Mind-Matter Interactions and Their Reproducibility

Inaugural-Dissertation

zur Erlangung des Doktorgrades der Philosophie

an der Ludwig-Maximilians-Universität München

vorgelegt von

Moritz Dechamps

aus München

2019

Erstgutachter: Prof. Dr. Markus Maier

Zweitgutachter: Prof. Dr. Günter Schiepek

Drittgutachter: Prof. Dr. Thomas Rabeyron

Datum der mündlichen Prüfung: 10. Oktober 2019

Table of Contents

1. Introduction

1.1. Mind and matter

At its core, this dissertation revolves around the relationship between mind and matter. As will become clear, this must mean it is about consciousness and quantum mechanics as well, two scientific topics that are notoriously difficult to describe. Mind and matter – the mental and the physical aspects of our experience – and their relation are topics that have been discussed heatedly for centuries and have given rise to numerous philosophical and scientific ideas. Perhaps most familiar to our everyday experiences is the notion of mind and matter as two distinct entities – the Cartesian dualism as famously propagated by René Descartes. This approach introduces a fundamental split between all things physical and non-physical (Appleby, 2014). Still, the mental and the physical world seem to interact with one another; thoughts become actions and experiences become impressions. Cartesian dualists would explain this correlation through a bidirectional causational interaction (Brüntrup, 1996). However, both causal directions present us with great difficulties as regards content and logic. They are often referred to as the *hard problem of consciousness* ("How can physical events elicit phenomenal experiences?"; Chalmers, 1995) and the *hard problem of free will* ("How can phenomenal experiences be translated into physical events?"; Shariff, Schooler & Vohs, 2008).

Solving these problems has proven to be at least enormously challenging and subsequently other forms of thought have replaced Descartes' notion. Besides other dualistic approaches, most mainstream science nowadays seems to favor a materialistic and therefore essentially monistic worldview (Atmanspacher, 2012). Physicalism states, that all aspects to reality – this includes mental states – can be explained by specific physical configurations. This includes the assumption that every conditional event has a physical cause, dubbed the *causal closure of the physical* (Atmanspacher, 2014; Kelly, 2015). Regarding mind and brain, this corresponds to the idea that conscious states can be represented one-to-one by matching neural correlates. So far, this has proven to be untenable (Anderson, 2010), which means the causal closure is far from realistic. Moreover, mental aspects here often are merely seen as a by-product, an epiphenomenon, of brain states and their behavior, which still implies the hard problem of free will: If the mind has no say at all, free will is just an illusion (see Kelly, 2015)

There are numerous reasons to be critical of a dogmatic physicalism and the therein-assumed causal closure of the physical (for a more detailed reasoning see Atmanspacher, 2012, 2014; Kelly, 2015; Todd, 2017) and subsequently the search for the nature of mind-matter correlations is shifting towards alternative approaches, the most prominent being 'dual-aspect theories' (Atmanspacher, 2014). In dual-aspect monism, mind and matter are not considered two separate entities, but rather distinctions of an unseparated underlying domain. The transition from this common ground to specific mental and physical aspects is represented by an epistemic split, which can be understood as a prerequisite for conscious knowledge and classical physical states respectively (Atmanspacher, 2014). Out of the various dual-aspect theories, the ideas presented by Wolfgang Pauli and Carl Gustav Jung and renowned physicist David Bohm seem to attract considerable interest.

The latter formulated his dual-aspect theory through the notions of the implicate and the explicate order (Bohm, 2000). Only in the explicate order, the empirically accessible side of reality, a distinction between mind and matter is made. This order emerges by an unfoldment of the undivided psychophysical implicate order, which cannot be experienced directly. Mind and matter are correlated as a consequence of their joint origin (Bohm, 1990; see also Pylkkänen, 2007). Similarly, Pauli and Jung assumed a basic universal and unfragmented reality, the *unus mundus*, out of which mental and material aspects are generated by decomposition (Atmanspacher, 2014). Analogous to the implicate order, the unus mundus itself is not empirically accessible. It can be approximated though from the mental side through the (collective) unconscious and from the physical side through the world's quantum nature. The transition to conscious knowledge on the one hand and classical physical states on the other is characterized by the epistemic split. In physical terms, this critical moment is described as 'measurement'. Pauli and Jung assume that this moment plays the central role in the mental aspect of the transition as well, therefore acting not only as a link between the local and concrete physical states and their holistic quantum counterpart, but also between moments of conscious realizations and the holistic unconscious content (Atmanspacher, 2012). In a way, the unconscious is the unmeasured and therefore superposed state vector of all possible conscious processes.

Furthermore, in this view, correlations between mind and matter are not grounded in direct causal interactions, but are moderated through their common psychophysical domain. Interestingly, the authors propose not only this self-evident, persistent and consequently reproducible unidirectional correlation as consequence of the same origin (*structural correlation*). Even more so, they argue that the interaction between the unus mundus and their two realizations can also be bidirectional. Every physical measurement changes the original system and in the same way, conscious realizations change the underlying unconscious. These *induced correlations* pave the way for an indirect but directional influence of mental aspects on the physical reality (and vice versa) moderated by changes of the unus mundus. This consequently enables deviations from rules like statistical baselines (Fach, 2014). For this connection to manifest, meaning is critically important, as Pauli wrote in a letter in 1952: "Wanted: a type of natural law consisting of a 'correction of chance fluctuations by meaningful or purposeful coincidences of non-causally connected events'" (Pauli, 1996, pp. 634-635). Jung and Pauli called these meaningfully but not directly causally related correlations *synchronistic* *events* and considered them to be an extremely rare special case of mind-matter interactions that are evasive and not easily (if all) reproducible (Atmanspacher, 2012).

Some of the core principles of the unus mundus theory have been later developed to a systematic formalization in the Generalized Quantum Theory (GQT; Atmanspacher, Filk, & Römer 2006, Atmanspacher, Römer, & Walach 2002, Filk & Römer 2011). Here, mind-matter interactions are described as examples of nonlocal correlations between complimentary, i.e. incompatible, global and local subsystems connected by a strong common systemic boundary (Walach, von Lucadou, & Römer, 2014). Similar to Pauli and Jungs' concept this boundary is described through a common meaning, which, in an extension to the theory, is operationalized through so-called pragmatic information (Lucadou 2015; see also von Weizsäcker, 1974). The theory recognizes the similarities between synchronistic correlations and entanglement correlations in quantum systems and aims to apply quantum concepts like complementarity or entanglement to systems going beyond a typical quantum one, such as conscious individuals, or even the unus mundus as a whole (von Lucadou, Römer, & Walach, 2007). Indeed, most dual-aspect approaches seem to be connected to ideas that arose during the development of quantum theory in one way or another (Atmanspacher, 2012).

1.2. Quantum mechanics and consciousness

To begin with, the idea of mind and matter as dual aspects of one underlying domain and the moment of measurement as the critical epistemic split that separates them resonates astoundingly well with findings from quantum mechanics and consciousness research. Measurement is indeed one of – if not the greatest mystery of quantum mechanics; it describes the moment of the reduction of the superposed quantum state to a single, classically describable state, a process that is curiously not predicted by quantum theory and therefore an additional postulate (Greenstein & Zajonc, 1997). The central aspects of the quantum mechanical measurement process can be described mathematically. They include the propagation of the wave function over time (the Schrödinger equation), the probability distribution of all quantum states being measured (the Born rule) and the independence of local hidden variables (Bell's theorem). Nonetheless, there is vast disagreement on the meaning of these rules. Consequently, numerous interpretations have emerged over the last 100 years (for a detailed discussion see Wheeler & Zurek, 2014). Firstly, they disagree on the fate of those quantum states that do not become measured reality. Collapse theories like the Copenhagen Interpretation propose that the wavefunction containing the superposed states is collapsing into a single state when coming in contact with a measurement device. All other possibilities never truly were, or are, 'real'. Conversely, no-collapse theories like Everett's Many World interpretation assume that all quantum states become actually realized states. Each measurement creates divided but superposed 'worlds', each containing one of the possibilities, rendering it impossible for the observer to experience effects outside of their world. David Bohm once described the quantum state as a "set of potentialities"; this phrasing illustrates that measurement in a quantum sense can be understood not so much as being about finding out about reality, but more about creating it to begin with (Greenstein, & Zajonc, 1997).

Not only is there disagreement regarding the fate of non-measured quantum states, it is also unclear what exactly constitutes a measurement and at what moment during the measurement chain the state reduction actually happens. This discussion, held under the name *Heisenberg cut*, essentially boils down to the question: Is there a natural limit of quantum systems' entanglement with their surroundings ('decoherence') or is an agent outside this cascade needed? Proponents of the latter view conscious observation – a mental, not a physical act – as the obvious candidate, since the measurement process logically culminates when the knowledge of the result is registered in the observer's mind (e.g. von Neumann, 1932, London & Bauer, 1939; Wigner, 1963). Some researchers go even beyond that and propose that consciousness relies necessarily on quantum effects or is a direct effect thereof (Mensky, 2013; Penrose & Hameroff, 2011; Stapp, 2017; see also 'quantum mind theories' in Atmanspacher, 2015). Attaching great importance to a conscious observer often makes physicists uneasy though, because this process cannot be described by the Schrödinger equation and eludes a purely physicalist worldview. Whereas dual-aspect theories assume the emergence of conscious moments to be synchronous to quantum mechanic's state reduction, these theories attribute a much more active role to consciousness: Measurement is defined as conscious processing of a quantum state, or is even seen as the cause for consciousness to emerge altogether. Nevertheless, all these views are providing a natural connection between the mental and the material.

Finally, there is also debate concerning the role of the measuring device or subject in constructing the classical outcome. Whereas orthodox interpretations like the Copenhagen Interpretation rely on a measurement device, that somehow stands outside of the measured system and is not entangled with it, some interpretations include the apparatus into the measurement. The Transactional Interpretation (TI) by Cramer (1986) for example views the measurement process as a 'handshake' of two sub processes; an emitter – the source of the quantum system – is sending a retarded offer wave forward in time. This wave prompts a confirming response from an absorber, the measurement device, traveling back in time (Kastner, 2015). The idea of retroactive waves ('advanced waves') was already established in the Wheeler-Feynman absorber theory (Wheeler & Feynman, 1945) and gave rise to explaining quantum theory's nonlocal causality through retrocausal mechanisms (Lear, 2019). It can actually be derived pretty straightforwardly from the mathematics behind the Born Rule, which states that the probabilities of quantum states being measured can be calculated by squaring the amplitudes of the wavefunction (Born, 1926), but fails to deliver an explanation for this fact. The TI postulates that the Born Rule does not represent a squaring of the amplitudes but a multiplication of the offer and confirmation waves respectively, resulting in a handshake and actualization of the corresponding quantum state (Kastner, 2015). The actual outcome therefore is a literal product of the quantum state on the one side and the absorber, that is the measuring entity, on the other. QBism (short for Quantum Bayesianism) is another approach to the measurement problem that emphasizes the importance of the measuring agent. Proponents of this theory hold a Bayesian view of probabilities. They argue that probability is not a physical property but is always dependent on an agent's assignment and should consequently instead be interpreted as a personal degree of belief. With each measurement, the prior belief resulting from previous experience is updated accordingly (Fuchs, 2014; Fuchs, Mermin, & Schack, 2014). Since quantum states can be translated directly into probabilities via the Born Rule, the same should apply to them. A quantum measurement therefore is seen as a subjective process in which a personal degree of belief by the measuring observer is stated (Fuchs, & Schack, 2014).

In summary, quantum properties like superposition and entanglement persist until the quantum state is reduced to a classical one in an action called measurement. Measurement is often regarded as a chain of entanglement events leading to an ever more complex system. This infinite regress finds an end only with an individual's conscious observation, which is consequently seen as the decisive factor in some interpretations of quantum mechanics. Since the results of the measurement process can be interpreted as a product of both the initial quantum state and the measurement subject, (pre-)conscious mental content of the observer may play a role in the actualization process (see e.g. Pradhan, 2012). The importance of the observer is recognized in quantum mechanical interpretations like the TI or QBism and even though these interpretations traditionally do not allow for an influence mechanism, a biasing of the probability distribution of the state vector could be a consequence thereof. This reality-shaping mechanism could represent an information flow from observer to observed system, which constitutes a prerequisite for induced correlations and an essential element of psychophysical theories (Stapp, 2015; Walker, 2000).

1.3. Micro-psychokinesis and reproducibility of psi

As outlined earlier, in a dual-aspect framework the measurement's outcome must be meaningfully connected to the observer for this interaction to manifest (Fach, 2014). That means it must address implicit core ideas important to the observer. Since this is usually not the case with ordinary quantum experiments, in general quantum mechanics' predictions like the Born rule and Bell's theorem hold true and the randomness postulate of quantum indeterminacy prevails. If meaning is involved however, non-local correlations of observer states with quantum states could arise and lead to deviations from the mathematically derived predictions. These kind of correlations can serve as a basis to explain so-called psi phenomena, which include seemingly inexplicable phenomena, like precognition and micro-psychokinesis (micro-PK), a psychogenic anomalous perturbation on random events (Cardeña, 2018). Even though an overall meta-analytical micro-PK effect on quantum random number generators can be found in the literature (Bösch, Steinkamp, & Boller, 2006), the included studies usually focused more on intentional, deliberate effects than on implicit beliefs on the one hand and often showed a surprising lack of direct replications of high-powered studies on the other (e.g. Jahn et al., 2000). The latter can be seen as a form of a more general phenomenon that is a decline of initially present effects. Declining effects are prominent in psi literature (and in other research fields as well) and have been noticed on an individual subject level, but also on a more global between subjects level and even across multiple studies (Bierman, 2001; Varvoglis & Bancel, 2015) and the meta-analysis as a whole (Walach, von Lucadou, Römer, 2014). Especially the more global decline effects challenge researchers, since they can hardly be explained through psychological phenomena, like tiredness or boredom. Declines in direct replications speak against varying study quality as a cause. Instead, often times it is argued that the non-local correlations responsible for the effect must in principle be unreplicable. A consistent and replicable effect could in theory be used as a mean to transfer signals non-locally, a process that quantum mechanics' no-signal theorem forbids. This postulate is described in a similar form, as Non-Transmission Axiom (NT Axiom; von Lucadou, Römer, & Walach, 2007), in the GQT (and in an extension of the theory, the Model of Pragmatic Information MPI; von Lucadou, 2015) where it serves as an explanation for declining psi effects. Identical replicability of generalized non-local effects (e.g. between mind and matter) is ruled out in this view, since these too could be used to transfer a signal (Walach, von Lucadou, & Römer, 2014). The underlying mechanism is based on a change of the systems pragmatic information, which is composed of the products of its novelty and confirmation and its autonomy and reliability. A confirming behavior is not expected from novel systems' states. This would consequently predict only elusive psi effects, which can neither be predicted nor replicated and therefore elude any experimental verifiability. Pauli and Jung argue in a similar fashion and postulate that induced correlations and synchronistic events must only occur unsystematically, since they depend on meaning and therefore highly subjective context such as the personal situation or environment (Atmanspacher, 2012).

Does this mean that micro-PK studies as means to research mind-matter interactions are doomed to fail? In paper 2 and especially in paper 3, we argue that the occurrence of an effect, which does not occur consistently but is met with a decline or even randomness restoring counter-effect should nonetheless produce a somewhat different pattern than a completely random null effect. This behavior prevails the no-signal theorem on a global scale since it predicts a decline leading to an eventually random result, but still enables a scientific testability. We argue that the interplay of effect and decline should lead to systematic time-dependent fluctuations, which can be assessed with appropriate methods. It therefore constitutes a shift towards a more process-oriented and temporal line of research, instead of the often tried but rarely successful focus on replicability of end results.

This thesis contains empirical studies that aim to investigate these facets of research regarding mind-matter interactions. This includes testing the plausibility of a directed influence on random systems with high-powered micro-PK study designs. We designed experiments containing randomly generated meaningful outcomes that should be able to address implicit core ideas of the observing participants. These comprised generally positive and negative states, i.e. pleasant or unpleasant pictures and sounds (paper 2) and the subconscious need for addiction-relevant stimuli within smokers in comparison to non-smokers (papers 1 and 3). We decided to address the replicability problematic of the research field as well; hence, the second part of this research is focusing on the reasons for a decline of initial effects and whether non-random behavior still can be measured. For that reason, especially in paper 3, we will not analyze an effect in terms of an anomalous end result, but will consider the temporal change of the effect as main hypothesis. To do so, different methods revolving around the change of evidence towards a micro-PK effect over the course of multiple studies will be assessed.

References

Anderson, M. (2010). Neural reuse: A fundamental organizational principle of the brain. *Behavioral and Brain Sciences, 33*(4), 245-266. doi:10.1017/S0140525X10000853

Appleby, M. (2014). Mind and matter. A critique of Cartesian thinking. In H. Atmanspacher & C. A. Fuchs (Eds.). *The Pauli-Jung Conjecture and Its Impact Today* (pp. 7-36). Exeter: Imprint Academic.

Atmanspacher, H. (2012). Dual-aspect monism à la Pauli and Jung. *Journal of Consciousness Studies, 19*(9-10), 96-120.

Atmanspacher, H. (2014). 20th century variants of dual-aspect thinking. *Mind and Matter, 12*(2), 245-288.

Atmanspacher, H. (2015). Quantum Approaches to Consciousness. In E.N. Zalta (Ed.). *Stanford Encyclopedia of Philosophy.* Accessible at http://plato.stanford.edu/entries/qt-consciousness/

Atmanspacher, H., & Fuchs, C. A. (2014). *The Pauli-Jung Conjecture and Its Impact Today.* Exeter: Imprint Academic

Atmanspacher, H., Filk, T., & Römer, H. (2006). Weak quantum theory: formal framework and selected applications. In G. Adenier, A. Khrennikov, T.M. Nieuwenhuizen (Eds.). *Quantum Theory: Reconsiderations of Foundations* (pp 34–46). New York: American Institute of Physics.

Atmanspacher, H., Römer, H., & Walach, H. (2002). Weak quantum theory: Complementarity and entanglement in physics and beyond. *Foundations of Physics, 32*(3), 379–406.

