with these criteria: forced-choice = 1; free-response = 2; physiological responses = 3. Applying the above criteria to each meta-analysis presented in Table 1, we produced rank scores and corresponding effect sizes listed in Table 4.

Table 4

Ranking Scores Related to State of Consciousness and Type of Response

Meta-analysis	Source	State of consciousness	Response type	Sum of Ranks	ES
1.	Honorton & Ferrari (1989)	1	1	2	.02±.009
2.	Stanford & Stein (1994)	2	1	3	.048±.01°
	Stanford & Stein (1994)	1	1	2	.01±.01°
3.	Steinkamp, Milton & Morris (1998)	1 1	1 1	2 2	.01±.00015 .005±.0002
4.	Mossbridge et al. (2012)	1	3	4	.21±.08
5.	Storm et al. (2012)	1	1	2	.014±.008
6.	Baptista et al. (2015)	2	2	4	.39±.25
7.	Bem et al. (2016)	1	1	2	.11±.03
	Bem et al. (2016)	1	n/a*	-	.03±.04
8.	Storm et al. (2017)	2 2	2 2	4 4	.33±.10 .14±.08
9.	Duggan & Tressoldi (2018)	1	3	4	.28±.10
10.	Storm & Tressoldi (2020)	2	2	4	.072±.05
	Storm & Tressoldi (2020)	1	2	3	.027±.05
11.	Tressoldi & Storm (2021b)	2	2	4	.09±.04

° = proportion index transformed into $z/\sqrt{n}$ effect size; * n/a = not applicable given the responses were neither forced-choice nor free-response.

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In order to check the robustness of the results, two types of rank order correlation (Spearman and Kendall tau) between the sum of the rank scores assigned to the State of Consciousness plus the rank scores assigned to the Type of Responses with the overall effect size were applied. rs(14) = .81; 95%CIs [.52, .94], p = 1.9 ´ 10-4; TauB(14) = .71; 95%CIs [.50, .91]; p = .001. Confidence intervals (CIs) were estimated using a bootstrap procedure with 1000 resamplings. These results support the hypothesis that the combination of state of consciousness and type of response are strong outcome (ES) moderators.

Discussion

A first point to be made in regard to the quality of the meta-analyses, even of the older ones, is that they are supported by a high level of adherence to the reporting standards guidelines, which militate against an explanation of questionable research practices. Given the range of effect sizes presented in Figure 1 and Table 1, we can reach a few conclusions. It is evident that the effect sizes (ESs) were stronger (above .30) in two meta-analyses that featured altered states of consciousness (ASC) and Free Response (FR) protocols—Remote Viewing (meta-analysis #6) and Dream-ESP (meta-analysis #8). We note that two meta-analyses also had relatively strong ESs (.21 and .28), though they did not feature AsCs (#4 & #9), but used physiological responses as dependent variables. The Ganzfeld condition, however, seeks to induce an ASC and is invariably an FR protocol, although the ESs were somewhat weaker, falling just below .10 (#11). Turning to the non-ASC meta-analyses, these generally yielded the weakest ESs of all (#1, #2, #3, #5, & #10), and tended to feature forced-choice protocols, so we conclude that the combination of ASCs and FR conditions gives the experimenter a clear advantage when relatively strong ESs are sought.

It is important to consider that each of these 11 meta-analyses includes more information than is reported in Table 1. For example, in Honorton and Ferrari (1989), delays in feedback of milliseconds yielded a mean effect size almost three-times as large as the mean when delays were in months. Furthermore, selected participants (e.g., previously tested, or trained in meditation or relaxation techniques) yielded larger effect sizes up to three times greater than non-selected (first-time or non-trained) participants (Storm et al., 2010, Storm & Tressoldi, 2020; Tressoldi & Storm, 2021b). We acknowledge the importance of participant type, but the observed strong correlations between the overall effect sizes and the combination of State of Consciousness plus Response Type suggest that the manipulation of these two variables are most critical for the emergence of anomalous/nonlocal cognition. Our advice to researchers interested in this area is that the best methods to use include free-response involving selected participants in modified or controlled states of consciousness, or studies with physiological measures as dependent variables.

Study limitations

The updated standards for the best scientific evidence require registered meta-analyses (see Tressoldi & Storm, 2021a, as an example) of registered reports (Chambers, 2013), or multi-laboratory studies with preregistered methods and data analyses (e.g., Open Science Collaboration, 2015; Protzko et al., 2020) that limit not only the use of the QRPs, but also the degrees of freedom in the experimental designs and data analyses.

None of our meta-analyses satisfy such criteria. Most of the included meta-analyses were carried out applying the standards available and agreed by the scientific community at the time of their completion. As a consequence, our interpretations of what they can say about the evidence and the moderators of an anomalous cognition must be taken with caution and see if they will hold with the results of new meta-analyses carried out with modern standards.

Conclusions

Notwithstanding the limitations of this study, we can provisionally state that the overall picture is that anomalous cognition manifests its potentialities by bypassing normal waking consciousness, either by modifying it or using implicit (unconscious) physiological mechanisms. It seems then that humans (and probably also animals; see Alvarez, 2010, 2018) possess two alternative ways of obtaining information: first, by using their physiological functions, sensory organs, and brain, and second, by using an anomalous/nonlocal mental capacity that might be used as a complement to the ordinary local perceptual abilities, which therefore pushes for a modified interpretation of mind and consciousness in general.

It is evident that this anomalous perceptual capability requires a revised theoretical interpretation of the nature of the human mind-brain relation (for an overview of the different hypotheses and theories, see Cardeña, 2018). Although it is clear that the proposal of an anomalous human cognition is incompatible with, say, a physicalist or an eliminative materialist interpretation (Ramsey, 2020), it is compatible with some Western and Eastern philosophical interpretations that may be familiar to the reader such as idealism (Kastrup, 2018), dual-aspect monism (Walach, 2020), and Advaita Vedanta (Sedlmeier & Srinivas, 2016). All these philosophical interpretations support the view that Consciousness and Mind contents are primary and not a by-product of physical and biological matter such as the brain.

Authors' Contribution

Both authors contributed equally to the conceptualization, methodology, and writing of the paper.

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[Included meta-analyses are marked with an asterisk]

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Open Peer Comment to

"Anomalous Cognition: An Umbrella Review of the Meta-Analytic Evidence"

Stefan Schmidt[1],
Institute for Frontier Areas of Psychology and Mental Health

[Note from the Editor: JAEX uses an anonymous system for both authors and reviewers because in a small area of inquiry identifying either of them would make it more likely that bias for or against, or future reciprocation would creep into the process. In this case, both the authors of the paper and one of the reviewers recognized each other nonetheless, and the authors of the paper recommended that the reviewer write a comment to which they would respond. I should mention that the statistician to whom Professor Schmidt alludes is someone I first approached for an opinion, besides requesting the opinion of two other eminent authors, trying to clarify the issues raised in this comment. Also, I did not accept the second revision "straightaway" but requested some additional changes in response to comments by additional consultants.]

Background: The approach of the authors to systemically compile meta-analyses from psi research is a very fruitful one and I was happy to get selected as one of two reviewers of the manuscript. The first version of this publication was quite short (2,400 words) and lacked detailed information in several places. Thus, it was difficult to follow the methodological approach of the authors. The first revision provided some more details on procedures. To some of the comments of the reviewers the authors were not very responsive. Furthermore, the new information on the methodological details raised more concerns regarding the methodological adequacy of some approaches. I pointed them out in my second review and informed the editor accordingly. When the second revision came in the editor accepted it straightaway. After that he sent me the manuscript and invited me to write an accompanying letter should I not be satisfied. In what follows, I will raise some critical issues regarding the publication.

Inclusion Criteria: The authors performed a systematic research in order to find anomalous cognition meta-analyses. However, the inclusion/exclusion of studies

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seems to be arbitrary. Both reviewers had the feeling that the exclusion of Milton and Wiseman (1999) was not systematic. The authors argued "We also excluded the Milton and Wiseman (1999a) meta-analysis because it was related to mass participation without any control over recruitment and motivation of participants who were requested to predict masked targets, similar to the lottery guessing tasks." After this critique, the authors added the inclusion criteria to the manuscript which had not been mentioned before. However, it is still puzzling that, for instance, the presentiment meta-analysis is included while all the DMILS/remote staring meta-analyses are not. Regarding this issue the authors replied: "DMILS is not generally argued to be a form of ESP (anomalous perception)." This statement is a mystery to me. Why should sensing that somebody is staring at me from behind not be some form of ESP or anomalous perception?

Heterogeneity: The quality of the results of a meta-analysis can be assessed by several criteria. There are, for instance, the mean effect size and the significance level. Another crucial indicator is heterogeneity. It assesses whether within the sample of the effect-sizes there is more variance than would be expected by sampling error. Since some of these meta-analyses are quite old and some have complex combinations of studies, heterogeneity is an important issue to report. It is a standard in mainstream reviews. The authors refused to report this information.

Quality of Meta-Analyses. In a similar fashion, I suggested to them to include a quality rating of the different meta-analyses since in the last 30 years of meta-analyses the methodology and reporting standards have made some advances. My idea was to select variables referring to quality issues that vary throughout the sample. The authors insisted to remain with the MARS criteria. I consider them useless because they are so simple that the sample has hardly any variance. Thus, I also suggested deleting table 2. Since almost all studies but two report the exactly same features the information contained in this table is close to zero and could be easily summarized in one sentence.

Effect Size Metric: The authors combine and compare different effect types of effect sizes in their approach. They also compute correlations with these values. This requires that they be mathematically equivalent in the sense that, for instance, the double in size refers to an effect twice as large. Whether this is true for the different types of effect sizes in this review and whether all these effect sizes in the paper share the same metric is difficult to say. My request to give more background information on effect size types, formulas, and converting procedures were unfortunately declined. I made a few tests with my own data, read the literature, and debated with a statistician about this issue. I remain uncertain whether all these effect sizes share the same metric as the authors claim. This is especially problematic regarding the ES = $z/\sqrt{n}$, where so far nobody found a reference stating that this belongs to the *d*-type effect size family. It might be that such an ES underestimates the size of effect if taken as a *d*-type effect size. So, all comparisons and computations with this set of effect sizes reported here need be interpreted in a very cautious way. This is even more true since some of the primary studies are contained in several meta-analyses.

Line in the Graph: In figure 1, the mean effect sizes of the different meta-analyses are depicted graphically. A line connects them and a line in a graph indicates that several observations reflect moments in a continuous variable such as temperature in a weather chart. In this case, the graph displays single independent observations. Furthermore, the sequence of these observation was chosen by the authors based on the size. In such a graph, single observations should not be connected by a line since this is misleading, which is basic knowledge in statistics. The authors did not agree to this reasoning and insisted on the connecting line.

Moderator Analyses: The authors chose two moderators, one is response type and the other state of consciousness. They gave point ratings for each of the moderators. For instance, a study with a physiological dependent variable received three times as many points as one with applying a forced choice variable. In order to assess the effects of the moderators on effect size they combined these two moderators into one score by adding points. This correlation turned out to be significant. The authors state in their reply to my comments that the decision to combine these two moderators "did not derive from theoretical reasoning, but was empirically tested." This sounds a bit like *p*-hacking. An appropriate approach would be to report the results of the respective moderators separately and to combine them in a simple meta-regression.

There a couple of more issues I disagree with (e.g., the arguments regarding QRPs) but this comment should not become too long. As a scientist, my approach to the peer review process is to make contributions better in a joint effort. I have learnt many important things from reviewers of my manuscripts and I think the peer review process is one of the strengths of science. What happened here is that the authors chose to ignore almost all suggestions and insisted on their approach. This has never happened to me before. I am thus, thankful to the editor for giving me a chance to publish my deviating opinions together with the original publication.

Response to Stefan Schmidt's Open Peer Comment

Patrizio Tressoldi, University of Padova

Lance Storm, University of Adelaide

As supporters of the Open Peer Review system that has been adopted by many scientific journals to serve both the reviewers' important task and let readers form an independent opinion about the strengths and limitations of a paper, we take this opportunity to reply to the comments raised by Stefan Schmidt regarding our paper.

With respect to Schmidt's criticism that DMILS/remote staring meta-analyses are excluded, our response is that we did not intend this study to be a theoretical exercise into the suitability and validity of a study based on psi terminology or processes underlying psi for which there is no broad consensus. We went by the current working hypotheses in parapsychology. DMILS is not generally argued to be a form of ESP (anomalous perception).

With respect to Schmidt's criticism that the quality of the results of a meta-analysis can be assessed by using several criteria, our reply is that we preferred to refer to the MARS (Meta-Analysis-Reporting Standards) of the American Psychological Association guidelines and not to build new criteria.

With respect to Schmidt's suggestion to delete table 2, our response is that it is the main table of the study summarizing the relevant information we used for our moderators analysis.

With respect to Schmidt's comments about effect size metric, on page 62 of our paper we expanded the description of the effect sizes and why they can be considered compatible.

With respect to Schmidt's suggestion to omit the line in figure 1, our reply is that the legend clarifies that the effect sizes are in decreasing order of magnitude with re-

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spect to the various experimental designs. The line is useful for conveying the overall decreasing slope but does not imply missing designs.

With respect to Schmidt's comments related to the moderators analyses our reply is that the choice of how to combine the two moderators did not derive from theoretical reasoning, but was tested empirically. The suggestion to test the effect of each moderator separately does not allow one to test their joint effect in particular with a correlation test given the limited range of the moderators values, from 1 to 2 for the consciousness status and from 1 to 3 for the type of response.

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Psi Performance as a Function of Demographic and Personality Factors in Smartphone-Based Tests: Using a "SEARCH" Approach

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Abstract: *Objective*: We set out to gain a better understanding of human psychic or "psi" functioning by using a smartphone-based app to gather data from thousands of participants. Our expectations were that psi performance would often be revealed to be in the direction opposite to the participants' conscious intentions ("expectation-opposing"; previously called "psi-missing"), and that gender and psi belief would be related to performance. *Method*: We created and launched three iOS-based tasks, available from 2017 to 2020, related to micro-psychokinesis (the ability to mentally influence a random number generator) and precognition (the ability to predict future randomly selected events). We statistically analyzed data from more than 2,613 unique logins and 995,995 contributed trials using null hypothesis significance testing as well as a pre-registered confirmatory analysis. *Results*: Our expectations were confirmed, and we discovered additional effects *post-hoc*. Our key findings were: 1) significant expectation-opposing effects, with a confirmatory pre-registered replication of a clear expectation-opposing effect on a micro-PK task, 2) performance correlated with psi belief on all three tasks, 3) performance on two of the three tasks related to gender, 4) men and women apparently used different strategies to perform micro-PK and precognition tasks. *Conclusions*: We describe our recommendations for future attempts to better understand performance on forced-choice psi tasks. The mnemonic for this strategy is SEARCH: Small effects, Early and exploratory, Accrue data, Recognize diversity in approach, Characterize rather than impose, and Hone in on big results.

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Highlights

- To better understand psi, we designed a smartphone app with three "games" that test precognition (prediction of random future events) and micro-psychokinesis (micro-PK; mental influencing of random number generators).
- We performed exploratory analyses on data from more than 2,613 unique logins and 995,995 contributed trials to determine demographic and personality traits that correlate with psi performance.
- We found significant psi performance on all three games and complex relations with psi belief, gender, and personality traits.
- In a pre-registered confirmatory analysis, we confirmed the existence of a large and initially unexpected micro-PK effect.
- We discuss our approach to analyzing data from non-laboratory forced-choice psi experiments and make recommendations for future research.

From the beginning of systematic psi research, progress has been inhibited by funding issues largely resulting from an under-informed taboo and by assumptions about what effects are possible from the perspective of scientific materialism (cf. Cardeña, 2018; Franklin et al., 2018; Mossbridge & Radin, 2018a,b). In addition, three research problems have reduced the speed of discovery in the field. First, psi effects tend to be small and heterogeneous when drawing unselected test participants from the general population. This makes psi difficult to demonstrate or to replicate within typical brief laboratory experiments that rely on small numbers of participants. Second, the number of individuals required to identify participants who exhibit consistent talent on specific psi tasks is not feasible to obtain for most psi laboratories. And third, individual differences appear to affect performance on psi tasks, making it difficult to find a single "gold-standard" task that can be reliably used to probe factors that influence performance.

Fortunately, with the rise of the Internet, each of these problems can now be addressed through the use of online psi experiments (e.g., Radin, 2018). Here we report data from three smartphone tasks active from 2017 to 2020. The data were obtained from 2,613 participants (or more precisely, by that number of unique logins), who together contributed 995,995 trials. The tasks were designed to investigate micro-psychokinesis (micro-PK) and precognition. Our focus was on understanding how demographic and personality factors affected psi performance on these tasks.

To help explain our approach, consider that when the neural strategies for processing visual input were only partially understood, one key method used in visual neuroscience was to analyze correlations among perceptual skills to probe the brain's perceptual strategies (Karni & Bertini, 1997). Later, this same approach was used in auditory neuroscience (Mossbridge et al., 2006; Mossbridge et al., 2008). The idea is that if an individual were trained to improve their performance on one task, and that improvement translated into improvement on another task that was not trained, then those two tasks were likely to share a common substrate. A similar approach in psi research has been the finding that a robust meditation practice seems to have positive influences on precognition (Roney-Dougal & Solfvin, 2011; Roney-Dougal et al., 2008) and micro-PK (Braud, 1989; 2002) performance, a finding that may suggest that meditation drives changes that benefit psi. By comparison, brief alterations of consciousness using hypnotic suggestion have had no consistent effect on precognition or micro-PK tasks (Lantz, 1989; Mossbridge et al., 2021). Taken together, these results suggest that for those who are not naturally talented with psi abilities, the mechanisms responsible for improved precognition or micro-PK performance require long-term changes in neural plasticity that cannot be induced by a temporary change in one's state of consciousness.

Although it would be ideal to apply the learning-generalization approach to psi functioning, previous attempts to do so have failed due to the small and inconsistent effects obtained on the types of forced-choice psi tasks that are most easily amenable to daily training (Mossbridge et al., 2009). Thus, we took the approach of ignoring any potential learning effects and instead examined overall performance on different tasks as a function of gender, age, psi belief, confidence in psi abilities, and the Big-5 personality factors. The logic was that if any of these factors reliably related to performance on any psi task, these correlations could provide hints about mechanisms underlying task performance. Further, by examining performance across multiple types of psi tasks we might possibly gain insight into the strategies used to perform those tasks and the relations among their underlying mechanisms.

This trait-analysis approach is not new to psi and was used decades ago in an attempt to create a "signature" for psi performance (Radin, 1989). In terms of the Big-5 personality traits and their relation to psi performance, openness to experience and extraversion have been positively related to psi performance in general, especially for precognition (Hitchman et al., 2012; Honorton et al., 1998; Palmer & Carpenter, 1998; Zdrenka & Wilson, 2017). Psi belief, which is closely related to psi experience, also seems to be related to better performance on psi tasks (Braud, 2002; Lawrence, 1993; Marcusson-Clavertz & Cardeña, 2011; Palmer, 1971; Storm & Tressoldi, 2017). And when psi belief was manipulated, psi performance on a clairvoyance task was successfully manipulated as well (Walsh & Moddel, 2007). In addition, gender seems to influence both precognition and psychokinesis tasks, but in complex and inconsistent ways that do not allow firm conclusions to be drawn, except that as in many non-psi behavioral tasks men and women sometimes have different ways of responding to certain tasks and stimuli (Bierman & Scholte, 2002; Jahn et al., 2017; Lobach, 2009; Mossbridge, 2017; Mossbridge et al., 2012; Radin & Lobach, 2007; Wittmann et al., in press).

The psi performance we investigated involved an iOS-based "Psi3" smartphone app available from 2017-2020. The app presented three tasks designed to measure performance on micro-psychokinesis, conscious precognition, and unconscious precognition. Given the many factors we examined, there are many analyses that could have been performed. We took an exploratory approach on initial data, and then pre-registered confirmatory analyses on new data where we felt the exploratory effects were intriguing or robust enough to warrant it. Although a case has been made that psi functioning may be "trickster"-like (Kennedy, 2003; Maier et al., 2018; Radin, 2019), or that it cannot function consistently as a result of inherent quantum constraints on signaling (Atmanspacher & Filk, 2012), we did not adopt those assumptions. This is because of ample evidence that pre-screened and trained individuals performing free-response remote viewing experiments can access psi skills consistently at a rate above chance (May & Marwaha, 2018; Mossbridge & Radin, 2018a; Utts, 1996). So, instead of assuming that psi can never reveal its nature to us, we assumed that until recently we simply had insufficient statistical power and overly simplistic designs to demonstrate consistent psi performance on brief trials with untrained participants.

Methods

Experimenter Information

This was a smartphone-based study and there were no interactions between the experimenters and the participants, though it is likely that many participants knew who the experimenters were. Both experimenters had a strong belief that the data would support the existence of psi functioning.

Data Separation by Date

We examined two batches of data both separately and together. The first batch consisted of data recorded from the launch date of the app, June 12, 2017, to midnight GMT on April 30, 2019, and the second batch consisted of data recorded from 12:01 am GMT on May 1, 2019 to midnight GMT on April 30, 2019. They were separated into two batches because: 1) preliminary data and analyses were presented at a conference in June 2019, and 2) based on that analysis we found effects for which we felt a confirmatory analysis was warranted, so the second batch allowed us to gather those data. However, the data were only analyzed separately when it was necessary to perform confirmatory analyses (see Participants).

Random Number Generation

All games used a random number generator that drew from a truly random source. Specifically, we used the KISS07 Java algorithm XOR'd with a rapidly changing low-order output of the phone's accelerometer (second-to-fastest-changing output). Random bits generated in this way have been checked with standard randomness testing suites and deemed adequately random. The KISS07 algorithm passes the diehard test battery and has a period greater than 10^{36} (https://groups.google.com/g/comp.lang.fortran/c/5Bi8cFoYwPE/m/pSFU7NaK224J). In any case, phone accelerometers are good sources of true randomness even in their stationary state (Voris et al., 2011), and the output of a pseudorandom process XOR'd with truly random output must necessarily be truly random.

Procedure

Participants were required to indicate their consent using a within-app informed consent form approved by the Institutional Review Board of the Institute of Noetic Sciences (IONS_IRB#: 01-11-17-102). After indicating consent, they were asked to complete a brief survey that asked their age, gender, belief in their psi abilities, and confidence in their psi performance. To indicate gender they moved a slider, with the default position of the slider in the middle of the range, anchored by a male symbol on the left end and a female symbol on the right end. They did not have to change the position of the slider to continue the survey. Belief in psi and confidence in psi abilities were indicated as values 1 through 5, where 5 indicated greater belief and confidence. Finally, participants were asked to take the 10-item Brief Big-5 Personality Trait Inventory (Gosling et al., 2003; McCrae & John, 1992; Tupes & Christal, 1961), scored according to the method used by McCrae & John (1992). After completing these survey items, they were able to play any of the three games or none of them, at will, for as many or as few trials as they desired.

Participants

Except where noted in the results, we included as participants all users of the Psi3 app who performed any of the three games during the periods included within the two data batches, who listed their age as between 18 and 100 years old, and whom we considered "attentive" participants. To score attentiveness, we used their responses to the Brief Big-5 Personality Trait Inventory. Participants who responded to 2 or more reverse-scored questions with the same response as they did to its opposite were not included in the analysis. For example, those who responded the same way to both "I see myself as someone who does a thorough job" and "I see myself as someone who tends to be lazy," and also responded the same way to both "I see myself as someone who is relaxed, handles stress well" and "I see myself as someone who gets nervous easily," were considered to not be paying attention or taking their responses seriously and were excluded from all further analyses, except those pre-registered as confirmatory.

This amounted to 2,192 unique attentive participants in the first batch (M_{age} = 43, SD = 14.5), and 421 participants in the second batch (M_{age} = 43, SD = 12.5), 131 of which were new users in the second batch. The tasks called *Heart Quest, Future Feelings,* and *Hidden Gurus* (described later) were played by 1,969 (first batch)/359 (second batch), 1,869/298, and 1,857/393 unique attentive participants in the first/second batches, respectively. An email address was the only requirement for registration, so it is possible that some participants used more than one email address. Further, most (290) participants who contributed data to the second batch also contributed data to the first batch. Thus, we combined all participants across the two data batches in all analyses except those used in the pre-registered confirmatory analyses.

In terms of gender demographics, we assumed that those who did move the gender slider were committed to their gender expression, but because the default was the center of the slider we cannot assume that all participants who did not move the slider were non-binary or gender non-conforming. The slider recorded values from 0 (100% male) to 1 (100% female), with few participants moving the slider all the way to the ends to indicate gender. Thus, we arbitrarily chose a cutoff of <0.25 for "trending toward male gender" and >0.75 for "trending toward female gender." In the remaining text, we call these participants "male" and "female." According to these cutoffs, there were 945 and 240 (first and second batch) participants trending toward female gender and 1,003 and 40 (first and second batch) participants trending toward male gender.

Tasks

Of the three tasks included with the smartphone app, *Heart Quest* was designed to measure micro-PK performance, *Future Feelings* to measure unconscious precognition performance, and *Hidden Gurus* to measure conscious precognition performance (Figure 1). In no case were participants required to play a full game. If they desired, participants could see their standing in a list that ranked performance in each of the three games, a method we hoped would increase motivation to perform multiple trials and create an intention to score well.

Micro-PK/Heart Quest

For Heart Quest, a completed game consisted of 10 trials in which participants were instructed to try to mentally make the heart of an animated robot glow red and play a celebratory sound. On each trial, participants pressed anywhere on the screen (Figure 1, left image), whereupon one of three sound/image sets were presented: a glowing red heart and harp-like sound (+10 points), a bright red heart and a bell sound (0 points), or a dark red heart and no sound (-10 points). All images were faded in over 150 ms, held static for 1,500 ms, and then faded out over 1,500 ms for a total display duration of 2,650 ms. Sounds were concurrent with the images but sometimes ended before the display duration was complete (and we cannot assume that all participants used the app with audio turned on). The timing between trials depended on the participant's choice as to when to press on the screen to begin the next trial.

After each screen press, two bits were gathered from the true random number generator, without respect to the location of the screen press. If the two bits matched two reference bits that were randomly selected prior to the start of the game, the trial was worth +10 points (e.g., reference bits: 01, trial bits: 01). If one bit matched and the other did not, it was worth 0 points (e.g., reference: 01, trial: 00). And if both bits differed, it was worth -10 points (e.g., reference: 01, trial: 10). Higher cumulative scores indicated more accurate matches between trials and the reference bits. Scores were reported to users after each trial, with the final score presented at the end. An explanation of the scoring procedure was available on the app.

Unconscious Precognition/Future Feelings

In a complete Future Feelings game, participants were instructed to respond as quickly as possible to the randomized sequential presentation of 40 target images (20 positive, 20 negative). They were instructed to press a happy face if they considered the image to be positive and a sad face if they considered the image to be negative (Figure 1, middle image). The target images were the same 40 photos as those selected from the International Affective Picture System (IAPS; Lang et al., 1997) for the laboratory version of this experiment (Bem, 2011, experiment 4). There was no time-out, that is images were displayed and stayed on screen until a response was made. However, if a response took longer than 2,500 ms, participants were shown a screen suggesting that they respond more quickly. After a response and at least a 100 ms delay, the true random number generator determined an adjective prime word they would see next on the screen; the prime was either congruent or incongruent with the valence of the image (e.g., a picture of a butterfly followed by the word "beautiful" would be a congruent pair, but a butterfly image followed by "ugly" would be incongruent). The two possible priming words associated with each target image were the same as those used by Bem (2011, experiment 4). Each priming word was presented for 1,500 ms. Then a blank screen was held for 1,500 ms prior to the presentation of the next target image. A high score indicated that correct responses were faster for congruent than incongruent pairs. Unlike in Bem's original task, we did not play calming music or show a picture of the universe before a game was played. The user's final score was presented at the end of a game and an explanation of the scoring was available on the app.