Bierman, D. J. (2001). On the nature of anomalous phenomena: Another reality between the world of subjective consciousness and the objective world of physics. In P. Van Loocke (Ed.). *The Physical Nature of Consciousness* (pp. 269–292). Amsterdam: John Benjamins.

Bohm, D. (1990). A new theory of the relationship of mind and matter. *Philosophical Psychology, 3*(2-3), 271-286.

Bohm, D. (2000). *Wholeness and the Implicate Order.* New York: Routledge.

Born, M. (1926). Quantenmechanik der Stoßvorgänge. *Zeitschrift für Physik, 38*(11-12), 803-827.

Bösch, H., Steinkamp, F., & Boller, E. (2006). Examining psychokinesis: The interaction of human intention with random number generators—A meta-analysis. *Psychological Bulletin, 132,* 497–523. doi:10.1037/0033-2909.132.4.497

Brüntrup, G. (1996). Das Leib-Seele-Problem. *Stuttgart: Kohlhammer.*

Cardeña, E. (2018). The Experimental Evidence for Parapsychological Phenomena: A Review. *American Psychologist*. doi:10.1037/amp0000236

Chalmers, D. J. (1995). Facing up to the problem of consciousness. *Journal of Consciousness Studies*, *2*(3), 200-219.

Cramer, J. G. (1986). The transactional interpretation of quantum mechanics. *Reviews of Modern Physics*, *58*(3), 647-687.

Fach, W. (2014). Complementary aspects of mind-matter correlations in exceptional human experiences. In H. Atmanspacher & C. A. Fuchs (Eds.). *The Pauli-Jung Conjecture and Its Impact Today* (pp. 255-274). Exeter: Imprint Academic.

Filk, T., & Römer, H. (2011). Generalized quantum theory: Overview and latest developments. *Axiomathes*, *21*(2), 211–220.

Fuchs, C. A. (2014). Introducing QBism. *New Directions in the Philosophy of Science*, *5*, 385-402.

Fuchs, C. A., Mermin, N. D., & Schack, R. (2014). An introduction to QBism with an application to the locality of quantum mechanics. *American Journal of Physics*, *82*(8), 749-754.

Fuchs, C. A., & Schack, R. (2014). Quantum Measurement and the Paulian Idea. In H. Atmanspacher & C. A. Fuchs (Eds.). *The Pauli-Jung Conjecture and Its Impact Today* (pp. 93-107). Exeter: Imprint Academic

Greenstein, G., & Zajonc, A. G. (2006). The Quantum Challenge: Modern Research on the 544 Foundations of Quantum Mechanics (2nd ed.). Boston: Jones and Bartlett.

Jahn, R., Dunne, B., Bradish, G., Dobyns, Y., Lettieri, A., Nelson, R., Mischo, J., Boller, E., Bösch, H., Vaitl, D., Houtkooper, J., & Walter, W. (2000). Mind/machine interaction consortium: PortREG replication experiments. *Journal of Scientific Exploration*, *14*(4), 499–555.

Kastner, R. E. (2015). *Understanding our unseen reality: Solving quantum riddles*. Hackensack, NJ: Imperial College Press.

Kelly, E. F. (2015). Empirical challenges to theory construction. In E. F. Kelly, A. Crabtree, & P. Marshall (Eds.), *Beyond physicalism: Toward reconciliation of science and spirituality* (pp. 3-38). Lanham, MD: Rowman & Littlefield.

Kelly, E. F., Crabtree, A., & Marshall, P. (2015). *Beyond physicalism: Toward reconciliation of science and spirituality*. Lanham, MD: Rowman & Littlefield.

Lear, C. W. (2019). The Case for Advance Wave Causality. *Journal of Scientific Exploration*, *33*(1), 61-72.

London, F., & Bauer, E. (1983). The theory of observation in quantum mechanics. In J.A. Wheeler & W.H. Zurek (Eds.) *Quantum Theory and Measurement* (pp. 217–259). Princeton: Princeton University Press.

von Lucadou, W. (2015): The Model of Pragmatic Information (MPI). In E. C. May & S. Marwaha (Eds.). *Extrasensory Perception: Support, Skepticism, and Science: Vol. 2: Theories and the Future of the Field* (pp. 221-242). Santa Barbara, CA: Praeger Publications.

von Lucadou, W., Römer, H., & Walach, H. (2007). Synchronistic phenomena as entanglement correlations in generalized quantum theory. *Journal of Consciousness Studies, 14*(4), 50–74.

Mensky, M. B. (2013). Everett Interpretation and Quantum Concept of Consciousness. *NeuroQuantology, 11*(1), 85–96.

von Neumann, J. (1932). *Mathematische Grundlagen der Quantenmechanik*. Berlin: Julius Springer.

Pauli, W. (1996). Letter to Fierz of 3 June 1952. In K. von Meyenn (Ed.) *Wissenschaftlicher Briefwechsel, Band IV, Teil I: 1950-1952* (pp. 634-635). Berlin: Springer

Penrose, R., & Hameroff, S. (2011). Consciousness in the universe: Neuroscience, quantum space-time geometry and Orch OR theory. *Journal of Cosmology, 14*, 1–17.

Pradhan, R. K. (2012). Psychophysical Interpretation of Quantum Theory. *NeuroQuantology, 10*(4), 629-645.

Pylkkänen, P. T. (2007). *Mind, Matter and the Implicate Order*. Berlin, Heidelberg: Springer-Verlag.

Shariff, A. F., Schooler, J., & Vohs, K. D. (2008). The hazards of claiming to have solved the hard problem of free will. *Are we free? Psychology and free will*, 181-204.

Stapp, H. P. (2015). A Quantum–Mechanical Theory of the Mind–Brain Connection. In E. F. Kelly et al. *Beyond Physicalism* (pp. 157–193). Lanham: Rowman and Littlefield.

Stapp, H. P. (2017). *Quantum Theory and Free Will*. New York: Springer.

Todd, P. B. (2017). Dual-aspect monism, mind-matter complementarity, self-continuity and evolutionary panentheism. *Australian Journal of Parapsychology, 17*(2), 147.

Varvoglis, M., & Bancel, P. A. (2015). Micro-Psychokinesis. In E. Cardeña, J. Palmer, & D. Marcusson-Clavertz (Eds.). *Parapsychology: A Handbook for the 21st Century* (pp. 266–281). Jefferson NC: McFarland.

Walach, H., von Lucadou, W., & Römer, H. (2014). Parapsychological phenomena as examples of generalized nonlocal correlations—A theoretical framework. *Journal of Scientific Exploration, 28*(4), 605–631.

Walker, E. H. (2000). *The Physics of Consciousness*. Cambridge: Perseus.

Weizsäcker, E. V. (1974). Erstmaligkeit und Bestätigung als Komponenten der pragmatischen Information. In E. v. Weizsäcker (Ed.). *Offene Systeme I* (pp. 82–113). Gütersloh: Klett-Cotta.

Wheeler, J. A., & Feynman, R. P. (1945). Interaction with the absorber as the mechanism of radiation. *Reviews of Modern Physics*, *17*(2-3), 157-181. doi:10.1103/RevModPhys.17.157

Wheeler, J. A., & Zurek, W. H. (Eds.) (1983). *Quantum Theory and Measurement*. Princeton: Princeton University Press.

Wigner, E. P. (1963). The problem of measurement. *American Journal of Physics*, *31*(1), 6 – 15.

2. Paper 1: Testing Micro-Psychokinetic Effects of Smokers on Addiction-related Stimuli

Maier, M. A.*, & Dechamps, M. C.* (2018). Observer Effects on Quantum Randomness: Testing Micro-Psychokinetic Effects of Smokers on Addiction-related Stimuli. *Journal of Scientific Exploration, 32*(2), 265-297. doi:10.31275/2018.1250 **Contributed equally*

Journal of Scientific Exploration, Vol. 32, No. 2, pp. 261–293, 2018 0892-3310/18

RESEARCH ARTICLE

Observer Effects on Quantum Randomness: Testing Micro-Psychokinetic Effects of Smokers on Addiction-Related Stimuli

Markus A. Maier *
markus.maier@psy.lmu.de

Moritz C. Dechamps *
Department of Psychology, Ludwig Maximilians University, Munich, Germany

* Shared first authorship

Submitted September 26, 2017; Accepted February 16, 2018; Published June 30, 2018
doi: https://doi.org/10.31275/2018.1250

Abstract—A vivid discussion revolves around the role of the human mind in the quantum measurement process. While some authors argue that conscious observation is a necessary element to achieve the transition from quantum to classical states during measurement (Wigner 1963), some go even further and propose a more active influence of the human mind on the probabilities of quantum measurement outcomes (e.g., Atmanspacher, Römer, & Walach 2002, Penrose & Hameroff 2011). This proposition was tested in micro-psychokinesis (micro-Pk) research in which intentional observer effects on quantum random number generators (RNGs) were investigated. In the studies presented here, we extended this line of research and tested the impact of unconscious goals on micro-Pk. Our focus was cigarette addiction as an unconscious drive, and we hypothesized that regular cigarette smokers would influence the outcome of a quantum RNG that determined whether the participant was going to see a smoking-related or a neutral picture. Study 1 revealed strong evidence for micro-Pk (*BF* = 66.06), supporting H_1. As expected, no deviation from chance was found with non-smokers. In Study 2, a pre-registered highly powered replication attempt failed to reproduce this result and showed strong evidence for H_0 (*BF* = 11.07). When the data from both studies are combined, a remarkable change in effect across time (resembling a combination of appearance followed by decline) can be seen only in the smokers' subsample. Appearance and decline effects were absent in the non-smokers' sample and in a simulation. Based on von Lucadou's Model of Pragmatic Information, we suggest that (micro-)Pk effects follow a systematic pattern comparable to a dampened harmonic oscillation. This concept may shed new light on past and future Pk research.

Keywords: micro-psychokinesis—observation—quantum measurement—mind–matter

Introduction

Theories about the relation between mind and matter belong to the hot topics of current science. Some early interpretations of quantum physics located a possible mind–matter interaction at the measurement process of quantum states. Wigner and von Neumann for instance suggested that the act of measurement was only complete when conscious observation of the result has taken place. They argued that conscious observation was the central factor causing the collapse of the wave function, i.e. the transition from quantum to classical states (e.g., Wigner 1963). This transition apparently occurs in a probabilistic fashion (Born 1926). Thus, consciousness was supposed to determine the collapse but not the exact outcome. Although mainstream quantum physics regards quantum-randomness as ontic and inherent in nature (Greenstein & Zajonc 2006), newer theories and empirical findings challenge this view (see Varvoglis & Bancel 2015). According to this research, intended observers might be able to influence the outcome of a quantum experiment. The goal of the studies presented here was to test the effect of motivated observation on quantum processes and to explore corresponding deviations from quantum randomness.

The first discovery of quantum theory started when Plank (1900) detected that energy was quantized and postulated as a "Wirkungsquantum" (quantum of action). Since then through the groundbreaking work of leading physicists such as Bohm, Bohr, Born, de Broglie, Dirac, Einstein, Feynman, Heisenberg, Pauli, Schrödinger, von Neumann, Wheeler, Wigner, and many others, this theory has evolved into a mathematically well-defined framework explaining many phenomena of the micro-world with an astonishingly high degree of accuracy (Byrne 2010, Greenstein & Zajonc 2006). One dramatic implication of this theory constitutes the probabilistic behavior of quantum systems when a measurement takes place. The act of a measurement turns a deterministically evolving quantum state into a probabilistically transformed existence within the macro-world. For example, before a measurement is performed, the place of an electron can be described through a wave function, the Schrödinger equation (Schrödinger 1935). It summarizes all potential locations of the electron within the system, treating them as a superposition. During the act of measurement this electron is found in one specific place only with a probability exactly corresponding to the square of the amplitude of the wave function (Born 1926). This probabilistic nature of the results of an observation is considered to be a basic principle inherent in quantum mechanics. Randomness at the level of a detector signal cannot be attributed to any inaccuracy of the measurement process but is a true and fundamental aspect of nature (but see Bohm 1952, Broglie 1927, 1953). There is apparently no yet-unknown underlying principle (so-called 'hidden variables') as proposed by Einstein who was unsatisfied with a probabilistic nature ("God does not play dice") explaining or causally affecting this random behavior (Bell 1964).

Some authors have challenged this proposition, arguing that the human mind plays a central and active role during the measurement process that goes beyond being responsible for the transition to happen. Under specific circumstances, mental processes related to consciousness presumably influence the likelihood of an outcome of a quantum process, leading to slight deviations from randomness. Those scientists revised the standard quantum theory accordingly. Atmanspacher, Römer, and Walach (2002), for instance, developed the Generalized Quantum Theory (GQT) (see also Atmanspacher & Filk 2012, Filk & Römer 2011, Römer 2004). In this framework, a measurement is characterized by an epistemic split that occurs when pre-consciously experienced potential quantum alternatives are transferred into conscious knowledge about one of them. This knowledge transfer can be shaped by the observer's mindset. Observer effects are thus described as entangled correlations between observer and the observed system (von Lucadou & Römer 2007). As a consequence, non-random deviations are allowed, but they should decline shortly after their first detection as will be explained more in depth later. Another revision, the orchOR theory, has been proposed by Penrose and Hameroff (2011) (see also Hameroff 2012, Hameroff & Penrose 1996, Penrose 1989, 1994). In their theory, the act of measurement constitutes an objective reduction of the wave function leading to the emergence of a conscious moment when realizing the result of the measurement. These reductions are at the quantum level gravitation-dependent and mathematically described as small curvatures between space–time geometries that represent the potential quantum states. The authors assume that objective reductions are not random and can be influenced by specific information embedded in fundamental space–time geometry. Penrose identifies these as Platonic values that among others include mental concepts (Hameroff & Chopra 2012). Thus, intentional observers might be able to non-randomly influence the transition of potential quantum states into one specific classical state. Similarly, Stapp (2007) equates measurement with the act of conscious observation (see also Wigner 1963) and proposes a conscious choice of the quantum alternatives during the measurement process. Mensky (2011, 2013) takes a different route and provides an extension of the Everettian interpretation of quantum mechanics (Everett 1957). Here he assumes a corrective process, called post-correction, that allows an individual to navigate through the potential quantum worlds. He termed this mechanism 'super-intuition'. Although this might not be an exhaustive list of the revisions of quantum theory, all these approaches have in common that they postulate a correlation between a mental state of the human mind and the outcome of a quantum experiment. This specific mind–matter interaction will be tested in the studies presented here and has been an empirical challenge for researchers for many decades. Their work has become known as micro-psychokinesis research. We will review and highlight their main findings in the following paragraphs.

Micro-Psychokinesis

Psychokinesis research has a long history and dates back to the early work of Crookes, Horsley, Bull, and Myers (1885), Crookes (1889), James (1896), Richet (1923), and Schrenck-Notzing (1924) during the late 19th and early 20th centuries. In these early years, case study reports and field investigations involving participants who mentally tried to move objects dominated the field (see Varvoglis & Bancel 2015). Later on, in the Rhine era, more scientifically designed studies testing mental effects on random sources such as dice tosses were performed (e.g., Rhine 1944, Rhine & Humphrey 1944). However, it took until the 1960s when the first experimenters used quantum states as a source for true randomness (Beloff & Evans 1961). In this early stage, participants were prompted to influence a quantum superposition of a decayed and non-decayed radioactive state to intentionally slow down or speed up the rate of decay. Random number generators that produced numerical outcomes based on quantum sources, so-called true RNGs (tRNGs), became a standard tool in this area of research (Jahn, Dunne, & Jahn 1980, Schmidt 1970a) and have been accompanied by the development of quantum theoretical explanations for psychokinesis ever since (e.g., von Lucadou & Kornwachs 1977, Schmidt 1975, Walker 1975).

During that time the term micro-psychokinesis was born. According to Varvoglis and Bancel (2015),

> micro-psychokinesis can be defined as mental influences on inanimate, probabilistic systems, producing effects that can only be detected through statistical means. The target systems may include tumbling dice, coin tossing systems, or hardware random number generators (RNGs). (p. 266)

Numerous studies have been performed since then testing intended observer effects on true, i.e. quantum, random number generators' outcomes and leading to a vast amount of data even until recently (e.g., Tressoldi et al. 2014). The majority of these studies used an instructed intention protocol where participants were prompted to influence the RNG in a way that produced a specific non-random visual or auditory outcome. Since we are primarily interested in intended observer effects on quantum systems, we will focus only on research findings obtained with true random number generators (tRNGs). Also, for clarity purposes we decided to summarize the results by referring to aggregated data reported in several meta-analyses authored by the most prominent research groups and skeptics in the field (for an excellent overview, see Varvoglis & Bancel 2015).

The first meta-analysis reported micro-psychokinesis effects of individual mental activity on various kinds of random sources (Radin & Nelson 1989). The 597 experimental studies reported covered a time range from 1959 to 1987 and included experiments using tRNGs but also algorithmically based random number generators, so-called pseudoRNGs. The overall effect size ES ($\times 10^{e-4}$) was always greater than 2 and significantly different from zero for various analyses, indicating that on average mental activity during intended observation had an effect on random outputs in these studies. This meta-finding was confirmed by a followup meta-analysis reported by Radin and Nelson (2003) in which the database was updated with 176 new studies. A more recent meta-analysis by Bösch, Steinkamp, and Boller (2006) included only studies that tested the effect of intended human interactions with tRNGs. This is the only and most complete summary of research investigating mental effects on quantum randomness exclusively. The final analysis of 380 experimental studies covering the years from 1961 to 2004 revealed a significant but very small and heterogeneous overall effect size. This confirmed the results of the earlier meta-analyses that documented an overall micro-psychokinetic effect on different types of RNGs, but this time focusing on tRNGs only. It could be interpreted as tentative evidence favoring the idea of intended observer effects on quantum randomness. However, the authors also observed a correlation between sample size of the studies and their effect sizes. Given the heterogeneity, the small overall effect, and this correlation, the authors speculated that the meta-analytic effect could be due to publication bias (but see Radin, Nelson, Dobyns, & Houtkooper 2006). This raised some doubts about the validity of the effect reported by this meta-analysis. Although many proponents of micro-psychokinesis (e.g., the Princeton Engineering Anomalies Research program PEAR) share a policy of open data and reporting data from all studies that have been conducted—long before the publication crisis reached mainstream psychology and led to the same recommendations—this argument always reappears when new findings or new evidence are presented.

Another, yet more convincing, empirical argument against micro-psychokinesis is the astonishing lack of successful direct replications. One prominent example for this is the Jahn, Dunne, and Nelson (1987) benchmark experiment done at the PEAR laboratory. It involved data from 2.5 million trials from 91 participants collected over 12 years of research. At the end of the study, they had found a highly significant effect of intended observation on tRNGs, yielding a z-score of 3.8. In 1996 a consortium consisting of two research groups the Grenzgebiete der Psychologie und Psychohygiene at Freiburg and at the Center for Behavioral Medicine at the Justus-Liebig University of Giessen started a three-year exact replication attempt. Data involving 750,000 trials per condition from 227 participants were collected and reported by Jahn et al. (2000). The results were disappointing since the overall z-score obtained was not significant. Micro-Pk of this type appeared to not be replicable, and this and similar failures increased skepticism toward PSI. However, a closer inspection of the original PEAR data by Varvoglis and Bancel (2015) revealed that two highly performing subjects seemed to have contributed to about a quarter of the overall effect size observed. According to the authors, this incident led to an overestimation of the proposed average effect size in the population. As a result, the power estimation for the replication attempt was misleading. A much higher sample size would have been needed to document the effect in the replication study than the number that was actually used. Thus, a severely underpowered study served as the test for replicability. This important finding was largely ignored. As a consequence, the replication failure was considered as evidence that no robust effect could be documented.

Another way of dealing with replication failure was to identify potential moderators of the effect (e.g., Bösch et al. 2006), but in many cases this could not account for the failures. Not satisfied by giving up their beliefs in micro-Pk, some authors suggested that PSI effects for specific theoretical reasons cannot be documented objectively. Some argue that such effects are subjective and self-referential processes and objectivity standards of modern time science do not apply (see, e.g., Atmanspacher & Jahn 2003, Etzold 2004, Kennedy 2003). Von Lucadou (2006, 2015) provided an elaborate model that refers to the concept of "Pragmatic Information". In his framework, novelty and confirmation are considered to be complementary variables. This is true for data obtained with quantum systems that violate the no-signal theorem such as non-random effects on quantum states. Although such effects would be highly novel, they would quickly vanish (or re-appear somewhere else) when confirmation (i.e. replication) efforts were made. Declining effects should therefore be natural in micro-Pk. The main problem with this kind of theory is that the accumulation of scientific evidence would always need to decline and would thus be indistinguishable from replication failures obtained with null effects (Etzold 2004).

The findings within micro-Pk research seemed to be fluctuating, and in the search for potential reasons we as trained experimentalists took one step back during the planning phase of our studies presented here and focused on the independent variable. The majority of the studies using tRNGs manipulated their participants' intentions toward the tRNG by giving explicit instructions such as "try to move up the graph" or "try to delay the decay". In this way the observer's consciousness was put into action assuming that it would affect the quantum random choices. The silent theoretical assumption behind this treats consciousness as being outside the physical reality influencing the physical quantum world like a "deus ex machina". This idea traces back to the origins of quantum mechanics where some researchers emphasized the role of the conscious observer to determine the quantum collapse while keeping the randomness postulate intact (e.g., Wigner 1963, see also von Neumann's position described in Byrne 2010). However, the revised quantum approaches reported above (e.g., Atmanspacher, Römer, & Walach 2002, Mensky 2011, Penrose & Hameroff 2011) regard consciousness only as a byproduct of the measurement process. In these theories both the classical outcome and its conscious experience emerge from a common quantum source during a measurement. Before the measurement takes place, unconscious knowledge of the potential states and quantum superpositions of the different states coexist. This idea was first described by the 'unus mundus' theory developed in a letter exchange lasting from 1932 to 1958 between C. G. Jung and W. Pauli (see Atmanspacher 2012). During quantum measurements, unconscious information and corresponding quantum states evolve into one specific conscious perception of one classical state (either gravitation-dependent: Penrose & Hameroff 2011; as an epistemic split: Atmanspacher, Römer, & Walach 2002; or through mental effort: Mensky 2011, 2013, Stapp 2007). Conscious mental occurrences together with quantum system outcomes are in this way entanglement correlations rather than causal effects. True causality takes place in the realm of the unconscious.

This theoretical gap between predictions and empirical practice has to some extent been overlooked in previous psychokinesis research. Nevertheless, there is some groundbreaking work that has pursued this idea of passive volitional effects on micro-Pk in the past. For example, the animal-psi work from Schmidt (1970b, 1973, 1979) and Peoc'h (1988, 2001) found micro-Pk effects with different animals. Others reported similar effects with human participants put into meditative (e.g., Bancel 2014, Radin & Atwater 2012, Tressoldi et al. 2014) or various emotional (e.g., Debes & Morris 1982) states. In addition, research that used 'hidden' RNGs also reported evidence for correlations between passive volitional or emotional states on outputs produced by unknowingly present trueRNGs. The most impressive findings were obtained within the Global Consciousness Project which relates global events to RNG data (see http://noosphere.princeton.edu/results.html#alldata).

Early on, theoretical attempts were also made to explain these effects. The PMIR and 'conformance behavior model' (Stanford 1977) theoretically addressed these non-intentional characteristics of PSI by relating Pk events to the Jungian term 'synchronicity'. According to these models, individuals non-intentionally express their inner states through sudden environmental changes. The GQT (Atmanspacher, Römer, & Walach 2002) is just a more elaborate and mathematically refined version of these early ideas. For a recent overview of this area of research and its relation to the more conscious intention approach, see also Varvoglis and Bancel (2015).

The advantage of the GQT (e.g., Atmanspacher, Römer, & Walach 2002) above these early explanations of micro-Pk is that it breaks up the separation of observer and observed object and includes the observer of a tRNG into the working mechanics of the output generator. The observer with their unconscious desires and the tRNG with its potential outputs during the quantum processing stage are considered to form a unity within an experimental trial. This entity subsumes an undivided co-existence of potential quantum states and unconscious desires before a conscious observation takes place. The act of observation then non-randomly results in a state of perceiving one tRNG output that is more likely in line with the underlying desire.

From this perspective, the micro-Pk studies that used intentional instruction protocols, such as the Jahn, Dunne, and Nelson (1987) PEAR study and others, might also produce the expected effects but only if the participants were able to form intentions in a way that included simultaneous activations of corresponding unconscious desires. In other words, the intentional instruction protocol needed a two-step induction procedure to ensure success, whereas our goal was to directly activate the unconscious mode. This might also explain why there are often reports of strong individual differences in the traditional approaches as Varvoglis and Bancel (2015) found for the original PEAR experiment and which were also present in Schmidt's work. Only individuals who were able to deeply ground the artificially induced instruction into their selves and related unconscious system might be able to produce an effect in such designs.

Encouraged by these findings and based on the GQT (Atmanspacher, Römer, & Walach 2002), we thus proposed to directly manipulate the unconscious desire of our participants instead of their conscious intentions. This could be achieved by either manipulating the unconscious desire experimentally or pseudo-manipulating the unconscious desire by using preestablished desires within certain individuals toward a specific state (that is a physical state that is correspondent to the desire). Hence, we designed the independent variable in our studies using a primarily unconsciously driven intentional state, the desire for cigarettes within smokers and compared it to non-smokers. We tested its effect on a tRNG that on each trial randomly chose pictures displaying either cigarette-related or neutral content. In this way, we tried to close the aforementioned gap as much as possible.

With regard to the direction of the effect, two opposite outcomes were equally likely. On one hand, the smokers' unconsciously rooted desire could affect the tRNG toward an increased likelihood for cigarette pictures. That is on average smokers should observe more of those pictures than expected by chance. No deviations from chance level were expected for non-smokers. Another completely opposite prediction was derived from the emotional transgression model, developed by the author MM. Since some smokers are addicted, they should have an unconsciously grieving drive toward cigarettes. On the unconscious level, they experience a permanent deficit of nicotine and therefore are convinced of not having enough of it most of the time. This unconscious fear of not "having enough" translates into a self-fulfilling prophecy of never getting enough. For smokers, this should on average result in a less-than-chance observation of cigarette pictures, an outcome that would reflect the deficit on the physical level. No statistically relevant deviations from chance were expected for non-smokers.

Since the direction of the effect investigated in our first study was unclear, we started with a two-tailed hypothesis stating that the average score of cigarette pictures should deviate from chance for smokers but not for non-smokers.

Study 1 Methods

All research presented was conducted in accordance with the ethical requirements of the American Psychological Association (APA). The instructions did not reveal the study's purpose, but ensured the data's anonymization and emphasized the participants' choice to withdraw from the experiment at any given time.

Consent

Voluntary participation was ensured, and written consent was obtained from all participants. If participants were interested, an explanation about the study's purpose was given individually after the tasks were completed. This procedure and the experiment were approved by the ethical board of the Department of Psychology.

Participants

In sum, 254 participants have been tested in the first study (145 female, 109 male; mean age = 30.3 years, *SD* = 12.88). The sample size was a result of the Bayesian sequential design that will be explained more in depth later. Participants were recruited through the department's announcement board, through handouts in psychology classes, through Facebook university groups, and through direct contact by the experimenters. Participants enrolled in the university's psychology bachelor's degree classes were able to acquire credits within their program.

Smokers and non-smokers were identified via self-assessment. Upon arriving at the experiment, all participants were asked to provide information about their smoking behavior. They were asked to choose between 'being a regular cigarette smoker' (at least 1 cigarette per day), 'being a smoker of other tobacco products' (e.g., pipe), 'being a casual smoker', 'being a non-smoker', and 'being a former smoker'. Only participants who smoked cigarettes regularly were labeled as smokers. Casual smokers, i.e. participants who smoked less frequently than daily, and former smokers were labeled as non-smokers. Also, smokers of other tobacco products (e.g., pipe) were assigned to the group of non-smokers since the addiction-related stimuli used in the experiment focused on cigarettes. In addition, the German version of the Fagerström Test for Nicotine Dependencies (FTND-G) (Schumann, Rumpf, Meyer, Hapke, & John 2003) was used to assess the degree of nicotine addiction within the group of smokers. Finally, the attitude toward smoking was assessed with all participants via a questionnaire containing 10 statements about smoking. Participants were asked to indicate their level of agreement toward positive (e.g., *smoking is fun*) or negative (e.g., *smokers smell badly*) statements. These two questionnaires were only used for exploratory purposes.

Materials

Software and computers. The study was conducted on a set of four different laptops that had all been prepared in an identical fashion. Due to this, differences in the presentation of the experiment were minimal at most, e.g., due to slight differences in the size of the display. The stimuli were presented on a black background with a size of 500 × 400 pixels. For this, a presentation procedure was programmed in C# that translated the output of the random number generator into choosing either smoking-related (cigarette) pictures or non-smoking pictures.

Stimuli. Non-smoking pictures were taken out of the International Affective Picture System (IAPS) (Lang, Bradley, & Cuthbert 2008), which provides an experimental set of 1,169 digitized photographs rated on arousal and valence using a 9-point rating scale. A set of 10 neutral (mean valence = 4.90, *SD* = 1.09) and unexciting (mean arousal = 2.61; *SD* = 1.86) pictures displaying everyday objects was chosen. Addiction-relevant stimuli (cigarette pictures) were taken out of the Geneva Smoking Photographs (GSP) (Khazaal, Zullino, & Billieux 2012), a normative database providing 60 addiction-relevant photographs for nicotine and tobacco research. A set of 10 pictures was chosen from the database providing variation in terms of product, smoking behavior, and tobacco-related cues (e.g., cigarette packs, ashtrays, smoking individuals, etc.).

Generation of quantum randomness. A tRNG, a quantum number generator (Quantis-v10.10.08) developed by the company ID Quantique from Geneva, was used (http://www.idquantique.com/random-number-generation/quantis-random-number-generator/). This apparatus produces quantum states by using photons that are sent through a semi-conductive mirror-like prism. The photon has an equal chance to be deflected in one or another direction producing a superposition of both states until a measurement is performed. Upon measurement, the photon is found on either route with a 50% probability which is then transformed into a numerical score such as 0 or 1, depending on the track it was found on (technically Quantis transforms 8 such bits into 1 Byte). This procedure is thus a reenactment of the famous double-slit study known in quantum physics testing the wave–particle duality. This hardware passed all serious tests of randomness such as the DIEHARD and the NIST tests (see certificates from various independent agencies on the website) and is one of the most effective tRNGs worldwide (Turiel 2007). In this way a true quantum source for randomness was established within each experimental trial.

Experimenters

For this study, informally trained research assistants were used as experimenters. Their task was to find smokers and non-smokers in equal numbers. They had only rudimentary knowledge about the aim of the experiment at the point of data collection. Data on smokers and non-smokers were randomly collected. The experimenters sent their raw data to the study supervisor on average every other day or so, depending on the number of participants tested.

Procedure

Participants were tested in different locations with mobile test stations. This was necessary since most student participants were non-smokers, forcing experimenters to expand the participant pool beyond students. Experimenters made sure to test in a distraction-free environment with no other persons present. At the beginning of the experiment, experimenters read a written instruction to the participants:

> Thank you for participating in this experiment! In the first part of the study you will sit in front of the computer and look at pictures. I know that this can be very tiring, I ask you nonetheless to not get distracted and focus your attention on the computer for the whole time of this part. It is *absolutely necessary* for this experiment that you look at the pictures! This will take approximately 10 minutes. Of course you can quit the experiment at any time, should you feel uncomfortable.
>
> As soon as you have finished there will be a message on the screen. Please let me know, so I can prepare the computer for the second part of the experiment. This will be a questionnaire. Filling it out will take about 5 more minutes. All data are collected anonymously.
>
> Do you have any questions?

When the participant had no more questions, the experimenter opened the software and told the participant to start the display of the pictures by pressing the spacebar as soon as they were ready. To avoid any interference by the experimenters, they were instructed to stay aside and distract themselves mentally during the experiment while checking on the participant only once in a while.

Participants attentively observed a consecutive series of 400 photographs. A tRNG decided if the next photograph would be pulled out of the set of addiction-related stimuli or out of the neutral stimuli. A software program used the randomness process of Quantis to decide which of the stimuli in the chosen set would be displayed. Stimuli were chosen by sampling without replacement. This means in the second trial there were only 9 pictures to choose from in each set since the "partner image" in the set not shown would be dismissed as well, and in the third trial 8, and so on. After every 10th trial, all pictures had the same probability to be chosen again. This process ensured that each picture in either category had an equal chance to be displayed over the course of the experiment. Therefore, different aspects of smoking in the pictures had an equal chance to be displayed and affect the participant. Participants looked at a centered cue (700 ms) first, then at the addiction-related or neutral stimuli (400 ms), and finally at a black screen (400 ms). This process was repeated 400 times (see Figure 1).

After the completion of the picture-presentation, the experimenter opened a batch file that added a unique code to the data and connected the code to the questionnaire that was subsequently opened via a web browser.

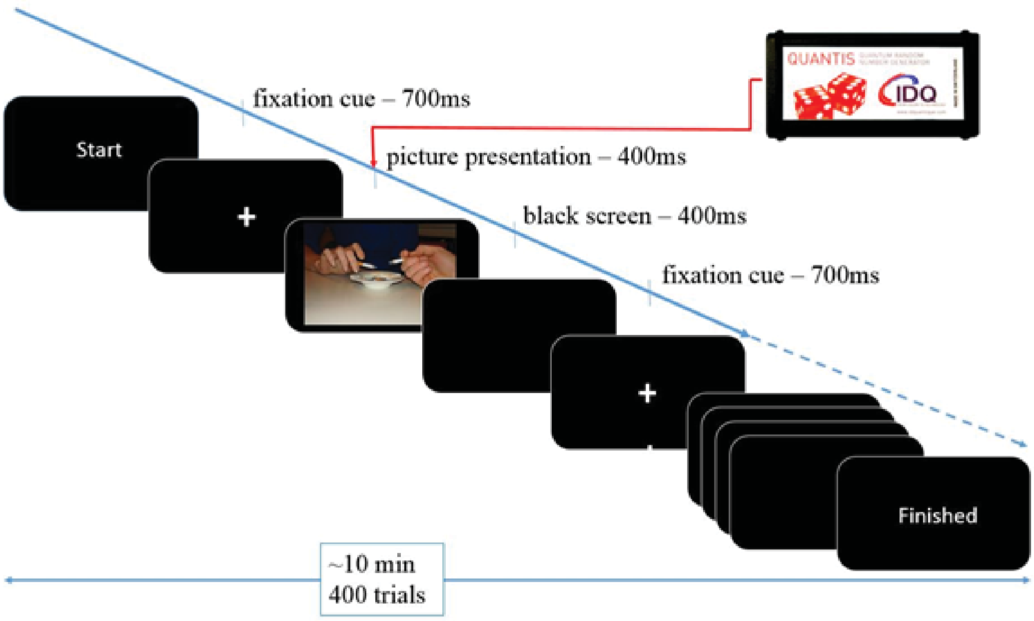

Figure 1. The 400 trials of the experiment consisted of the display of a fixation cue, a smoking or non-smoking-related picture, and a black inter-trial interval.

Data Analysis

Data collection and analysis was performed by using Bayesian inference techniques for hypotheses testing as recommended by Wagenmakers, Wetzels, Borsboom, and van der Maas (2011). The Bayesian theorem provides us with information on how to update our beliefs given new incoming data. Whereas the frequentist approach makes assumptions about theoretically repeated replications of the same study, the Bayesian method accumulates data concerning the effect and repeatedly updates the likelihood for an effect given the additional data. The strength of evidence for the effect is in this framework considered to be dependent on both the likelihood of the data given that H_0 is true as well as on the likelihood of the data given that H_1 is true. Thus, to find out whether the data provide more evidence for H_1 or for H_0, these two likelihoods are pitted against each other. The resulting score is called the Bayes Factor (*BF*) and resembles the relative amount of evidence that the data provide for or against a postulated effect. In this way, the existence and the non-existence of an effect can be tested against each other within the same dataset. A Bayes factor of 10 or higher is considered to indicate strong evidence for H_1 or H_0, respectively.