Conscious Precognition/Hidden Gurus

In a complete Hidden Gurus game, participants tried to predict the future location of an avatar or "guru" image that would appear after the user pressed on the screen of the smartphone to make their prediction (Figure 1, right image). The location on the screen where the guru would appear on each trial was determined by the random number generator *after* the participant made their prediction. Guru images were faded on for 150 ms, then faded off over 1,500 ms. Participants determined the timing between each of 10 trials by choosing when to press on the screen to predict the next guru's location. Scores were calculated within the app by creating an ordered list of numbers representing the distances between every pixel on the screen and the actual location of the guru, then finding the ranking on that list for the pixel representing the user's predicted location. This method was used to create a score scaled from -10 to +10, with the final summed score provided to users at the end of the game. An explanation of the scoring was available on the app.

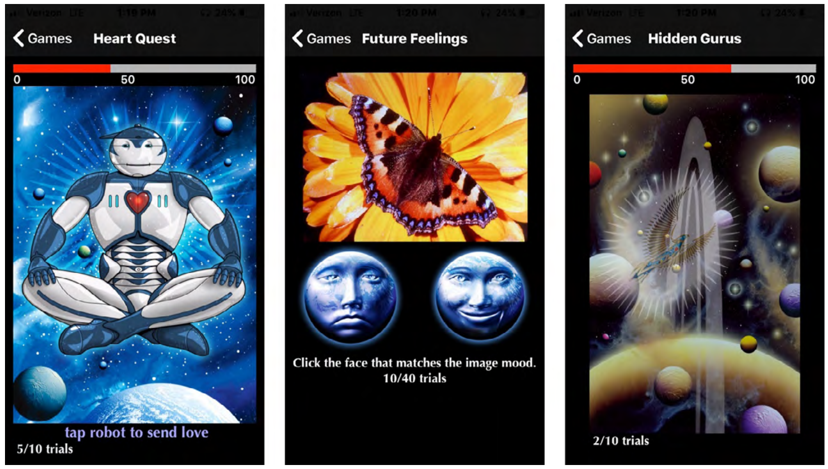

Figure 1. Screenshots of the three tasks or "games" on the Psi3 app. (Left) Heart Quest, a test of micro-psychokinesis in which participants attempted to mentally influence a random number generator to make the heart of the robot glow. (Middle) Future Feelings, a test of unconscious precognition, in which participants attempted to select a sad or happy face to reflect the valence of a target image; once selected, the image disappeared and was followed with an adjective that was congruent or incongruent with the valence of the target image just presented. (Right) Hidden Gurus, a test of conscious precognition in which participants attempted to click on the screen near where a "guru" might appear in the space-themed background.

Analysis

Overall

Data were analyzed in Microsoft Excel and Matlab 2018b. The threshold for statistical significance was set at p = 0.05. Two-tailed null hypothesis significance testing was used, but we report statistical measures that allow for other analyses to be performed by interested researchers. Except where noted below, or in the Results section, we considered all complete trials without regard to the number of trials required to complete each game, and we removed from analysis all incomplete trials (where a response was not made). Raw data are available upon request. All analyses were exploratory except for the pre-registered confirmatory analysis of the micro-PK effect on the micro-PK game.

Micro-PK/Heart Quest

For the micro-PK task, a score for each completed trial was obtained by counting the number of reference bit pairs randomly generated at the beginning of each game that matched with the bit pairs randomly obtained in each trial. The score was no match (0 points), partial match (1 bit matching = 1 point), or complete match (2 bits matching = 2 points). We used binomial tests to examine potential deviations from randomness in these three reference-trial bit matching levels as well as four other dependent variables: matches just to reference bit 1, reference bit 2, trial bit 1 and trial bit 2. Note that for this task we pre-registered some confirmatory analyses, and for those we did not use the "attentiveness" criterion to filter participants.

Unconscious Precognition/Future Feelings

To analyze data from the unconscious precognition task, we removed from analysis all incorrect trials in which participants selected the incorrect affect for the target image, as well as correct trials with response times less than 500 ms or greater than 2,500 ms. We then categorized each trial's response according to whether it represented a response to a positive or negative target image and whether a congruent or incongruent retro-priming word appeared after the response. This resulted in four picture-word congruence types (positive image with positive retro-prime [positive congruent]), positive image with negative retro-prime [positive incongruent], negative image with positive retro-prime [negative incongruent], and negative image with negative retro-prime [negative congruent]). This sub-categorization was necessary because there was a large bias toward responding more slowly to negative images than to positive images and we wanted to ensure that this bias did not mask any precognition effects. When we averaged response times for each participant across all trials, if there was not an averaged value for each of these four picture-word congruence types we excluded that participant's data, as our dependent variables and their interaction required a mean value for each congruence type. These dependent variables were called $RTdiff_{pos}$ (positive congruent reaction time [RT] minus positive incongruent RT) and RTdiffneg (negative congruent RT minus negative incongruent RT).

Conscious Precognition/Hidden Gurus

The dependent variable for the conscious precognition task was the same as the trial-by-trial score calculated for each participant. This score was either -10, -5, +5, or +10 (see Tasks, above), with higher scores indicating that the user chose a "guru" location closer to the future target than expected by chance.

Results

Micro-Pk Task/Heart Quest

Trial-Level Analysis and Associated Pre-Registered Confirmatory Analyses

Data from the Heart Quest game provided evidence for micro-PK across all eligible trials performed in both data batches. In the first batch (N_{trials}= 304,153), there were significantly fewer trials than expected by chance that matched both reference bits, and significantly more trials than expected by chance that matched only one reference bit (first batch proportion for two matches: 0.248, $p<0.030$; proportion for one match: 0.502, $p<0.020$; proportion for no matches: 0.250, $p>0.600$ [binomial tests]). Thus, the first batch of data showed an expectation-opposing (i.e., psi-missing) effect, however this outcome was not replicated in the second data batch (N_{trials}= 70,165).

We found a more interesting effect when examining the reference bits in the first batch. Although both of the bits generated for unique trials were equally likely to be 0 or 1, both of the reference bits generated once per game were significantly more likely to be a 0 rather than a 1 (Figure 2a; proportion of zeros in 1st reference bit: 0.503, $p<0.003$; 2nd reference bit: 0.506, $p<2x10-10$; 1st trial bit: 0.499, $p>0.337$; 2nd trial bit: 0.500, $p>0.955$ [binomial tests]). This was the case even though the same software function was used for generating all reference and trial bits, indicating a possible micro-PK effect (or unknown source of bias) in the randomly selected reference bits.

We pre-registered a confirmatory analysis of this effect with the University of Edinburgh's Koestler Unit registry prior to downloading and analyzing the data from the second batch. When we applied the same analysis to the second batch, the data revealed the same effect (Figure 2b; proportion of zeros in 1st reference bit: 0.506, $p<0.001$; 2nd reference bit: 0.504, $p<0.02$; 1st trial bit: 0.501, $p>0.586$; 2nd trial bit: 0.503, $p>0.147$). Although the power analysis specified in the pre-registration suggested we would need at least 79,000 trials to ensure an 80% chance of showing the effect and we only had 70,165 trials, the second batch revealed the same significant effects, and in the same directions, as data from the first batch, providing a clear replication.

Examining first-batch trials sorted by self-reported gender suggested that trials from individuals who reported that they were women were responsible for the apparent micro-PK effect on the reference bits. Specifically, women showed a large and significant tendency toward obtaining more zeros in both of the two reference bits (Figure 2a; first batch proportion zeros: 1st reference bit: 0.505, $p<0.003$; 2nd reference bit: 0.511, $p<5\times10^{-15}$; 1st trial bit: 0.498, $p>0.109$; 2nd trial bit: 0.502, $p>0.240$). Men showed a small but significant tendency toward more zeros than ones in only the first reference bit (first batch proportion zeros: 1st reference bit: 0.503, $p<0.02$; 2nd reference bit: 0.501, $p>0.520$; 1st trial bit: 0.499, $p>0.727$; 2nd trial bit: 0.498, $p>0.278$). In data from the first batch, the proportion of zeros in the second reference bit was significantly greater for women than men (first batch $\chi^2 = 11.55$; $p<0.0007$).

Given these results, we also pre-registered a confirmatory gender difference analysis to determine whether data from the second batch would replicate this effect. The confirmatory analysis did produce a significant gender difference, but in the direction opposite to that found in the first batch of data. In the second batch, reference bits from men were more likely to show the predominant-zeros effect than those from women, although women still showed the effect (Figure 2b; women, second batch proportion zeros: 1st reference bit: 0.506, $p<0.02$; 2nd reference bit: 0.511, $p<0.000004$; 1st trial bit: 0.503, $p>0.212$; 2nd trial bit: 0.505, $p>0.066$; men, second batch proportion zeros: 1st reference bit: 0.525, $p<6\text{x}10\text{-}9$; 2nd reference bit: 0.511, $p<0.02$; 1st trial bit: 0.499, $p>0.840$; 2nd trial bit: 0.499, $p>0.840$).This time the difference was more apparent in the first reference bit, with trials from men showing a significantly higher proportion of zeros in the first reference bit as compared to trials from women (Figure 2b; second batch $\chi^2=5.16$; $p<0.03$).

This pattern (men being responsible for the reference bit effect) was the opposite of the pattern found in the first data batch, but it is worth noting that the relation between gender and the proportion of zeros in reference bits 1 and zero was the same in both batches. That is, in both batches women had more zeros in the second than the first reference bits, while men had more zeros in the first than the second reference bits (Figure 2). Although this finding was not pre-registered, we performed chi-squared tests on the number of zeros in the first and second reference bit for men and women and found this pattern to be significant in the first batch and nearly significant in the second (first batch $\chi^2=6.39$; $p<0.012$; second batch $\chi^2=3.84$; $p<0.051$). Overall, some of the results observed across trials revealed significant micro-PK effects that were consistent while others differed between the two data batches; we also found a replication of an effect of gender on the relative proportion of zeros in the two reference bits.

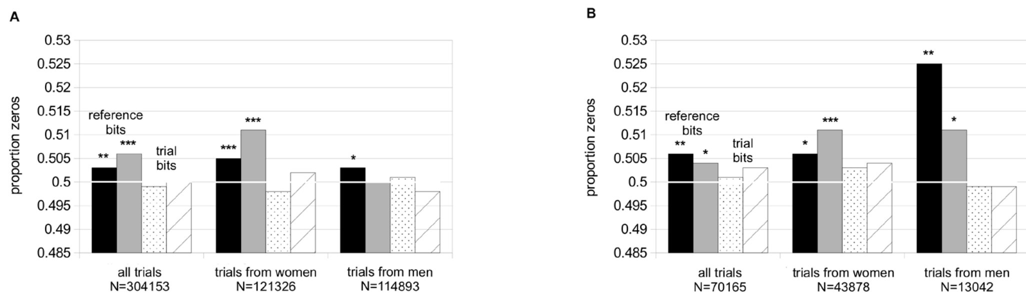

Figure 2. Data from the micro-PK task for the trial-level analysis. Graphs give the proportion of zeros for both reference bits (filled bars) and both trial bits (patterned bars) for (A) trials in the first and (B) second data batches; the pre-registered analysis was performed on the second data batch. The white horizontal line across the bars at proportion = 0.5 indicates chance (zero values half the time and ones the other half). N values show the number of trials under consideration; the number of trials from men and women do not add up to the total number of trials because not all participants indicated male- or female-trending genders. Asterisks indicate significance via a binomial test vs. chance (* = $p<0.05$, ** = $p<0.01$, ***=$p<0.001$).

Alternative Game-level Analysis

We had a concern with the pre-registered analyses in that while they allowed us to examine all trials performed by each participant and to compare non-deviations from chance among trial bits to deviations from chance among reference bits, they might provide a false impression of reference bit consistency, because reference bits are the same for every 10 trials while trial bits are not. We recognized this problem after performing the pre-registered analyses, so we could not pre-register any alternative analyses. Thus, to double-check the original results we performed an alternative analysis of reference bits at the game level (Figure 3). Within the first batch, women had significantly more zeros in the second reference bit as compared to chance, regardless of whether the games were from all women or whether we took into account only the attentive participants (as described in Methods; all women: $p<0.007$; attentive women: $p<0.04$ [binomial tests]). In the second batch the same pattern emerged, but it was only significant among attentive participants (proportion zeros in 2nd reference bit vs. chance: all women $p<0.106$; attentive women $p<0.012$ [binomial tests]). Note that the reason Figure 2 and Figure 3 do not match perfectly for reference bits is that at the game-level analysis the number of trials performed with each pair of reference bits is ignored, making reference bit pairs used in complete games (10 trials) under-represented as compared to a trial-level analysis. Importantly, the relative proportion of zeros in the two reference bits showed the same pattern across batches and matched the pattern found in the trial-level analysis (Figure 2).

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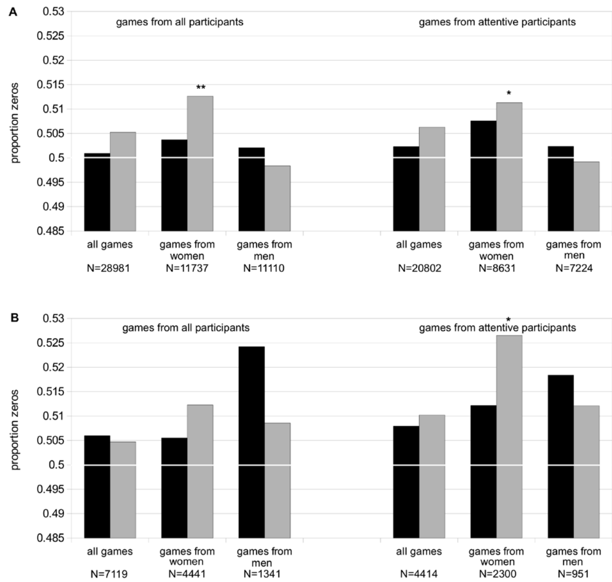

Figure 3. Data from the micro-PK task for an alternative game-level analysis. Graphs give the proportion of zeros for both reference bits for (A) games in the first and (B) second data batches. The white horizontal line across the bars at proportion = 0.5 indicates chance. N values show the number of games under consideration. Asterisks indicate significance via a binomial test vs. chance (* = $p<0.05$, ** = $p<0.01$).

Participant-level Analyses Across Both Data Batches

To examine overall and individual difference effects, we averaged data from attentive participants across all trials performed by each unique participant regardless of the data batch (first or second). Overall, there were no significant effects on the average score or on the proportion of zeros in either of the reference or trial bits (Figure 4, Table 1). Splitting the data by gender or a median split on psi belief revealed no significant effects for average score or for the average proportion of zeros in trial bits. However, with respect to the average proportion of zeros in reference bits, for individuals with low psi belief this value was both significantly lower than chance and lower than among those with high psi belief ($t_{692}=1.98$, $p<0.05$ vs. chance; $t_{2185}=2.50$, $p<0.013$ vs. high psi belief; Figure 4, Table 1). There was a tendency for women to have more zeros in the second reference bit than chance expectation and versus men, but these results were not significant ($t_{1038}=1.68$, $p<0.095$ vs. chance; $t_{1924}=1.93$, $p<0.055$ vs. men; Figure 4, Table 1). Overall, women and high psi believers showed similar patterns, while men and low psi believers showed similar patterns in terms of the relative proportion of zeros in the first and second reference bits, a pattern that matched those in Figures 2 and 3.

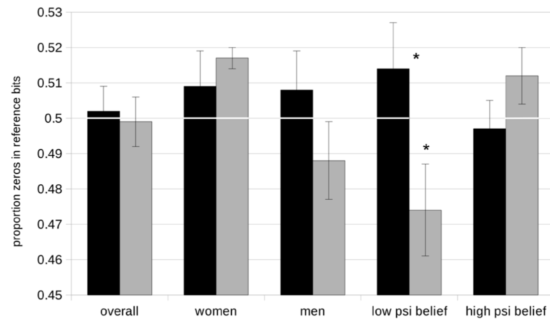

Figure 4. Results from the micro-PK task for attentive participants. Bars show mean proportion zeros for the two reference bits determined by the random function at the beginning of each game (black = 1st reference bit; gray = 2nd reference bit). The white horizontal line across the bars at proportion = 0.5 indicates chance (zero values half the time and ones the other half). Error bars give +/- 1 standard error of the mean (S.E.M.). Asterisk above a bar indicates significance; asterisk between two bars indicates a significant comparison (* = $p<0.05$ on appropriate t-test).

Table 1

Descriptive Statistics and Tests for Micro-PK Task Data from Attentive Participants

	$N_{participants}$	Score	1st ref. bit prop. zeros	2nd ref. bit prop. zeros	1st trial bit prop. zeros	2nd trial bit prop. zeros
Overall	2187	0.997; 0.154	0.502; 0.328	0.499; 0.332	0.501; 0.102	0.501; 0.107
Women	1039	0.993; 0.153	0.509; 0.325	**0.517; 0.328; *p*<0.095**	0.502; 0.111	0.502; 0.106
Men	887	1.000; 0.156	0.508; 0.331	0.488; 0.337	0.497; 0.115	0.502; 0.108
Low psi belief	693	1.001; 0.156	0.514; 0.346	**0.474; 0.348; *p*<0.05**	0.504; 0.116	0.498; 0.113
High psi belief	1494	0.995; 0.153	0.497; 0.319	0.512; 0.324	0.499; 0.111	0.502; 0.103

Note: Descriptive statistics and tests against chance for the micro-PK task on averaged data from unique attentive participants. Where two values are shown, the first value is the mean, the second is the standard deviation. All comparisons versus chance giving *p*-values < 0.1 are shown and bolded. "Score" (average proportion of 'hits') and the proportions of zeros in both trial bits are given for completeness sake, but they never revealed significant effects.

To further examine these patterns, we calculated an interaction term Ref_1-Ref_2 by subtracting the proportion of zeros in the second reference bit from that in the first reference bit for each participant, and then examined this term according to gender

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and a median split on psi belief. There were no significant effects for gender, but for low psi believers Ref_1-Ref_2 was significantly more positive than chance and also more positive than for high psi believers (low psi believers Ref_1-Ref_2 vs. chance: $t_{692}=3.81$, $p<0.033$ vs. chance; $t_{2185}=2.58$, $p<0.01$ vs. high psi belief). Thus, the interaction term Ref_1-Ref_2 appears to be the most informative for this task, suggesting that the psi effect was largely expressed in the differential proportion of zeros in the first and second reference bits. Further, it appears that the difference initially attributable to a gender difference might have instead reflected a difference in psi belief (also see demographic analyses, below).

We used multiple linear regression to examine potential relations among the interaction term Ref_1-Ref_2 and factors of personality (Big-5) and demographics (age, gender, belief in psi, and confidence in psi abilities). Results revealed a significant overall model, and when the model was reduced to include only the most powerful predictors, they were psi belief ($p<0.04$), age ($p<0.03$), openness ($p<0.07$), conscientiousness ($p<0.011$) and extraversion ($p<0.003$; Table 2), with the only negative predictor being conscientiousness. Note that gender was not included in the reduced model, suggesting that in this case psi belief was more predictive than gender, despite the gender effects described above (Figures 2 & 3). However, this difference could have been due to the participants who did not choose to report their gender (leaving the gender slider in the middle of the continuum – these participants were ignored in the group-split gender comparisons). Overall, the analysis of data from the micro-PK task provides insight into factors that may have influenced micro-PK performance in general (as discussed later), and it illustrates the complexity of expectation-opposing effects.

Table 2

Multiple Linear Regressions on DVs for All Three Tasks with Personality and Demographic Traits as Predictors

	DV micro-PK	DV unconscious precog	DV conscious precog
Full model	**adj. R^2=0.009 p<0.0009**	**adj. R^2=0.005 p<0.025**	adj. R^2=0.007 p<0.128
Openness	0.011		**0.095**
Conscientiousness	**-0.016**		
Extroversion	**0.016**	2.901	
Agreeableness			

Neuroticism		-3.58	**-0.082**
Age	**0.002**		
Gender (higher is female)		-16.45	0.204
Psi belief	**0.028**	**-24.6**	0.162
Psi confidence			-0.123
Reduced model	**adj. R^2=0.010 p<0.00007**	**adj. R^2=0.006 p<0.002**	**adj. R^2=0.012 p<0.025**

Note: Results of multiple linear regressions on averaged data from unique attentive participants who performed the micro-PK, unconscious precognition ("unconscious precog"), or the conscious precognition ("conscious precog") task. A single multiple linear regression (full model) was performed to predict one dependent variable (DV) for each task; independent variables were personality traits and demographic traits and DVs are described in the main text (micro-PK: averaged Ref_1-Ref_2; unconscious precognition: averaged $RTdiff_{pos}$ minus $RTdiff_{neg}$; conscious precognition: inverted averaged game score). Bold adjusted R^2 values indicate significance. Estimates for each participating factor in reduced model are shown, bolded estimates indicate independent significance for that factor. Rows marked "reduced model" give results for the reduced model as a whole. Shaded cells indicate the factor was not included in the reduced model because the adjusted R^2 improved when that factor was removed.

Unconscious Precognition Task/Future Feelings

To examine the overall effects and individual differences in the *Future Feelings* task we averaged response time data for correct trials performed by attentive participants across the trials performed by each unique participant, regardless of the data batch, to obtain average response time (RT) differences $RTdiff_{pos}$ and $RTdiff_{neg}$. This segregation according to target affect was critical because response times to positive images were significantly faster than those to negative images, regardless of the word primes presented after the participants' responses (mean RT: positive target images: 1,341 ms, negative target images: 1,396 ms; positive vs. negative images t_{2009}=16.79, p<1x10^{-58}). Overall, $RTdiff_{pos}$ and $RTdiff_{neg}$ were both positive, indicating that for both positive and negative images, on average participants reported the target affect more quickly for targets that were incongruent with subsequent word primes as compared to congruent (Figure 5; Table 3). This was the reverse of Bem's originally reported effect (Bem 2011, experiment 4), but the observed effect was borderline sig-

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nificant for RTdiff$_{pos}$ (t_{2009}=1.73, p<0.083) and significant for RTdiff$_{neg}$ (RTdiff$_{neg}$: t_{2009}=3.04, p<0.002).

Examining the two dependent variables as a function of gender or a median split on psi belief revealed interesting effects in both cases (Figure 5, Table 3). As observed in the micro-PK task, women and men showed an inverse pattern, such that for women RTdiff$_{pos}$ was negative while RTdiff$_{neg}$ was positive, while for men they were both positive (interaction term RTdiff$_{pos}$ minus RTdiff$_{neg}$ for women versus men: t_{1772}=1.94, p<0.053). As would be expected from this pattern, RTdiff$_{pos}$ was significantly higher in men as compared with women (t_{1772}=3.17, p<0.0016). Further, while for women only RTdiff$_{neg}$ approached significance (t_{956}=1.72, p<0.085), for men both measures were significant (RTdiff$_{pos}$: t_{816}=3.34, p<0.0009; RTdiff$_{neg}$: t_{816}=2.14, p<0.033). A median split on psi belief showed that participants with high psi belief had a similar pattern to that shown by women, in that RTdiff$_{pos}$ was more negative than RTdiff$_{neg}$, while an inverse pattern was apparent for participants with low psi belief (interaction term RTdiff$_{pos}$ minus RTdiff$_{neg}$ for low vs. high psi belief: t_{2008}=1.89, p<0.059). For low psi believers, only RTdiff$_{pos}$ was significantly higher than chance, while for high psi believers, only RTdiff$_{neg}$ was significantly higher than chance (low psi belief RTdiff$_{pos}$: t_{635}=2.23, p<0.027; high psi belief RTdiff$_{neg}$: t_{1373}=3.20, p<0.0015).

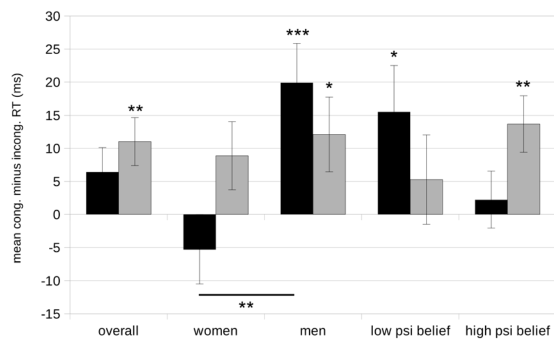

Figure 5. Results from the unconscious precognition task for attentive participants. Bars show the grand means for congruent minus incongruent trials for positive (RTdiff$_{pos}$ – black bars) and negative (RTdiff$_{neg}$ – gray bars) target images (see Methods). Chance is at zero. Error bars give +/- 1 S.E.M. Asterisks above bars indicate significant versus chance; asterisks underneath line indicate significance of men vs. women comparison on RTdiff$_{pos}$ via independent samples t-test (* = p<0.05, ** = p<0.01, *** = p<0.001).

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Table 3

Descriptive Statistics and Tests for Unconscious Precognition Task Data from Attentive Participants

	$N_{participants}$	$RTdiff_{pos}$	$RTdiff_{neg}$
Overall	2010	**6.425; 166.082; *p*<0.083**	**11.034; 162.606; *p*<0.002**
Women	957	-5.295; 163.794	**8.884; 159.424; *p*<0.085**
Men	817	**19.894; 170.456; *p*<0.0009**	**12.117; 161.801; *p*<0.035**
Low psi belief	636	**15.532; 175.853; *p*<0.027**	5.280; 170.783
High psi belief	1374	2.210; 161.251	**13.697; 158.672; *p*<0.002**

Note: Descriptive statistics and tests against chance for the unconscious precognition task for averaged data from unique attentive participants ($RTdiff_{pos}$ = average RT for positive targets with congruent primes minus RT for positive targets with incongruent primes; $RTdiff_{neg}$ = same calculation for negative targets; see Methods). Where two values are shown, the first value is the mean, the second is the standard deviation. All comparisons versus chance giving *p*-values < 0.1 are shown and bolded.

The consistent trends shared by women and high psi believers on the one hand, and men and low psi believers on the other, prompted us to investigate whether these effects could have been caused by differing responses to word primes with different affects. It is common to examine the effects of congruency between a target and a prime within a priming experiment, but it is possible that for at least some participants the congruency between target and prime was not as salient as the affect of the psi cue, that is, the affect of the adjective following the response. The reason we suspected that differing responses to word primes could have been a differentiating factor is that if one type of participants (e.g., women or high psi believers) responded more swiftly to positive prime words and were less affected by congruency, then those participants would respond faster on positive-congruent trials and also faster on negative-incongruent trials (the two trial types with positive word primes), which is the pattern observed here (Figure 6). Both interactions were borderline significant versus the comparison category (for women vs. men: t_{1772}=1.94, $p<0.053$; for low vs. high psi believers: t_{2008}=1.90, $p<0.059$). Together these data suggest that the affect of the images, the congruence between images and subsequent primes, and the affect of the primes themselves influenced performance on the unconscious precognition task. Thus, the most informative dependent variable to describe performance on this task was an interaction term ($RTdiff_{pos}$ minus $RTdiff_{neg}$).

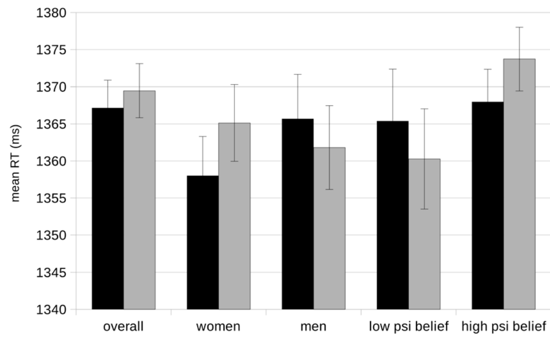

Figure 6. Results from the unconscious precognition task for attentive participants, differentiated by word prime affect. Bars show the grand means for response times (in ms) for positive (black bars) and negative (gray bars) word primes. Error bars give +/- 1 S.E.M. Interaction comparisons between women and men and low and high psi belief showed borderline significance (see text).