In order to calculate the Bayes Factor, a probability distribution for effect size that is centered around zero with scale parameter r needs to be specified a priori. This Cauchy distribution ($\delta \sim$ Cauchy (0, r)) identifies the prior, i.e. the likelihood of the data given there is an effect, i.e. p(data|H1). Wagenmakers et al. (2011) recommend an r equal to 1. The statistical software JASP designed to perform basic Bayesian analyses uses a default r of .707. Other authors recommend a lower r of .5 (Bem, Utts, & Johnson 2011) or of .1 (Maier et al. 2014) knowing that PSI effect sizes are usually very small (mostly in the range of .1 to .2). The choice of the prior provides a degree of freedom within the Bayesian approach. For data analysis in the studies presented here, we decided to use an r of .5, i.e. $\delta \sim$ Cauchy (0, .5). This score was determined before data collection was started.

Bayesian hypothesis testing comes with several valuable advantages. One is that the Bayes Factor combines information about the effect and the sample power within its score. A high *BF* can only be reached when sufficient power was provided through sample size, whereas the frequentist approach might accidentally detect an effect within a severely underpowered study. Thus, although the frequentist approach needs an a priori power analysis and pre-definition of sample size to compensate for this potential problem, the a priori definition of sample size is not necessary when applying Bayesian techniques. On the contrary, the Bayesian approach allows for data accumulation, i.e. additional subjects can be tested and included in the dataset until a pre-specified *BF* criterion for H_1 (or H_0) has been reached.

This also permits optional stopping after hitting the *BF* and is therefore a more effective way of hypothesis testing than the frequentist method. We decided to use a Bayesian sequential design with a *BF* of 10 as a stopping rule. The Bayes factor was monitored on a regular basis and data collection was stopped as soon as the stopping criterion was met. Nevertheless, additional data were available at this point and we decided to include all available data in our analysis, resulting in a slightly larger sample size than necessary. Since researchers in the field of psychology are more familiar with the frequentist approach and less so with Bayesian hypotheses testing, we outlined the reasons for using the Bayesian approach in the studies presented here in more detail. Before the study, we also decided to analyze the data with a Bayesian one sample *t*-test. For each subgroup, smokers and non-smokers, separate tests have been applied, each testing the respective sub-sample's mean score of cigarette pictures against chance level. For all Bayesian analyses, the statistical software tool JASP (Version 0.8.2) (JASP Team 2017) has been used.

Study 1 Results

In this first study, the authors of this paper disagreed about the expected direction of the effect tested here. On the one hand, it was proposed that smokers through their desire for cigarettes unconsciously attract pictures displaying those items. Hence, smokers should affect the random number generator to produce on average more than 200 cigarette pictures, since 200 was the expectancy value for purely random selections. On the other hand, the emotional transgression model views the desire for cigarettes within smokers as an anxious expression of a deficit, i.e. smokers supposedly believe they have actually not gotten enough of it. This in turn should be similar to a self-fulfilling prophecy and decrease the number of cigarette pictures being presented to smokers than expected by chance. Thus, a mean score of less than 200 could also have been expected. To account for the controversial predictions of both models, a two-tailed approach was chosen to test any substantial sample mean deviations from chance level. For non-smokers, null effects were expected, i.e. evidence for H_0 should be found.

Data for smokers and non-smokers were tested separately by one-sample Bayesian *t*-tests (two-tailed) with 200 as testing criterion and mean number of cigarette pictures as dependent-variable. As outlined above, data for each subsample were accumulated and repeatedly tested when new data came in until at least one Bayes factor of 10 or more was reached.

Smokers

The final Bayesian *t*-test analysis with 122 smokers yielded a *BF* of 66.06 for H_1. The mean score of cigarette pictures for these participants was mean = 196.7, *SD* = 9.87, indicating very strong evidence for the effect that participants who identified themselves as smokers viewed fewer smoking-relevant pictures than expected by chance. The graph below represents a sequential analysis of the Bayes factor for smokers (see Figure 2).

No significant correlations between the average mean score of cigarette pictures and the level of addiction measured with the Fagerström Test for Nicotine Dependencies nor between the score and the attitude toward smoking was found (see Table 1 in the Appendix).

Non-Smokers

The same analyses were performed with participants identifying themselves as non-smokers. The final Bayesian *t*-test analysis with 132 smokers yielded a *BF* of 6.13 for H_0. The mean score of cigarette pictures for these participants was mean = 200.5, *SD* = 9.68, indicating moderate evidence

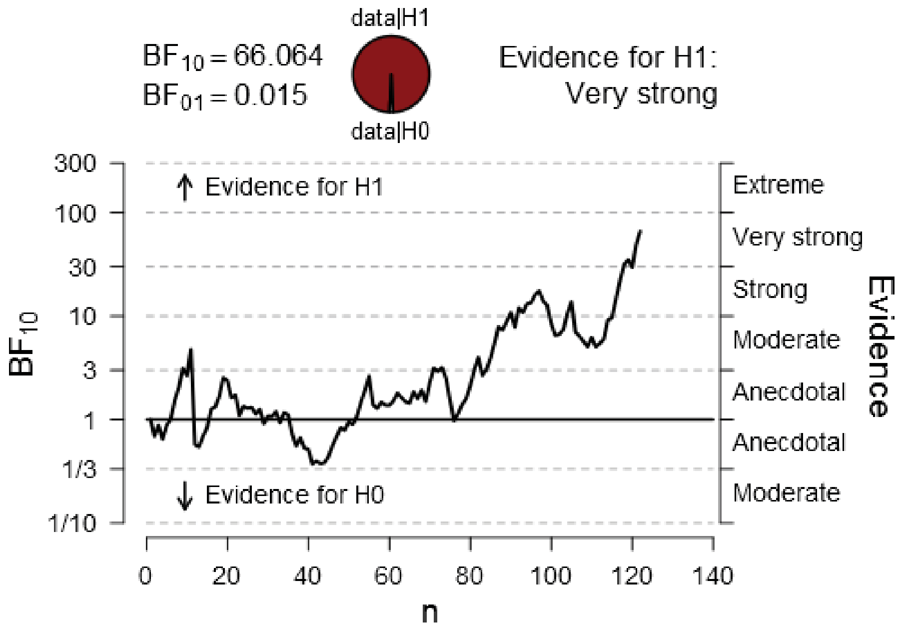

Figure 2. **The curve displayed within the graph indicates the temporal change in BF when additional smokers were tested, i.e. when more and more evidence was included in the analysis.**

for the null effect.[1] Participants who identified themselves as non-smokers viewed on average a number of smoking-relevant pictures around the chance level. The graph below represents a sequential analysis of the Bayes factor for non-smokers (see Figure 3).

From the beginning, a clear trend toward H_0 could be seen.

Study 1 Discussion

The results of Study 1 provide evidence for a very substantial deviation of the mean number of cigarette pictures from chance level within smokers. Smokers who passively observed the pictures chosen at each trial by a highly sophisticated and effectively working quantum random number generator seemed to unconsciously affect the quantum process toward non-randomness. They saw fewer cigarette pictures than was expected if the tRNG was working in a purely random fashion. Assuming that the generator was working properly, this would mean that motivated human observation can produce deviations in quantum randomness in line with their underlying desire. The data also support the emotion transgression model that predicted on average a negative deviation of smoking-relevant pictures for this group of individuals. A *BF* much higher than 10 also underlines the robustness of this effect. It states that it is 66 times more likely to obtain such data if H_1 is true than if H_0 was correct.

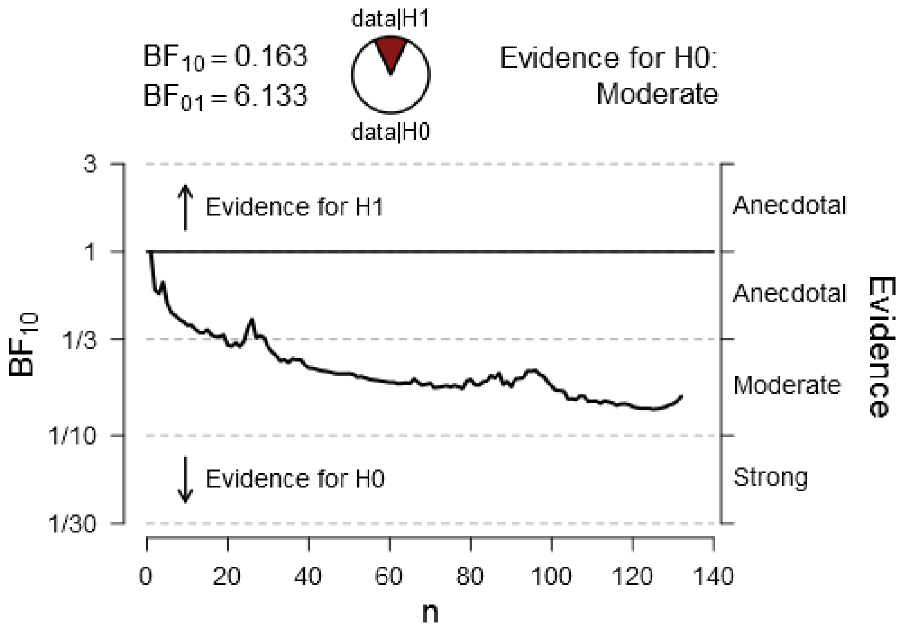

Figure 3. The curve displayed within the graph indicates the temporal change in BF when additional non-smokers were tested, i.e. when more and more evidence was included in the analysis.

For non-smokers, moderate evidence for a null effect was found supporting the idea of random presentations of the cigarette pictures on average across the trials. Since non-smokers should not have had any desire toward the picture sets, they should also lack any motivated observation. Thus, no influence on quantum choices was expected as reflected by the data of this subgroup. One could argue that non-smokers might have had strong rejecting attitudes toward cigarette pictures and should therefore also be considered to be motivated observers. However, we think that this attitude is not based in a deep physically grounded anti-desire as compared to the desire existent within smokers and therefore is not deeply enough rooted in someone's existence. Our model of motivated observation restricts mind-quantum randomness interactions to those deeply rooted motives and goals only. This is supported by a correlation, r = .05 (BF_{01} = 10), between attitude toward smoking and the number of smoking-related pictures within the overall non-smokers group, indicating strong evidence for no impact of this attitude on non-random picture presentations.

Overall, the data are in line with our predictions and with similar research documenting effects of the human mind on quantum random number generators (for an overview, see Varvoglis & Bancel 2015).

To test the robustness of the effect reported above, we decided to do an exact replication of Study 1. Although replications are the cornerstone of empirical research and although conceptual replications are available for micro-Pk (for an overview see, e.g., Bösch et al. 2006), there is a lack of successful one-to-one replications for a central experiment in micro-Pk research, the PEAR study (see Varvoglis & Bancel 2015).

This spectacular example involves the replication failure of an original experimental protocol developed and performed by the PEAR lab at Princeton University (Jahn, Dunne, & Jahn 1980). This study was attempted to be replicated by a combined research group from the Institute für Grenzgebiete der Psychologie und Psychohygiene at Freiburg and the Center for Psychobiology and Behavioral Medicine at Justus-Liebig University Giessen (Germany). The replication attempt failed and could not find evidence for intended observation on RNGs. Although Varvoglis and Bancel (2015) offered an explanation for the failure by proposing an overestimation of the original effect size due to outliers' data, a number of scientists also speculated about the inherent elusive manner of PSI effects, arguing that such mind–matter interactions involving the quantum realm are based on subjective and self-referential processes and cannot therefore be documented objectively (see, e.g., Atmanspacher & Jahn 2003, Kennedy 2003). Von Lucadou (2006, 2015) went further and provided a model based on the idea of Pragmatic Information proposing that quantum effects that violate the "no-signal theorem" need to vanish when researchers try to replicate them. According to him, the amount of initial novelty a data pattern contains with regard to this theorem is reciprocally related to the amount of later confirmation: The stronger the violation the quicker the disappearance (or re-appearance somewhere else) of this effect in an additional data collection.

Although superficially knowing about the hassle of replication in this area of research and the discussion around it, we ignored these warnings for two reasons: First, a *BF* of 66.06 gave us a pretty firm belief that the effect would show up again in an exact, careful replication. And second, if an effect was not replicable, any attempt at its empirical documentation would not make sense from the beginning. Since we had already done Step 1, we felt we had to do Step 2 as well.

Study 2 Methods

In Study 2 we performed an exact replication of Study 1. The study was pre-registered at the Open Science Framework (OSF) (https://osf.io/4fzq8). Procedural details, including selection of the participants, stimuli, apparatus, experimental protocol, and questionnaires used were the same as in Study 1. Also the statistical analyses were the same with one important change: The effect within the smokers in Study 2 was tested using a one-tailed statistical approach. The reason for this change was that after Study 1 we had a clear prediction about the direction of the effect. We expected smokers to show a lower-than-chance deviation with regard to the mean number of cigarette pictures being observed. All these procedural details and statistical techniques were pre-specified in the preregistration. Again, a prior distribution of $\delta \sim$ Cauchy (0, .5) was used.

Apparatus, Stimuli, and Procedure

All experimental setups were the same as in Study 1.

Participants

In sum, 175 smokers and 220 non-smokers (208 female, 184 male, 3 chose not to specify their gender; mean age = 31.30, *SD* = 13.11) were tested in the second study. Acquisition strategy and their labeling were done in the same way as reported above. Data collection again was stopped as soon as a Bayes factor reached 10 in either direction, resulting in a similar but slightly larger sample size than in Study 1.

Consent

Voluntary participation was ensured, and written consent was obtained from all participants. If participants were interested, an explanation about the study's purpose was given individually after the tasks were completed. This procedure and the experiment were approved by the ethical board of the Department of Psychology.

Study 2 Results

Data for smokers and non-smokers were tested separately by one-sample Bayesian *t*-tests with 200 as the testing criterion and the mean number of cigarette pictures as dependent-variable. As outlined above, data for each subsample were accumulated and repeatedly tested when new data came in until at least one Bayes factor of 10 or more was reached.

Smokers

The final Bayesian *t*-test analysis with 175 smokers yielded a one-tailed *BF* of 11.07 for H_0. The mean score of cigarette pictures for these participants was $M = 200.3$, $SD = 10.38$, indicating strong evidence for the null effect. Smokers viewed an average number of cigarette pictures close to and not different from chance level. The graph below documents a sequential analysis of the Bayes factor for smokers (see Figure 4).

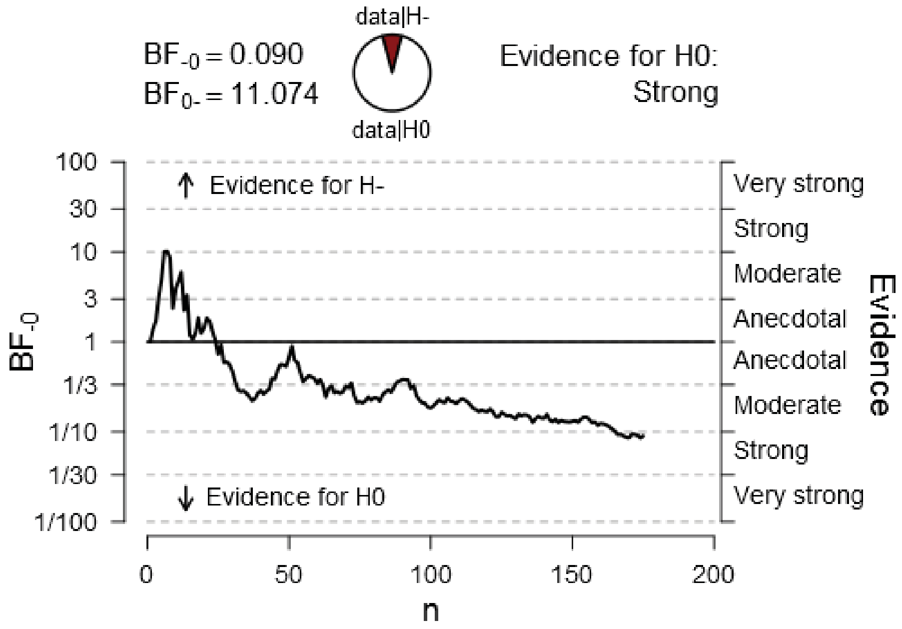

Figure 4. The curve displayed within the graph indicates the temporal change in BF when additional smokers were tested, i.e. when more and more evidence was included in the analysis.

No significant correlations between average mean score of cigarette pictures and the level of addiction and attitude toward smoking was found (see Table 2 and Table 3 in the Appendix for an analysis for both studies combined).

Non-Smokers

The same analyses were performed with participants[2] based on their self-reports being labeled as non-smokers. The final Bayesian *t*-test analysis with 220 non-smokers yielded a two-tailed *BF* of 3.74 for H_0. The mean score of cigarette pictures for these participants was mean = pictures around chance level. The graph below represents a sequential analysis of the Bayes factor for non-smokers (see Figure 5).

Study 2 Discussion

Contrary to our predictions made in the pre-registration phase of the study, the results of Study 2 did not replicate the effects found in Study 1. For smokers, strong evidence for the null hypothesis was revealed. Moderate evidence for the null effect was also found for non-smokers, which was in line with our predictions. It seems that the data pattern shown by the smokers is with each added subject consistently moving in the opposite

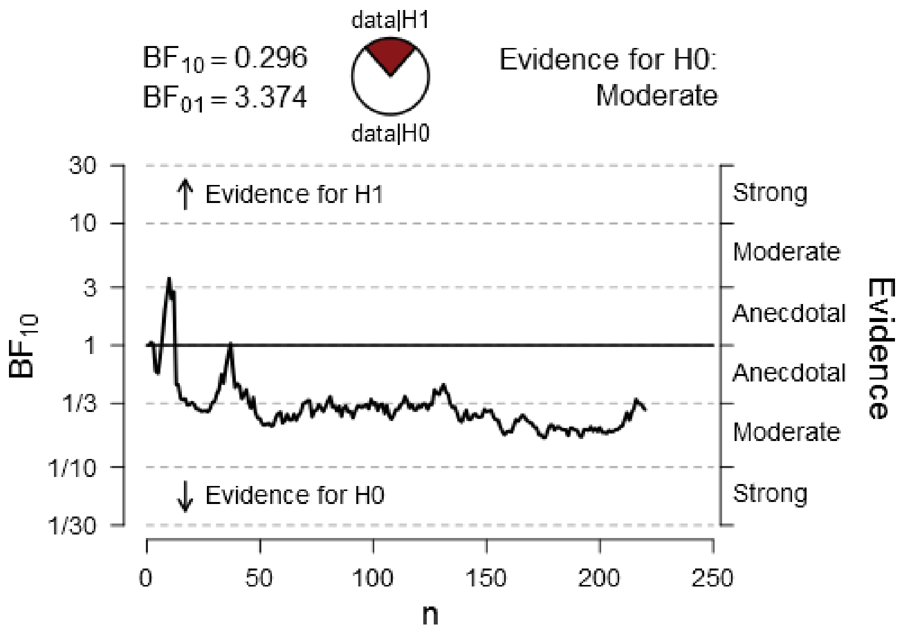

Figure 5. The curve displayed within the graph indicates the temporal change in BF when additional non-smokers were tested, i.e. when more and more evidence was included in the analysis.

direction of that found in Study 1. Although initially the effect was strongly present within the first 10 to 20 participants, it quickly dropped, and, given the mean score, even went in the opposite direction. Overall, applying the standards of scientific research we need to declare that the replication attempt clearly failed and a robust effect could not be determined.

When looking at the Bayesian sequential analyses (Figures 2 to 5) separately for smokers and non-smokers and separately for Study 1 and Study 2, some interesting patterns are noteworthy. Non-smokers in both studies uniformly show a null effect through the course of each experiment, indicated by a smooth asymptotic trend toward evidence for H_0. In contrast, Smokers in Study 2 who eventually revealed a clear null finding displayed a quite volatile trend before they hit the stopping criterion. Smokers within the first 20 participants in this group initially almost reached a $BF_{10} = 10$ in evidence for the H_1 before the trend went in the opposite direction. This is surprising and stands in contrast to all trends for non-smokers or any simulation performed (see below). Although random fluctuations might be a plausible explanation for this, it could also be considered as a hint that additional mechanisms might be at work. One potential explanation might be individual differences that might moderate the effect within the smokers between Study 1 and Study 2. This would imply that certain personality

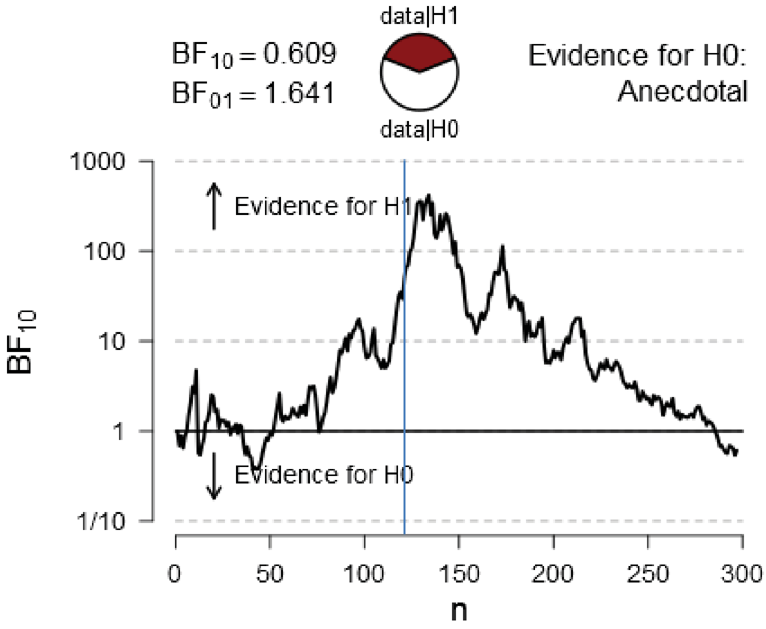

Figure 6. The curve displayed within the graph indicates the temporal change in BF when additional smokers were tested, i.e. when more and more evidence was included in the analysis. The transition from Study 1 to Study 2 is indicated by a vertical line at n = 122.

traits were strongly different in Study 1 compared with Study 2. Although we do not have empirical data to rule out this alternative explanation, we do not think that individual differences could fully account for the effect changes between the studies. One had to assume that a specific personality pattern would be present in the first experiment and an opposite one in the other. Such a homogeneous distribution of personality types within studies yet opposite between studies seems rather unlikely. We tried to make sure that smokers for both studies were invited from the exact same population. In addition, changes in emotional states or relevance of the pictures might also not fully explain the difference in the results. The moderators should have had an equally strong impact on the data of Study 1, which would have made the observed result of strong evidence for H_1 almost impossible. Rather we think that a more lawful mechanism could be responsible for the effect changes. We will elaborate on this idea in the following sections.

The raw data of both studies are available at the Open Science Framework (OSF): https://osf.io/4fzq8.

Overall Analyses of Study 1 and Study 2

In a final set of analyses, we included all data from Study 1 and Study 2 into one dataset to document the overall *BF* scores and the overall sequential

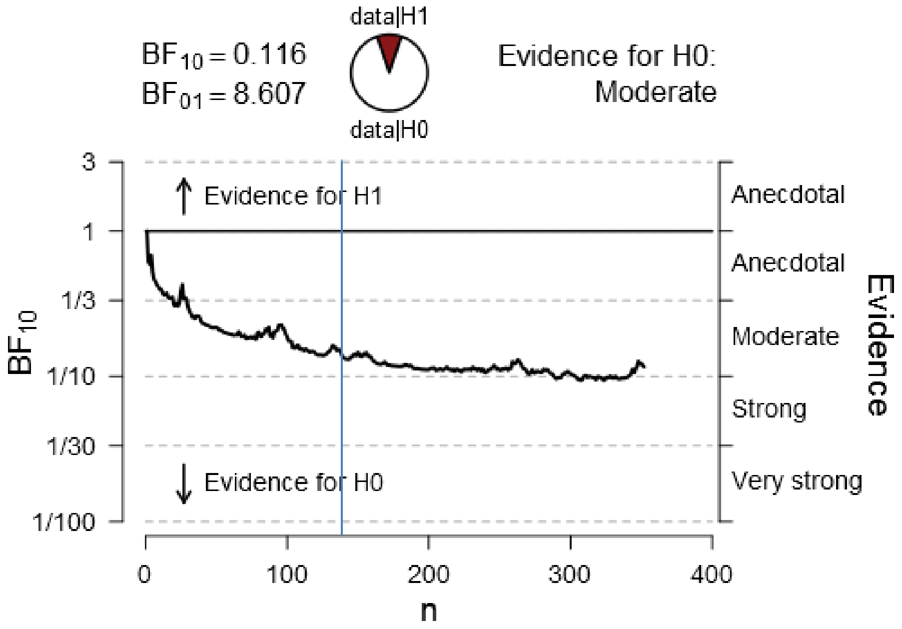

Figure 7. The curve displayed within the graph indicates the temporal change in BF when additional non-smokers were tested, i.e. when more and more evidence was included in the analysis. The transition from Study 1 to Study 2 is indicated by a vertical line at *n* = 132.

analyses. Data from identical experiments can be included in one analysis within Bayesian statistics, since this approach evaluates the accumulative evidence for or against an effect. All parameters were the same as in the studies reported above. For all following analyses, a two-tailed approach was applied.

Smokers Combined from Study 1 and Study 2

A Bayesian *t*-test with 297 smokers yielded a *BF* of 1.19 for H_1. The mean score of cigarette pictures for these participants was $M = 198.8$, $SD = 10.31$, indicating no evidence for either H_1 or H_0. The graph before the previous graph documents a sequential analysis of the Bayes factor for smokers (see Figure 6).

Non-Smokers Combined from Study 1 and Study 2

A Bayesian *t*-test with 352 non-smokers yielded a *BF* of 8.61 for H_0. The mean score of cigarette pictures for these participants was $M = 199.6$, $SD = 10.11$, indicating moderate evidence for H_0.[3] The graph above represents the sequential analysis of the Bayes factor for non-smokers (see Figure 7).

Discussion of Both Studies

An obvious detail when comparing both graphs of the overall analyses is that there was a strong change in effect across time (= additional participants) within the smokers' data, but no such change appeared within the non-smokers' dataset. One could argue that the temporal change of effect observed in smokers is just a random fluctuation. We therefore conducted a simulation run in which the experiment was executed without any observing participants.

For the simulation, one of the computers was equipped with mouse-recording software. This software handled the experimental software by itself in the same way the participants did. To get comparable results to our combined smokers' data, it was set to run until $n = 297$ datasets were collected. A Bayesian *t*-test showed a *BF* of 6.65 in favor of H_0 (M = 200.6; *SD* = 10.06). As can be seen from the sequential analysis in the graph below, no strong change appeared in the data over time. Development of the effect and final result rather resemble those of the non-smoking group (see Figure 8).

General Discussion

Our goal in the two studies presented here was to test micro-psychokinetic effects of unconsciously rooted desires during the observation of quantum experimental outcomes. Smokers and non-smoker participants were told to look at pictures that were randomly chosen by a true random number generator at each trial. Pictures with neutral or cigarette-related content each had a 50% chance of appearance. Before observation, both picture types were supposed to exist in a superposition. Through the act of measurement, the observer's unconscious mind was assumed to select the one of the two states with a slightly higher likelihood that best fits their unconscious desires. We focused on unconsciously rooted intentional states of the observers rather than on conscious intentions, since the theoretical models from which our hypothesis was derived postulate a desire-driven non-random emergence of classical states and their conscious perception out of the realm of the unconscious (see, e.g., Atmanspacher, Römer, & Walach 2002, Mensky 2013, Penrose & Hameroff 2011). Thus, mental activity originating from an observer's unconscious was assumed to causally affect motive-driven biases from randomness. In two studies, we tested the hypotheses that an observer's unconsciously rooted desire toward cigarettes should affect the tRNG's quantum probabilities for cigarette picture presentations. In Study 1 the mean score of cigarette pictures obtained with smokers was predicted to deviate from chance (two-tailed approach). In Study 2 a deviation lower than chance was expected (one-tailed approach). Null effects were expected for non-smokers.

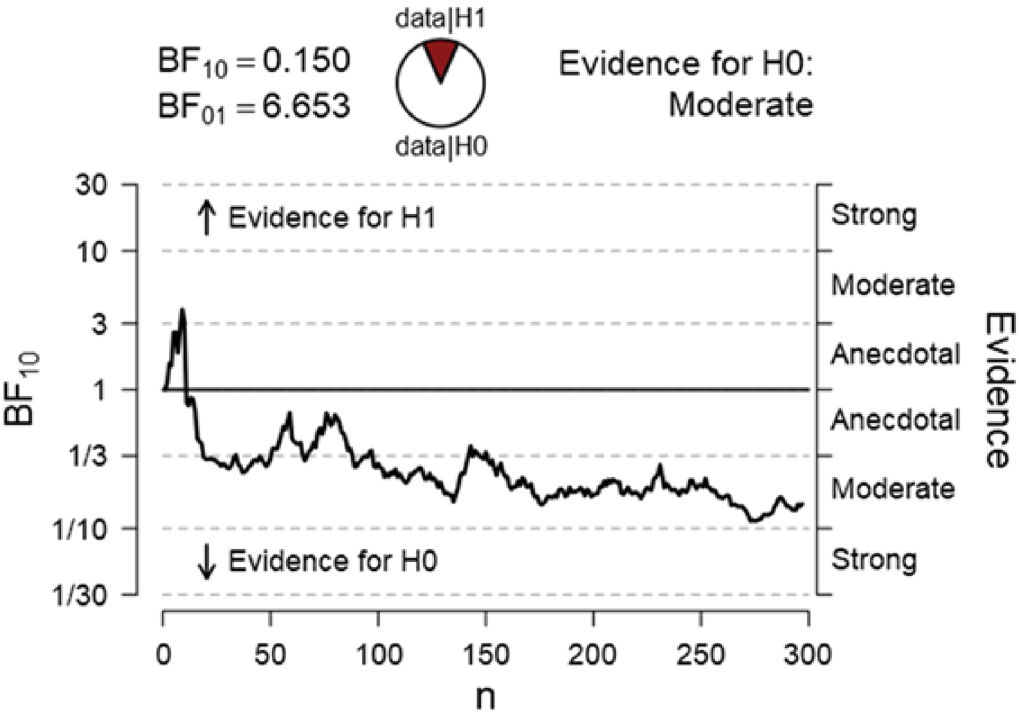

Figure 8. The curve displayed within the graph indicates the temporal change in BF when additional simulated participants were created, i.e. when more and more evidence was included in the analysis.

The results were rather mixed. In Study 1 strong evidence for H_1 was found, indicating that on average smokers observed fewer cigarette pictures than expected by chance. No deviations from chance were found with non-smokers. This is in line with the revised quantum models described above that also allow for observer-dependent deviations from randomness. The results also match with the prediction of the emotional transgression model: If the unconscious mind of the observer of smokers is convinced of not having had enough cigarettes yet, it will bias the random selection toward a lower likelihood for cigarette pictures. Thus, the unconscious belief and the established reality coincide similarly to a self-fulfilling prophecy. Subjectivity of smokers turns into objectivity here.

In Study 2, a pre-registered replication attempt, strong evidence for H_0 was found within the smoker group. This was unpredicted and surprising since a BF_{10} of 66.67 found in Study 1 was considered to provide a high likelihood for replication success, and the earlier effect could not easily be attributed to a chance finding of an underpowered sample. The overall analysis which included the data from all the smokers tested in both studies illustrated the temporal change of effect from initial appearance to later complete disappearance. Non-smokers in both studies and in the overall analysis as well as a simulation that contained no human interaction at all showed moderate to strong evidence for no deviations from randomness. No remarkable changes in evidence for H_1 to H_0 in the course of the experiment were detected in this subgroup and the simulation data. As expected, with increasing data accumulation a smooth trend toward strong evidence for H_0 was found.

How can this data pattern be interpreted? According to the standards of scientific practice, an unequivocal replication failure indicates that there is no robust micro-psychokinesis effect in this data. Thus, the randomness postulate of quantum mechanics remains intact. This also casts doubt on the validity of the revised quantum theories presented by Atmanspacher, Römer, & Walach (2002), Mensky (2013), and Penrose and Hameroff (2011). 'No replication—game over' is what the data are saying.

Common sense would recommend accepting this as the ultimate answer to our research efforts. However, there are some indications both from other research findings as well as within our data that urge us to speculate a bit more about the existence of micro-Pk reported here despite the lack of replication. There are similar reports of replication failures of originally strong effects. One famous example is the huge micro-Pk study conducted by the PEAR group (Jahn et al., 1987) that could not be replicated by an independent research team (IGGP Freiburg and CPBM at the University of Giessen reported in Jahn et al. 2000). Parallel to this case many others have reported decline effects despite originally strong evidence (see Radin 2006). This led to speculations about moderators but also to the development of theoretical models trying to understand such decline effects. The most elaborate one was proposed by von Lucadou (2006, 2015) and is based on the idea of Pragmatic Information. According to this proposal, quantum effects such as micro-psychokinesis that violate the "no-signal theorem" should vanish when additional data are collected. The initial novelty of a study should reciprocally be related to the likelihood of later confirmation. The stronger the observed violation was, the quicker the effect would disappear during replication efforts. This would exactly match our dataset whereby an initial occurrence suddenly changes with additional data collection to a disappearance of the effect. This temporal variation was neither observed in the data obtained with non-smokers nor in the simulation where null effects were obtained throughout the data collection. This difference is striking and supports von Lucadou's (2006, 2015) assumption, admittedly on a post-hoc basis only.

The theoretical problem with this approach, however, is that real null effects documented by replication failures of spurious findings cannot

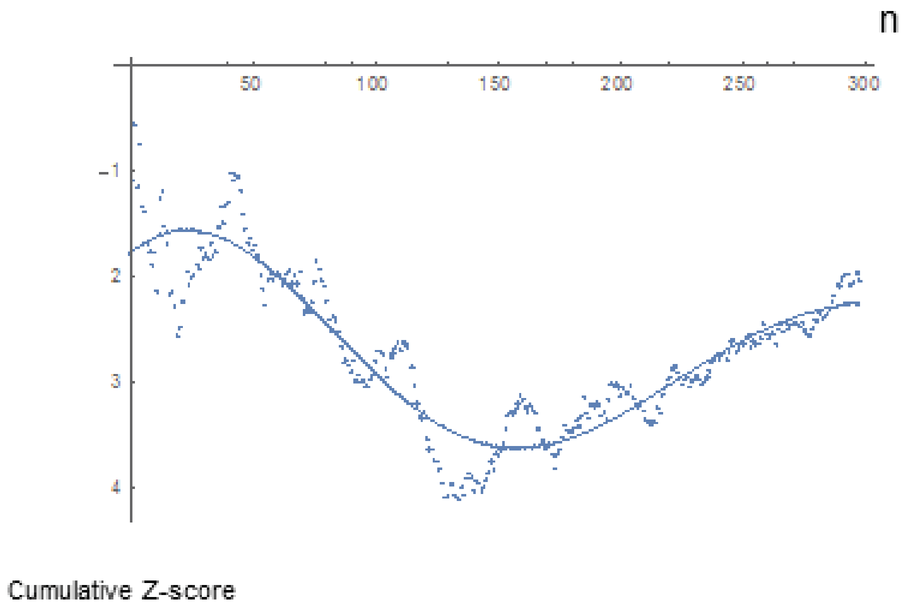

Figure 9. Cumulated Z-Score of the effect (z-transformed cumulative average score for cigarette pictures for smokers) with curve-fitting.

be distinguished from decline effects. The consequence is that with the standard scientific replication approach micro-psychokinesis effects cannot be scientifically studied. Either way, this would mean we should abandon PSI research from science (for a similar argument, see Etzold 2004).