Multiple linear regression and follow-up model reduction again allowed the examination of potential relations between the interaction term as the dependent variable versus all recorded demographic and personality traits as independent variables (see Methods). The overall model was significant, with the reduced model including psi belief, gender, extraversion and neuroticism (Table 2), with the only positive estimate being the one for extraversion, and with psi belief as the only independently significant predictor ($p<0.009$). Together these results support the idea that expectation-opposing effects are commonplace, and that psi belief and gender are related to performance on more than one psi task.

Conscious Precognition Task/Hidden Gurus

The data from this conscious precognition task revealed a significant expectation-opposing effect. First, it is worth noting that for this task an alternative analysis drawing on dependent variables other than the overall score had previously been performed (Mossbridge et al., 2019). That analysis consisted of dividing the device's screen into a four-part grid and examining accuracy within each of the four quadrants. However, this had the drawback of marking as "misses" screen presses that may have been very close to the location of the future target but appearing in a neighboring quadrant. It also had the drawback of marking as "hits" screen presses within a quadrant but actually quite far away from the future target. As a result, we abandoned that analysis and used as our dependent variable the score for each trial, averaged for all trials performed by each attentive participant across both batches. Higher scores indicated that, on average, a participant's predictions were closer to the future location of the target. Average scores were significantly lower than 0 (t_{2153}=-2.15, p<0.033). There were no clear additional effects when the data were separated according to gender or a median split on psi belief (Figure 7; Table 4).

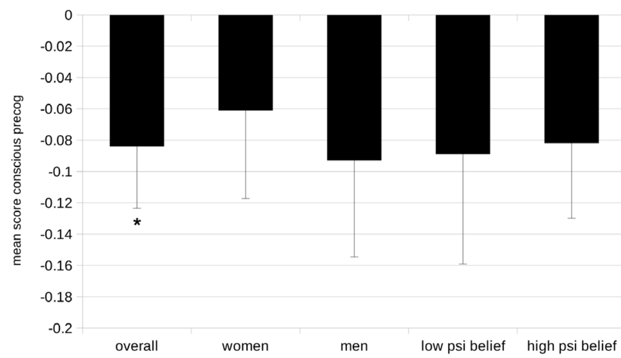

Figure 7. Results from the conscious precognition task for attentive participants. Bars show the grand means for trial scores. Negative values indicate that participants choices were farther from the "guru" to be revealed in the future than expected by chance; chance is at zero. Error bars give +/- 1 S.E.M. Asterisk below bar indicates significant versus chance (p<0.05).

Table 4

Descriptive Statistics and Tests for Conscious Precognition Task Data from Attentive Participants

	$N_{participants}$	**score**
Overall	2154	**-0.084; 1.833; *p*<0.033**
Women	1036	-0.061; 1.814
Men	865	-0.093; 1.809
Low psi belief	690	-0.089; 1.841
High psi belief	1464	**-0.082; 1.830; *p*<0.085**

Note: Descriptive statistics and tests against chance for the conscious precognition task for averaged scores from unique attentive participants. Where two values are shown, the first value is the mean, the second is the standard deviation. Any comparisons versus chance giving a p-value < 0.1 is shown and bolded.

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Because there was a significant expectation-opposing effect, we inverted the signs of the average scores for each participant prior to regression analyses, as the psi effect was clearly in the direction of avoiding the "hidden gurus" at a rate higher than chance. The full linear regression model on the inverted averaged scores including all recorded factors was not significant, but because the adjusted R^2 value was on par with the other two tasks, we examined the reduced model. The reduced model was significant and included psi belief, gender, psi confidence, openness, and neuroticism (Table 2), with gender and psi belief as positive estimates, psi confidence and neuroticism as negative estimates, and openness and neuroticism as the only independently significant predictors ($p<0.03$ for both). In sum, analyses of data from the conscious precognition task underscore the complexity and task dependence of psi performance patterns, and once again support the inclusion of psi belief as a predictive factor.

Correlations Across Performance on the Three Smartphone Tasks

Across the three tasks there were some similarities in performance patterns, especially in the conscious micro-PK task and the unconscious precognition task. However, we saw clear differences in the multiple linear regression results, indicating that the traits we examined may differently influence performance on the tasks. This suggests that performance on the tasks was governed by different mechanisms, an idea that would be supported if there were no relations between performance measures across the three tasks. To investigate this possibility, we first eliminated averaged data from attentive participants who did not contribute to the dependent variables from all three tasks. Among the 1,881 remaining participants, we found no significant correlations between these dependent variables (DV) (predicting conscious precognition DV with other two tasks as IVs: $p>0.237$, adj. R^2=0.0005; unconscious precognition DV with other two tasks as IVs: $p>0.277$, adj. R^2=0.0003; conscious micro-PK DV with other two tasks as IVs: $p>0.483$, adj. R^2=-0.0003), apparently providing support for the idea that performance on the tasks might have been governed by at least partially independent mechanisms.

However, repeating these regression analyses on the same data but separated by gender (men alone, women alone) or by a median split on psi belief (low psi belief alone, high psi belief alone), indicated that these differentiations highlighted contrasting strategies used to perform the tasks (Table 5). For women there were no consistent or significant correlations between dependent variables from the three smartphone tasks. By contrast, men's performance measures from the micro-PK task and the conscious precognition task were significantly correlated, suggesting that men used related strategies to perform these tasks while women did not.

For low psi believers no correlations were significant, but for high psi believers, the unconscious precognition task DV was predicted by performance on the other two tasks, and the DV from the conscious precognition task was predicted by performance on the other two tasks as well (Table 5). As might be expected based on these results, we found significant relations across task performance in men who were also high psi believers, for whom performance on the other remaining two tasks predicted performance on the micro-PK task and the conscious precognition task (Table 5). We take these results to indicate that men who were high psi believers may have used a consistent strategy to perform all three smartphone tasks, while other groups were less likely to do so.

Table 5

Multiple Linear Regressions on DVs from All Three Tasks with DVs from Other Tasks as Predictors, Separated by Gender and Psi Belief

	Women	Men	Low psi belief	High psi belief	Men with high psi belief
Full models					
DV micro-PK	adj. R^2=-0.001 p>0.604	**adj. R^2=0.008 p<0.02**	adj. R^2=-0.003 p>0.937	adj. R^2=0.0009 p>0.204	**adj. R^2=0.014 p<0.02**
DV unconscious precog	adj. R^2=-0.0008 p>0.526	adj. R^2=-0.001 p>0.604	adj. R^2=-0.003 p>0.855	**adj. R^2=0.003 p<0.05**	adj. R^2=0.003 p>0.194
DV conscious precog	adj. R^2=0.0003 p>0.317	**adj. R^2=0.008 p<0.03**	adj. R^2=-0.003 p>0.836	**adj. R^2=0.004 p<0.03**	**adj. R^2=0.014 p<0.02**
Reduced models – estimates					

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IV micro-PK		**0.386 for DV conscious precog**		0.169 for DV conscious precog; 16.541 for DV unconscious precog	**0.488 for DV conscious precog**
IV unconscious precog				**-0.0005 for DV conscious precog**	-0.0005 for DV conscious precog; 0.0001 for DV micro-PK
IV conscious precog		**0.024 for DV micro-PK**		**-7.959 for DV unconscious precog**	**0.03 for DV micro-PK**

Note: Results of multiple linear regressions to examine the relations between dependent variables (DVs) from each of the three tasks. Data were averaged for each unique attentive participant who performed all three smartphone tasks in both data batches, then separated into women, men, low psi belief, and high psi belief for independent regressions. Three independent multiple linear regressions (full models) were used to predict performance on each task as the DV; independent variables (IVs) were from the remaining tasks (micro-PK: averaged Ref_1-Ref_2; unconscious precognition: averaged $RTdiff_{pos}$ minus $RTdiff_{neg}$; conscious precognition: inverted averaged score). Rows marked "reduced model" give results for the reduced model where full models were significant at p<0.05. Shaded cells mean the factor was not included in the reduced model because the adjusted R^2 improved when that factor was removed. Bold indicates significance for full models and the significance of independent factors for reduced models.

Table 6

Results of Multiple Linear Regression on Psi Belief with Demographic and Personality Traits as Predictors

	DV psi belief
Full model	**adj. R^2=0.273 p<3x10^{-16}**
Openness	-0.009
Conscientiousness	

Extroversion	
Agreeableness	**0.026**
Neuroticism	
Age	**0.0049**
Gender (higher is female)	**0.154**
Psi confidence	**0.368**
Reduced model	**adj. R^2=0.2739 $p<3x10^{-16}$**

Note: Results of multiple linear regression examining the factors predicting psi belief among participants who performed all three tasks during the time periods of both data batches. Independent variables included all collected demographic and personality traits. Shaded cells indicate the factor was not included in the reduced model because the adjusted R^2 improved when that factor was removed. Bold indicates significance for full models and the significance of independent factors for reduced models. Rows marked "reduced model" give results for the reduced model as a whole.

Predictors of Psi Belief for Participants Performing All Three Smartphone Tasks

Psi belief was the only predictor that was consistently included in the reduced model for each smartphone task. But what is the relation between psi belief and the other traits we examined? To answer this question, we performed a full multiple linear regression on psi belief, using as predictors data from all other available demographic and personality traits. The results revealed a significant prediction of psi belief (adjusted R^2 = 0.274 in the reduced model; Table 6). Psi belief was positively and independently predicted by gender ($p<0.000003$), psi confidence ($p<2x10^{-16}$), age ($p<0.000005$), and agreeableness ($p<0.004$). These results indicate that these four predictors were closely associated with psi belief, so that psi belief is likely to be stronger among people who self-report that they are more female, have greater confidence in their psi abilities, are older, and are more likely to go along with what is requested of them.

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Discussion

Expectation-Opposing Effects Are Prevalent

Across all four psi tasks, the main effects had a tendency to oppose at least the principal investigator's explicit performance expectations, sometimes significantly so. Psi performance was evident in all three tasks; the effects were just in the opposite direction from the outcomes that we believe were intended by participants, who presumably wanted to score well. This over-arching finding supports the idea that one of the reasons effect sizes for forced-choice psi tasks are generally small is that there are active psi-suppressive biases at work when conscious awareness is focused on pushing task performance in a given direction (e.g., Freedman et al., 2018; Kennedy, 2003; Rabeyron, 2020).

The results from the unconscious precognition task deserve special attention, as this was the only task in which we attempted to adapt an existing psi task protocol for online use (Bem, 2011, experiment 4). Since the original presentation of the retroactive priming effect, a meta-analysis examining 90 precognition experiments, including 15 retroactive priming experiments, revealed a significant effect in the predicted direction for the retroactive priming results, with a small effect size and relatively high heterogeneity (Bem et al., 2015). This indicates a weak effect in which responses to congruent trials were significantly *faster* than responses to incongruent trials. In the current results, responses on congruent trials were *slower* as compared to responses on incongruent trials. However, at least one laboratory examination of retroactive priming conducted following the meta-analysis described above also revealed significant effects in the reverse-congruency direction (Wittmann et al., in press).

What could cause this reversal of the canonical congruency effect? One explanation is that when participants are aware that a task is testing for an unconscious bias of some sort, and they are motivated to perform accurately, responses can reflect an unconscious compensation for the bias. This effect has been demonstrated in forward-priming experiments (Glaser & Kihlstrom, 2005; Hermans et al., 2003). However, in the latter case the authors interpreted the results to indicate that when priming stimuli are presented subliminally versus supraliminally the priming effect reverses direction (Banse, 2001). In the case of our unconscious precognition task, because they knew we were looking for an unconscious bias, it is possible that participants attempted to put themselves in a mode in which all input was regarded as sub- or trans-liminal, even though all stimuli were presented supraliminally, albeit with primes from the future. Further, in our task extreme contrasts between targets and primes were presented among the stimuli (e.g., a picture of a toilet with excrement in it followed by the word "beautiful"). According to Glaser and Kihlstrom (2005), among highly motivated individuals performing a forward-priming task such extreme contrasts between primes and targets can produce unconscious compensation that can again produce priming effects with directions that counter expectations. Finally, we found a remarkably consistent effect in which participants responded more slowly to negative than positive target images. Using images as primes, a previous forward-priming experiment revealed that anxious individuals were significantly slower to respond to negative images (Hermans et al., 2003), suggesting that our participants may have experienced performance anxiety on this task. In any case, there were multiple elements in our unconscious precognition task that were seemingly consistent with forward-priming demonstrations of reverse-congruency effects. Future research will be necessary to determine why some retroactive priming experiments induce such expectation-opposing effects.

Psi Strategies Differ Across Demographic and Personality Traits

Previous examinations of forced-choice psi task performance have provided some indications that belief in psi and personality traits such as extraversion and openness can influence accuracy, albeit in a task-specific way (Hitchman et al., 2012; Honorton et al., 1998; Marcusson-Clavertz & Cardeña, 2011; Palmer & Carpenter, 1998; Zdrenka & Wilson, 2017) and that gender or sex at birth can also have task-specific influences on psi accuracy (Bierman & Scholte, 2002; Lobach, 2009; Mossbridge, 2017; Mossbridge et al., 2012; Radin & Lobach, 2007; Wittmann et al., in press). Our exploratory conclusion after examining data from the four online forced-choice tasks described here is that the task-specificity of these factors is strongly supported.

Age influenced performance only on the micro-PK task, such that with higher age the dependent variable (the difference between the proportion of zeros in the two reference bits) increased in the same direction as it did with increases of extraversion and psi belief. Meanwhile, the most powerful predictor of performance on the unconscious precognition task was psi belief, such that with increases of psi belief the dependent variable (the difference between the congruency effects for positive minus negative targets) moved in the opposite direction as it did with increases in extraversion. Finally, performance on the conscious precognition task was most strongly predicted by openness and neuroticism, such that greater openness was related to increases and neuroticism was related to decreases in the dependent variable (inverted score). All significant regressions had very small effect sizes, suggesting that the relations between demographic and personality traits and psi task performance were relatively weak. Two of the more consistent effects were: 1) those at the binary poles of the self-identified genders/sexes showed opposing patterns in two of the three tasks (i.e., not the conscious precognition task), and 2) psi belief was related to performance on all three tasks.

Comparisons of performance across all three tasks revealed significant correlations for men and high psi believers. Correlations between performance on different tasks can be taken as evidence that the correlated tasks draw on at least one overlapping resource or strategy (Karni & Bertini, 1997; Mossbridge et al., 2008). Given that women were more likely than men to self-report having high psi belief, this result suggested to us that both factors contributed to the strategy used for psi task performance. The most intriguing interpretation of these results is that for men the dominant strategy for conscious psi tasks might be to use micro-PK, while women and low psi believers seem to be using more diverse, task-specific approaches. The argument for this interpretation relies on our finding that for men in general, and for men with high psi belief in particular, performance on the conscious precognition task was significantly positively correlated with performance on the micro-PK task and vice versa. How might this strategy work for men? It is easy to imagine a micro-PK strategy being used to influence the location of the hidden gurus in the conscious precognition task and thereby boost users' scores. One can also imagine a precognition strategy being used to start the micro-PK task at a time when the reference bits maximized the dependent variable, but for the micro-PK task the dependent variable was not related to the score presented to the user, while for the conscious precognition task the dependent variable was exactly the score presented to the user. Thus, we think a more likely possibility is that men were using a micro-PK strategy for both the micro-PK and conscious precognition tasks.

In contrast, women showed significant psi effects on the micro-PK and unconscious precognition tasks, but their performance was not related across any of the three tasks, suggesting a more task-specific strategy. Within two tasks, women seemed to have taken different approaches from men, their results significantly contrasting with men in the micro-PK and unconscious precognition tasks. Note that for the unconscious precognition task, there is precedent for gender differences both within retroactive (Wittmann et al., in press) and forward (Gohier et al., 2011) priming experiments. Women have been shown to have greater sensitivity to negative images from the IAPS dataset, the set of images from which we drew our stimuli for the unconscious precognition task (for review see Barke et al., 2012). Supporting this idea, we saw a pattern in the results from the unconscious precognition task suggesting that women may have focused on the affective valence of the upcoming adjective prime rather than the cognitive congruency of the image and the prime. This idea is bolstered by results from Gohier and colleagues (2011) indicating that for women when word primes are used in forward-priming experiments the affective valence of the word prime drives response

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time more than does congruency with the target. Thus, on the unconscious precognition task, women may have had a very different strategy than men, who showed reverse-congruency effects for both positive and negative word primes (Figures 5 and 6).

When it comes to gender or sex differences, we are inclined to agree with the conclusions stated in a study characterizing the neural correlates of creativity in a sustained attention task: in some cases, it may not be appropriate to present only average results since brain activity is so clearly differentiated between genders (Silberstein et al., 2019). There was a stark contrast between genders or sexes not only in psi task performance data on two of the three tasks (i.e., not the conscious precognition task) but also in the finding that people who rate themselves as more female are much more likely to believe in psi than those who rate themselves as more male. The relation between gender and psi belief is not a novel result (e.g., Wiseman & Watt, 2004; Wolfradt, 1997), but all of these results support the idea that the effects of gender or sex should not be ignored.

Micro-Pk Effects May Vary Over Time

Micro-pk effects have been established to be small and especially difficult to replicate with unselected participants (Dechamps, 2019; Maier et al., 2018; Maier et al., 2020; Varvoglis & Bancel, 2015; 2016). Here, data from the micro-PK task revealed overall expectation-opposing effects on scoring as well as additional micro-PK effects that were replicated in a pre-registered confirmatory analysis. Two previous findings are especially intriguing in light of the present results. First, high trait anxiety or induced stress have both been shown to produce expectation-opposing ("psi-missing") results on micro-PK tasks (Varvoglis & Bancel, 2015), just like we found when all trials in the first data batch were examined together. However, this effect was not pre-registered as a confirmatory analysis, and it did not replicate in the second data batch. Second, there is evidence that micro-PK as evidenced by performance on online tasks with unselected participants may follow a decline, peaking near the beginning of the task and falling to nothing by the end of task performance in a temporal pattern that is not yet well understood (Dechamps, 2019; Maier et al., 2018, 2020). The significant micro-PK effect that we found was not on the metric used to calculate participants' scores: matches between trial and reference bits. Instead, the effect was that while the number of times "1" and "0" were produced for the two trial bits was distributed at chance levels, the two reference bits had more zeros than expected by chance. This was the case even though the same software function was used to obtain trial and reference bits. Intriguing to us is the notion that the present effect may relate to the within-experiment decline effect described for other micro-PK studies in that the reference bits were selected at the beginning of each game of 10 trials, right after the participant pressed a button to start the game.

The micro-PK effect replicated in the confirmatory analysis was on the bits chosen at the earliest possible time point in each game, perhaps suggesting some kind of temporal constraint on micro-PK. One possibility is that unselected participants who are not trained in mental focus or meditation may not be able to sustain the intention to do well throughout the course of a game. Another possibility is that micro-PK intention could build up over the course of a game and act retrocausally, creating the biggest effect for the games on which participants take the most time. It is tempting to test this hypothesis by examining the relation between game duration and scoring. This analysis reveals a massive effect that is quite impressive until one realizes that participants can choose to take as long as they like for each game. Thus, if they start out well they could be much more likely to take their time and draw out the game duration, producing a significant correlation between duration and score. Future designs might examine a potential effect of task duration and/or effort on micro-PK effects by offering a trial-pacing feature in which a trial must be performed within a short period after a signal is presented to the participant. Varying the total duration of the task across participants or across task iterations could then reveal a potential retrocausal effect.

Confirmatory Conclusion: Micro-Pk Effects Can Be Related to Gender

The interaction of the proportion of zeros in each of the two reference bits with gender was the most consistent effect across all three versions of the data analysis (all trials, Figure 2; all games Figure 3; all participants Figure 4). This consistency is important because one could imagine that the fact that the reference bits having significantly more zeros than expected by chance (all trials, Figure 1) could have something to do with people moving their iPhones in a different way at the beginning of a game (when the reference bits were selected) as compared to during a game. Because the random number generator was derived from an XOR-ing process between a fast-moving bit on the accelerometer and the output of a pseudorandom process, it would be difficult to explain how a consistent effect could be caused by a difference in moving the phone. In addition, the fact that the most consistent effect was due to gender further decreases the value of hypotheses relating to phone movement, because to explain these effects one would have to hypothesize that at the beginning of a game self-identified women moved their phones differently than self-identified men did, and this movement difference consistently resulted in output that survived XOR-ing with a completely independent pseudorandom output.

Finally, it is worth briefly pointing out that at the game-level analysis women showed the only significant effect (Figure 3), while at the trial-level analysis overall data and data from men showed a significant effect as well (Figure 2). This is likely due to a reduction in degrees of freedom (or statistical power) between the trial- and game-level analysis. Men performed many fewer trials and games than women on this task. Future examinations of gender effects on online micro-PK tasks might do well to include pre-determined numbers of participants for each gender.

Recommendations for Future Research

Our approach to analyzing these data was based on decades of psi research performed by psychologists and physiologists and it bore fruit here in terms of improving our understanding of forced-choice psi performance. We have created an acronym, "SEARCH," to help other experimenters remember the key points of this approach.

Small effects: We know that performance on forced-choice psi tasks produces small effects, so let us not expect big ones.

Early and exploratory: We are at the early stages of understanding what influences psi performance, so we need to do a lot of exploratory work before deciding that psi is trying to "trick" us.

Accrue data: Large numbers of participants give us the statistical power to observe influences on psi performance and within the last two decades it has become relatively easy to gather forced-choice data from a large number of participants.

Recognize diversity in approach: Multiple strategies as well as conscious and unconscious biases influence psi performance and they operate in distinct ways on different tasks for different participants.

Characterize, do not impose: Understanding the strategies used for each task requires determining the most psi-informative measure for that task, so imposing ideas about expected performance and its directionality is not productive. Two-tailed tests are therefore always in order for null hypothesis significance testing, at least in exploratory work.

Hone in on big results: Conduct pre-registered confirmatory analyses to determine if larger psi effects found in exploratory analyses are replicable.

It is particularly important to consider that these SEARCH recommendations are most useful when used in combination. For instance, the "A" in SEARCH ("Accrue data") can result in very large datasets such as ours, increasing the possibility of spurious cor-

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relations causing Type 1 interpretive errors (Calude & Longo, 2017; Gandomi & Haider, 2015). However, when accruing large datasets is followed by characterizing and honing in on the found effects, meaningful anomalous effects can be confirmed. In the present case, we accrued almost 1 million trials and therefore reasonably expected some significant effects, but the most convincing results were the micro-PK effects confirmed in a pre-registered analysis and the significant relations between psi performance and belief, gender, and extraversion, which matched the results of previous studies.

Future efforts in this field are likely to employ more sophisticated and engaging tasks than used here. However, using the SEARCH analysis approach will go a long way towards determining the many factors that influence psi performance, as well as the strategies and mechanisms that correspond to these factors. Over time, these observations will allow the scientific community to further understand the conscious and unconscious mechanisms underlying performance on psi tasks.

Author Contributions

Author 1 co-designed the mobile app, organized the data collection, carried out the statistical analyses, drafted the first version of the manuscript, and read and approved the final manuscript. Author 2 helped secure the initial funding for this project. co-designed the mobile app, was involved in revising the manuscript, and read and approved the final manuscript.

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Observer Dependent Biases of Quantum Randomness: Effect Stability and Replicability[1]

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Abstract. Quantum mechanics (QM) proposes that a quantum system measurement does not register a pre-existing reality but rather establishes reality from the superposition of potential states. Measurement reduces the quantum state according to a probability function, the Born rule, realizing one of the potential states. Consequently, a classical reality is observed. The strict randomness of the measurement outcome is well-documented (and theoretically predicted) and implies a strict indeterminacy in the physical world's fundamental constituents. Wolfgang Pauli, with Carl Gustav Jung, extended the QM framework to measurement outcomes that are meaningfully related to human observers, providing a psychophysical theory of quantum state reductions. The Pauli-Jung model (PJM) proposes the existence of observer influences on quantum measurement outcomes rooted in the observer's unconscious mind. The correlations between quantum state reductions and (un)conscious states of observers derived from the PJM and its mathematical reformulation within the model of pragmatic information (MPI) were empirically tested. In all studies, a subliminal priming paradigm was used to induce a biased likelihood for specific quantum measurement outcomes (i.e., a higher probability of positive picture presentations; Studies 1 and 2) or more pronounced oscillations of the evidence than expected by chance for such an effect (Studies 3 and 4). The replicability of these effects was also tested. Although Study 1 found strong initial evidence for such effects, later replications (Studies 2 to 4) showed no deviations from the Born rule. The results thus align with standard QM, arguing against the incompleteness of standard QM in psychophysical settings like those established in the studies. However, although no positive evidence exists for the PJM and the MPI, the data do not entirely falsify the model's validity.

Keywords: Micro-Pk, Mind-Matter Interaction, Pauli-Jung model, Model of Pragmatic Information, Subliminal Priming, Change of Evidence

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Highlights:

- An extension of quantum mechanics proposes observer influences of (un)conscious mental states on measurement outcomes.
- In a set of 4 studies with more than 12,000 participants in total, a subliminal priming paradigm was used to induce a biased likelihood for specific quantum measurement outcomes.
- Even though strong evidence for an observer influence effect was found initially, later replications failed to reproduce the finding.
- The results are discussed in light of the so-called 'decline effect' in psi research and a temporal analysis of the change of evidence over time is proposed.

The theoretical framework of quantum mechanics (QM) has provided a powerful scientific approach for the understanding of physical reality (Rosenblum & Kuttner, 2011). At its core, it highlights the prominent role of the measurement process in quantum state reduction. None of QM's predictions have been falsified and doubts regarding its completeness, first raised by Einstein (e.g. Einstein et al., 1935), have been ruled out by the theoretical work of Bell (1964) and empirical evidence provided by Aspect et al. (1982) and others since. QM holds that measurement of a quantum system does not register a pre-existing reality but rather creates reality from the quantum superposition of potential states—so-called quantum states. A measurement reduces the quantum states' superposition according to a probability function—the Born rule (Born, 1926)—realizing one of the potential states. Consequently, a classical reality is observed. The strict randomness of the measurement outcome and the question of what exactly constitutes a measurement are among QM's most profound enigmas. Some physicists in the early days of quantum theory (e.g. London & Bauer, 1939; Wigner in his early years, see Primas & Esfeld, 1997) and subsequently (e.g. Mensky, 2013; Stapp, 2007) have struggled with orthodox interpretations of the measurement problem and proposed that consciousness might play a crucial role in quantum state reduction. The research reported herein aimed to test the validity of this proposition by exploring the circumstances under which an observer's mental state might influence quantum state reductions.

We generally agree with mainstream QM interpretations that deny the role of consciousness-related quantum state collapse (e.g. Yu & Nikolić, 2011), but believe that this is only true insofar as the specific outcome of a measurement provides no personally relevant meaning to a conscious observer. This is usually the case for standard experiments in quantum physics. However, for rare experimental cases involving meaning we think that the observer's specific mental state will be correlated with the quantum measurement process, leading to a biased outcome. We thus argue for the incompleteness of QM in situations in which psychologically relevant information evolves from quantum state reductions and is individually observed or experienced. For all other circumstances, the validity and causal closure of QM remains intact. So, if it is posited that physical theories are not concerned with meaning in the above-mentioned scenario, QM can be considered complete. However, for situations in which meaning is attached to conscious observation of a quantum system's measurement outcomes, the observer's psychological state might need to be included as a biasing factor. This extended QM framework was initially proposed by Wolfgang Pauli and Carl Gustav Jung in a letter exchange between 1932 and 1958. Some propositions derived from this theory were tested experimentally in the studies presented here.