Nevertheless, we suggest a way out of this dead-end situation. Going a bit beyond von Lucadou's (2006, 2015) Model of Pragmatic Information, we speculate that maybe the lowered confirmation trend follows a systematic pattern. A violation of the no-signal theorem in quantum physics constitutes a severe violation of the Second Law of Thermodynamics that states that entropy needs to increase over time. Hence, we assume that at the moment of the occurrence of mentally-induced deviations from quantum randomness entropy sets in to counteract this trend. Once the effect has weakened, the entropic counterforce also decreases allowing the effect to reappear although with a lowered effect size than initially shown; this interplay between effect and entropy should lead to a temporal change in effect comparable to a dampened harmonic oscillation. We estimated a mathematical function describing such a harmonic oscillation with our smokers' data (see Figure 9).

The function displayed in the Figure 9 graph was obtained with curve-fitting algorithms using the mathematical software tool Wolfram Mathematica Version 11.1.1.0 (https://www.wolfram.com/mathematica/):

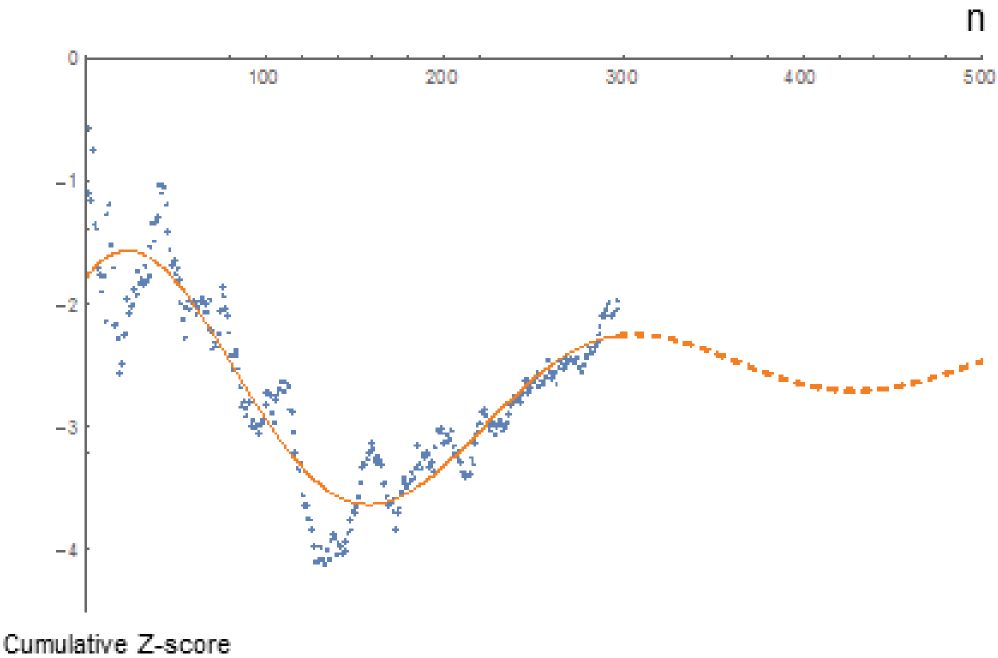

Figure 10. Cumulative time z-score of the effect (z-transformed cumulative average score for cigarette pictures for smokers) with curve-fitting and extrapolation (dotted line) to 500 subjects.

$$y = -1.650641811645734\, e^{-0.004549840402099492t} \cos(0.022532398160298193t + 2.457511536269481) + 0.0013342140582305 25t - 3.064904989339309$$

with y representing the effect (negative scores indicate a cumulative average score below chance) and t representing the participants in temporal order of data collection.

The prediction derived from this function would be that within the next not-yet–tested 200 smokers the effect should reappear to a lower degree in effect size and further slightly oscillate down toward the zero line. Our trend prediction can be inferred from the dotted line (Figure 10) which is an extrapolation of the accumulated effect when additional data are collected. The local maximum for this additional data should occur around subject number 410 to 450. The exact z-score for the maximum might be around −2 to −3 but could also be lower due to a further decline trend which is actually not present in the estimated part of the graph.

Our research group is currently working on similar trend estimations with other datasets, and up to now this approach seems promising. However, at present we admit that this idea of a *systematic* decay of a micro-Pk effect supplementing von Lucadou's model is highly speculative, and the goal here is just to inform other research groups about our findings and to encourage them to re-analyze their data with harmonic oscillation functions of this kind:

$$y(t) = \alpha e^{-\beta t} \cos(\omega t + \varphi) + mt + h$$

Future research will show whether systematic decline effects can be documented and thus whether micro-psychokinesis can still be studied scientifically or not.

In addition, an alternative explanation for this null effect in Study 2 or for the oscillating pattern might also be found in experimenter effects on micro-Pk that are specifically tied to the Bayesian approach. Bayesian sequential analysis requires a continuous observation of the evidence for or against the effect. The experimenter might unconsciously affect the evidence through his expectations. In Study 1 the experimenter might have been confident about finding the expected effect, but in Study 2 due to the preregistration he might have been fearing and thus anticipating a failure. In other words the experimenter himself could evoke an oscillating micro-Pk effect on the data fully explaining the decline effect found. Such experimenter effects are discussed in Pk research (e.g., Varvoglis & Bancel 2015), and suggestions to avoid them should be taken seriously. We are not sure whether this would fully explain the non-existence of the effect in Study 2 or its oscillation, but in future research an "experimentally and theoretically blind" data analyst or an automatic analysis procedure that simply indicates when the stopping criterion is met would be recommended. For now the conclusion about the results of our studies is: There is no evidence for micro-Pk, but . . . !

Notes

1 To gain a deeper understanding of the null effect (H_0) within the non-smokers' group, separate analyses were conducted on different subgroups of non-smokers. As can be seen from the results for casual smokers (n = 34, M = 200.7, SD = 9.33, BF = .27), former smokers (n = 12, M = 201.1, SD = 8.94, BF = .40), strict non-smokers (n = 82, M = 200.5, SD = 10.16, BF = .19), smokers of other tobacco products (n = 4, M = 197.3, SD = 6.55, BF = .65), as well as a more conservative non-smokers group consisting of strict non-smokers and former smokers who stopped smoking for at least 1 year (n = 93, M = 200.77, SD = 10.0, BF = .19), no unusual differences were found, indicating that our addiction-related stimuli did not produce an effect and these groups can be combined.

2 Analyses for subgroups of the non-smoking sample were conducted for casual smokers (n = 36, M = 198.7, SD = 8.88, BF = .34), strict non-smokers (n = 137, M = 199.8, SD = 10.60, BF = .14), smokers of other tobacco products

(*n* = 9, *M* = 201.6, *SD* = 8.02, *BF* = .47) and the conservative non-smokers group (*n* = 168, *M* = 199.0, *SD* = 10.74, *BF* = .28). Former smokers showed a moderate deviation from the expected mean (*n* = 38, *M* = 195.6, *SD* = 10.74, *BF* = 3.33).

[3] Regarding the subgroups, a slightly different result was only found for former smokers (*n* = 50, *M* = 196.9, *SD* = 10.52, *BF* = 1.39).

References

Atmanspacher, H. (2012). Dual-aspect monism à la Pauli and Jung. *Journal of Consciousness Studies*, *19*(9–10):96–120.

Atmanspacher, H., & Filk, T. (2012). Contra classical causality violating temporal bell inequalities in mental systems. *Journal of Consciousness Studies*, *19*(5–6):95–116.

Atmanspacher, H., & Jahn, R. G. (2003). Problems of reproducibility in complex mind–matter systems. *Journal of Scientific Exploration*, *17*(2):243–270.

Atmanspacher, H., Römer, H., & Walach, H. (2002). *Weak quantum theory: Complementarity and entanglement in Physics and Beyond*. Retrieved from http://arxiv.org/pdf/quant-ph/0104109v2

Bancel, P. A. (2014). *The PEAR protocol: An experiment with Meditators*. [Unpublished manuscript]

Bell, J. S. (1964). On the Einstein–Podolsky–Rosen paradox. *Physics*, *1*(3):195–200.

Beloff, J., & Evans, L. (1961). A radioactivity test of psycho-kinesis. *Journal of the Society for Psychical Research*, *41*:41–46.

Bem, D. J., Utts, J., & Johnson, W. O. (2011). Must psychologists change the way they analyze their data? *Journal of Personality and Social Psychology*, *101*(4):716–719. https://doi.org/10.1037/a0024777

Bohm, D. (1952). A suggested interpretation of the quantum theory in terms of "hidden" variables. I. *Physical Review*, *85*(2):166.

Born, M. (1926). Quantenmechanik der Stoßvorgänge. *Zeitschrift für Physik A Hadrons and Nuclei*, *38*(11): 803–827.

Bösch, H., Steinkamp, F., & Boller, E. (2006). Examining psychokinesis: The interaction of human intention with random number generators—A meta-analysis. *Psychological Bulletin*, *132*(4):497.

Broglie, L. de (1927). La mécanique ondulatoire et la structure atomique de la matière et du rayonnement. *Journal de Physique et Le Radium*, *8*(5):225–241.

Broglie, L. de (1953). *La physique quantique restera-t-elle indéterministe?* Paris: Gauthier-Villars.

Byrne, P. (2010). *The Many Worlds of Hugh Everett III: Multiple Universes, Mutual Assured Destruction, and the Meltdown of a Nuclear Family*. Oxford, UK: Oxford University Press.

Crookes, W., Horsley, V., Bull, W. C., & Myers, A. T. (1885). Report on an alleged physical phenomenon. In *Proceedings of the Society for Psychical Research, 3*:460–463.

Crookes, W. (1889). Notes of seances with D. D. Home. In *Proceedings of the Society for Psychical Research, 6*:98–127.

Debes, J., & Morris, R. L. (1982). Comparison of striving and nonstriving instructional sets in a PK study. *Journal of Parapsychology*, *46*(4):297–312.

Etzold, E. (2004). Ist die Existenz von Psi-Anomalien beweisbar. *Zeitschrift für Anomalistik*, *4*:14–24.

Everett, H. (1957). "Relative state" formulation of quantum mechanics. *Reviews of Modern Physics*, *29*(3):454–462. https://doi.org/10.1103/RevModPhys.29.454

Filk, T., & Römer, H. (2011). Generalized quantum theory: Overview and latest developments. *Axiomathes*, *21*(2):211–220.

Greenstein, G., & Zajonc, A. G. (2006). *The Quantum Challenge: Modern Research on the Foundations of Quantum Mechanics* (second edition). Boston, MA: Jones and Bartlett.

Hameroff, S. (2012). How quantum brain biology can rescue conscious free will. *Frontiers in Integrative Neuroscience*, *6*(1): 93. https://doi.org/10.3389/fnint.2012.00093
Hameroff, S., & Chopra, D. (2012). The "Quantum Soul": A Scientific Hypothesis. In *Mindfulness in Behavioral Health. Exploring Frontiers of the Mind–Brain Relationship* edited by A. Moreira-Almeida & F. Santana Santos, New York, NY: Springer Science+Business Media, pp. 79–93. https://doi.org/10.1007/978-1-4614-0647-1_5
Hameroff, S., & Penrose, R. (1996). Orchestrated reduction of quantum coherence in brain microtubules: A model for consciousness. *Mathematics and Computers in Simulation*, *40*(3–4):453–480. https://doi.org/10.1016/0378-4754(96)80476-9
Jahn, R. G., Dunne, B. J., & Jahn, E. G. (1980). Analytical judging procedure for remote perception experiments. *The Journal of Parapsychology*, *44*(3):207.
Jahn, R. G., Dunne, B. J., & Nelson, R. D. (1987). Engineering anomalies research. *Journal of Scientific Exploration*, *1*(1):21–50.
Jahn, R., Dunne, B., Bradish, G., Dobyns, Y., Lettieri, A., Nelson, R., . . . Vaitl, D. (2000). Mind/machine interaction consortium: PortREG replication experiments. *Journal of Scientific Exploration*, *14*(4):499–555.
James, W. (1896). Great Men and Their Environment. A Lecture before the Harvard Natural History Society. *Atlantic Monthly, 46*(276)(October 1880):441–459.
JASP Team (2017). *JASP* (Version 0.8.2) [Computer software]. https://jasp-stats.org/
Kennedy, J. E. (2003). The capricious, actively evasive, unsustainable nature of psi: A summary and hypotheses. *The Journal of Parapsychology*, *67*(1):53.
Khazaal, Y., Zullino, D., & Billieux, J. (2012). The Geneva Smoking Pictures: Development and preliminary validation. *European Addiction Research*, *18*(3):103–109.
von Lucadou, W. (2006). Self-Organization of Temporal Structures—A Possible Solution for the Intervention Problem. In *AIP Conference Proceedings, 863*:293–315.
von Lucadou, W. (2015). The Model of Pragmatic Information (MPI). In *Extrasensory Perception. Support, Skepticism, and Science. Volume 2: Theories and the Future of the Field* edited by E. C. May, S. B. Marwaha, & J. H. Fallon, Santa Barbara, CA: Praeger, pp. 221–242.
von Lucadou, W., & Kornwachs, K. (1977). Beitrag zur systemtheoretischen Untersuchung paranormaler Phänomene. *Zeitschrift für Parapsychologie und Grenzgebiete der Psychologie*, *19*:169–194.
von Lucadou, W., & Römer, H. (2007). Synchronistic phenomena as entanglement correlations in generalized quantum theory. *Journal of Consciousness Studies*, *14*(4):50–74.
Maier, M. A., Büchner, V. L., Kuhbandner, C., Pflitsch, M., Fernández-Capo, M., & Gámiz-Sanfeliu, M. (2014). Feeling the future again: Retroactive avoidance of negative stimuli. *Journal of Consciousness Studies*, *21*(9–10), 121–152.
Mensky, M. B. (2011). Mathematical models of subjective preferences in quantum concept of consciousness. *NeuroQuantology*, *9*(4).
Mensky, M. B. (2013). Everett interpretation and quantum concept of consciousness. *NeuroQuantology*, *11*(1). https://doi.org/10.14704/nq.2013.11.1.635
Penrose, R. (1989). *The Emperor's New Mind Concerning Computers, Minds and the Laws of Physics*. New York: Oxford University Press.
Penrose, R. (1994). *Shadows of the Mind*. Oxford, UK: Oxford University Press.
Penrose, R., & Hameroff, S. (2011). Consciousness in the universe: Neuroscience, quantum space-time geometry and Orch OR theory. *Journal of Cosmology*, *14*:1–17.
Peoc'h, R. (1988) Chicken imprinting and the tychoscope: an ANPSI experiment. *Journal of the Society for Psychical Research, 55*:1–9.
Peoc'h, R. (2001). Chicks' distant psychokinesis (23 km). *Revue Francaise de Psychotronique*, *2*.
Plank, M. (1900). Zur Theorie des Gesetzes der Energieverteilung im Normalspektrum. *Verhandlungen der Deutschen Physikalischen Gesellschaft*, *2*:237–245.
Radin, D. (2006). *Entangled Minds: Extrasensory Experiences in a Quantum Reality*. New York: Simon and Schuster.

Radin, D. I., & Nelson, R. D. (1989). Evidence for consciousness-related anomalies in random physical systems. *Foundations of Physics*, *19*(12):1499–1514.

Radin, D., & Nelson, R. D. (2003). Meta-analysis of mind–matter interaction experiments: 1959–2000. *Healing, Intention & Energy Medicine. London: Harcourt Health Sciences*, pp. 39–48.

Radin, D., Nelson, R., Dobyns, Y., & Houtkooper, J. (2006). Reexamining psychokinesis: Comment on Bösch, Steinkamp, and Boller (2006). *Psychological Bulletin*, *132*(4):529–532.

Rhine, J. B. (1944). "Mind over matter" or the PK effect. *Journal of the American Society for Psychical Research*, *38*:185–201.

Rhine, J. B., & Humphrey, B. M. (1944). The PK effect: Special evidence from hit patterns I. Quarter distributions of the page. *The Journal of Parapsychology*, *8*(1):18–60.

Richet, C. (1923). *Traité de métapsychique* (second edition revised). Paris: Alcan.

Römer, H. (2004). Weak quantum theory and the emergence of time. *Mind and Matter*, *2*(2):105–125.

Schmidt, H. (1970a). A PK test with electronic equipment. *Parapsychology*, *34*:175–181.

Schmidt, H. (1970b). PK experiments with animals as subjects. *Journal of Parapsychology, 34*(4):255–261.

Schmidt, H. (1973). PK tests with a high-speed random number generator. *Journal of Parapsychology, 37*(2):105–118.

Schmidt, H. (1975). Toward a mathematical theory of psi. *Journal of the American Society for Psychical Research*, *69*(4):301–319.

Schmidt, H. (1979). Search for psi fluctuations in a Pk test with cockroaches. *Research in Parapsychology 1978*:77–78. Metuchen, NJ: Scarecrow Press.

Schrenck-Notzing von, A. (1924). *Experimente der Fernbewegung (Telekinese)*: Union Deutsche Verlagsgesellschaft.

Schrödinger, E. (1935). Die gegenwärtige Situation in der Quantenmechanik. *Naturwissenschaften*, *23*(48):807–812.

Schumann, A., Rumpf, H. J., Meyer, C., Hapke, U., & John, U. (2003). Deutsche Version des Fagerström-Test for Nicotine Dependence (FTND-G) und des Heaviness of Smoking Index (HSI-G). In *Elektronisches Handbuch zu Erhebungsinstrumenten im Suchtbereich (EHES)* edited by A. Glöckner-Rist, F. Rist, and H. Küfner, Version 3.

Stanford, R. G. (1977). Experimental psychokinesis: A review from diverse perspectives. In *Handbook of Parapsychology* edited by B. Wolman, New York: Van Nostrand Reinhold, pp. 324–381.

Stapp, H. P. (2007). *Mindful Universe Quantum Mechanics and the Participating Observer*. *The Frontiers Collection*. Berlin: Springer.

Tressoldi, P., Pederzoli, L., Caini, P., Ferrini, A., Melloni, S., Richeldi, D., . . . & Duma, G. M. (2014). Mind–matter interaction at a distance of 190 km: Effects on a random event generator using a cutoff method. *NeuroQuantology*, *12*(3).