Any measurement device interacting with a quantum superposition will form a combined system following the fundamental rules of QM. This process is repeated for any additional measurements of the combined system, leading to a theoretically infinite chain of combined systems for which QM theory provides no ending point. To suggest a natural final step, von Neumann (1932) speculated that this chain must eventually end with the subjective perception of a human observer. In line with this, London and Bauer (1939) explicitly proposed that an observer's consciousness causes the collapse of the wave function. Wigner also strongly favored this idea and became an important proponent (Esfeld, 1999) but abandoned this view completely when faced with the problem of solipsism (Atmanspacher, 2004).

Although some scientists have pursued subsequent models that favored a role for consciousness (e.g. Mensky, 2013; Stapp, 2007), they remain a minority within the scientific community in which mainstream quantum physics considers this hypothesis to be empirically falsified. For example, Yu and Nikolić (2011) analyzed the validity of the consciousness-causes-collapse argument by referring to empirical data from experiments in which the collapse of the wave function is dissociated from the conscious observation of the outcome. In these studies, "which-path-information" was assessed in either idler photons or single atoms. Under such circumstances, the interference pattern was destroyed even if the actual status of the signal stimuli was not registered macroscopically (Dürr et al., 1998; Eichmann et al., 1993; Mandel, 1999; Zeilinger, 1999; Zou et al., 1991). Their conclusion was that if "which-path-information" is identifiable in principle, it constitutes a sufficient condition for the collapse of the wave function. Conscious observation or any other concrete registration of quantum states is thus not a necessary condition for state reduction. This rendered any strong versions of consciousness-only-causes-collapse models implausible. QM and quantum measurement work well even without conscious observation (but see Radin et al., 2016; Tremblay, 2019).

Nevertheless, some prominent physicists with a special interest in mind-matter relations have proposed ideas that include mental states in physical theories within a quantum theoretical framework. These approaches elaborate on dual-aspect monism, a philosophy of mind that states that the mental and physical realms evolve from an underlying common domain in which both form an undivided union. Bohm (2002) formulated a distinction between an explicate order that describes the classical world and an implicate order that refers to the world's quantum theoretical evolution. He related the disjunctive nature of mental and physical states to the explicate order, whereas in the implicate order this distinction vanishes "*with this deeper reality … [being] something beyond either mind or matter*" (Bohm 1990, cited in Atmanspacher, 2012, p. 99; see also Bohm & Hiley, 1993; Hiley, 2001). Similarly, d'Espagnat (1999, 2006) argued that the deepest level of reality—the 'Real'—is "*prior to mind-matter splitting*" (d'Espagnat, 2006, p. 454).

A more elaborate theory, although not mathematically formalized, was formulated by Pauli and Jung in a correspondence exchange between 1932 and 1958 (for a summary see Atmanspacher, 2014, 2020). In their view, at the deepest level of reality quantum states and unconscious knowledge of them constitute a union that Jung called the *unus mundus*. This level is ontic and thus not empirically accessible. Any transition from this level to a higher level represents an epistemic split upon which conscious knowledge and corresponding classical physical states appear. Within the mental realm, this process is expressed by a knowledge transition from unconscious (i.e., unknown) to conscious (i.e., known) mental states. This parallels the transition in the material domain from quantum to classical physical states during the measurement process. Because conscious observation and classical physical states both evolve from a common ground, a psychophysical correlation can be assumed.

Two types of psychophysical correlations between mind and matter are addressed by Pauli and Jung: First, structural correlations are proposed. They are persistent and reproducible owing to ordering factors located in the *unus mundus* (*archetypes* in Jung's terminology) and are evident in the parallelism of mind-brain activities described above. Second, induced correlations (ICs) are proposed: the psychophysically neutral domain of the *unus mundus* can be affected by mental activity causing certain changes in an individual's unconscious mind. These unconsciously activated mental states are also manifested as changes in their corresponding physical quantum states that exist in a superposition and are described by a wave function. Specifically, mental activation of certain unconscious states co-produces biased amplitudes of physical states of the wave function that represent the corresponding quantum reality. During the occurrence of an epistemic split, this will lead to the increased likelihood of a conscious experience of the previously activated unconscious state and the realization of its interrelated classical physical state. Thus, ICs of this nature predict local violations of the Born rule and of the indeterminacy principle of standard QM. Importantly, ICs are restricted to situations in which conscious observations of *meaningfully* related physical states occur during the measurement of a quantum system. Aware of the potential conflict with standard QM, Pauli emphasized the local—as opposed to generalized—nature of such effects. Those phenomena were labeled *synchronistic events* and were supposed to be evasive, occasional, and not (easily) reproducible (Pauli, 1952 in von Meyenn, 1996, pp. 634-35, cited in Atmanspacher, 2012, p. 114 and Atmanspacher, 2014, p. 254). Jung and Pauli's consideration of these mind-matter interactions as rare and unsystematically occurring special cases, even within a meaningful observation context, ensured that overall their theory was in line with the indeterminacy principle of QM. A downside of the unsystematic nature of ICs is that they should hardly be detectable empirically. This issue will be addressed in the paragraphs that follow.

A mathematically consistent formalization of the Pauli-Jung model (PJM) was recently provided by Atmanspacher and colleagues (Atmanspacher et al., 2006; Atmanspacher et al., 2002; Filk & Römer, 2011). In their generalized quantum theory (GQT), they referred to QM only in analogical form. Within GQT, mind-matter interactions are described as analogous to entanglement correlations. Entanglement involves acausal correlations based on the principle of complementarity. Accordingly, unconsciously induced mind-matter interactions are thought to vary unsystematically across time.

Consequently, Lucadou et al. (2007) formulated a set of axioms subsumed under the label *model of pragmatic information* (MPI) (see also Lucadou, 1995, 2015, 2019). In this model, novelty is defined as initial evidence for ICs and is complementary to the confirmation—that is, the replicability—of the effect. Thus, a first-hand empirical documentation of an IC should be followed by the effect's decline in a later replication attempt, leading to a reversed u-shaped curve of evidence for the effect across time. The MPI therefore predicts that any replication attempt with the same design will most likely result in a null finding. Thus, ICs would be, in principle, non-replicable and cannot be distinguished from chance effects in this way. To escape this scientific dead end, the MPI also proposes a replacement of the effect during replications. This phenomenon also occurs unsystematically and may manifest itself, for example, in the effect's shift toward the control condition or other experimental data that have been collected in addition to the main dependent variable. These anomalies may be detected in a

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correlational matrix that might reveal more significant correlations between multiple relevant variables than expected by chance. The matrix method was initially applied successfully (Lucadou, 2006), but recent attempts to replicate the matrix data with an independent experiment yielded null findings using the exact same data matrix but showed significant effects with a larger matrix that included more variables than those originally included (Walach et al., 2019).

The author of the MPI, Lucadou (2019), has provided a summary of all replication attempts using the matrix method and concluded that, given that some matrix replications failed, a degree of elusiveness is inherent in the empirical investigation of ICs and cannot be circumvented solely by switching to a higher level of testing, such as the matrix method. Regardless of the methods applied, exact replications will therefore most likely produce null findings. A potential way out of this maze might be to abandon attempts at exact replication and to proceed with conceptual replications. The less similar a replication design is to the original design, the more likely it is that the ICs will reappear. The problem with this proposition is that the "degree of similarity" necessary for a replication design to be potentially successful cannot be easily specified. Moreover, the MPI is very reserved in this respect and assigns this option only a low likelihood of success.

Taking a different route, some authors have recently challenged the MPI and the unsystematic nature of the ICs proposed therein. Maier and Dechamps (2018) slightly extended the MPI's theoretical framework, arguing that the decline does not necessarily lead to white noise (see also Dechamps & Maier, 2019; Maier et al., 2018). Based on their own empirical data, they proposed a non-random oscillating temporal pattern of effect change across time. The appearance of ICs in the data constitutes a local reduction of entropy, and with continuous data collection, the inevitable increase of global entropy leads to a vanishing of the original effect. Once this state is re-established, ICs with local violations of entropy can be set in again. Such entropic corrections may recur several times within a sufficiently lengthy data collection process, leading to a pattern of oscillation in the evidence for and against the effect. Thus, average quantum measurement outcomes in a given data set should obey the indeterminacy postulate and appear to be random (and, on the mean score level, obey the Born rule), but occasional deviations from randomness should display a periodic pattern (i.e., vary systematically across time).

Taken together, the central predictions with regard to the occurrence of ICs in a quantum measurement experiment derived from such a revised PJM are as follows: (a) Induced correlations during quantum measurement involving a conscious observer are established when the potential classical physical states are meaningfully related to the observer's unconscious state. The unconscious mind thus serves as an ordering factor. (b) Any activation of unconscious mental states should affect the likelihood of a conscious experience of this state and its corresponding physical manifestation after the epistemic split occurs. And (c) such effects should globally follow the indeterminacy principle and thus occur randomly when looking at the mean scores of the potential measurement outcomes but should follow a non-random, systematic pattern across time.

Testing the Existence of ICs Empirically

A large body of research has tested the existence of ICs during the last five decades (for an overview see Varvoglis & Bancel, 2015). This line of research is called micro-psychokinesis (micro-PK) and typically uses quantum-based random number generators. The studies conducted involved the participation of human observers and equipment that allowed the production of quantum-based outcomes, so-called quantum random number generators (qRNGs). A qRNG uses a quantum process to establish the superposition of two potential states, such as the decay or non-decay of an atom (Schmidt, 1974) or a photon taking one of two potential paths (Quantis qRNG). The specific quantum states were then translated into a consciously experienced event, such as the illumination of a lamp to the left or to the right in a circular display (Schmidt, 1970) or the presentation of a positive or negative picture on a computer screen in front of the participant (Maier et al., 2018). The volunteer's explicit or implicit task was to mentally influence the outcome. Hundreds of studies with different variations on observers' intentions and various outcome measures have been conducted and have yielded an impressive amount of data. A meta-analysis of these studies found an overall significant effect and thus evidence for observer-dependent variations in quantum randomness, that is, evidence for the existence of ICs (Bösch et al., 2006; Duggan & Tressoldi, in prep.; Radin & Nelson, 1989). However, it quickly became obvious that many micro-PK studies, including Schmidt's original work, could not be easily replicated (see Varvoglis & Bancel, 2015). This is exemplified by the PEAR benchmark study published by Jahn et al. (1997). The authors of this study employed a strict universalist approach, working with unselected participants, keeping the experimental environment constant, and following a strict predefined experimental protocol. This study took 12 years and included 91 participants with over 2.5 million trials altogether. They presented a qRNG-based random walk to the observers as a moving line on a computer screen, and the participants were instructed to mentally influence the walk upwards or downwards or to leave it unmoved. The results yielded a Z-score of 3.8 (difference between up and down conditions) at which the null hypothesis could

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be rejected. A pre-registered exact replication with 227 participants invited to three participating labs, however, yielded a non-significant *Z*-score of 0.6. Although different explanations may be offered as to why the replication failed—for example, insufficient study power due to an overestimation of the original effect (Varvoglis & Bancel, 2015)—proponents of the MPI interpret these findings as evidence of the unsystematic variation of the effect in later replications and thus the theoretically inherent decline of evidence for ICs (Lucadou et al., 2007).

Most studies completed in this area made no explicit reference to the PJM, which provides a set of circumstances for the occurrence of ICs. Hence, they did not simultaneously test the three predictions outlined above. In particular, the contribution of unconscious processes to the initiation of ICs has been widely ignored. This is not a major issue, since it was not the only theory to predict micro-PK effects, but to take the PJM seriously, it is necessary to study the participants' unconscious states and their variations in combination with qRNG outputs that correspond to these unconscious psychological states.

An exhaustive test of the PJM and its extension was recently provided by Maier et al. (2018) and Dechamps and Maier (2019). In some of their studies, they used smokers as participants and non-smokers as controls. Smokers were believed to have an (unconscious) need for smoking-relevant stimuli (such as cigarettes) that would be absent in non-smokers. All participants observed images depicting either smoking-relevant or neutral material. These were randomly chosen for each trial using a qRNG. Across three experiments, the authors applied Bayesian analysis and found that the evidence for a deviation from chance expectations in the smokers' sample was undecisive (while moderate evidence for a random behavior was found for the non-smokers). However, the effect varied non-randomly and periodically to a significant degree. A fast Fourier transform (FFT) analysis applied to the sequential Bayes factors (BFs) obtained from the smokers and non-smokers revealed that the number of significant amplitudes found within the smokers' data was significantly different from chance (the amplitudes of the resulting frequencies were found to exceed 95% of the corresponding amplitudes obtained from 10,000 simulated data sets. The latter were created without meaningful stimuli and without conscious observation during trial generation).

Additional analyses of the area under the BF curve and the highest BF reached also confirmed this data pattern. The non-smokers' temporal effect change was undistinguishable from the simulated data and thus from the chance variations. The smokers' unconscious mind set seemed to systematically correlate with the consciously observed output of the qRNG. Thus, the conscious experience and the physical display of smoking-related images matched the unconscious state of the observer from which both were supposed to emerge. This was the first promising test of the revised PJM, although, with regard to non-random variations of effect, admittedly on a post-hoc basis.

The data obtained from these studies were primarily based on a quasi-experimental design comparing smokers with non-smokers. In the studies presented here, an experimental manipulation of the unconscious state of the participants with a within-subject design was performed to conceptually replicate the above-described findings and to provide a more stringent test of the theory. Each participant performed 40 trials. During each trial, either a positive or a negative picture from a given set (e.g., aggressive dog vs. friendly dog) was chosen by a qRNG and presented to the participants for conscious observation. In each trial, before the picture presentation, a subliminal priming technique was applied. In the experimental condition, the positive outcome was subliminally primed, and thus an unconscious expectation toward the positive outcome was established. The effectiveness of positive (priming) stimuli to activate approach tendencies is well established in the literature (Phaf et al., 2014; Zech et al., 2020). In the neutral condition, a neutral mixture of both states was primed; that is, no preferred expectations were activated here.

Our predictions were as follows:

P1: Standard QM would assume that the outcome of a quantum measurement process as performed by an accurately working qRNG should be independent of any of the observers' states and should therefore be random, as expressed by the Born rule (i.e., 50% positive and 50% negative pictures), regardless of condition.

P2: A simpler model proposing the existence of ICs according to the PJM that ignores the elusive nature of these effects would predict strong evidence for more positive images than would be expected by chance in the experimental condition and smaller or null effects in the control condition. This prediction was our starting point in Study 1 and was also the pre-registered prediction in Study 2, which attempted to replicate Study 1.

P3: A more elaborate model proposing the existence of ICs according to PJM that assumes an oscillating pattern of evidence for the effect across time would predict a non-random fluctuation of the evidence for the effect (oscillating sequential BF) in the experimental condition and smaller or no oscillations in the control condition. This prediction became central over the course of Studies 1 and 2, when sequential testing (which is allowed in BF testing) provided some hints. This prediction should be replicable in an independent pre-registered Study 3.

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P4: The MPI, a sophisticated elaboration of the PJM, would predict initial evidence for an effect following a decline of the effect over the course of a study (given high study power). Such a pattern or any other non-random oscillations should not be replicable in Study 3. The effect might reappear in a different pre-registered Study 4 when the degree of design similarity is low, that is, when a conceptual rather than a direct replication is performed.

We ran four studies to test these different predictions. In Study 1, we tested P1 and P2. In Study 2, we attempted to replicate Study 1, again testing P1 and P2, and explored P3 on a post-hoc basis. In Study 3, we tested P3 and P4 on an a priori basis. In Study 4, we tested P4. Studies 2, 3, and 4 were pre-registered. In sum, the starting point of this research was a test of P1 and P2 in Study 1 and 2. P3 and P4 were added to this research later after Study 2 and led to the predictions tested in Study 3 and 4. All studies reported in this article consisted of online experiments. Recruitment was performed using two polling agencies called Norstat and Kantar, together providing a representative pool of over 100,000 volunteers. Participants were invited from their professional subject pools via email. They were paid about 2 Euros for participating in one of the studies described here. Each participant could only participate once and was then deleted from the invitation list.

Study 1

Overview

In Study 1, we tested P1 and P2. Each participant ran 40 trials. During each trial, a positive or negative picture was chosen by a qRNG and presented on the screen for conscious observation of the result. In half of the trials, the corresponding positive picture was primed subliminally before the qRNG's choice, and in the other half neutral subliminal priming had been carried out in advance. Although no pre-registration was made, our prediction was that in the priming condition more positive images than expected by chance would be selected on average by the qRNG (see P2). This is the standard prediction in micro-Pk studies. Smaller or no effects should be found in the control condition. For both conditions planned one-sample Bayesian *t*-tests were performed to test the actual mean scores of positive pictures against chance expectation (50%) separately. Since a Bayesian approach was used, data collection continued until a pre-specified stopping criterion (BF > 10) for evidence for either the H0 or the H1 in the experimental condition had been reached. Since Bayesian testing allows for the confirmation of the H_0, P1 (no deviation from chance in the experimental condition) could be tested against P2 (deviation from chance in the experimental condition). No or smaller effects in the control condition—compared to strong evidence for an effect in the experimental condition—would support the role of unconscious activations of meaningful picture contents in producing ICs and therefore support the PJM's central assumption.

Participants

Study 1's sample consisted of German participants distributed throughout the country. Participant recruitment and data collection were organized by Norstat, a professional data collection company specializing in online surveys. The invitations to participate in the study were sent out by Norstat to a random selection of their participant pool daily via email, aiming for a completion rate of about 100 per day. Twenty-two percent of invited participants took part in the study, with a drop-out rate of 44%.

Participants gave their consent for participation in the study electronically by pressing an accept button prior to the experiment. They were also informed in general terms about the study and advised that participation was voluntary. Volunteers received a short, written explanation of the study's purpose after its completion. All data were coded, stored, and analyzed anonymously. The ethical board of the Department of Psychology at the LMU Munich and Norstat approved this procedure.

Statistical Approach and Data Collection

We used a Bayesian approach in this and all subsequent studies. Bayesian inference statistics allow for data accumulation (i.e., the addition of individuals' data until a specific stopping criterion has been met). A BF of 10 in the experimental condition indicating strong evidence for either H0 or H1 was defined as the stopping rule. For Study 1, an uninformed prior following a Cauchy distribution centered around 0 with an r = 0.1 was a priori chosen and used for the analyses (i.e. $\delta \sim$ Cauchy (0, 0.1)). This prior was based on an estimated effect size of Cohen's *d* = .1 and has previously been applied in our micro-Pk research (Maier et al., 2018).

We predicted more positive stimuli than expected by chance in the experimental condition and a smaller, possibly non-substantial effect in the same direction for the control condition. Consequently, we decided to use two separate one-sample Bayesian *t*-tests with a one-tailed approach for the analyses performed. Since data accu-

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mulation allows for repeated testing, the Bayesian *t*-tests for the experimental and the control conditions were performed on a regular basis (more or less weekly) with the respective actualized sample's mean scores. We used the statistical software JASP (Version 0.9; JASP Team, 2018) for the Bayesian analyses. The data collection took place between March 2018 and July 2018.

Sample Size

Although the stopping criterion of BF_{10} = 10 for Study 1 was reached several times in the experimental condition during data collection, these hits remained unnoticed, since for each analysis we added multiple data points, sometimes from several hundreds of participants collected on a weekly basis and the final BF at the end of a week always underscored the predefined threshold for a longer period. We thus continued data collection until the stopping criterion had been securely met. This was the case at *N* = 4,092 (demographic data available for 4,034 participants: 54.82% male, 45.18% female; mean age = 47.96, SD_{age} = 11.15) at the end of one week. We then stopped data collection in accordance with the Bayesian rules of analysis.

Materials

Experimental program

The study was run as an online experiment. All participants could participate from any location using their private computers and internet access. The experiment was executed using a dedicated webserver based in the university's computer center and displayed on the participants' web browsers. This was implemented using jsPsych (de Leeuw, 2015), a JavaScript library designed to run online behavioral experiments.

Stimuli

Positive and negative pictures were used as target stimuli with a mixture of them as prime stimuli. The target stimulus sets consisted of photographs obtained on Shutterstock, a provider of royalty-free stock images. The positive target stimuli comprised 20 photographs depicting pets, peaceful landscapes, and groups of happy-looking people. Negative target stimuli were 20 photographs depicting dangerous or attacking animals and other negative scenarios. These pictures were pre-selected

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by the two first authors of this paper, both experts in experimental emotion induction techniques using pictorial material. Stimulus selection was primarily based on independent valence estimations. Strongly negative and positive photographs were chosen based on the experts' ratings in case of mutual agreement. In addition, effort was made to create matched target pairs; that is, the content of each positive target picture was similar in content to a negative counterpart. These pairs of target pictures represented specific subjects (e.g., a dog) with either positive (e.g., a friendly dog) or negative (e.g., an aggressive dog) valence. The stimulus material was converted to black-and-white to balance out a general inequality with regard to the coloring of the positive and negative images.

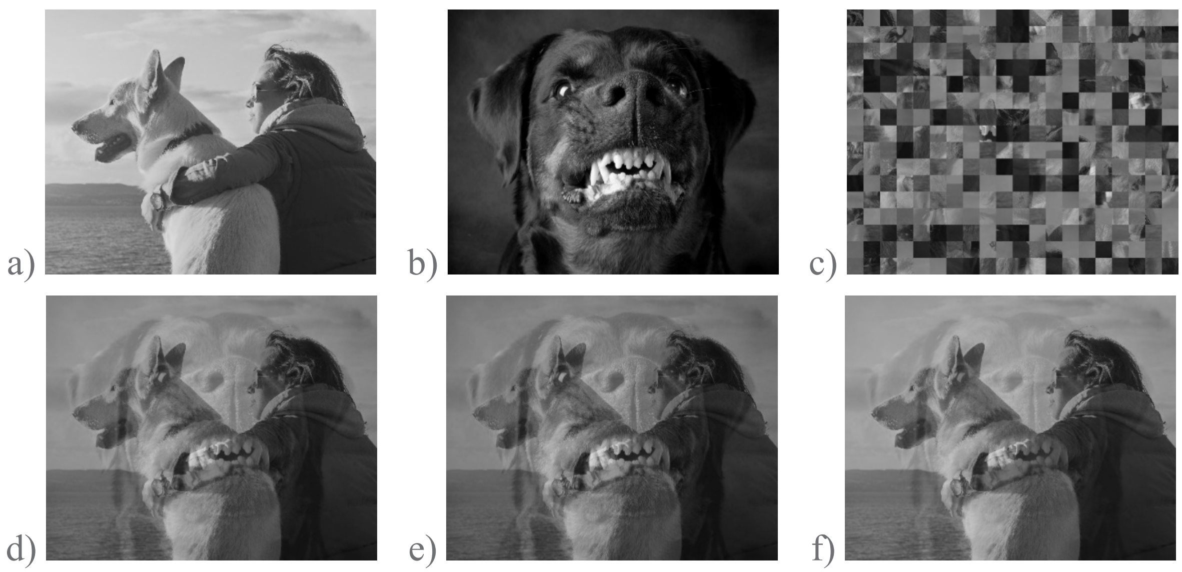

Fig 1. Sample stimuli**.** One trial consisted of a positive target picture (a) or a negative target picture (b), chosen by the qRNG. Beforehand, participants were primed with either an equal mixture of the two outcomes (d; neutral priming) or with a sequence of mixtures becoming more accentuated towards the positive target (d, e, and f; positive priming). Each prime was accompanied by a scrambled-up version of the 50/50 mixture that served as a mask (c).

From the target stimuli, two classes of priming stimuli were created: a neutral (control) and a positive priming (experimental) condition. For the neutral priming condition, each priming stimulus comprised an overlay of two matched target pictures. Those primes were constructed by coalescence between two matched targets into one final combined target. Each was designed in such a way that the positive and negative stimuli were both arranged with an equally strong appearance (50/50). Therefore, the prime represented a homogenous mixture of both matched target pictures. Since 20 matched target pairs existed, the resulting number of corresponding priming stimuli was 20. Homogeneous mixtures of both target pictures were considered to constitute neutral primes since such arrangements were assumed to reflect the superposed existence of both affective states in the *unus mundus* and would not activate any specific affective tendency above the other. Primes were accompanied by forward and backward masks comprising scrambled and indefinable versions of each prime. These masks preceding and following the primes were generated by dividing the priming image into a 20 x 16 block grid, and randomly shuffling these blocks in horizontal and vertical positions. For the resulting scrambled versions of the priming pictures the local image information remained the same, but the meaningful content of the image was destroyed. Using such scrambled versions of the original stimuli as masks optimizes the masking process and is a standard procedure in subliminal priming (e.g., Huang et al., 2019). Each priming stimulus was presented three times during a given trial before the target display. The latter was chosen randomly by a qRNG from the pair of targets from which the corresponding prime stimulus was created.

The positive priming condition used the same mixtures from the matched target pairs and the same presentation modes during the trial, but following the first perfect 50/50 mixture presentation, two slightly different priming images were displayed during each priming sequence in a given trial. The first prime was identical to the neutral priming condition and depicted both matched target stimuli equally (50/50). For the second prime presentation, however, the same matched target pair was used, but the positive share was more distinct (60/40) and in the third prime presentation even more so (70/30) (1). In this way, the positive picture became more dominant during the priming sequence and was expected to be more strongly activated in the perceiver's unconscious mind. This rather unusual positive priming procedure should within a trial mimic the evolution of a classical reality and its conscious perception out of the *unus mundus* under the biasing impact of an induced correlation. The assignment of positive or neutral priming to a trial was performed by a pseudo-RNG (pRNG). Following the priming sequence, the quantum-based RNG (qRNG) randomly selected one of the two target pictures from which the priming stimuli were created in a given trial (see fig 1 for sample stimuli and fig 2 for a schematic display of the procedure).

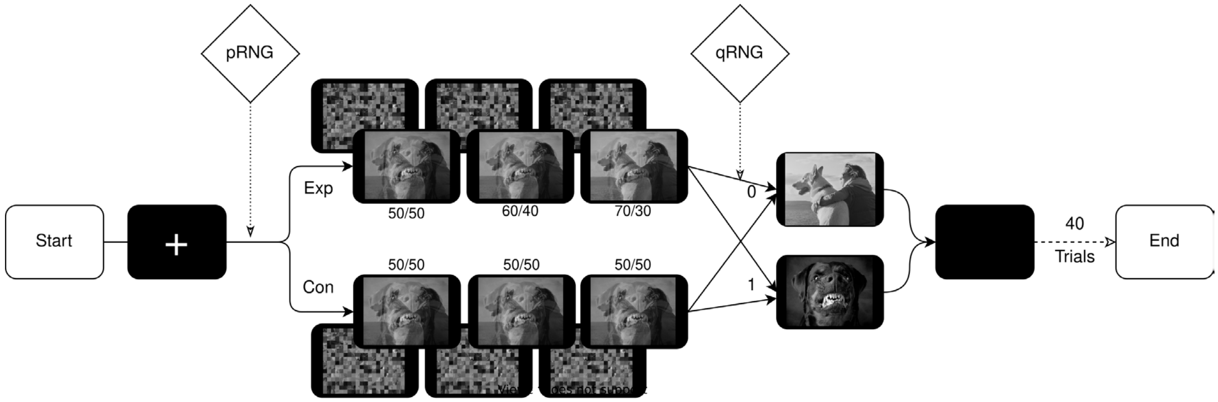

Fig 2. Schematic display of a trial. It represents the order of stimuli presentations for the positive priming condition (Pos: upper line) and for the neutral priming condition (Neu: lower line). A pseudoRNG (pRNG) was used to determine the order of positive and neutral priming trials. After masked priming with either increasingly positive primes in the positive priming condition (Pos: from 50/50 to 70/30) or neutral primes in the neutral priming condition (Neu: 50/50), the qRNG selected the corresponding target picture (attacking dog or friendly dog).

Generation of Quantum Randomness

During each trial after the priming sequence, a qRNG was used to determine whether a target stimulus from the positive or negative picture set was presented. To achieve this, a Quantis qRNG by idquantique was connected to the webserver. This device generates two equally likely superposed quantum states by sending photons through a semi-conductive mirror-like prism. Upon measurement, only one of the two states can be observed and is translated into either a 0 or a 1 bit. Using the random nature of quantum state reduction, a truly unpredictable result is generated. The qRNG passed all major validation tests of randomness, such as the DIEHARD and NIST test batteries, and is regarded as one of the most effective sources of randomness (Turiel, 2007). The device was connected directly to the server via USB and generated a random bit for each trial after completion of the priming sequence and immediately before the display of the target stimulus, therefore working without a buffer. Care was also taken to ensure that each participant received an individual bit.

Design

The study employed a within-subjects design with two conditions: a positive priming condition in which the positive pictures from respective matched target pairs predominantly served as prime stimuli and a neutral priming condition in which neutral mixtures from respective matched target pairs served as neutral prime stimuli.

Procedure

The invitation to participate in the study was issued via email by the polling company Norstat to their pool of professional clients. Participants were advised to ensure an undisturbed environment before commencing the survey. They were asked for some basic demographic information to ensure the inclusion criteria. They were then provided with a link, and by clicking on it they were subsequently taken to the experiment running on the university's webserver. After the participants were asked to activate their browser's full-screen mode, they were shown the written instructions for the task. Participants were advised that over the course of the experiments they would repeatedly see flickering visual stimuli as well as positive and negative images and that these stimuli should be passively watched. They were reminded that they could abort the experiment at any time. Prime and picture presentations began after the participants had acknowledged the instructions and had given their consent for participation.

Each participant viewed a total of 40 trials. For each individual, half of the 20 matched target pairs were randomly assigned to the positive priming condition and the other half to the neutral priming condition using a software randomizer (pseudo-RNG) at the beginning of the experiment. Each of the 20 target pairs was used twice in this setting, resulting in a total of 40 trials. Next, the pseudo-RNG was used to individually permutate the order in which the 40 trials were presented via sampling without replacement. During each trial, a fixation cross was first presented on the center of the screen (1200 ms) to direct participants' attention toward this location. Next, in the priming sequence, a mixture (neutral priming condition) or different mixtures (positive priming condition) of the two pictures that corresponded to the respective target pair of a given trial were used as prime stimuli. In the neutral priming condition, the 50/50 mixture prime stimulus was displayed three times for 55 ms each and each time was accompanied by a corresponding forward mask (110 ms) and a backward mask (110 ms) to ensure a subliminal presentation. Each prime stimulus had a specific masking stimulus that was a scrambled version of the original. In the positive priming condition, the presentation mode and times were the same as in the control, but the prime stimuli varied between a perfect mixture (50/50), a 60/40 mixture, and a 70/30 mixture of the positive/negative target pair used in a given trial. In each trial, after the priming sequence had been displayed, the qRNG was activated to provide an individual random bit that determined whether the positive or negative target stimulus from a given matched pair would be presented for 1000 ms. After this, a black inter-trial interval was presented for another 1200 ms, before the next trial started. The two dependent variables consisted of the mean number of positive pictures and therefore the number of 0 bits generated by the qRNG in the positive and neutral priming conditions.

After they had completed the task, participants were asked to complete a short questionnaire. Stimulus-seeking behavior was assessed using a scale containing two statements (Bem et al., 2011): “I am easily bored” and “I often enjoy seeing movies I’ve seen before” (reverse scored). Additionally, a self-efficacy attitude measure related to general life outcome expectancies was assessed (6 items) (Maier et al., 2018), as well as the Life Orientation Test-Revised (LOT-R) (Scheier et al., 1994), which assesses generalized optimism and pessimism with three items each. We had no a priori hypothesis regarding these questionnaires and their relationship to any micro-Pk results. We used these measurements for purely exploratory reasons, and these results will be reported in a future publication.

Results

Two separate Bayesian one-sample *t*-tests (one-tailed) were performed to test whether the mean number of positive pictures was higher than expected by chance (P2) in the positive and neutral priming conditions. The expected mean score expected to occur by chance (P1) was 10 positive pictures (out of 20 possible) on average for each condition. For the positive priming condition, BF_{10} = 13.35, indicating strong evidence in support of H_1 (frequentist *t*-test for comparison: $t(4091) = 2.89$, $p = .002$) The mean score of positive pictures in this condition was $M = 10.10$ (SD = 2.27). For the neutral priming condition, BF_{01} = 4.19, indicating moderate evidence for H_0 ($t(4091) = 0.73$, $p = .23$). The mean score of positive pictures in this condition was $M = 10.03$ (SD = 2.26). Fig 3 shows the sequential Bayesian analyses for both *t*-tests separately for each condition. While the BF of the positive priming condition hit the pre-specified stopping rule of BF > 10, the BF of the neutral priming condition showed a linear trend for a null effect because the accumulated evidence increasingly supported the null hypothesis at least moderately.

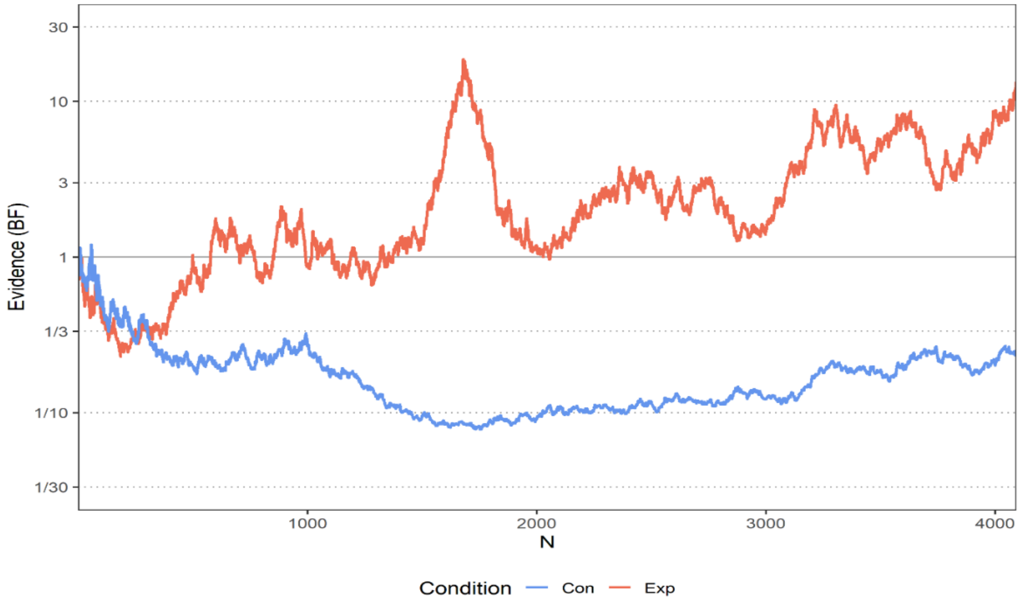

Fig 3. Sequential Bayes factors from study 1 for positive (red line) and neutral (blue line) priming conditions

Discussion

The results of Study 1 clearly matched our predictions. In the positive priming condition, strong evidence for the appearance of more positive pictures than expected by chance was found. Moreover, in line with our expectations, no substantial deviation from chance was observed in the neutral priming condition. This data pattern supports our proposition 2 (P2), according to which induced correlations (ICs) should be detectable when meaningfully—in this case, emotionally and approach-motivating—relevant outcomes (targets) are observed during quantum measurements obtained from a qRNG after unconscious activation by subliminal priming. Such deviations from chance expectation violate the Born rule (i.e. P1) and, according to Pauli and Jung, can be interpreted as ICs. The difference in the results between the positive and the neutral priming conditions suggests the central role of unconscious activations, since ICs seem to be limited to contextual circumstances in which unconscious activations precede quantum observation. The data are therefore in line with propositions derived from the PJM that emphasize the unconscious origin of such effects. The sample size, in addition to the high BF reached in the positive priming condition, indicates a robust effect. One limitation of the study, however, was that it was not pre-registered. Although the Bayesian prior and all procedural details were a priori determined by the researchers based on their earlier work (Maier et al., 2018) and data collection was delegated to a professional data collection agency, such extraordinary findings must be more rigorously processed. In addition, micro-Pk research is characterized by a considerable lack of successful replications (e.g. Dechamps & Maier, 2019; Jahn et al., 2000). The PJM classified ICs as spurious and perhaps even unsystematically varying across time. This idea was formalized in the MPI (e.g. Lucadou et al., 2007) that predicts a decline effect in later replication attempts. We therefore decided to replicate our findings precisely in a pre-registered study.

Study 2

Overview

In Study 2, we performed an exact replication of Study 1 to test its replicability. Study 2 was pre-registered at the Open Science Framework (OSF) (https://osf.io/83efr). All predictions were the same as those in Study 1. Specifically, we expected a positive deviation in the mean score of positive pictures from chance in the positive priming condition and no or smaller deviations from chance in the neutral priming condition. This would fit the assumptions made in P2 and test it against P1. The latter would predict a clear null result, with no deviations from chance in either condition. At this point, we did not consider P3 or P4 to be persuasive alternative outcomes given the evidence found in Study 1.

A BF of 10 was again used as a stopping criterion. Since we had more precise information regarding the effect size, we decided to use an informed prior of $\delta \sim$ Cauchy (0.05, 0.05). This was the only deviation from the original protocol. Data were collected between September and October 2018.

Participants

Participant recruitment and data collection were again performed by Norstat and followed the same protocol as Study 1. Over the course of data collection, the sequential BF reached the predefined threshold for stopping at n = 937. Since the predicted effect was supposed to be very small, at this stage of data collection a lack of power could have been responsible for the strong evidence for the H0. In addition, we deemed this sample size to be too small compared to that used in Study 1and therefore decided to continue collecting data while closely monitoring the BF. The final sample size was N = 2,063, at which point we ceased recruiting (demographic data available for 2,021 participants: 56.16% male, 43.84% females; m_{age} = 57.37, SD = 15.07).

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Materials, Design, and Procedures

All materials, study design, and procedures were identical to those used in Study 1.

Results

Two separate Bayesian one-sample *t*-tests (one-tailed) were performed to test whether the mean number of positive pictures was higher than expected by chance (P2) in the positive and neutral priming conditions. The mean score expected to occur by chance (P1) was 10 positive pictures (out of 20 possible) on average for each condition. For the positive priming condition, BF_{10} = 0.09 (BF_{01} = 11.31), indicating strong evidence in support of H_0 ($t(2062) = -0.79$, p = .78). The mean score of positive pictures in this condition was M = 9.96 (SD = 2.23). For the neutral priming condition, BF_{01} = 4.48, indicating moderate evidence for H_0 ($t(2062) = 0.32$, p = .38). The mean score of positive pictures in this condition was M = 10.02 (SD = 2.23). Fig. 4 shows the sequential Bayesian analyses for both t-tests separately for each condition. The sequential BFs of both conditions showed a linear trend for a null effect with the positive priming condition in particular.

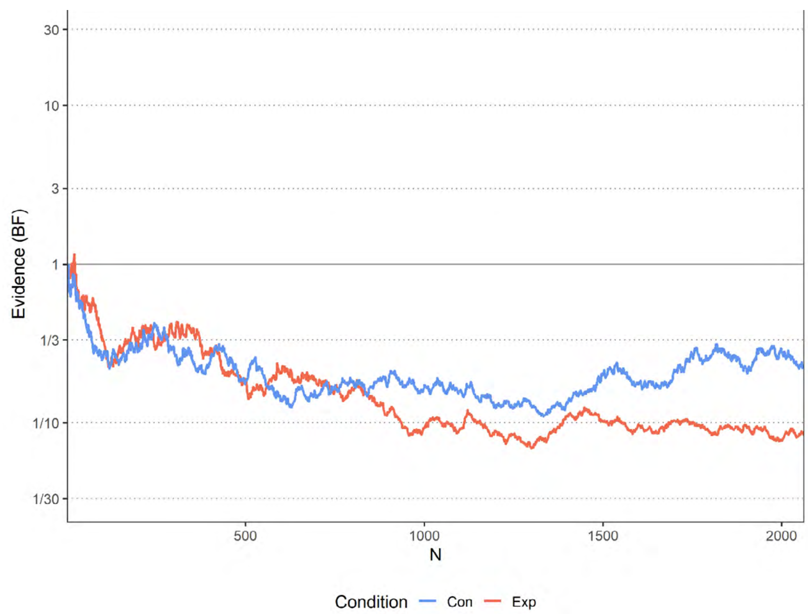

Fig 4. Sequential Bayes factors from study 2 for positive (red line) and neutral (blue line) priming conditions

Discussion

The results of Study 2 indicated that the pre-registered replication attempt failed. Contrary to our prediction, strong evidence was found for a null effect in the positive priming condition. Moderate evidence for the null hypothesis was also found for the neutral priming condition, similar to Study 1. These data support the argument that the original effect found was not replicable and may therefore have been a false positive. Although the Study 2 results could also be interpreted as a false negative, at this point, P1, which propagates the overall validity of the indeterminacy principle and the Born rule in any distributions of quantum measurement outcomes, seems to be the more valid assumption with respect to QM and the role that observation might play therein. P2 could not be confirmed in this replication.

Post-hoc Analyses of the Data from Studies 1 and 2 Combined

In the following sections, several post-hoc analyses that addressed the elusive nature of ICs as proposed by the PJM are reported. This idea was ignored in propositions P1 and P2 and was therefore not addressed a priori in Studies 1 and 2. The MPI, which formally describes the elusive nature of ICs, proposes a decline in the evidence for ICs after initial detection to conserve the indeterminacy principle of QM. In other words, only local deviations from the Born rule are assumed, and a strict temporal order of effect detection and subsequent disappearance is proposed. Building on this model, Maier and Dechamps (2018) argued that the change of a micro-PK effect across time might follow a systematic pattern that could be detected by corresponding temporal change analyses (see P3). They suggested testing the existence of ICs within the PJM in the form of systematically oscillating patterns of evidence for the effects across time. This should reveal itself in the combined data sets of Studies 1 and 2 as non-random oscillations of the evidence for the effect (oscillating sequential BF) in the positive priming condition and smaller or no oscillations in the neutral priming condition. Three methods, originally developed by Dechamps and Maier (2019), were used for the analysis of the present data to test non-systematic variations of the evidence for the effect as expressed by the sequential BF. We will describe each method in the following section and apply them in a purely post-hoc fashion to the combined sequential Bayesian evidence data sets from Studies 1 and 2 by keeping the data in the strict temporal order in which they were collected (Fig 5). We planned to replicate any results obtained by these analyses in a pre-registered Study 3.

Temporal Change Analyses

Three methods (see Dechamps & Maier, 2019) were applied to test the oscillations of the effects for data that combined the initial effect detection and replication attempt across time. To this end, we first concatenated the sequential Bayesian analysis scores of Studies 1 and 2 for the positive and the neutral priming conditions separately (Fig 5).

The time courses of the two sequential BFs were then analyzed using (a) an identification of the highest reach BF found within each of the two conditions at any time during the data collection compared with the highest BFs reached in 10,000 simulations of the data obtained from the same QRNG used in the original design (MaxBF analysis); (b) a test of the areas under the sequential BFs (energy of the curve). The sequential BF curve's energy indicates the general orientation toward the concurring hypotheses over the course of data aggregation. It is calculated as the area between the sequential BF curve obtained from each condition and the BF = 1 horizontal as baseline compared to areas obtained in the same fashion from 10,000 simulations (BF energy analysis); and (c) FFTs of the sequential BFs of each condition and the 10,000 simulations with a comparison of the amplitudes obtained. These three analyses test the non-random variation of the effect across time and provide a conservative test of non-random fluctuations. We wish to emphasize that these analyses were purely exploratory and were proposed here for testing during future confirmatory research in Study 3.

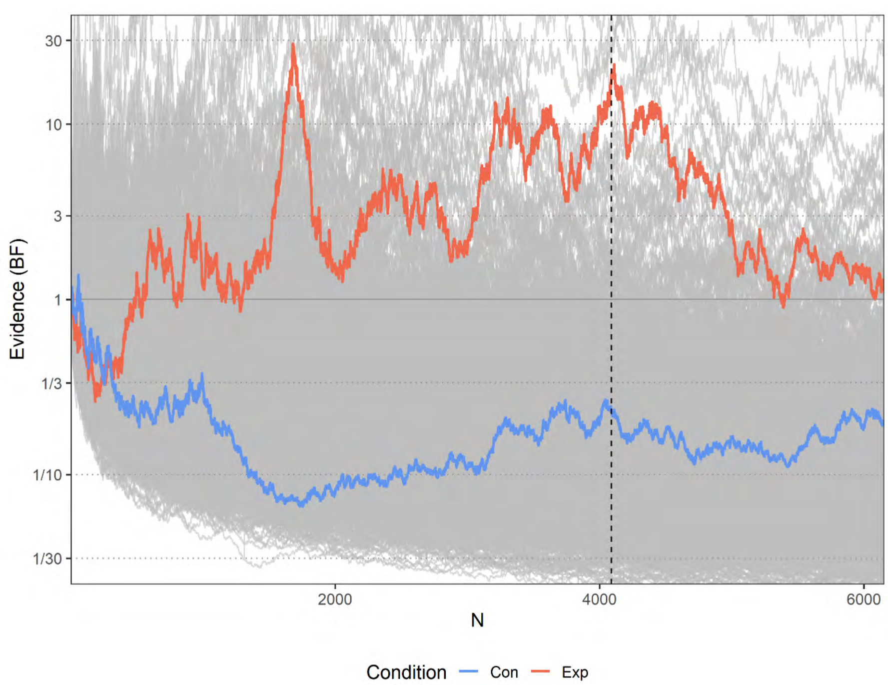

Fig 5. Combined sequential Bayes factors from studies 1 and 2 for the positive (red line) and neutral (blue line) priming. The gray lines indicate the sequential Bayes factors obtained from the 10,000 simulations. The dashed vertical line indicates the transition from Study 1 to Study 2.

Results

MaxBF Analysis

The MaxBF analysis performed on the sequential BF of the positive priming condition revealed that the highest BF reached in this data set was BF_{max} = 28.78 at *n* = 1,680. Only 2.72% of the simulations showed the same or a higher BF at any point within these data sets. For the neutral priming condition, a BF_{max} = 1.38 at *n* = 58 was found, which was surpassed by 63.16% of the BF_{max}s in the simulations.

BF Energy Analysis

The sequential BF curve's energy provides information about the evidence over the course of data aggregation. A positive score indicates that, on average, the energy is above the BF = 1 line (evidence points towards H1), and negative scores denote an energy overhang below the BF = 1 (evidence points towards H0) line. The BF energy analysis revealed that the positive priming condition's energy was 19,964.42, which was found to be surpassed by 1.37% of the simulations' energy. The neutral priming condition's energy was -5,033.84, which is surpassed by 60.81% of the simulations' energy. The mean energy of the simulations was -2,586.55 (SD=20724.52).

FFT Analysis

Third, the sequential BF curves for the positive priming condition, the neutral priming condition, and each of the 10,000 simulations was Fourier-transformed via an FFT. The FFT decomposes an empirical time course of data into its underlying frequencies and calculates their amplitudes. The resulting transform thus indicates the amplitudes of all frequencies (sample rate 1/N) that comprise the original curve. Since the transform is symmetric, only the first half is considered in the analysis, resulting in 3,078 tested frequencies. To test the FFT results from the experimental data and the control data against chance occurrence, all 3,078 amplitudes obtained from the FFT of the experimental data set were added up, creating a sum score of the amplitudes obtained from all tested frequencies of this set. This was also performed for the control data. In the same way, for each of the 10,000 simulations, the sum score of amplitudes was computed (see Maier et al., 2020). The latter provided a null distribution of amplitude sums. Earlier, a similar but less sophisticated test was used (Dechamps & Maier, 2019). The test used in the present analysis investigates the non-random oscillatory nature of the experimental and control time course data: the amplitude sum of the positive priming condition was 30.75, which was surpassed by 2.3% of simulations. The amplitude sum of the neutral priming condition was 1.34, which was surpassed by 75.39% of simulations. The mean amplitude of the simulation was M_{amp} = 6.95 (SD = 63.8).

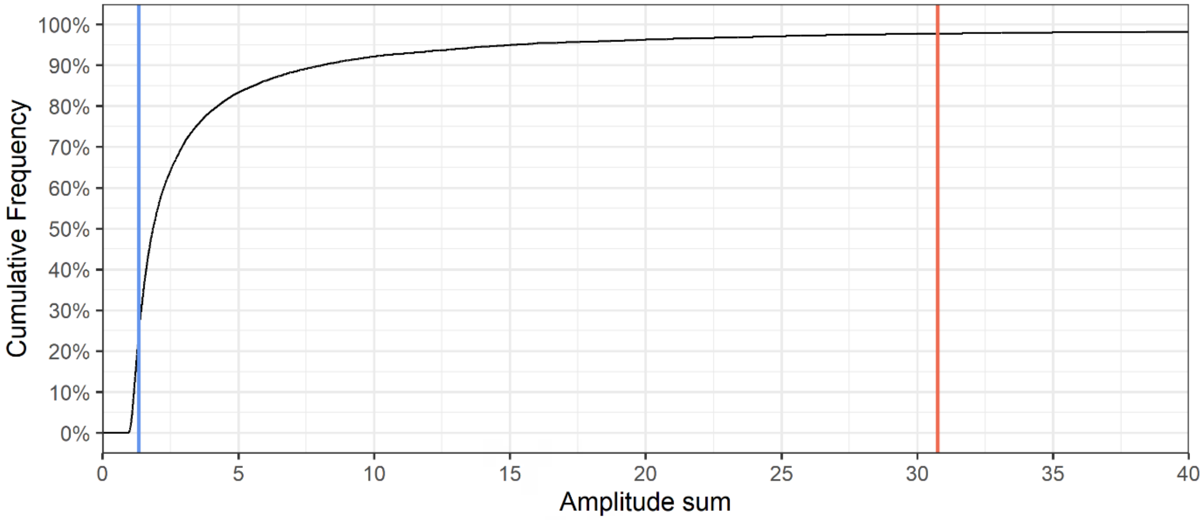

Fig 6. Cumulative frequency distribution. Amplitude sums of all 10,000 Fourier-transformed Monte Carlo simulations and values of the positive (red line) and neutral (blue line) priming conditions of studies 1 and 2 combined.

Discussion

The post-hoc analyses revealed significant deviations from chance occurrence in the positive priming condition and no deviations in the neutral priming condition in the three analyses employed. This aligns with P3, which proposes systematic non-random oscillations of IC effects across time. What looked like a false positive (Study 1) and a true negative (Study 2) given the failed replication may thus have been an effect of oscillation that mimicked such a pattern. The fact that only a few of the simulations (< 5%) displayed similar pronounced oscillatory effects across time may support the idea of systematic effect variations owing to the elusive nature of ICs, as proposed by P3. It has been argued that such oscillations were stable and can thus be replicated in an independent study (Dechamps & Maier, 2019), whereas the MPI predicts the impossibility of successful replications even at this or any other level of data accumulation (P4). Also, standard QM that denies the existence of ICs (P1) would not expect a successful replication of the data pattern described in the previous paragraphs. In any event, since these findings were obtained on a post-hoc basis only after an inspection of the data, it was necessary to confirm them in another study. This was the goal of the next study.

Study 3

Overview

The study presented here was a pre-registered experiment to test P3. The pre-registration was stored at the OSF: https://osf.io/894cb. P3 is a more elaborate model than P2, which also proposes the existence of ICs according to PJM, but contrary to P2 it assumes a non-random oscillating pattern of evidence for the effect across time. Specifically, for the study reported herein, it predicted a non-random oscillation of the evidence for the effect (oscillating sequential BF) in the positive priming condition and smaller or no oscillations in the neutral priming condition replicating the post-hoc results. MPI with P4 would argue for the impossibility of successful direct replications that should also extend to oscillations of the kind proposed by P3. A successful replication of the post-hoc analyses' results—as attempted here—would provide some initial confirmatory evidence for P3 while invalidating P1, P2, and P4. It can thus be considered a test of one of the four propositions made. Because we designed Study 3 to confirm and replicate the results obtained in the post-hoc analyses of Studies 1 and 2, the goal was to collect data from an equal total number of participants. We thus aimed for a comparable sample size as a stopping criterion (N ≈ 6,000), as specified in the pre-registration.

The prediction derived from P3 was tested using the same three temporal analyses that were performed in the post-hoc analyses described above: for the positive priming and the neutral priming conditions, the maximal BF reached (maxBF analysis), the energy of the sequential BF (BF energy analysis), and the sum of amplitudes obtained from FFT analyses (FFT analysis) were computed and compared to 10,000 simulations of these conditions on which the same analyses were conducted and which served as null distributions.

Participants

Participant recruitment and data collection were again performed by Norstat and followed the same protocol as Studies 1 and 2. Because the German participant pool was exhausted at some point during data collection in Study 3, further invitations were distributed to Austrian panelists. Data collection began in October and ended in December 2019. It resulted in a final N = 6,099 (demographic data available for 6,047 participants: 50.42% males, 49.57% females; M_{age} = 51.25, SD_{age} = 14.44).

Materials, Design, and Procedures

All materials, study design, and procedures were identical to Studies 1 and 2.

Results

The data were analyzed only once, after the pre-specified number of participants was reached. Sequential Bayesian analyses based on one-sample Bayesian t-tests were performed for the positive priming condition, the neutral priming condition, and for data from each of the 10,000 simulations. The chance expectation for the number of positive pictures chosen by the qRNG in each condition was 10. Again, an informed prior of δ ~ Cauchy (0.05, 0.05) was used. These sequential BFs obtained were subsequently subjected to the three temporal change analyses to test for non-random oscillations within the positive priming and the neutral priming conditions compared to the oscillations found in the simulations' sequential BFs. The sequential BFs found in Study 3 can be seen in Fig 7.

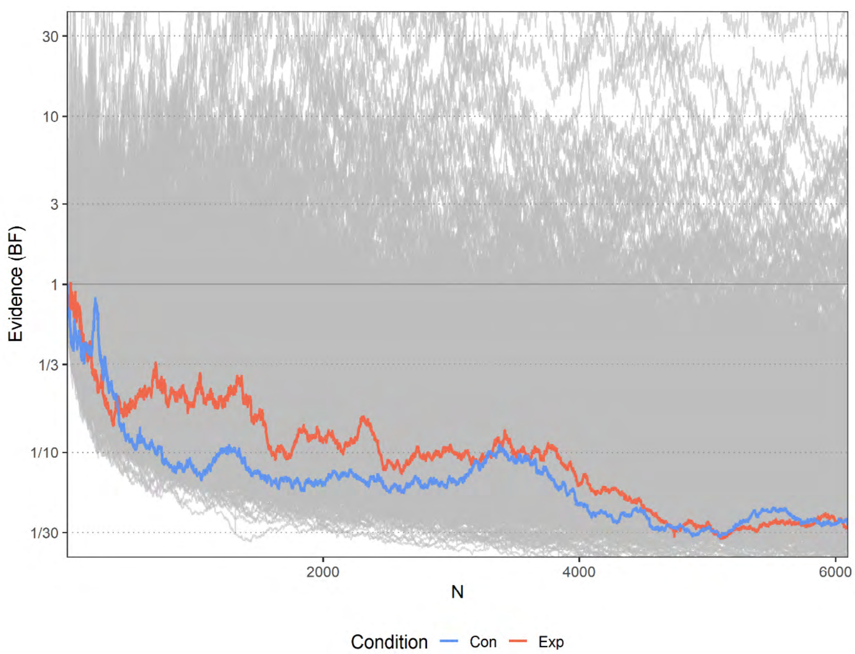

Fig 7. Sequential Bayes factors for the positive (red line) and neutral (blue line) priming conditions of study 3. The gray lines indicate the sequential Bayes factors obtained from the 10,000 simulations.