Turiel, T. P. (2007). Quantum random bit generators. *The American Statistician*, *61*(3):255–259.

Varvoglis, M., & Bancel, P. A. (2015). Micro-Psychokinesis. In *Parapsychology: A Handbook for the 21st Century* edited by E. Cardeña, J. Palmer, & D. Marcusson-Clavertz, Jefferson NC: McFarland, pp. 266–281.

Wagenmakers, E.-J., Wetzels, R., Borsboom, D., & van der Maas, H. L. J. (2011). Why psychologists must change the way they analyze their data: The case of psi: Comment on Bem (2011). *Journal of Personality and Social Psychology*, *100*(3):426–432. https://doi.org/10.1037/a0022790

Walker, E. H. (1975). Foundation of paraphysical and parapsychological phenomena. In *Quantum Physics and Parapsychology*, *Proceedings of an International Conference Held in Geneva, Switzerland, Aug. 26–27, 1974* edited by L. Oteri, New York: Parapsychology Foundation.

Wigner, E. P. (1963). The problem of measurement. *American Journal of Physics*, *31*(1):6–15.

Appendix: Correlational Analyses

TABLE 1
Correlations between Mean Score of Cigarette Pictures, Positive Attitude Toward Smoking (Attitude), and Addiction Score on the Fagerström Test for Nicotine Dependencies (Fager_Score) for Study 1

		CP	Attitude	Fager_Score
Cigarette Pictures	Pearson's r	—		
	BF_{10}	—		
Attitude	Pearson's r	–0.062	—	
	BF_{10}	0.142	—	
Fager_Score	Pearson's r	–0.030	0.010	—
	BF_{10}	0.119	0.114	—

TABLE 2
Correlations between Mean Score of Cigarette Pictures, Attitude Toward Smoking, and Level of Addiction for Study 2

		CP	Attitude	Fager_Score
Cigarette Pictures	Pearson's r	—		
	BF_{10}	—		
Attitude	Pearson's r	0.184	—	
	BF_{10}	1.821	—	
Fager_Score	Pearson's r	0.018	0.079	—
	BF_{10}	0.097	0.162	—

TABLE 3
Correlations between Mean Score of Cigarette Pictures, Attitude Toward Smoking, and Level of Addiction for Both Studies Combined

		CP	Attitude	Fager_Score
Cigarette Pictures	Pearson's R	—		
	BF_{10}	—		
Attitude	Pearson's R	0.123	—	
	BF_{10}	0.681	—	
Fager_Score	Pearson's R	0.005	0.059	—
	BF_{10}	0.073	0.121	—

3. Paper 2: A Bayesian Analysis Reveals Evidence Against Micro-Psychokinesis

Maier, M. A., Dechamps, M. C., & Pflitsch, M. (2018). Intentional Observer Effects on Quantum Randomness: A Bayesian Analysis Reveals Evidence Against Micro-Psychokinesis. *Frontiers in Psychology*, *9*, 379. doi:10.3389/fpsyg.2018.00379

frontiers in Psychology

ORIGINAL RESEARCH
published: 21 March 2018
doi: 10.3389/fpsyg.2018.00379

Intentional Observer Effects on Quantum Randomness: A Bayesian Analysis Reveals Evidence Against Micro-Psychokinesis

Markus A. Maier*, Moritz C. Dechamps and Markus Pflitsch

Department of Psychology, Ludwig-Maximilians-Universität München, Munich, Germany

Intentional effects of human observation on the output of quantum-based random number generators (tRNG) have been studied for decades now. This research has been known as micro-psychokinesis (micro-PK) and many studies in the field reported evidence for mentally induced non-random deviations from chance. A most recent meta-analysis from Bösch et al. (2006) revealed a very small and heterogeneous overall effect size that indicated a significant deviation from chance across studies. There remains doubt among the scientific community on the existence of micro-PK given: (i) the small and heterogenous effect; and (ii) the fact that several independent replication attempts of prominent studies failed to confirm the original results. The study presented here was intended to provide decisive evidence *for* or *against* the existence of micro-PK. An online experiment with 12,571 participants was conducted. The Bayesian analysis revealed strong evidence for H_0 (BF_{01} = 10.07). Thus, micro-PK did not exist in the data. A closer inspection of the temporal change of the effect seemed to suggest a non-random oscillative structure with a higher frequency than observed in simulated data. The possible role of entropy and the relation to the model of pragmatic information from von Lucadou (2015) is discussed.

Keywords: quantum observation, micro-psychokinesis, random number generator, RNG, model of pragmatic information

OPEN ACCESS

Edited by:
Mark Nieuwenstein,
University of Groningen, Netherlands

Reviewed by:
Jacob Jolij,
University of Groningen, Netherlands
Fei Luo,
Institute of Psychology (CAS), China

****Correspondence:***
Markus A. Maier
markus.maier@psy.lmu.de

Specialty section:
This article was submitted to Cognition, a section of the journal Frontiers in Psychology

Received: *22 November 2017*
Accepted: *08 March 2018*
Published: *21 March 2018*

Citation:
Maier MA, Dechamps MC and Pflitsch M (2018) Intentional Observer Effects on Quantum Randomness: A Bayesian Analysis Reveals Evidence Against Micro-Psychokinesis. Front. Psychol. 9:379. doi: 10.3389/fpsyg.2018.00379

INTRODUCTION

From time immemorial, humans have been fascinated by the relationship between the spiritual and physical worlds. Speculation focuses on both the mind and body/brain connection and the relationship between the mind and the outside physical world. Specifically, the idea that the mind can materialize ideas/desires or modify aspects of physical reality has been widely addressed in religion, mythology, and philosophy. Descartes, the great philosopher, mathematician, and devoted gambler, wrote about his personal experience with mind and reality during the 1640s. He observed that an otherwise random gambling outcome could be positively influenced by a gambler with a happy and optimistic mood (cited in Davidenko, 1990, p. 306). It was another 300 years before empirical examination of mind-matter interactions occurred. In the 1940s Rhine (1944) explored mind effects on dice tosses. Since then, there have been a large number of studies that examined mental influence or mentally induced statistical variations on inanimate probabilistic systems such as tumbling dice, tossing coins, or random number generators (RNGs). This research is now incorporated in work that is termed "micro-psychokinesis" (micro-PK) research (Varvoglis and Bancel, 2015).

The use of quantum-based RNGs, so-called true random number generators (tRNGs), as an optimal source of randomness has become the standard in micro-PK research (e.g., Jahn et al., 1980). In meta-analyses of 100s of studies performed using tRNGs, a small but significant effect of the human mind on non-random deviations from chance was found (Bösch et al., 2006; see also Radin and Nelson, 1989, 2003). Despite this, micro-PK is not a generally accepted phenomenon in science. This is because meta-analysis has several flaws, including the ability to be biased by the inclusion of successful studies. In addition, high-powered attempts to replicate positive micro-PK tests have not been successful (e.g., Jahn et al., 2000; Maier and Dechamps, in press). The goal of this study was to conduct a decisive scientific test for micro-PK. A large-scale assessment was performed that used Bayesian techniques to consolidate data until clear evidence *for* or *against* the existence of micro-PK was found.

Micro-PK research using tRNGs began in the 1960s with researchers using quantum states as a source of true randomness. Over the following decades, the body of research data increased (e.g., Schmidt, 1970; Jahn et al., 1980, 1987). A meta-analysis by Radin and Nelson (1989), including 597 studies conducted up until 1987, found a strong effect supporting micro-PK. This result was confirmed 15 years later in a meta-analysis with additional 176 new studies (Radin and Nelson, 2003). However, these meta-analyses included studies using both tRNGs and poorer-quality algorithmically-based RNGs. A more recent meta-analysis by Bösch et al. (2006) only included studies using tRNGs. This analysis of 380 studies undertaken between 1961 and 2004 identified a very small and heterogeneous effect that indicated a significant deviation from chance (Bösch et al., 2006). A significant negative correlation between sample size and effect size was also found (Bösch et al., 2006). Given the small, heterogeneous effect and this correlation, the authors concluded that the observed effect might have been caused by publication bias (Bösch et al., 2006); other researchers have questioned this interpretation (Radin et al., 2006) and a deeper inspection of the Radin and Nelson (1989, 2003) meta-analyses confirms that these aspects do not apply to their data. Nevertheless many scientists agree that evidence derived from meta-analyses alone does not provide a convincing argument for the existence of micro-PK effects. In addition, meta-analysis methods have recently been criticized, especially with regard to the impact of heterogeneity (e.g., Ioannidis, 2016). This has led to the suggestion that "*a single high-quality, well-reported study can be recommended instead of a statistical synthesis of heterogeneous studies*" (Brugha et al., 2012, p. 450). A similar suggestion was made by van Elk et al. (2015).

However, high-quality studies aimed at replicating existing results are scarce in micro-PK research. One example is the Jahn et al. (2000) study that utilized research teams from the PEARlab at Princeton University, the Grenzgebiete der Psychologie und Psychohygiene at Freiburg, and the Center for Behavioral Medicine at the Justus Liebig University Giessen. They attempted to replicate the Jahn et al. (1987) benchmark study involving 97 subjects and data from 2.5 million micro-PK trials. The attempted replication, with 227 participants and over 2 million trials, failed to confirm the original results (Jahn et al., 2000). Another is the Maier and Dechamps (in press) micro-PK research that reported on two micro-PK studies using Bayesian methods. The authors reported strong evidence supporting micro-PK in Study 1 ($BF_{10} = 66.7$). However, in Study 2, a pre-registered, high-quality replication of Study 1, they found strong evidence for the null effect ($BF_{01} = 11.07$). Failure of these high-powered studies to replicate earlier results also raised doubts about the existence of micro-PK. To date, robust and convincing evidence for micro-PK is missing. One potential factor explaining some of the replication failures might lie in the way intentional observation was manipulated. So far, to the greater part explicit goal manipulation procedures have been used in micro-PK research. To our view, this might be less fruitful than a more subtle implicit manipulation. We will outline this in the following paragraphs.

In parallel with empirical efforts, theoretical models have been proposed to explain and predict the effect of the human mind on quantum-based outcomes. Orthodox quantum physics regards the randomness that occurs during the act of measuring a quantum system as ontic and inherent in nature (see Greenstein and Zajonc, 2006). For example, the location of one electron is not classically defined before measurement but needs to be described as a superposition of several simultaneous locations. This phenomenon is captured by the mathematical concept of a "wave function" (Schrödinger, 1935). After measurement, an electron is found in one specific location with a probability given by the square of the amplitude of the wave function (Born, 1926). Thus, the results of a quantum measurement are only predictable with likelihoods, never with certainty. In addition, no measurement or observation can influence the probabilities to produce deviations from randomness. Although this is the standard interpretation of quantum mechanics, some revised versions of quantum theory have recently been developed that allow for mental processes during observation to slightly influence the likelihood of an outcome of a quantum process.

Atmanspacher et al. (2002) presented the Generalized Quantum Theory (GQT) (see also Römer, 2004; Filk and Römer, 2011; Atmanspacher and Filk, 2012). Here, a measurement in a quantum experiment is considered an observation when knowledge transfer takes place (epistemic split). This epistemic split occurs when unknown potential quantum alternatives are transferred into conscious knowledge. The knowledge transfer can be shaped by the observer's mind set, for example, his or her intentions. Observer effects are thus described as entanglement correlations between the intentional observer and the observed system (von Lucadou and Römer, 2007). Consequently, non-random deviations from quantum probabilities are allowed. This theory also proposes that such deviations should decline shortly after their first detection. The reason for this is that deviations from randomness constitute a severe violation of the "no signal theorem" in quantum mechanics. To utilize this as evidence-based documentation is forbidden. This leads to the disappearance of the micro-PK effect in later replication attempts. Thus, on the macroscopic level, the no signal theorem is saved (von Lucadou, 2006, 2015); in other words, if a signal transfer occurs, it cannot be used intentionally because its appearance and disappearance vary unsystematically. Maier and Dechamps (in press) also suggested that a micro-PK effect changes over time and argued by referring to the entropy principle that such effects might behave like dampened harmonic oscillations, reflecting the interplay between the quantum-PK effect and its counter-mechanism 'entropy.'

Another theory is the OrchOR model proposed by Penrose and Hameroff (2011; see also Penrose, 1989, 1994; Hameroff and Penrose, 1996; Hameroff, 2012). Similar to Atmanspacher et al. (2002), they view the act of measurement as a transfer from unconscious knowledge about the nature of a quantum state into a conscious experience of its exact existence. This transfer occurs through quantum gravitation and can be affected by Platonic values directly related to gravity. These values amongst others include mental concepts (Hameroff and Chopra, 2012). Thus, intentional observers might be able to non-randomly influence the transition of potential quantum states into one specific classical state. Both approaches have in common that the mental effect on quantum randomness takes place before the transition from the unconscious quantum to the conscious classical state. Micro-PK should thus be mainly affected by unconscious-related states of mind of the observer (Maier and Dechamps, in press).

Given this premise, in our study we put participants who observed the outcomes of a quantum experiment in a mindset that was related to specific unconscious inner states. Participants were presented with a brief relaxation and optimism inducing meditative episode before they participated in the experiment. This was designed to stimulate an inner, deeply rooted belief that everything was good and will remain good. On an unconscious level, this should attract more positive outcomes than negative ones during randomly chosen stimulus presentations in a micro-PK experiment with a tRNG. The stimuli selected by a quantum based RNG at each trial consisted of positive and negative pictures and auditory stimuli. Overall, we expected that the average mean score for positive stimuli presentations should be above chance (50%). No decline or harmonic oscillation effects were expected at the beginning of the study and were thus not the focus of our predictions. They are explored in the additional analyses of the result section. The main goal of our research was to provide a decisive, high-quality test for micro-PK. We therefore decided to apply a Bayesian testing approach. This method allows for data accumulation until a stopping criterion (i.e., a pre-specified amount of evidence) has been reached. As effects expected from micro-PK would be small, it was clear we would need a sample size in the 1000s.

MATERIALS AND METHODS

Participant recruitment and data collection were organized by Norstat, Germany[1], a professional data collection company specializing in online polling and testing with access to 650,000 potential participants in 18 European countries. The participant pool consists of pre-profiled volunteer adults and undergoes constant quality control.

[1] http://www.norstat.de

Participants

We decided to work with participant pools from three countries, resulting in a sample highly representative of the European population (see **Table 1**).

An invitation to participate in the study was sent from Norstat to a random selection of participants daily, aiming for a completion rate of about 100 per day. About 20–25% of invited individuals completed the study.

Ethics Considerations

The experiment was approved by the ethics boards of Norstat and the Department of Psychology (LMU). Norstat obtained written consent from participants electronically by having them press an "accept" button[2]. Within the consent form, participants were informed in general terms about the study and advised that participation was voluntary. Participants could also withdraw at any point during the study. All data were coded, stored, and analyzed anonymously.

Data Collection

The final sample size was not predefined. Instead an accumulative data collection and analysis strategy using Bayesian inference techniques for hypotheses testing was used (see Wagenmakers et al., 2011). This approach allows for data accumulation (i.e., additional subjects can be tested and results added into the data set) until a specified Bayes factor (BF) for H_1 (or H_0) has been reached. It also allows an option to stop data collection at a predetermined BF, so it is a more effective way of hypothesis testing than frequentist inference methods. We used BF = 10 as a stopping point for evidence collection of both an effect and a null effect.

The Bayesian approach provides information on how to update our beliefs given new incoming data. Bayesian methods accumulate data concerning the effect in question and repeatedly update the likelihood for an effect given additional data. The strength of evidence for the effect is considered dependent on both the likelihood of the data given that H_0 is true as well as the likelihood of the data given H_1 is true. Those two likelihoods are pit against each other leading to the so-called BF. The BF describes the relative amount of evidence that the data provide for or against a postulated effect. In this way, the existence (H_1) and the non-existence (H_0) of an effect can be tested. A BF of 10 or higher is considered to indicate strong evidence for H_1 or H_0, respectively. For instance, a $BF_{10} = 10$ means that the H_1 is 10-times more likely to be true than the H_0.

[2] http://opinion-people.com/dataprotection

TABLE 1 | Overview of the sample pools in Norstat.

Country	Pool size	Gender distribution (in %) female/male	Age distribution (in %) 18–24/25–34/35–44/45–54/55+
Germany	110,000	60/40	19/23/20/20/18
Spain	10,500	58/42	10/21/32/24/13
Italy	50,000	64/36	12/25/28/21/14

To calculate the BF, a probability distribution for effect size that is centered around zero with scale parameter r needs to be specified *a priori*. This Cauchy distribution ($\delta \sim$ Cauchy [0, r]) identifies the prior, i.e., the likelihood of the data given there is an effect, p(data|H_1). Wagenmakers et al. (2011) recommend an r equal to 1. The statistic software JASP designed to perform basic Bayesian analyses uses a default r of 0.707. Other authors recommend a lower r of 0.5 (Bem et al., 2011) or of 0.1 (Maier et al., 2014) knowing that PSI effect sizes are usually very small (i.e., mostly in the range of 0.1 to 0.2). The choice of the prior provides a degree of freedom within the Bayesian approach. For data analysis in the studies presented here we decided to use a r of 0.1, i.e., $\delta \sim$ Cauchy (0, 0.1). This parameter was selected before data collection had been started.

We also decided in advance to analyze the data with a Bayesian one sample *t*-test using a one-tailed approach given our directed prediction. On a regular basis, almost every week, a one-sample *t*-test was performed testing the actual sample's mean score of positive stimuli presentations against chance (50%). For all Bayesian analyses, the statistical software tool JASP (Version 0.8.2, JASP Team, 2017) was used. This was repeated over several months from November 2016 to July 2017 until the stopping criterion was met.

Final Sample

When the criterion to stop was satisfied (BF > 10), a total of 12,571 participants had been tested from three different countries. Due to a technical difficulty and some participants quitting the survey immediately after completing the study, demographic data was only available for 11,158 of the participants. Mean age of the final sample was 48.73 (*SD* = 13.60; range from 16 to 90) with 5,617 females (50.3%) and 5,541 males (49.7%). **Table 2** provides more demographic details of the participant sample.

Materials

A survey was created that included a link to the study materials on our webserver.