Although irrelevant to the hypotheses tested here, a final mean score of positive pictures of *M* = 10.00 (SD=2.24) in the positive priming condition and of *M*=10.01 (SD=2.23) in the neutral priming condition was found. *T*-tests revealed a BF_{01} = 11.44

(t(6098) = 0.05, p = .48) and a BF_{01} = 9.40 (t(6098) = 0.25, p = .40) respectively. The temporal change analyses yielded the following results.

MaxBF Analysis

The MaxBF analysis performed on the sequential BF of the positive priming condition revealed that the highest reached BF found in this data set was BF_{max} = 1.01 at n = 28, and that 82.33% of the simulations showed the same or a higher BF at any point within these data sets. For the neutral priming condition, a BF_{max} = 1.00 at n = 1 was found, surpassed by 83.02% of the BF_{max}s found within the simulations.

BF Energy Analysis

The BF energy analysis revealed that the positive priming condition's energy was -4,841.63, surpassed by 54.24% of the simulations' energies. The neutral priming condition's energy was -5,255.64, surpassed by 76.01% of simulations' energies. The mean energy of the simulations was -2,547.43 (SD=20690.58).

FFT Analysis

Third, the sequential BF curves for the positive priming condition, the neutral priming condition, and the 10,000 simulations were each Fourier-transformed via an FFT and their amplitudes were summed up. The amplitude sum of the positive priming condition was 1.36, which was surpassed by 74.2% of the simulations' amplitude sums. The amplitude sum of the neutral priming condition was 1.09, which was surpassed by 95.23% of the simulations' amplitude sums. The mean amplitude sum of the simulations was M_{amp} = 6.94 (SD = 63.68).

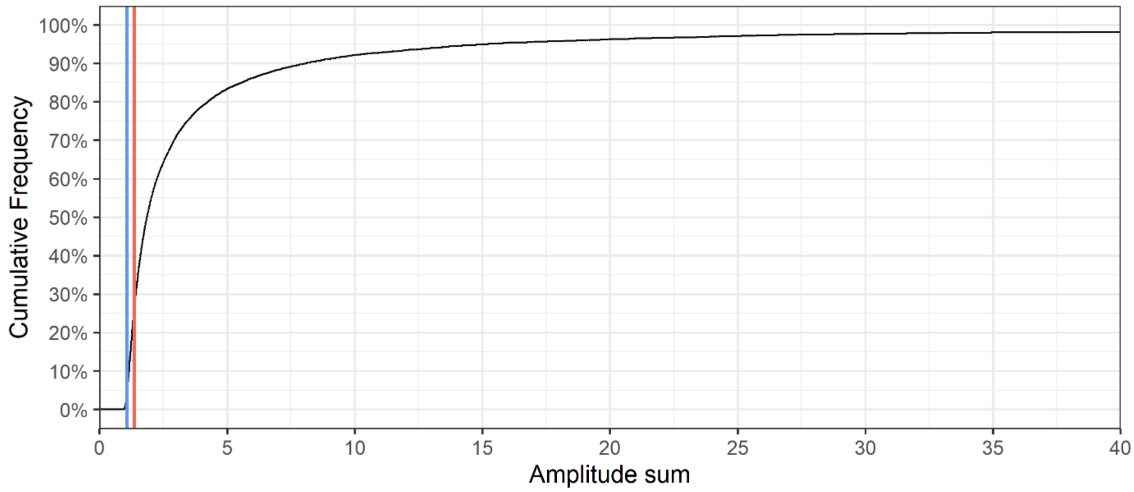

Fig 8. Cumulative frequency distribution of the simulations' amplitude sums and values of the positive priming condition (red line) and neutral priming condition (blue line) of Study 3.

Discussion

None of the three temporal change analyses revealed significant non-random oscillation of the sequential BF10 in the positive priming condition compared to the 10,000 simulations. Thus, the direct replication of the post-hoc analyses made across Studies 1 and 2 failed. No effects were found for the neutral priming condition either. This finding contradicts our predictions derived from P3, as made public in the pre-registration. The data did not support either P2, since the final BF01s for the final mean scores of positive pictures found in each of the two conditions were higher than or very close to 10, confirming a null finding.

Overall, the data obtained so far from three high-power studies clearly contradict the predictions derived from P2 and P3. For now, these two models are thus considered to be false assumptions concerning the appearance of ICs within the PJM. The only valid models that remain at this point are P1 and P4. P1 denies the existence of ICs and would argue that Study 1's results were false-positives due to the consistent lack of successful replications. P4 also remains unchallenged by the results obtained so far since it predicts an initial effect followed by a decline. The latter would reveal itself in unsuccessful replications of any non-random observation effects on qRNG outputs, even at the level of oscillations. Since after a first successful study, P1 and P4 made the same predictions for later replication attempts, a new study was designed focused on the difference between the two models.

Study 4

Overview

The difference between P1 and P4 is that whereas P1 would classify the presentation of more positive pictures than expected by chance in a qRNG-based task as observed in the unconscious priming condition in Study 1 as occasionally occurring false-positives, P4 considers them to be real effects produced by observers whose unconscious priming treatment initiated induced correlations (ICs) according to the PJM. However, the PJM considers them to be evasive, occasional, and not (easily) reproducible (see Atmanspacher, 2012, 2014) to meet the restrictions imposed by the indeterminacy principle of QM. A downside of ICs' unsystematic nature is that they should hardly be detectable empirically. Lucadou et al. (2007) formulated a set of axioms subsumed under the label "model of pragmatic information" (MPI) that formalized this central aspect of the PJM (see also Lucadou, 1995, 2015, 2019). In this model, novelty is defined as initial evidence for ICs and is complementary to confirmation, that is, replicability, of the effect. Thus, the appearance of an effect decline is proposed and any replication attempt with the same design will most likely result in a null finding. Thus, ICs are in principle non-replicable and thus cannot be distinguished from chance effects. Given these propositions, P1 and P4 could not decisively be tested against each other using a "direct replication" strategy, the standard scientific practice for identifying false-positives. Thus, an unorthodox path that the MPI explicitly suggests must be chosen: The MPI's authors propose to entirely skip exact replication attempts and proceed with conceptual replications. The less similar a replication design is to the original design, the more likely it is that the ICs might reappear. However, the necessary "degree of similarity" cannot be easily specified. Although the boundary conditions for a successful conceptual replication are only vaguely defined in the MPI, we decided to give this option a chance. We designed a new study in which the priming stimuli and the priming procedure deviated from the original design employed in Studies 1 to 3. Thus, a conceptual rather than a direct replication was performed. Admittedly, we were unsure as to whether these changes would induce a sufficient degree of dissimilarity between the original and new designs to work satisfactorily. Nevertheless, we predicted a reappearance of the effect in the experimental (positive priming) condition with a potentially later decline should enough data be provided. Specifically, we predicted in the pre-registration that at some point during data collection in the positive priming condition, the mean score of positive pictures would exceed chance expectation and that a Bayesian analysis (Bayesian one-sample *t*-test, one-tailed) would provide strong evidence ($BF_{10} > 10$) for this. Subsequently, the effect might decline, as proposed by the MPI. To test such an effect, the maxBF analysis described above was considered appropriate. This test would demonstrate the likelihood of such a finding under the null model. FFT analyses were also proposed to test the effect. Additionally, a BF energy analysis, as described above, was pre-registered as secondary analysis. Smaller effects of these kinds might also appear in the neutral priming condition. A significant maxBF test (with the maxBF10 in the positive priming condition being greater than or equal to 10), a significant FFT analysis and/or a significant BF energy analysis in the positive priming condition would support P4, whereas no significant effects would support P1. The experiment and our predictions were pre-registered at the OSF (https://osf.io/ckufx).

Participants

The analysis strategy was identical to Study 3 and focused primarily on the change of evidence tests performed on the sequential BFs produced by two Bayesian one-sample *t*-tests (one-tailed) applied to the raw data (mean of positive pictures) of the positive priming and the neutral priming conditions. Since we predicted a volatile effect, a fixed BF threshold could not be specified as a stopping criterion. Based on the positive results of Study 1, we therefore decided and pre-registered to aim for a sample size of about 4,000 participants. Data collection for Study 4 took place between February and March 2020 and was organized by Kantar, another data collection company providing a professional subject pool. Data collection was established with a protocol identical to that used in the previous studies. The data collection rate was about 100 participants per day. The final sample consisted of 3,996 participants (demographic data available of 3,951 participants: 48.04% males, 50.65% females, 1.32% other; M_{age} = 46.25, SD_{age} = 12.86). After reaching this number, data collection was discontinued and the data were analyzed.

Materials

An identical experimental setup to that used in the previous studies, including the generation of randomness, was implemented with two exceptions: a slightly different priming procedure and different stimuli for primes and targets were used to conduct a conceptual rather than direct replication of Studies 1 to 3.

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Stimuli

As stimulus material, images depicting affective facial expressions were selected from the Pictures of Facial Affect (Ekman & Friesen, 1976), a database of photographs widely used in facial expression research. These 110 photographs show the faces of 14 different actors expressing different emotional states. Out of these, the pictures showing happiness, anger, and neutral states were selected, yielding 14 picture sets each containing three images. The principal investigators based on their expertise in emotion induction techniques decided, in addition to neutral faces, to focus on affective facial expressions that were most aversive (angry faces) and most appetitive (happy faces) to human observers. Scrambled versions were created from each neutral facial expression to serve as masks in the priming procedure. Subliminal processing of facial expressions has been shown to be effective (e.g., Smith, 2012; Whalen et al., 1998).

Design

A design similar to that used in the previous studies was employed. Participants were exposed to 20 experimental (positive priming) and 20 control (neutral priming) trials in random order. Conditions differed with respect to the prime content that was presented prior to the selection of the target stimulus. Masked neutral facial expressions were presented as primes in the neutral priming condition, and masked happy facial expressions served as primes in the positive priming condition as primes. In this way, subliminal activation of happy or neutral facial content was intended.

Procedure

Recruitment of participants for this study was organized by Kantar, a polling company, via email communication. Participants were invited to visit the study by clicking on a weblink in the invitation email. The study itself was run on an LMU webserver with access from individual web browsers. Participants were asked to enable their browser's full-screen mode, received a short instruction, and were asked to provide basic demographic details. A pseudo-RNG then determined the order of trials and conditions. First, the 40 trials were randomly assigned to either the positive (happy face priming) or neutral priming (neutral face priming) condition, resulting in 20 trials for each condition. Forty stimulus sets were then selected from the 14 available sets via sampling with replacement. This procedure was repeated for each individual. After the participants signaled that they were ready by pressing a button, picture presentation was initiated. Within each trial, a fixation cross was displayed for 1200 ms, followed by a forward mask (160 ms), a prime consisting of a neutral or happy facial expression (40 ms), and a backward mask (200 ms). The prime presentation was repeated three times in each trial using the identical prime. Neutral or happy primes, masks, and target faces were matched; that is, within a trial, they were derived from the same actor. A qRNG was then used to determine whether a happy ("0" bit) or angry facial expression ("1" bit) was displayed as target stimulus to the participant for 1000 ms. The next trial commenced following a black inter-trial interval of 1200 msec.

After the presentation of 40 trials, in which individuals were simply required to watch the stimuli presented on their screens, they were asked according to two overall ratings (1 "do not agree at all" to 7 "completely agree") whether they perceived the friendly faces as positive and the angry faces as negative. They were also presented with a single item asking to indicate whether they "have the feeling that [they] will succeed in everything today" using the same seven-point scale. Finally, they were thanked and linked back to the polling company for a short debriefing.

Results

The data were analyzed only once, after the pre-specified number of participants had been reached. Sequential Bayesian analyses based on one-sample Bayesian *t*-tests were performed for the positive priming condition, the neutral priming condition, and each of the 10,000 simulations' data. The chance expectation for the number of positive pictures chosen by the qRNG in each condition was 10. Again, as specified in the pre-registration, an informed prior of $\delta \sim$ Cauchy (0.05, 0.05) was used. These sequential BFs obtained from the positive priming and neutral priming conditions were subsequently submitted to primary (maxBF and FFT) and secondary (BFenergy) analyses and were compared to the oscillations found in the simulations' sequential BFs. The sequential BFs found in Study 4 are illustrated in Fig 9.

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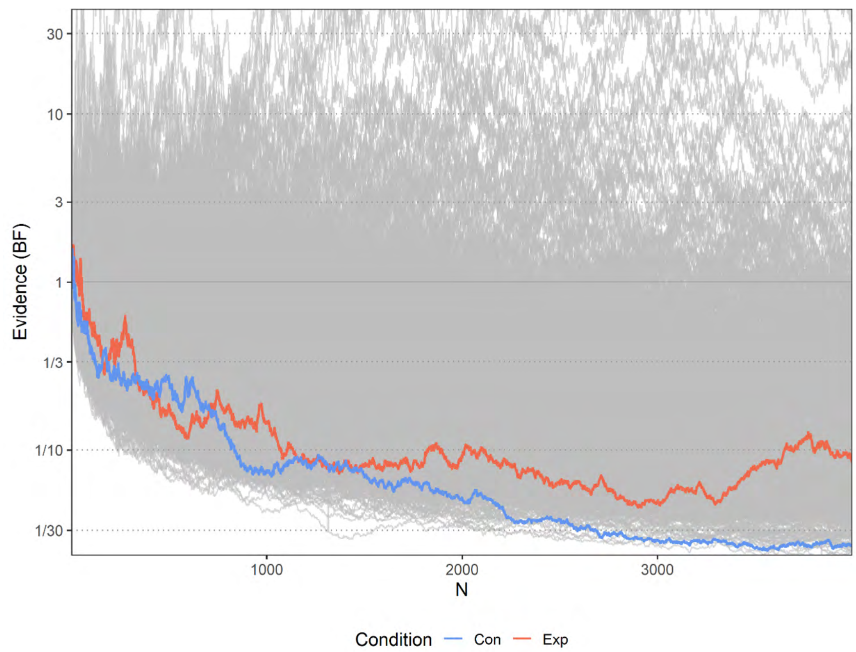

Fig 9. Sequential Bayes factors for the positive (red line) and neutral (blue line) priming condition of study 4. The gray lines indicate the sequential Bayes factors obtained from the 10,000 simulations.

Although not relevant to the hypotheses tested here, a final mean score of happy faces was *M* = 9.99 (SD=2.19) in the positive priming condition (final BF_{01} = 11.90; $t(3995) = -0.30$, p = .62) and *M* = 9.91 (SD=2.25) in the neutral priming condition (final BF_{01} = 36.70; $t(3995) = -2.42$, p = .99).

Primary Analyses

MaxBF Analysis

First, the MaxBF analysis performed on the sequential BF of the positive priming condition revealed that the highest reached BF found in this data set was BF_{max} = 1.65 at n = 11, and that 52.51% of the simulations showed the same or a higher BF at any point within these data sets. For the neutral priming condition, a BF_{max} = 1.56 at n = 5 was found, which was surpassed by 55.36% of the BF_{max}s found within the simulations.

FFT Analysis

Second, the sequential BF curves for the positive priming condition, the neutral priming condition, and the 10,000 simulations were each Fourier-transformed via an

FFT and their amplitudes were summed up.. This was also performed for the control data and for each of the 10,000 simulations. The amplitude sum of the positive priming condition was 1.50, which was surpassed by 59.88% of the simulations' amplitude sums. The amplitude sum of the neutral priming condition was 1.33, which was surpassed by 69.82% of the simulations' amplitude sums. The mean amplitude sum of the simulations was M_{amp} = 6.43 (SD = 58.67).

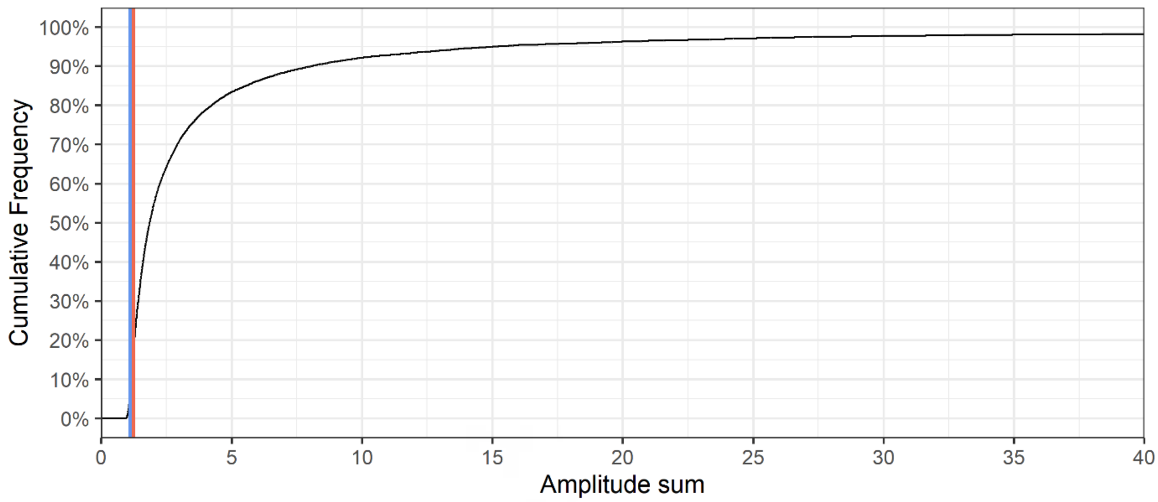

Fig 10. Cumulative frequency distribution. Simulations' amplitude sums and values of the positive priming condition (red line) and neutral priming condition (blue line) of Study 4.

Secondary Analyses

BF Energy Analysis

The BF energy analysis revealed that the positive priming condition's energy was -3,459.29, which was found to be surpassed by 87.56% of the simulations' energies. The neutral priming condition's energy was -3,609.59, which is surpassed by 97.27% of the simulations' energies. The mean energy of the simulations was *M* = -1,203.86 (SD=18635).

Discussion

Contrary to our prediction, none of the pre-registered primary analyses performed on the sequential BF_{10} in the positive priming condition revealed significant effects compared to the 10,000 simulations. The same pattern was found for the neutral priming condition. Neither the BFmax analyses nor the FFT analyses found any indication of the ICs' appearance in one of the two conditions. Rather, a clear null effect pattern was observed in the positive and neutral priming conditions, with both final BF_{01}s greater than 10. Similarly, no significant effects were found in the secondary analysis. The BF energy was not appreciably different from that of the simulations. The results clarify that the null hypothesis could not be rejected in any of the analyses performed. Thus, neither the results of Study 1, which originally showed strong evidence for the occurrence of ICs, nor the findings reported in the post-hoc analyses of Studies 1 and 2 combined, which showed pronounced oscillations of IC effects across time, could be replicated in this conceptual replication attempt. In sum, a first test of P4, which predicted a reappearance of the effect in one of the two ways described above, failed. The data, rather, support P1, which is based on standard QM and denies an active role for human observation in quantum measurement outcomes.

It would be premature to claim, based on these findings, that the MPI should be considered to have been falsified. The MPI predicts the reappearance of an IC effect if the original and the replication designs are dissimilar to a certain extent. One might therefore argue that, in the case of Study 4, a sufficiently high degree of dissimilarity was not reached. Additional studies that continuously vary the design similarities are needed to determine the validity of the MPI. Study 4 is the beginning of a program aimed at addressing this issue.

Given the results obtained in Study 4 with those reported in Studies 2 and 3, we can say that P1 passed all these tests successfully, whereas P4 still lacks positive confirmatory evidence in this set of studies. However, there is promising evidence for P4 in past micro-PK research (Bierman, 2001; Walach et al., 2019) and we expect additional confirmatory evidence to be found with future research. The data found here in our studies, however, require a conservative interpretation. Based on these results, it seems appropriate to favor P1 since it is based on an accepted and well-proven theoretical QM framework, despite the results of Study 1 that challenge (or rather extend) this view. The PJM and its formalized version, the MPI, would imply an extension of the standard QM that comes close to a paradigm shift. Such a shift can only be initiated with resounding confirming evidence, which, given the results of Study 4, has not been obtained. The main question for future research will be how such a confirmation might look, given the lack of replicability inherent in the PJM and MPI frameworks. All raw data and analyses scripts are available at https://osf.io/hgxt3/.

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General Discussion

This study aimed to test a set of propositions derived from a theory first presented by Pauli and Jung. According to this theory, which we refer to as the "Pauli-Jung model" (PJM), human observers can unconsciously influence the outcome of a quantum measurement when meaningfully relevant outputs are involved. Such observational effects were originally called "induced correlations" (ICs) and were supposed to manifest as entanglement correlations between observers' mental states and quantum outcomes. ICs were described as elusive and occurring unsystematically, therefore preventing violations of the indeterminacy principle of standard QM. The model of pragmatic information (MPI) (Lucadou, 1995, 2015, 2019; Lucadou et al., 2007) addressed this elusiveness and proposed that an initial empirical documentation of ICs would be followed by declines of effects in later direct replication attempts. This non-replicability theorem, formulated as a necessary condition, renders that theory unfalsifiable by scientific observations, since the same causal effect must occur under the same circumstances when tested empirically. The MPI emphasizes the acausal nature of entanglement correlations underlying ICs and suggests conceptual replications as an alternative testing strategy to ensure the minimum amount of falsifiability. In four studies, the propositions derived from the PJM/MPI and variations of these (some of which ignored the non-replicability theorem) were empirically tested (P2, P3, and P4) against the predictions derived from standard QM (P1).

An unconscious priming paradigm with human observers was used together with meaningfully loaded qRNG outcomes (i.e., pictures displaying affective contents (Studies 1 to 3)) or affective facial expressions (Study 4), to test these propositions in four experiments. Although, in line with P2, strong evidence for the existence of ICs—in terms of more positive pictures chosen by the qRNG than were expected by chance—was found in Study 1; this effect could not be replicated in subsequent studies. Rather, Studies 2 and 3—two direct replications—and Study 4, a conceptual replication, revealed strong evidence for a null effect. These data support P1, which propagates the ubiquitous validity of the indeterminacy principle and the Born rule. The same is true for P3, which proposes a replicable non-random oscillating data pattern in the priming condition, which could not be confirmed in Studies 3 or 4. On the one hand, this aligns with the assumption that Study 1 represents a false positive finding caused by failed direct replication attempts. On the other, this fits the non-replicability-theorem of the MPI (P4), which proposes a decline after an initial true-positive within a series of direct replications. The MPI's non-replicability theorem can arguably only be circumvented by conceptual replications (P4). Under such circumstances, ICs may reappear. However, a first test of P4 with Study 4, a conceptual replication of Study 1 did not support this proposition either. In sum, most findings except those from Study 1 are in line with the assumptions derived from standard QM, and no confirmatory evidence deriving from the MPI was found for P4.

Since the PJM, with its mind-matter unification approach, and the MPI, with its "limitations of replicability" issue, pose a severe challenge to mainstream theories concerning mind and matter as well as science as a whole, and since no confirmatory evidence could be provided from the studies presented here, some readers might favor standard QM over any extensions of this theory, such as PJM and MPI. There are some hints in the data and some theoretical considerations that motivate further exploration and testing of the propositions derived from the PJM and the MPI. We highlight these findings, including some theoretical arguments and their potential impact on the validity of both models, below.

First, if Study 1 is considered a false positive, then it would be particularly extraordinary. The results of Study 1 obtained in the positive priming condition revealed strong evidence for the effect, with a $BF_{10} > 13.35$ at a remarkable sample size of $n = 4{,}092$. Reaching such a BF with such a sample size makes a successful replication much more (13 times) likely than a failed replication. This argument is also supported by the time course analyses of the sequential BF obtained from the positive priming condition across Studies 1 and 2 combined (see post-hoc analyses reported at the end of Study 2 results section), which indicates an unusual time course of the sequential BF. We also calculated the probability of finding a BF of 10 or a higher given this sample size and found a $p < .004$ based on 10,000 simulations. Such a high p-value would make this result a highly unusual false positive. The MPI, which predicted both the effect and failed replications, addresses these results more successfully. Admittedly, Study 1 was not pre-registered and was therefore susceptible to questionable research practices (QRPs). However, this study was free of any obvious QRPs, with outsourced data collection and predefined analyses and methods that followed the exact procedural details reported in a similar micro-PK study (Maier et al., 2018). Additionally, although Bayesian analyses do allow for optional stopping, we ran more participants than necessary, since a BF of 10 was exceeded several times. That is, we did not stop when it was convenient for our hypothesis to do so but continued until the stopping criterion had been securely met.

Second, the MPI predicts a displacement of the effect in later replication attempts. This may include anomalies in the control condition (Lucadou, 2019). We found such an anomaly for the neutral priming control condition in both replication studies. In the secondary analyses, an amplitude sum lower than 95.23% of simulations was found in Study 3 and a BF energy of the sequential BF lower than 97.18% of the simulations was found in Study 4. This implies that the control data behaved more neutrally than expected by chance (i.e., followed an “ideal” null model), which is a typical displacement effect as proposed by the MPI.

Third, although no confirmatory evidence for the MPI was found in Study 4, one could argue that the design dissimilarity between Study 1 and Study 4 did not meet the criterion for a conceptual replication to work. Thus, further conceptual replications must be performed, varying the degree of similarity between the designs before the MPI could be considered falsified.

Speculating a bit more, if the MPI interpretation was correct, the question would arise at which level of observation did the micro-PK effect and its decline take place? Novelty and confirmation are less relevant for the participants being the primary observers, but rather for experimenters, data analyst, and the readers of the data report who will interpret the data in exactly these ways (novel and/or confirmative). That is, the MPI might primarily address the impact of second order observations and might therefore be considered a theory about experimenter-psi (epsi) and similar phenomena. Epsi has long been suspected of playing a role in micro-PK research (e.g. Kennedy & Taddonio, 1976) and the Bayesian testing approach in which the investigators repeatedly update their knowledge about the existence or absence of micro-PK by watching interim results would be a pretty likely scenario for epsi to occur. Although we favored the participants’ observational impact in our theoretical framework, it is unclear at which level of observation a biasing impact on quantum randomness has occurred in case micro-PK and decline would be considered confirmed by the present data (cf. Rabeyron, 2020). Given these empirical and theoretical arguments, PJM and MPI merit further exploration, even though the actual data at this point support standard QM.

Author’s contributions:

MCD designed the first study, co-designed studies 2 to 4, organized data collection and carried out the statistical analyses. MM co-designed studies 2 to 4 and drafted the first version of the manuscript. MP participated in the data collection and revised the manuscript. MD revised the manuscript.

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Carlos Salvador Alvarado (1955-2021): A Man for All Eras

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Photo courtesy of Nancy Zingrone

Even more than his erudite and punctilious (e.g., Alvarado, 1984) historical contributions and articles contributing to make the study of out-of-body experiences scientifically respectable, I mourn the passing of a warm and generous friend of many decades. I first met Carlos (and Nancy Zingrone, of course) in the mid-80s, when I attended an intense and extraordinary Summer Research Institute of the Foundation for the Research on the Nature of [Hu]Man (FRNM), which later became the Rhine Research Institute. Those were heady days, all of us drenched in sweat under the Durham sun and the lectures and discussions of all matters psi, not to mention participating in the odd psi experiment. In one, I learned first-hand the capricious nature of psi research, having had a clear and bizarre image during a ganzfeld session which I drew despite my reluctance to commit anything to paper. Alas, it was not the randomly-chosen target (that was my second choice). So, in a sense I did not score according to the pre-established rules, in another it was obvious to me that in some way the

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image I later saw had affected my mentation earlier on. I got a poltergeist book from Richard Broughton as a reward for being the highest scorer in his PK Poink game, although I have not since showing any appreciable PK talent. John Palmer was another important faculty in the institute and has been a friend for decades. I also remember that Summer for some unforgettable performances at the American Dance Festival at Duke Universe, and for losing my bike-theft innocence (I have had various other bikes stolen since then).

I came back later to the FRNM as a faculty, not a student, and stayed with Carlos and Nancy once or twice, generosity being one of their cardinal traits. We collaborated later on two papers on OBEs (Cardeña & Alvarado, 2014, Zingrone et al., 2010) and, when I was named Editor of the *Journal of Parapsychology* I did not hesitate for a second to ask Carlos to be the journal's book reviews editor. His vast network and ability to read various languages brought that section of the journal up to a new standard. Although usually gentle, Carlos was also courageous when the situation demanded it. At my forced departure as Editor of that journal, he was the first (out of many) members of the Editorial Board to resign from it and support the creation of a new journal (this one, in which a number of us are honoring him). I had asked him to be an Associate Editor of this journal as well, but alas his cancer took him from us way too early. The German poet Heinrich Heine wrote that if he were to meet again his deceased father, he would not wish to encounter him as a transfigured being, but wearing his old brown coat (Hofmann, 2021). Similarly, were I ever to meet Carlos again, I hope it will not be in some purified version of him, but sporting his whimsical smile and talking in his mellifluous *boricua* accent.

I will introduce now the other sections of this tribute to Carlos. Invariably the contributors expressed great affection for him in our related correspondence. First, the German historian Andreas Sommer describes the impact Carlos had in showing that at the inception of psychology and psychiatry as disciplines there was no "woo" (the pejorative term used by some to refer to psychical research and parapsychology) science and "real" science, but a plethora of foundational figures that drank from the same knowledge well. That Carlos carried this message through mainstream publications certainly helped the field immensely.

The following contribution, by the Australian Harvey Irwin, himself also someone of international stature in the study of parapsychology and Out-of-Body-Experiences (OBE), emphasizes the landmark contributions of Carlos (and Nancy Zingrone) to the study of the OBE, bringing it from the esoteric literature into mainstream psychology. Alfonso Martínez-Taboas, a Puerto Rican psychologist, describes the young Carlos as a charming and courageous young person burrowing his personal path intro parapsychology. The Italian Massimo Biondi focuses on the international scope and interest of Carlos to make parapsychology not a discipline purely of the USA and Northern Europe, but one that has to acknowledge and integrate the contributions and perspectives from other lands. The last two testimonials, by Wellington Zangari and Fatima Machado, and by Alexander Moreira-Almeida, show what a boon Carlos was for psi research in Brazil through his works and, as importantly, his personal and professional support for his colleagues.

These contributions are not intended to offer a longitudinal and comprehensive overview of Carlos's work. Fortunately, the Society for Psychical Research's encyclopedia has one entry that does just that: https://psi-encyclopedia.spr.ac.uk/articles/carlos-s-alvarado#Professional_Posts_and_%20Honours).

Carlos, this issue of the *Journal of Anomalous Experience and Cognition* is dedicated to you.

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A Remedy for Historical Split Personalities: In Memory of Carlos S. Alvarado[1]

Andreas Sommer

One of the proudest moments in my career was when I received a request last year to review a funding proposal for Carlos's planned book with the preliminary title *The Hidden and Fragmented Mind, 1880s-1900*: *The Society for Psychical Research*. This was to be an elaboration on material he had published in the *Journal of Trauma and Dissociation* almost twenty years ago (Alvarado, 2002). As I was grateful to state in my report, together with earlier work by Carlos – such as an article in the journal *Dissociation* (Alvarado, 1989) – this essay had significantly shaped the direction of my own research on historical cross-links between modern psychology and psychical research from the very start.

The path of investigation followed by Carlos himself was first laid out in encyclopedic scope by psychiatrist Henri F. Ellenberger (1970), who demonstrated fundamental omissions and distortions in official chronologies of the modern mind sciences: Whereas psychologists and psychiatrists often seem conditioned to view the historical relation between their disciplines and the "occult" in simplistic terms of a victory of "science" over "superstition," Ellenberger was the first to show in great detail the indebtedness of modern concepts of the subconscious mind to traditions like mesmerism, spiritualism, and psychical research. Of course, not all of Ellenberger's work was specifically concerned with the "paranormal." One could even say he had only begun to scratch the surface in this regard, so there was still plenty of work left for Carlos and the few others who would follow him.

Carlos's name is familiar to anyone in the small community of parapsychological investigators today, but it is perhaps not widely known that his research has informed the work of several mainstream scholars. One of the first to draw on Carlos's findings was Harvard historian of science and medicine Anne Harrington (1987), in a major contribution to the history of the neurosciences. Carlos had only started warm-

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ing up at the time, so the material used by Harrington had not been even published yet. Six years later, Mark Micale (1993), a leading historian of psychiatry, included Carlos's published output in a bibliographical essay on important contributions to Ellenberger-style historical research.

Harrington's book was part of a growing body of sophisticated historical studies challenging Western obsessions with "brainhood" (Vidal, 2009) – the belief that anything worthwhile learning about human nature could be known by studying the brain. Although popularizers of mind-brain reductionism are fond of asserting this as an inevitable corollary of centuries of unbiased science, historians of neurosciences have shown such claims to rest on little more than cultural myths. Several proponents of brainhood have also maintained that open-minded scientific curiosity in reported psychic phenomena is inherently motivated by a wish to uphold beliefs in immaterial souls. Carlos's essays on French physiologist Charles Richet – several of which were compiled in his first book (Alvarado, 2019) – are therefore an important reminder of the actual metaphysical *pluralism* of parapsychological research: Richet, a Nobel Laureate in physiology and the doyen of psychical research in France, was in fact an outspoken proponent of the view that minds are reducible to brain processes. Yet, he still published empirical evidence for the occurrence of parapsychological phenomena.

Carlos's works on Richet, along with overviews of investigations and ideas by many other historical key authors writing in French, German, Italian, Spanish, and Portuguese, are a testament to his mastery of primary and secondary sources in languages not limited to English. When I guest-edited a special section with articles on psychical research for the journal *Studies in History and Philosophy of the Biological and Biomedical Science*, I was therefore grateful to have Carlos on board as a reviewer of an article about another research specialty of his: the Italian psychiatrist Enrico Morselli and his experiments with the medium Eusapia Palladino (Brancaccio, 2014).

Richet and Morselli might not be scientific household names today, but William James – a pioneer of experimental psychology in the USA – certainly is. Modern psychologists are bound to be surprised to learn that James published most of his *empirical* work in unorthodox periodicals, predominantly the *Proceedings of the American Society for Psychical Research* (ASPR). Thanks to Carlos, one of these texts by James, his 1886 report of the ASPR's research committee on mediumship, was republished in the journal *History of Psychiatry*, and Carlos wrote the introduction (Alvarado, 2016; for the wider context of James's psychical research see also Sommer, 2020).

Until about the 1990s, it was almost customary for James scholars to downplay if not completely bypass his psychical research, as something supposedly unrelated

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to his “real” scientific and philosophical work. The continuing denial that, for example, James considered English psychical researchers Edmund Gurney and F.W.H. Myers (the inventor of the word *telepathy*) his closest allies in experimental psychology (for evidence see Kelly et al., 2007, Sommer, 2013), has led to the construction of James as a historical “split personality” in the public understanding of psychology. It therefore seems that what Carlos once observed concerning the history of dissociation applies to the history of the mind sciences in general: “much of our current understanding of the history of dissociation has been itself ‘dissociated’ in the sense of becoming separated from aspects of its origins” (Alvarado, 2002, p. 28).

Science historians have long recognized that the very writing of history has been a powerful means to create artificial boundaries between legitimate sciences and certain stereotypical “pseudosciences.” I was therefore happy to accept an invitation to edit a special issue of the Parapsychological Association’s magazine *Mindfield*, whose articles explored strategies by which serious research on the paranormal has been kept out of the scientific mainstream. An important focus of contributions was on the marginalization of various research questions from within parapsychology itself and, as my last formal collaboration with Carlos, I invited him to write an article which he chose to specifically dedicate to this topic (Alvarado, 2020).

Carlos’s output in mainstream academic journals was considerable, but the bulk of his works have been published in periodicals not usually read by orthodox scientists. By sharing his immense knowledge, Carlos wanted to help both conventional and heterodox scientists maintain a certain level of historical literacy – which I can assure you is no easy task, as scientists often seem to regard history a waste of time. That this is wrong was often shown by Carlos himself, for example in a historically informed chapter on the clinical status of out-of-body experiences in the first edition of the seminal *Varieties of Anomalous Experience* (Alvarado, 2000) and a joint article on related problems in the second edition (Cardeña & Alvarado, 2014).

Let me say farewell to Carlos by coming back to his dissociation metaphor quoted above. I believe that what is true for individual therapeutic contexts broadly applies to a collective level as well: Suppressed vital aspects of our biographies, of who we *are*, typically come back to bite us unless we make a conscious effort to integrate them. Works like *Varieties of Anomalous Experience* have responded to an egregious practical and clinical consequence of this suppression as part and parcel of Western modernity: the long history of blanket diagnoses of certain exceptional experiences as intrinsically morbid and pathological. Historical illiteracy, especially if it is an expression of reluctance to face certain cultural realities, thus comes at a cost. By losing Carlos, we have been deprived of one of our richest remedies for it.

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Carlos Alvarado's Research on the Out-of-Body Experience

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The prolific and remarkably diverse writings of Carlos Alvarado represent a major contribution to the parapsychological literature. In particular, two types of his contributions have played a valuable role in the development of many researchers' academic outlook, including my own. First, by virtue of Carlos's extensive familiarity with the historical literature he has frequently drawn our attention to historical precedents for some of the explanatory concepts emerging in the contemporary literature; the notion of transliminality is one such instance. Second, his knowledge of languages other than English has alerted us to important work published in non-English sources, thereby serving to broaden the discipline of parapsychology beyond a simple Anglo-American context.

In addition to these salutary influences on the field's perspective Carlos has contributed to our empirical knowledge of specific anomalous phenomena such as aura perception, synesthetic experiences, and travelling clairvoyance. A phenomenon of sustained interest to him was the out-of-body experience (OBE) in which experients have the impression that the "self" or center of awareness temporarily is located outside their physical body and typically can observe the immediate environment from this external position. Carlos's doctoral dissertation (Alvarado, 1997) focusses on the OBE, and over the years approximately 40 of Carlos's papers address the experience, many of them co-authored by his devoted soul mate Nancy Zingrone. By way of humble homage to Carlos Alvarado I summarise here his principal contributions to OBE research.

The OBE is an intrinsically fascinating phenomenon and is a popular topic for college students' research projects. Such projects are certainly facilitated by Carlos's

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periodic comprehensive reviews of OBE research and theoretical developments, perhaps most notably the chapter in *Varieties of Anomalous Experience* (Alvarado, 2000), and by his documentation of useful online resources that address the topic (e.g., Alvarado, 2010).

More fundamental in nature are his empirical reports of the phenomenology of the experience (e.g., the presence of specific sensations at the onset and/or the termination of the OBE) and some factors underlying variations in OBE phenomenology. Publications bearing on the latter identify a range of contextual correlates such as the distinction between a spontaneous experience and a deliberately induced experience, the frequency with which the person has had OBEs, the extent to which the context of occurrence incorporated a perceived threat to life, the extent and nature of concurrent physical activity, and the experient's personality and cognitive characteristics (e.g., Alvarado & Zingrone, 2015; Alvarado, Zingrone, & Dalton, 1999). Attention is also given to the aftereffects of the experience, a matter that few other researchers have investigated (e.g., Alvarado & Zingrone, 2003). Several publications address the veridicality and ontological reality of the OBE and more broadly, the potential theoretical accounts of the experience; among the latter are purely psychological interpretations, the OBE as a psi-conducive state of consciousness, and the notion that something is "projected" or literally leaves the body during the experience (e.g., Alvarado, 2000, pp. 200-205). Among methodological issues Carlos examines the possibility that reports of an OBE may be embellished over time, and critically analyses the evidential status of case collections of "astral projection" such as those compiled by British researcher Robert Crookall (Alvarado, 2012).

As with Carlos's writings on other topics these papers seem to be permeated by his wonderful generosity of spirit; indeed, while I am reading his work I can almost sense his presence. In more objective terms, the conceptual breadth and the utility of Carlos's OBE publications are truly exceptional, and collectively they stand as an enduring testament to the quality of this remarkable man's life work in parapsychology.

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Carlos's First Steps in Parapsychology

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I was 19 years old and I already had a serious interest in parapsychology. I was a member of the Society for Psychical Research (SPR) and wanted to know if there was another member in Puerto Rico. Therefore, I wrote to its secretary and she replied that indeed there was another member: Carlos S. Alvarado. I was delighted but fearful because I assumed that Carlos would be a much older person and that I was to be dismissed by my young age. We shared our phone and to my surprise Carlos was one year younger than I was. Not only that, our respective mothers had been friends when they were much younger!

In a couple of months, we began to share not only our interest in parapsychology but also a friendship that would last for five decades. I clearly remembered that we both had a passion for the history of the field, specifically mental and physical mediums. In addition, we developed an interest in spontaneous psi phenomena, like poltergeist. Much of our money was spent in buying books in antique bookshops where we obtained many historical treatises. I remember that we shopped a lot in a bookstore located in New York by the name of Samuel Weiser.

A couple of years later we founded a privately published journal titled *Explorando lo Paranormal* (Exploring the Paranormal). We only had about 20 people subscribing to the journal, but it brought us immense satisfaction to have the opportunity to elaborate our ideas. We also tried to group a few people to talk about the field but were unsuccessful in that task. Nobody else in Puerto Rico was a member of the SPR or the ASPR. We eventually joined a group of enthusiastic people, but their main interest was UFOs. Although I developed also a strong interest in UFOs, Carlos was never curious enough to read systematically or write about UFOs.

As part of our joint efforts, I remember that we tried to investigate some ostensible mediums and psychics. We never encountered a single incident that convinced either

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of us of a genuine paranormal effect. We investigated also hauntings and apparitions. I remember that we traveled to a small town in Puerto Rico where an apparition of a woman was repeatedly seen by night floating in front of a tree. We talked with the family and passed the entire night trying to see something unusual. Once again: nothing.

After a decade of friendship, we decided to write two papers. One was a critique of the psychopathological model of poltergeist phenomena. The other paper questioned some basic assumptions of the super-psi hypothesis to explain mediumistic phenomena (Martínez-Taboas & Alvarado, 1981, 1983). Moreover, many years later we published in Spanish an article about some common misunderstandings that Puerto Rican psychologists had about parapsychology (Alvarado & Martínez-Taboas, 2002).

As time passed, I decided to study clinical psychology. Carlos's father tried, unsuccessfully, to convince Carlos to study a more conventional field like psychology. Carlos was very clear that he wanted to dedicate his life to parapsychology. Therefore, he was accepted to a Master's Degree in Parapsychology at J. F. Kennedy University in the USA, and so his formal commitment to the field began.

Even in those early years, Carlos's passion to the field was remarkable. As a very young man, he dedicated much effort to maintain an impressive private collection of books and journals on the field: especially on the history of the field. We dedicated countless hours discussing historical figures such as Eusapia Palladino, D.D. Home, Mrs. Piper, and many others.

With the passage of time, he became one of the most respected historical scholars of parapsychology and psychical research. I am glad that we both shared those precious moments when we vigorously debated parapsychological phenomena with an open mind. When he departed to the J.F. Kennedy University, I already knew that he would become a notable scholar. His splendid memory for details, his passion, and commitment were evident. Thank you Carlos for sharing with me such remarkable memories and for your friendship. You are sorely missed.

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Carlos S. Alvarado: An Irreplaceable Landmark on the International Arena

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"It sounds interesting." This was one the most frequent remarks by Carlos S. Alvarado when I (and others) submitted to his judgment new information, a proposal for an original study, preliminary conclusions of studies, or when we talked of ongoing research performed by university students for their theses or by private enthusiasts. Faced with the possibility of new good-level additions to common knowledge, his reaction was steadily characterized by acceptance and enthusiasm, without rejecting anyone or anything. He was firmly convinced that parapsychology should come out of the fringe area where it is traditionally enclosed and gain well-deserved respect by science and culture representatives. So, he gladly accepted everyone seemingly able of helping the growth and development of the discipline. As a result of such a "politics of inclusion," and for his very wide knowledge of the field (Zingrone et al., 2015), he became a recognized leader at the international level.

It was in the field of historical studies that the international scope of his engagement was most evident. In a 1989 article, Carlos (Alvarado, 1989a, pp. 5-6) pointed out that historical studies in parapsychology should follow the two approaches, internal and external, described by Thomas Kuhn: "An internal history emphasizes the subject matter of the field," while according to the external or social approach "parapsychology historians could… study the institutions of the field… the funding organizations… the constituency… and the dissemination of concept and research findings in the popular press." Then, expanding that program, he underlined that a "particularly problematic limitation of most current work on the history of parapsychology" was represented by "the absence of studies that consider developments in countries other than America and England… More in depth research on different countries is still needed." Significantly, in the subsequent decades he conducted himself many studies along those lines.

He rediscovered in the past of many countries many "forgotten pioneers" of par-

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apsychology, personalities gone unnoticed who proposed interesting studies, suggestions, and hypotheses, and described ways to remedy the distortions –caused by the emphasis on English-language–in reconstructing the history of psychical research (Alvarado, 2012). He dealt with the negative effects of language barriers on the sharing of information (Alvarado, 1989b), and focused on the International Congresses of Psychical Research on the first half of the twentieth century, where the exchange of opinions and information between peers has been crucial to keeping alive and sustaining psychical research (Alvarado, 2017). Furthermore, he identified specialized journals as the main tool for the dissemination of information at an international scale (Alvarado et al., 2006), and analyzed the role and social impact of "psychics" and "gifted subjects" studied in a number of countries (Alvarado, 1993).

It may be appropriate to point out here one of Carlos' productive ideas which was the basis of the recently published study on Emelie Sagée (Hövelmann et al., 2019). That work began in 2011 from Carlos' intention to understand how a story of apparent OBEs with vision at a distance, initially recounted by Robert Dale Owen on 1860, was identified, picked up, and used by later authors all over the world. His purpose was to "map" the circulation of information and related ideas over the time and in different cultural contexts. Carlos asked Gerd Hövelmann and me to trace old references in the literature of our countries. After some time, the study took another direction (we chose to deepen true details of the story) and was interrupted by the illness and then death of Gerd. It was revived only a few years ago and clearly shows the usefulness of such an inquiry. Like many of his stimuli, proposals, and contributions, this idea deserves to be taken into consideration and applied again to further cases. It would be an unjustified regression in our part to forget his many proposals, or not to continue on the paths that, with so much skill, delicacy, and expertise, he pointed out to all of us.

However, the study of historical issues is not an end in itself, but also serves to further research proposals (Alvarado, 2010, 2013) and express broad-spectrum considerations of parapsychology and its place within the sciences (Alvarado, 2002, 2003). Carlos's articles have been published in mainstream journals as well parapsychological ones and magazines, and have been translated in Italian, Spanish, Portuguese, German, and other languages, so they have reached scientists and parapsychologists, as well as simple lovers of parapsychology in many countries.

Besides historical studies, during the years he also carried out studies on neglected issues of possible relevance also for psychology, such as inquiries on hauntings (Alvarado & Zingrone, 1995), OBEs and spontaneous cases (Alvarado 1996, 2015), perception of auras (Alvarado & Zingrone, 1994), and synaesthesia (Simmonds-Moore et al., 2019). In most of these investigations he sought the collaboration of scholars belonging to institutions other than his own and often in different countries. One of the indexes of the growth and reaching maturity of a science is a consistent number of papers with multiple authors.

Opening up to new ideas and going beyond cultural and linguistic barriers were policies actively pursued by Carlos. In the early 2000s he consolidated his role within the Parapsychology Foundation, thanks to the collaboration of his wife Nancy Zingrone (who often shared his ideas) and the support of the Foundation's Presidents, Eileen and Lisette Coly. In that position he favoured the creation of a board of friends of the PF, a list of "International Affiliates" that included representatives from 26 countries in 4 continents (PF International Affiliates, 2021). In 2008, by organizing the "Utrecht II" Conference, he invited scholars and researchers from many areas of Europe and America. And when he was an editor of the *International Journal of Parapsychology*, he wanted all the articles followed by abstracts in six languages, in order to make them accessible to the greatest number of people in the world. He showed the same interest as a consultant to the Bíal Foundation, and when he worked as a book reviews editor for parapsychology journals.

Finally, let me conclude this brief remembering of Carlos Alvarado by saying how grateful I am to him for not only having included me as a co-author in studies, but also for his friendships and the fruitful exchanges of ideas and information maintained for decades.

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Carlos S. Alvarado's Contribution to Psi Research in Brazil[1]

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Our personal and professional contact with Carlos S. Alvarado began in the 1990s, when a strong personal friendship and professional collaboration were created, extended to the also eminent researcher Nancy L. Zingrone, Alvarado's wife. The contact between us became more and more frequent and provided a deep exchange of ideas and experiences that inspired our work throughout the history of our research group in Brazil, that became the laboratory InterPsi – Laboratory of Psychosocial Studies "Belief, Subjectivity, Culture & Health," established at the University of São Paulo (USP) the most important public university in the country.

Carlos Alvarado, as well as Nancy Zingrone and Stanley Krippner, were/are instrumental for the development of psi research in Brazil. Regarding specifically Alvarado's contribution, we highlight his studies and writings on different psi research topics, his encouragement to "introduce psi research" into the Brazilian academic environment, and his joint works with Brazilian colleagues; his enthusiasm, personal engagement, and presence in academic-scientific activities in the country were fundamental. His avid interest in knowing how parapsychology was developed and/or perceived in different contexts tied to his ability to read several languages (Portuguese, French, Italian, Spanish, and English) made him a great connoisseur of different "psi cultures." Therefore, he was aware of how problematic are language barriers in parapsychology (Alvarado, 1989) and discussed how parapsychology's regionality circumscribed it to the Euro-American axis, local biases in other contexts, and suggested strategies to reduce them (e.g., Machado & Alvarado, 1997). He understood remarkably well how parapsychology was developed in Brazil, its different perspectives and problems derived from them, which allowed him to perceive what would be necessary to develop

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psi research in each context. Thus, Alvarado helped us to define strategic actions to develop psi research and introduce it into the Brazilian academic environment.

Alvarado was fundamental for education in psi research in our country. In 1995, 2002 and 2011 he carried out academic-scientific activities (courses, lectures and research meetings) in the country, besides having been interviewed by the local media talking about psi research to the general public. In 1995, Alvarado taught a course on consciousness studies, updating information on parapsychological studies, at Anhembi Morumbi College (now Anhembi Morumbi University). In 2002, he participated of the *First InterPsi Seminar "Intuitive Communication: Theoretical and Clinical Aspects"* at the Pontifical Catholic University of São Paulo. In 2011, besides attending the Parapsychological Association Convention held in Curitiba, in the South of Brazil, Alvarado and Zingrone (occasion when she taught a course on the psychological study of anomalous experiences at USP) also participated of research meetings with InterPsi members, as they had also done in 1995 and 2002. The activities developed by Alvarado in the country contributed to broaden general knowledge on psi research and emphasized the importance of empirical research and scientific production in the area.

Alvarado was also instrumental in encouraging joint works among Brazilian colleagues. He himself co-authored papers and chapters with Brazilian colleagues, mainly on dissociation and historical and/or methodological topics (Alvarado et al., 2007; Alvarado et al., 1997; Alvarado et al., 1998; Alvarado et al., 2014; Lange et al., 2018; Maraldi et al., 2016; Maraldi & Alvarado, 2018; Moreira-Almeida et al., 2007). Alvarado was always ready and open to discuss research projects and offer methodological suggestions. He felt happy especially in discussing and indicating specialized literature to base theoretically research projects and papers, as he did with USP master and doctorate candidates. More recently Alvarado (2020) presented the historical importance of psychical research studies for psychology in an open webinar organized by InterPsi-USP.

We also underline Alvarado's importance to the development of psi research in Latin America, with repercussions for the expansion of the field in Brazil. In the occasion of the PA Convention held in 1995 in Durham, NC, PA members who were researchers in Portugal and Latin American countries founded the *Associación Iberoamericana de Parapsicologia* (AIPA), whose aim was to discuss strategies to develop parapsychology according to specificities of the field in each geographic and cultural region. Besides being instrumental in AIPA'S foundation, Alvarado was unanimously elected its president. In partnership with Nancy Zingrone, one of the main AIPA's activities he carried out was the organization and teaching of a psi research program, whose aim was to spread basic parapsychological knowledge, reducing language and conceptual barriers. About 10 regional groups (three of them in Brazil) took part in that program, which contributed to collective growth, especially in methodological terms. As a consequence, our and other research groups reinforced their interest in empirical research and bringing psi research into academy. In this sense, AIPA, chaired by Alvarado, was a watershed for psi research in our context.

In addition to being a great friend of ours, Alvarado was one of the greatest inspirers for psi research in Brazil. He encouraged us to take psi research into academy and rejoiced with each new research, dissertation, or thesis in the area carried out in our country. It is not possible to think of the development of psi research in Brazil without remembering and referring to his constant and enthusiastic presence. We are eternally grateful to him and remain inspired by his efforts and support.

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A Meaningful Life:
The Joy of Learning, Loving, Caring, and Sharing

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Carlos was such a remarkable, kind and competent scholar and friend that it is hard to choose what to highlight in this brief tribute to this great soul. On a personal level, he was a major influence in my career, especially in my first moves to reach international academic audiences. He was always keen to promote not only better knowledge of past Latin America and Continental Europe psychical researchers, but also to support and stimulate internationalization of current researchers from beyond English-speaking countries. We first met in 2005, when I moved to US with my wife Angelica and our one-year-old boy Caio, for a postdoctoral fellowship at Duke University. The amazing couple Carlos Alvarado and Nancy Zingrone welcomed us for the first time in their own home during our visit to DOPS-UVA (Division of Perceptual Studies at University of Virginia). They helped us settle in the new country (including taking us to a Brazilian restaurant in Charlottesville to eat black beans and collard greens and drink Guarana, the favorite Brazilian soda) and to make academic contacts. Our families` friendship and academic partnership bloomed. He contributed to a book (Alvarado, 2012) and a journal issue (Alvarado et al., 2007) we edited and came to Brazil for conferences. In 2011, the couple spent one week delivering talks, workshops, and mentoring students and researchers at NUPES-UFJF (the Research Center in Spirituality and Health, School of Medicine, Universidade Federal de Juiz de Fora). In addition, Carlos graciously provided valuable feedback of papers and research projects and was a member of the Ph.D. examination board of Alexandre Sech Jr on William James (Sech Junior et al., 2013). Throughout these almost two decades of partnership and friendship, I have been constantly amazed by his astonishing scholarship and deeply touched by his kindness, supporting attitude, and great sense of humor.

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From a more academic perspective, his many personal virtues allowed him to make unique contributions to the fields of psychology, psychiatry, and parapsychology. Among these qualities are great generosity, openness tempered with academic rigor, prodigious broad knowledge of the history of psychical research, and being completely fluent in English and Spanish while also able to read several other languages (to my knowledge, French, Italian, and Portuguese).

One of his most meaningful academic contributions was rescuing neglected but valuable studies, researchers, and psychics, especially from beyond the English-speaking world, mainly from continental Europe. For example, Carlos performed in-depth studies about the prominent, but currently largely unknown, Italian psychical researcher Ernesto Bozzano (Alvarado, 2016). He also brought to contemporary academic light researchers such as Camille Flammarion (Alvarado & Zingrone, 2020) and Albert de Rochas (Alvarado, 2016a), as well as mediums such as Eusapia Palladino (Sommer, 2012) and William Stainton Moses (Alvarado, 2018a).

He also contributed to broaden the scholarship on the history of psychical research by investigating the studies performed by spiritualists, spiritists, and other researchers from mid-19th Century (e.g., Agénor de Gasparin, Allan Kardec, and William Stainton Moses). Carlos showed that the usual dismissal of studies before the founding of the SPR – Society for Psychical Research in 1882, as if they were all naïve, credulous and non-rigorous was unwarranted (Alvarado, 2018a, 2018b; Alvarado et al., 2007).

He also devoted a great deal of effort to build bridges between mainstream psychiatry and psychology and the fields of parapsychology and psychical research. He did this mainly through dozens of articles (often in mainstream psychology and psychiatry journals) that convincingly showed the many unrecognized interconnections between these fields (Alvarado, 2012; Alvarado et al., 2007). One strategy was to show that many prominent founders of scientific psychology and psychiatry not only were interested in but also actively involved in psychical research. Among these were Charles Richet (Evrard et al., 2021), Cesare Lombroso (Alvarado & Biondi, 2017), Theodore Flournoy (de Oliveira Maraldi & Alvarado, 2018), Alfred Binet (Alvarado, 2010), William James (Alvarado, 2015), Ambroise August Liébeault (Alvarado, 2009), and William McDougall (Alvarado & Zingrone, 1989). A complementary approach that Carlos took was to present relevant contributions to scientific psychology and psychiatry by authors most known for their psychical research such as Frederic Myers (Kelly & Alvarado, 2005) and James Hyslop (Alvarado, 2014). In truth, he showed that it was hard to distinguish between founders of psychical research and of psychology because they were often the same people. This was particularly clear in his studies of the First International Congresses of Psychology, between 1889 and 1905 (Alvarado, 2017). Finally, still in line with his mission of making good scholarship widely available worldwide, he also kept a blog and co-organized and participated in online courses with Nancy.

I would like to express my deepest gratitude to Carlos, who deeply influenced me, especially by showing how to live a meaningful and fulfilling life in which he found pleasure in learning and sharing with remarkable generosity and competency what he learned: All of this, surrounded by the love, admiration, and gratitude of his friends, academic colleagues and loved wife. These categories are not separate, but were usually mixed in a sacred blend.

Carlos devoted many of his studies to the topic of survival of bodily death and he now has surely seen the results of the crucial and ultimate test. May he continue to learn, love, and inspire us all who follow his steps down here.

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New Theoretical Horizons Regarding the Nature of Consciousness

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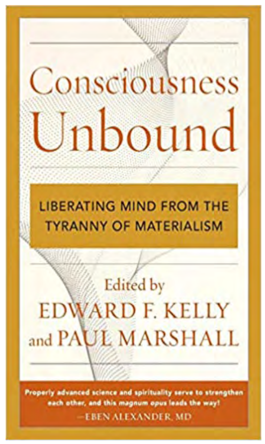

A Review of

CONSCIOUSNESS UNBOUND: LIBERATING MIND FROM THE TYRANNY OF MATERIALISM, edited by Edward F. Kelly and Paul Marshall. Rowman & Littlefield, 2021. Pp. xiii + 515 (hardcover). $60.00. ISBN 978-1-5381-394-24

Consciousness Unbound provides a thoughtful and thorough examination of modern theories about the non-material nature of the universe that are alternatives to the reductive nature of scientific materialism. This volume is the third major output of a series of Esalen Institute Research seminars discussing empirical evidence regarding the question of postmortem survival. The creation of the three volumes was spearheaded by Edward Kelly of the University of Virginia, in collaboration with other editors, and Kelly brings some of the best minds in this field together to discuss issues that makes the volumes compelling. The first two volumes, *Irreducible Mind* and *Beyond Physicalism* (Kelly et al., 2007, 2015), provide helpful additional resources that lay

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important groundwork for this volume, as well as providing research from neuroscience and philosophy that support the proposition that consciousness is a fundamental aspect of nature.

As I read through *Consciousness Unbound, I was fully engaged by how each contributor systematically unfolded their findings and insights, receiving a clear explanation of the roots and scientific bases of metaphysical theories such as idealism and dual-aspect monism, as well as their relevance in understanding the nature of the universe.* This volume starts with the statement that "most contemporary psychologists, neuroscientists, and philosophers of mind subscribe explicitly or implicitly to some version of 'physicalism,' the austere philosophical descendant of the 'materialism of previous centuries'" (Kelly, p. 1). This view holds that all aspects of mind and consciousness are produced by the brain and depend on it for their existence. Within this view all humans, other animals, and plants are seen as simply extremely complex biological machines. The contributors to this volume take a very different view.

The volume is divided into three parts. Part I focuses on phenomena considered challenging for theoreticians of consciousness, including chapters on Near-Death Experiences (NDEs) (by Greyson), Cases of the Reincarnation Type (by Tucker), and Precognition (by Rosenberg). These are difficult because they belong to a category of anomalous phenomena that challenge our understanding of what happens after death (NEDs and reincarnation), and of the nature of time, causality, and freewill (precognition). Part II introduces new theoretical horizons and includes five frameworks or metaphysical perspectives on the fundamental nature of consciousness that oppose the materialist perspective. These include chapters on C.G. Jung's holism (by Main), reflexive monism (by Velmans), A neo-Hegelian theory of mystical experience (by Magee), analytic idealism (by Kastrup), and a new quantum physics approach to the primacy of consciousness (by Faggin). Finally, Part III focuses on further horizons in science, the humanities and philosophy, with chapters on Expanding a Science of Consciousness (by Presti), The Future of the Humanities (by Kripal), Mind Beyond Brain, focusing on the mystical landscape (by Marshall) and an Epilogue, looking at an emerging vision of consciousness (by Kelly).

I have selected two chapters from Part II to highlight, the first, by Bernardo Kastrup, exploring analytic idealism, and the second, by Federico Faggin, exploring a new conceptual framework he derives from quantum physics, which he calls the CIP Framework. I chose them because they contain strong counter arguments to the physicalist perspective, with clear proposals about a view in which consciousness is seen as fundamental.

The chapter by Bernardo Kastrup is "Analytic Idealism and Psi: How a more Tenable Metaphysics Neutralizes a Physicalist Taboo." He begins it discussing what he calls the "cracks" now beginning to appear in the physicalist armor in his view, and then offers a more plausible metaphysics, "analytic idealism," that posits spatially unbound, universal phenomenal consciousness to be nature's fundamental ground, with all natural phenomena reducible to consciousness. He thus proposes that all living beings (including all forms of plants and animals) have a conscious inner life, and in addition, there is a consciousness beyond all these individual minds, which is universal and consists of the representation of transpersonal experiential states. This mental activity presents itself to us as the inanimate universe.

One of his innovative ways of explaining the primacy of consciousness is through patterns of observation within psychiatry and neuroscience that are, in fact, consistent with idealism. He proposes that certain forms of psychiatric dissociation such as dissociative identity disorder (DID) give us a strong analogy for explaining the emergence of individual minds within creation. Kastrup proposes that all living beings are simply dissociated mental complexes or, in psychological terms, alters, of a unitary universal mind. And he uses the analogy of the experience of someone with a DID having multiple separate centers of awareness. This creates a situation in which each living being and the universe as a whole is a conscious entity, each with their own first-person experience. But when we look out from that first-person perspective at others, we perceive them as other, as matter within a material universe. In fact, Kastrup proposes that all matter is simply what consciousness looks like from the view across the dissociative boundary.

Kastrup goes on to explain how the barriers of the universal DID can begin to become porous and therefore allow an expansion of consciousness. He notes that if analytic idealism is accurate, some forms of brain impairment should disrupt the dissociative boundary and be correlated with an expansion of consciousness. In fact, there are many reports in the medical literature of this phenomenon, notably the near-death experience (NDE) in which, under cardiac arrest and flat EEG, individuals perceive accurately events happening during resuscitation (Van Lommel et al., 2001) and psychedelic experiences, in which "the magnitude of the decrease in brain activity predicted the intensity of the subjective effects" (Carhart-Harris et al., 2012, p. 2138). Although I am a neuroscientist with a career working in neurological rehabilitation, and thus could also argue from the materialist perspective that there are many cases in which brain impairments from lesions such as a stroke severely impair sensory, motor, and cognitive function, I believe that Kastrup raises examples of interesting research countering this point of view. I have examined the literature that Kastrup references on this point and believe that the scientific literature gives evidence to support this point (Woollacott & Shumway-Cook, 2020).

Finally, Kastrup states that, according to analytic idealism, the living body is simply the representation, the extrinsic experience of a dissociative process of universal consciousness; thus the end of life is simply the end of dissociation, as the previously dissociated mind is reabsorbed into universal consciousness, with one's core subjectivity untouched. What would survive is the core sense of "I-ness," the one eye that looks out from all creatures.

Kastrup's proposals have many points of resonance with the perennial philosophies of the world, which are based on the mystical experiences of individuals who undergo states of unitive awareness (Nisargadatta, 2009; Marshall, 2015; see also Kripal, this volume). For example, a common phrase in many mystical traditions is "I am That," coming from the experience of mystics of having their individual identity dissolve into a vast consciousness, often described as infinite light and love. It is also in accordance with the experiences of some persons during NDEs, in which they merge with a vast consciousness, described as light and love, suggesting that this could be a state experienced at death of the physical body (Greyson, 2021).

What are the limitations of this view? As Kastrup himself says, "ultimately it all comes down to evidence, not theory." He states that "If there are strong enough indications that personal agency does persist—in some form—after bodily death, then theory must follow the evidence, not the other way around." (Kastrup, p. 277).

The second chapter I want to review in more detail is "Consciousness Comes First," by the physicist and computer scientist Federico Faggin. He begins his chapter describing a key aspect in the development of his theory: his story of how he came to begin to work on a new theory of consciousness. One night, as he was in the process of struggling to create a conscious computer, and in the midst of an existential crisis regarding the meaning of his life, he had a profound experience. In it he felt a rush of energy that felt like love emerging from his chest, a feeling beyond any idea he had of what love is. Simultaneously he perceived this energy as a beam of shimmering light. It then exploded and expanded to embrace the entire universe. He said that, in that moment, he knew, as a deep inner understanding, that this was the substance from which the universe was made, that this light had created the universe out of itself. He then became aware that he was also that light. This was the key moment that impelled him to move forward to find a theory of consciousness that would solve the problems of materialism he noted earlier in his career as a computer scientist. He said that for the first time he was aware of being both a part of the world and an observer of the world. And he saw that the world's essence, light/love, knows itself through self-reflection. He said it was a direct knowing from the inside, stronger than that from human logic. He described experiencing himself as both a particle, and a wave using the analogy of quantum physics: The particle aspect was his ability to experience his own identity, while he at the same time experienced being the entire world, the wave aspect. He was the One observing knowing itself, as one point of view of the One.

It was this experience that impelled him to withdraw from his other activities and focus on developing a model of reality based on the assumption that consciousness is fundamental.

His model is based on quantum field theory (QFT), which he states is "the most accurate current model of reality we currently have (Faggin, p. 287), with the addition of proposing that consciousness already existed before the creation of the universe. Though there are different interpretations of QFT, Faggin takes the position that the probabilistic aspect of QFT makes it compatible with free will. He also states that QFT proposes that the universe is an indivisible whole, in which forms keep emerging, changing, and disappearing. He goes on to propose that consciousness and freewill are holistic properties of each quantum field, thus allowing the outer physical states of a field to be changed from within. This is his fundamental hypothesis: that reality is made of conscious entities if we grant to the quantum fields the capacity to be conscious and to act with free will.

As he continues the explanation of his theory, Faggin's words also begin to sound like those of the authors of the perennial wisdom traditions of the past centuries, as his view of quantum physics merges with that of the experience of mystics. He notes that in order to manifest a universe like ours, the One, who is the totality of what potentially and actually exists, must be dynamic, holistic, and have both interiority and exteriority. He says these properties are what are missing from our current models of physics, and they express the capacity and desire of the One to experience and know itself.

In reading these words of Faggin's I was reminded of a quote from an ancient text (Abhinavagupta, quoted in Wallis, 2012, p. 63) that unfolds a similar theme, "The Self is an embodiment of the Light of Consciousness… As an independent play of intense joy, the Divine conceals its own true nature [by manifesting plurality], and may also choose to reveal its fullness once again at any time." Thus, for Faggin and for the 10th C. author of this text, Abhinavagupta, the One is seen as embodying the light of awareness and concealing its own true nature (infinite awareness) as it creates plurality (that is all of the individual conscious selves of the universe) out of its own joy, to experience and know its own self. Faggin ends his chapter by applying this theory

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to many psi phenomena, including reincarnation, telepathy, and out-of-body experiences.

Like Kastrup, Faggin includes in his chapter a proposal about what happens when we die. He states that when the body dies we lose the ability to observe the physical world from the point of view of the body, but keep the connection with the larger Self, so that we observe the world from this perspective, revealing our true nature. Thus, postmortem survival is associated with this theoretical framework.

One of the striking features of many of the chapters in this volume is that their exploration of consciousness is the result of a first-person experience regarding the nature of reality and of the unitary nature of an expansive consciousness. As a scientist working in neurological rehabilitation, I understand that not all first-person experiences are veridical, and some may in fact be hallucinations. Thus, a materialist scientist might dismiss the anomalous experiences described by these authors as simply hallucinations, as these experiences do not coincide with the reductive theory of reality. Therefore, any theory based on an interior experience could be judged as fallacious. However, the experiences described here offer interesting insights into possible theories of consciousness and thus they might inform new research. Jeffrey Kripal, the author of a later chapter in this volume, notes in his book *The Flip* (2019), that vast numbers of materialist scientists have had experiences akin to Faggin's, where they have an epiphany of mind, in which they have a reversal of perspective from the outside of things to the inside of things, and from the object to the subject. And he notes that they do this without giving up an iota of their remarkable scientific and medical knowledge. Thus, Kripal argues, the materialist framework is not wrong, it simply needs to be expanded to include mind as fundamental to the cosmos (Kripal, 2019). I agree.

What are the strengths and weaknesses of this volume? If I put my materialist/physicalist hat on (which I have worn during much of my career as a rehabilitation neuroscientist), I would have asked that some additional chapters be included in the volume from proponents of the physicalist perspective, with authors giving counter evidence that all phenomena discussed in the volume can be explained from what they might call a naturalist perspective. This could be considered a weakness. However, this argument could be softened and countered by the editors with the point that their authors have included in their chapters arguments presented from the physicalist point of view, and presented reasons that they believe these are untenable (see, e.g., chapters by Greyson [section on proposed physiological models for NDEs] and Kastrup [section on the insoluble problems of mainstream physicalism], as just two examples.

In conclusion, though I have not given detailed accounts of the other chapters in this volume, let me simply say that they were all highly engaging and, as a whole, give very convincing theoretical frameworks and scientific evidence supporting the idea of the fundamental nature of consciousness and its survival after the body dies. If read with open-mindedness and curiosity these chapters could have an incredible impact on our understanding of the nature of consciousness. Each of these theories offers answers to conundrums that materialism cannot explain, such as the nature of near-death experiences, mystical experiences, cases suggestive of reincarnation, and psi phenomena such as precognition. I highly recommend this book to all readers who see the real limitations of materialism/physicalism, but who also want to know more about the scientific evidence and practical benefits of alternative non-material worldviews regarding the nature of reality.

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Gentle Tenacity[1,2]

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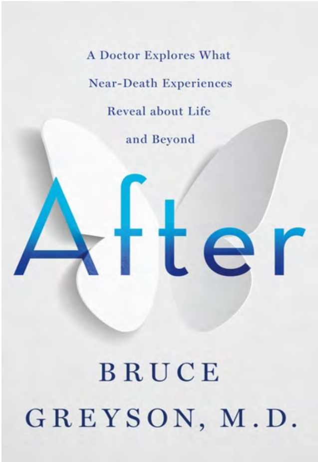

A Review of

AFTER: A DOCTOR EXPLORES WHAT NEAR-DEATH EXPERIENCES REVEAL ABOUT LIFE AND BEYOND. Bruce Greyson. Bantam, 2021. Pp. 259 (hardcover). $20.87. ISBN 978-1-7876-3462-6

Near-death experiences (NDEs) remain opaque to our full understanding. What to make of accounts by some of those who have had brushes with death (sometimes with cessation of recordable brain activity) and “come back” to tell about having left their physical bodies and arrived to timeless realm of pure love and acceptance in which they encounter divine beings and their dear departed, and from which they may be asked to return to their painful bodies and ordinary lives? Psychological and cultural theories fail to explain the consistency of core aspects of NDEs, despite some cultural variations (e.g., Belanti et al., 2008), and physiological theories are often little more than evidence-free speculations contradicted by the extant data (cf. Greyson,

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2014). And just to make matters more complex, NDEs at times include accurate accounts of anomalous cognition that the experient had no apparent way of knowing.

Bruce Greyson, Professor Emeritus of Psychiatry and Neurobehavioral Sciences at the University of Virginia, is the foremost researcher of NDEs (disclosure: I have asked him to contribute chapters to my books). He starts the summation of his decades-long career with an NDE that deeply stirred him. A patient recovering from a drug overdose told him of a conversation Greyson had had with her friend in a corridor the previous night, mentioning as well a tomato sauce spot on his tie (which was hidden under his lab coat), while she was sleeping in a room far away. Granted, this is what some skeptics might call a "mere anecdote," not data, but Greyson reminds the reader (p. 61) that the original quotation about anecdotes and data can be attributed to Raymond Wolfinger and is "The plural of anecdote is data," rather than the opposite as some critics state (e.g., https://sites.google.com/site/skepticalmedicine/the-plural-of-anecdote-is-not-data). There are also stronger instances in which NDEs included anomalous cognition, including meeting people who had already died unbeknownst to the person (for a review of dozens of cases see Holden, 2009, for detailed review of the cases of Maria and Pam Reynolds, described by health professionals who were in the scene, see Kean, 2017). The authors of the conclusion that NDEs are nothing but "the manifestation of normal brain function gone awry" (Mobbs & Watt, 2011) disregarded this information a priori (Greyson et al., 2012), which begs the question.

After that preamble, Greyson describes in various chapters (with copious quotations from individuals he has interviewed) the characteristics of NDEs, including a sense of timelessness, apparent perceptions from outside the physical body, a sojourn to a realm of bliss, and cognitive lucidity, so different from the musings of delirium. He does not shrug from also citing the small percentage of NDEs that have been far less than beatific, before offering his concluding remarks, which will make unhappy both those who a priori have concluded that they are nothing but misfunctioning brains and those who expect that they will offer *definitive* proof of survival after death. Along the way, Greyson offers some fascinating tidbits such as the fact that the young Einstein was a student of the first compiler of NDEs, the geologist Albert Heim, and might have been influenced by his account of the changes in time perception during them.

As a good scientist, Greyson has conducted research to answer specific questions, instead of offering empty opinions from whichever end of the spectrum. To offer but two examples of his programmatic approach, consider the criticism that the uniformity of NDEs could be explained by respondents having read the popular 1975 book by Raymond Moody *Life After Life* or subsequent media exposure. Greyson and a collaborator tested this hypothesis and showed that the only significant difference in 15 phenomenological features of pre- and post-1975 accounts was the greater incidence of reports of tunnels, which he considers not a discriminating feature for NDE because it appears in other alterations of consciousness (Athappilly et al., 2006). *After* does not mention which they are, but they include psychedelic (Siegel & Jarvik, 1975), shamanic (Harner, 1980), and spontaneous "deep" hypnotic (Cardeña, 2005) experiences. And in response to data-free criticisms that NDE accounts are exaggerated with the passage of time and contacts with others who also had them, Greyson conducted a study that showed that the scores of 72 surviving patients who had completed an NDE scale (which he created and validated) remained significantly consistent across factors and items (Greyson, 2007).

Greyson ends *After* with seven conclusions (pp. 216-221): NDE are common and can happen to anyone, under exceptional circumstances, that can lead to substantial life changes, including reducing the fear of death and motivating the person to live more fully. Greyson's last two conclusions will prove challenging for some readers, but then they should counter with better evidence and arguments than those offered by him: NDEs "raise questions" about the relation between mind and brain, and about personal consciousness surviving death. Despite the obvious relation between mental and brain processes in everyday life, Greyson questions the "received knowledge" that mind (or, in some discussions, consciousness) can be completely reduced to brain functioning, a conclusion that is supported by other bodies of evidence. They include the recent work on terminal lucidity, in which long-term senile and other CNS-damaged patients become lucid hours or days before dying, a literature to which he has also contributed (Batthyány & Greyson, 2021), and research on psi phenomena suggesting that organisms are affected by temporally and spatially distant events (for a review see Cardeña, 2018).

The last proposal, referring to what NDEs may tell us about the survival of personal consciousness, proves even more difficult to solve. They are consistent with the possibility of survival (although of course they are *near,* not *after* death experiences), as does research on the accuracy of purported communication from the dead through mediums, both in the past (e.g., Gauld, 1982) and more recently (Sarraf et al., 2020), and on the accuracy of statements by children claiming having lived a past life (for a review see Mills & Tucker, 2014). All of these, however, can be explained otherwise, for instance by anomalous cognition among living beings, even without having to dismiss them a priori, as some critics do.

Nonetheless, many NDE features (other than some such as being sent back to life or seeing the deceased) also occur in contexts not related to being close to death (cf. Cardeña et al., 2014), and a mere belief of being close to death may trigger some

NDE features except for the experience of light and enhanced cognition (Owens et al., 1990). Greyson is well aware of these complexities and speculates that NDEs may provide insight into other aspects of reality rather than being literal depictions of life after death. As for claims suggestive of reincarnation, Greyson (2021) himself mentions how difficult it is to interpret cases in which different children claim to have been the same person in the past. Nonetheless, he concludes that "We may eventually come up with another explanation, but until then, some form of continued consciousness after death seems to be the most plausible working model" (p. 221). We are far from making coherent sense of the various strands supportive of survival, let alone integrating them with neurocognitive theories (Gauld, 1982), but alternatives to a reductive materialist position provide potential solutions toward the integration of these disparate materials (Kelly & Marshall, 2021).

In his parting words, *Alive* returns to the point that, independently of other implications, NDE can transform the lives of those who experience them (and of some who are just in contact with those people) and inspire more compassionate, meaningful, and joyful lives. Greyson has brought his tenacity as a scientist to empirically ground this statement, and his kindness as a person to offer such inspiration to his readers.

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Recent Publications of Note[1]

Etzel Cardeña

Anomalous Experiences

1) Corneille J. S., &, Luke, D (2021). Spontaneous Spiritual Awakenings: Phenomenology, altered states, individual differences, and well-being. *Frontiers in Psychology, 12*. Doi: 10.3389/fpsyg.2021.720579

Describes and compares Spontaneous Spiritual Awakening with Kundalini Awakening experiences.

2) de Boer, Elpine M. (2020). Out of body, loss of self: Spiritual or scary? *Religions 11*(558). Doi: 10.3390/rel11110558

Distinguishes psychological characteristics related to OBEs being experienced as either positive or distressful.

3) Hirschfeld, T., & Schmidt, T. T. (2021). Dose–response relationships of psilocybin-induced subjective experiences in humans. *Journal of Psychopharmacology, 35*(4), 384–397. Doi: 10.1177/0269881121992676

Psilocybin shows a dose-response relation on various indexes of alterations of consciousness.

4) Hurlburt, R. T., Heavey, C. L., Lapping-Carr, L., Krumm, A. E., Moynihan, S. A., Kaneshiro, C., Brouwers, V. P., Turner, D. K., & Kelsey, J. M. (2021). Measuring the Frequency of Inner-Experience Characteristics. *Perspectives on Psychological Science.* Doi: 10.1177/1745691621990379

Descriptive experience sampling produces far fewer frequencies of inner-experience phenomena than questionnaires.

1 This section contains a list of recent publication which the Editor deems to be of particular interest. Feel free to suggest potential entries for future issues by sending the reference with a link to the paper to etzel.cardena@psy.lu.se

https://doi.org/10.31156/jaex.23496

5) Konkoly, K R., Appel, K., Chabani, E., Mangiaruga, A., Gott, J., Mallett, R,... Caughran, B. (2021). Real-time dialogue between experimenters and dreamers during REM sleep. *Current Biology 31*(7), 1417-1427.e6. Doi: 10.1016/j.cub.2021.01.026

Experimental investigation of real-time communication between researchers and REM sleepers, with 6 of 36 of them providing answers.

6) Luhrmann, T. M., Weisman, K., Aulino, F., Brahinsky, J. D., Dulin, J. C., Dzokoto, V. A., ... Smith, R. E. (2021). Sensing the presence of gods and spirits across cultures and faiths. *Proceedings of the National Academy of Sciences of the United States of America*, *118*(5), e2016649118. https://doi.org/10.1073/pnas.2016649118

The authors propose that absorptive experiences in cultures that see the mind as porous predict the experience of gods and spirits.

See also the exchange about limitations of an instrument/concept used in:

6a) Terhune, D. B., & Jamieson, G. A. (2021). Hallucinations and the meaning and structure of absorption. *Proceedings of the National Academy of Sciences of the United States of America*, *118*(32), e2108467118. Doi:10.1073/pnas.2108467118 (2021).

6b) Luhrmann, T. M., Weisman, K., Aulino, F., Brahinsky, J. D., Dulin, J. C., Dzokoto, V. A., ... Smith, R. E. (2021). Reply to Terhune and Jamieson: The nature of absorption. *Proceedings of the National Academy of Sciences of the United States of America*, *118*(32), e2109120118. Doi: 10.1073/pnas.2109120118

7) Sierra-Siegert, M., Jay, E.-L., Florez, C. and Garcia, A.E. (2019), Minding the dreamer within: An experimental study on the effects of enhanced dream recall on creative thinking. *Journal of Creative Behavior, 53*(1), 83-96. Doi:10.1002/jocb.168

Enhancing dream recall increased a measure of creativity, which is related to dissociation and mental thin boundaries.

Anomalous Cognition

1) Castagnoli, G. (2021). Unobservable causal loops as a way to explain both the quantum computational speedup and quantum nonlocality. *Psychical Review A, 104*(032203). Doi: 10.1103/PhysRevA.104.032203

A retrocausal explanation of the quantum computational speedup that may be of relevance to psi phenomena (although the latter are not discussed in the paper itsef).

2) Dean, C., E., Akhtar, S., Gale, T. M., Irvine, K., Wiseman, R., & Laws, K. R. (2021). Development of the Paranormal and Supernatural Beliefs Scale using classical and modern test theory. *BMC Psychology, 9*(1):98. Doi: 10.1186/s40359-021-00600-y

A newly developed 13-item scale with good psychometrics.

3) Kruijthoff, D. J., Bendien, E., Doodkorte, C., van der Kooi, C., Glas, G., & Abma, T. A. (2021). "My body does not fit in your medical textbooks": A physically turbulent life with an unexpected recovery from advanced Parkinson disease After Prayer. *Advances in Mind-Body Medicine*, *35*(2), 4–13.

An anomalous healing event through intercessory patient of a patient with Parkinson's disease.

4) Radin, D., Wahbeh, H., Michel, L., & Delorme, A. (2021). Psychophysical interactions with a double-slit interference pattern: Exploratory evidence of a causal influence. *Physics Essays, 34*(1), 79-88. Doi: 10.4006/0836-1398-34.1.79

Radin et al. replicate their previous studies showing a significant effect of selected participants' intention on double-slit interference.

5) Storm, L., & Tressoldi, P. E. (2020). Meta-analysis of free-response studies 2009-2018: Assessing the noise-reduction model ten years on. *Journal of the Society for Psychical Research, 84*(4), 193-219.

An MA of recent data continues to find evidence of anomalous communication, particularly using the ganzfeld technique and with selected participants.

6) Williams, G. R. (2021). Can the psi data help us make progress on the problem of consciousness? *Journal of Consciousness Studies 28*(5-6), 145-72.

Williams argues that serious consideration of psi research can help clarify the nature of consciousness in general

7) Yang, P., Rhea, P. R., Conway, T., Nookala, S., Hegde, V., Gagea, M.,...Cohen, L. (2020). Human biofield therapy modulates tumor microenvironment and cancer stemness in mouse lung carcinoma. *Integrative CancerTherapies*. Doi: 10.1177/1534735420940398

Research conducted in a world top cancer research center finds that the experimental condition using a previously-tested psi virtuoso (Sean Harribance) had a significant effect compared with a comparison condition.


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