Experimental Program

The study was constructed as an online experiment. This means participants were not tested in a laboratory but could participate from any computer with internet access and audio output. The experiment was displayed in the computer's browser in full-screen mode. It was implemented with jsPsych (de Leeuw, 2015[3]), a JavaScript library for creating and running behavioral experiments in a web browser and ran on a dedicated webserver in the university's computer center. The Quantis tRNG, used as random source for stimulus selection, was located in the same room and connected to the designated server via USB.

Stimuli

Visual stimulus material was obtained from Shutterstock[4], a provider of royalty-free stock photos. Out of the library of around 125 million photographs, 100 pictures reflecting a positive prevailing mood and 100 pictures reflecting a negative one were selected. Positive picture material consisted of photos showing aspects of social belonging and affiliation, landscape shots, and pictures of cute animals. The negative material was selected to evoke displeasure within the participants; this was accomplished through pictures depicting imminent danger (e.g., attacking predators or weapons directed at the viewer, imagery provoking distress or misery, or pitiful and nauseating images). Picture selection was performed by the first and the second author based on their experience in emotion induction.

In order to intensify the mediated affect, a multisensory approach was used and audio stimuli were presented in addition to the images. The positive and negative impacts were conveyed by consonant and dissonant chords respectively. These piano chords consisted of tones that either harmonize well (i.e., produce a harmonious and melodious experience) or tones that harmonize poorly (i.e., form sharp dissonances, which are usually perceived as unpleasant). A total of eight consonant and eight dissonant chords were generated out of which two positive and two negative ones were selected by the experimenters for the study.

Generation of Quantum Randomness

For the purpose of random number generation, a quantum number generator (Quantis-v10.10.08) developed by the company idquantique from Geneva, Switzerland was used on the webserver[5]. This apparatus produces quantum states by using photons that are sent through a semi-conductive mirror-like prism. Each photon has an equal chance of being deflected in one of two directions, producing a superposition of both states, until a measurement is performed. Upon measurement, the photon is found on either route with 50% probability which is then transformed into a numerical score such as 0 or 1, depending on the track it was found (technically Quantis transforms 8 such bits into 1 Byte). This procedure is thus a reenactment of the famous double-slit experiment known in quantum physics testing the wave-particle duality. The hardware passed validation tests of randomness, such as the DIEHARD and the NIST tests (see certificates from various independent agencies on the website), and is regarded as one of the most effective tRNG worldwide (Turiel, 2007). The tRNG was connected to the server via USB. Since it operates without a buffer, it was ensured that the bit responsible for the selection of the stimuli was created directly before the presentation. A user monitoring code made sure that

[3]www.jspsych.org

[4]www.shutterstock.com

[5]http://www.idquantique.com/random-number-generation/quantis-random-number-generator/

TABLE 2 | Overview of the participant sample.

Country	Participants	Demographic data	Female/ male (in %)	Mean age
Germany	10,316	9,015	51.0/49.0	48.78 (*SD* = 13.76)
Spain	1,130	1,116	47.7/52.3	46.9 (*SD* = 10.78)
Italy	1,125	1,027	47.8/52.2	50.22 (*SD* = 14.67)
Total	12,571	11,158	50.3/49.7	48.73 (*SD* = 13.60)

different participants did not access the tRNG at the exact same time but that everybody receives an individual bit.

Procedure

Participants received an email from the data collection company inviting them to take part in a survey. They were asked to relocate, if necessary, to an undisturbed environment. The participants' audio was tested by playing a short audio clip and asking them for its content. If they answered correctly, they were forwarded to the university's webserver, where the experiment was displayed in full-screen mode. Participants were asked to close their eyes and listen to a pre-recorded relaxation exercise designed to put them in a relaxed and optimistic mood. The exercise was repeated once with a total playing time of about 2 min[6]. It was available in German, Italian, and Spanish and spoken by a native speaker. The text of the relaxation exercise was:

> Leave all your thoughts and worries behind you. Breath slowly and calmly. Focus only on your breathing. Slowly and calmly... Slowly and calmly. . . slowly and calmly. . . slowly and calmly. You are feeling completely peaceful and relaxed and fully in the present. Release all your tension. Relax your muscles. You are feeling comfortable and safe! Completely comfortable and safe.

Following the relaxation exercise, participants were advised about the study. They were told that they would be presented with pleasant and unpleasant images and sounds and that they could abort the experiment at any time by closing the window. Presentation of stimuli began after these instructions.

During each trial, the tRNG chose a random number between 1 and 100 to decide which visual and auditory stimuli would be displayed, then a random number between 0 and 1 to determine whether the stimuli would be positive or negative. During this process, a fixation cross was shown to the participant for 700 ms. The stimuli (picture and sound) were presented for 400 ms. Before the next trial, a black screen was shown for 1100 ms. This process is illustrated in **Figure 1**. A total of 100 trials were performed on each participant, which took approximately 6 mins.

[6]The playing times varied slightly between different languages.

After completing the task, participants were asked to fill out a short questionnaire. With regards to our relaxation induction, we asked participants to indicate their belief toward a general contentedness and hopeful confidence by asking them to rate the following statement: "I am strongly convinced that everything is going to be fine" on a seven-point scale from *Not true* to *Very True*.

Subsequently stimulus seeking was assessed with a scale constructed by Bem et al. (2011) that contained two statements: "I am easily bored" and "I often enjoy seeing movies I've seen before" (reverse scored). Responses were recorded on five-point scales that ranged from *Very Untrue* to *Very True* and averaged into a single score ranging from 1 to 5 (Cronbach's α = 0.59).

Furthermore, we constructed a self-efficacy attitude measure related to general life outcome expectancies. This scale comprised the following six statements: "In life, you don't get anything for free," "You have to fight for everything," "Life generally doesn't mean well for me," "You have to take stick a lot if you want to succeed," "Nothing is going to change," and "When it rains, it pours." Responses were recorded on a seven-point scale from *Not true* to *Very true* and averaged into a single score. The scale provides a good reliability (Cronbach's α = 0.80).

Lastly we asked participants to fill out the Life Orientation Test-Revised (LOT-R; Scheier et al., 1994). This questionnaire assesses generalized optimism (Cronbach's α = 0.76) and pessimism (Cronbach's α = 0.73) with three items each.

RESULTS

To explore the effectiveness of our relaxation manipulation, we first analyzed the single item measure "I am strongly convinced that everything is going to be fine." Our hypothesis was that the sample's mean score of this conviction was above the average. A one sample *t*-test (two-tailed) testing the item's mean score against 4, which was the exact midpoint of a seven-point scale (ranging from not at all to very much), yielded a significant effect, $t(11157) = 67.05$; $p < 0.001$. On average the mean rating was significantly above the midpoint of the scale, $M = 4.96$ ($SD = 1.51$).

Next the observer effects on picture selection will be reported. The data were analyzed on average every week by

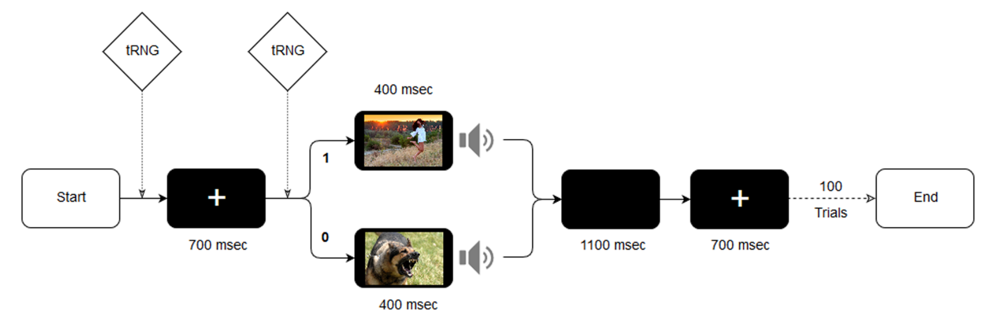

FIGURE 1 | Stimulus selections and presentation times during one trial.

the experimenter, the second author, depending on the number of participants tested during the preceding days (see Bayesian approach described above).

The study tested the hypothesis that after being exposed to a relaxing and optimism inducing intervention, participants will, on average, observe more positive stimuli than expected by chance. The dependent variable was the percentage of positive stimuli achieved by each participant across 100 trials. The average percentage of positive stimuli for all participants was then tested against the 50% score. The final Bayesian one sample *t*-test (one-tailed) with 12,571 participants revealed a BF_{01} of 10.07 for H_0. The mean score for positive stimuli for all participants was $M = 50.02\%$, $SD = 5.06$, providing very strong evidence for a null effect, with no deviation from chance. **Figure 2** represents a sequential analysis of the BF across all participants in the order of testing.

A standard practice in micro-PK research is to display the effect and its change over the time of data collection as a cumulative z-score. This data sequence is shown in **Figure 3**.

As depicted in the graph, the effect went in the predicted direction almost entirely throughout the experiment and several times hit the 1.96 z-score line but then finally dropped to zero. An identical variation in effect can be seen in the BF sequential analysis.

In an additional set of analyses we also explored the relationship between the personality variables assessed from 11158 participants and the mean number of positive stimuli obtained from each individual. No significant correlations between number of positive stimuli and general life outcome expectancies (GLOE6), generalized optimism (LOT_Opt) and pessimism (LOT_Pess) or Stimulus Seeking was found (see **Table 3**).

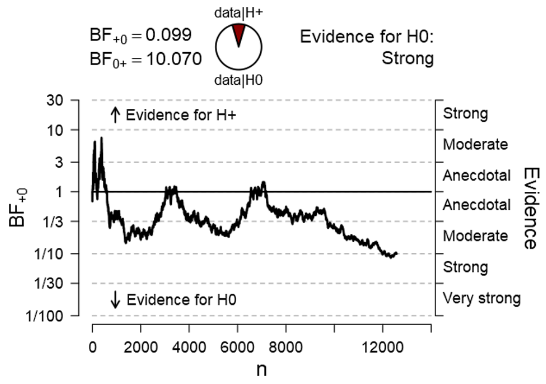

FIGURE 2 | Sequential Bayesian one-sample *t*-test analysis of the percentage of positive pictures across all 12,529 participants.

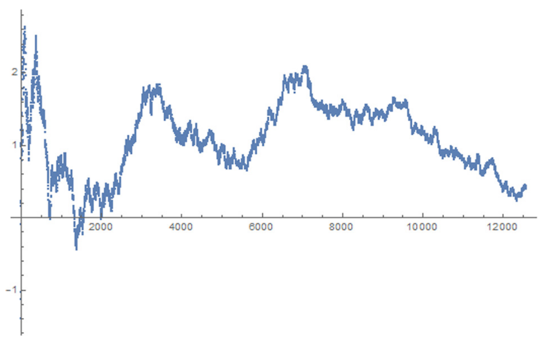

FIGURE 3 | Sequential analysis of data by computing a cumulative z-score from the percentage of positive stimuli obtained after each participant.

DISCUSSION

The results of our study provide strong evidence for H_0, indicating no deviation of the mean number of positive stimuli from chance in our sample. Relaxed and optimistically induced participants who passively observed the pictures and auditory stimuli, chosen at each trial by a highly sophisticated and effectively working quantum RNG, seemed not to unconsciously affect the quantum process toward non-randomness. The data support the null hypothesis that predicted no mental effects on quantum randomness. A BF higher than 10 also underlines the robustness of this effect. In sum, the evidence speaks against the revised quantum models of Atmanspacher et al. (2002) and Penrose and Hameroff (2011) which postulate non-random deviations of quantum outcomes by deeply rooted mental activity. The data rather support original quantum theoretical interpretations from Bohr, Bohm, Wigner, and von Neumann that claim the observer has no active influence on the probabilities of quantum experimental outcomes (see Greenstein and Zajonc, 2006; Byrne, 2010). Although there are many possibilities as to why an effect may not have occurred in this experiment (e.g., failure of the induction method, distractions on behalf of the subjects during performance, or low quality of stimuli used), we assume that these and other factors would only increase error variance. Even then, the power of several 1000 subjects should be sufficient to detect an effect given a high error variance. The study was designed to overcome these limitations with an enormous power and to provide a sincere test of the proposed micro-psychokinetic mind-matter interaction. We thus believe that the null effect documented here might very well-constitute a real absence of a mental influence on quantum randomness at least at the level of the average mean score for positive stimuli. This would fit with earlier skeptical arguments raised by Bösch et al. (2006) against micro-psychokinesis reported in meta-analyses who suggest that those effects might be due to publication biases. In addition, no moderating effects of personality traits were found.

ADDITIONAL ANALYSIS

The sequential Bayesian analysis and the z-score accumulation across participants also allowed for a closer inspection of statistical trends in the data. Interestingly, there seems to be a pattern of repeated change. The micro-PK effect appears to be alternatingly increasing and decreasing several times during

TABLE 3 | Bayesian Pearson correlations between number of positive stimuli and personality variables.

		Pos_Imgs	GLOE6	LOT_Opt	LOT_Pess
Pos_Imgs	Pearson's r	—			
	BF_{10}	—			
GLOE6	Pearson's r	−0.015	—		
	BF_{10}	0.039	—		
LOT_Opt	Pearson's r	−0.005	−0.301	—	
	BF_{10}	0.014	1.682e+228	—	
LOT_Pess	Pearson's r	−0.009	0.615	−0.425	—
	BF_{10}	0.019	∞	∞	—
SS	Pearson's r	0.002	0.025	−0.149	0.087
	BF_{10}	0.012	0.340	3.299e+52	4.088e+16

the data collection period. This fact is noteworthy, since a similar observation has recently been made in comparable micro-psychokinesis studies investigating uninstructed goal-dependent observation effects on tRNG's outputs (Maier and Dechamps, in press). In this research, two studies have been performed testing the hypothesis that smokers would cause a substantial deviation from chance on the mean number of cigarette-related pictures being presented. Without going into substantial detail, the general outcome of the studies was that the effect increased to an overall BF of above 100 until the beginning of Study 2; subsequently, there was a reversion of the effect back to a BF of 1 at the end of Study 2. This appearance-disappearance-pattern was not present in the non-smokers data nor in a simulation where no observers were present. In the latter two cases, no effect was there at any time. In addition, other research groups who extensively studied micro-psychokinesis also report such a decline of the effect during replication attempts (Jahn et al., 2000). Reports of similar decline effects in other studies complete this picture (see Radin, 2006).

Given these unexpected, yet broadly manifesting appearance-disappearance-patterns, theoretical efforts have been undertaken to understand such decline effects in micro-PK. One model that tried to understand the nature of this empirical phenomenon was proposed by von Lucadou (2006, 2015). His theory refers to the idea of Pragmatic Information and applies it to observer-related quantum effects. According to this theory, the novelty of a finding is complementary related to its likelihood of confirmation (i.e., the more novel a quantum effect, the lower the likelihood of a successful replication). The supposed principle behind this mutual relation is that quantum effects, such as micro-PK, violate the "no-signal theorem." To cure this violation, the later confirmation of this effect needs to be prevented such that the macroscopic evidence vanishes when additional data are collected. Empirically, this should lead during proceeding observation to a decline of the effect after initial appearance. According to von Lucadou (2015), rather, the effect might unsystematically re-appear on other indicators that were not initially studied. Any effects are thus unsystematically hidden within the additional data acquisition.

As Maier and Dechamps (in press) emphasize, "*the theoretical problem with this approach however is that real null effects documented by replication failures of spurious findings cannot be distinguished from decline effects. The consequence is that with the standard scientific replication approach micro-psychokinesis effects cannot be scientifically studied. Either way, this would mean we should abandon PSI research from science* (for a similar argument see Etzold, 2004) (p. 32)." To solve this dilemma, Maier and Dechamps (in press) adjusted von Lucadou's model arguing that a violation of the no-signal theorem in quantum physics constitutes a severe violation of the Second Law of Thermodynamics which states that entropy needs to increase over time. The consequence would be that a mentally induced deviation from quantum randomness causes entropy to set in and to counteract this trend. The weaker the quantum effect becomes by this intervention, the quicker the entropic counter-process decreases. This would allow the deviation effect to re-establish itself although with a lowered effect size than initially shown. The authors propose that this interplay continues until the quantum effect has completely vanished. The decline is thus proposed not to be unsystematically drifting toward other indicators but rather follows a systematic pattern of alternations within the same indicator best described as dampened harmonic oscillation of this type:

$$y(t) = ae^{-\beta t}\cos(\omega t + \varphi) + mt + h$$

With y indicating the effect (e.g., the accumulative z-score) and t representing the additional data collected. The meaning of the parameters for the proposed function can be found in **Table 4**.

We propose that the data presented in this study here also follow a similar systematic pattern of decline matching a dampened harmonic oscillation function as suggested by Maier and Dechamps (in press). In the following, we estimated the parameters of the mathematical function shown above for the human data reported here and compared the estimation found with a function derived from simulated data. The simulation was performed with the same experimental design, apparati, and procedures but without human observation. It contains data from 12,571 simulated participants.

Parameter Estimation for Human Data

Parameter estimation was performed with curve-fitting algorithms provided by the mathematical software tool Wolfram Mathematica Version 11.1.1.0[7]. The mathematical equation mentioned above, reflecting the dampened harmonic oscillation, was provided to the software. The program went through several reiterations, until according to the Maximum Likelihood principle, the group of estimated parameters best fit

[7] https://www.wolfram.com/mathematica/

TABLE 4 | Parameter description of the dampened harmonic oscillation.

Parameter	Meaning
a	Amplitude
β	Decline
ω	Frequency
ϕ	Phase Shift
m	Linear Slope Score
h	Shift along Axis of Ordinates

the empirical data pattern. The approximated function found for the data reported in this study here was:

$$y = -0,997268e^{-0,000165877t}\cos(0,0018058t + 3,29522)$$

$$+8,199{*}10^{-6}t + 1,0348$$

The minimal mean error variance obtained was 0.14 and constitutes the best fit to the data. Any other solution produced a higher error variance. A graphical display of this function together with the empirical effects described as cumulative z-score is displayed in **Figure 4**.

As can be seen, the course of the effect across time approximately follows an alternating pattern, similar to a dampened harmonic oscillation (see red line).

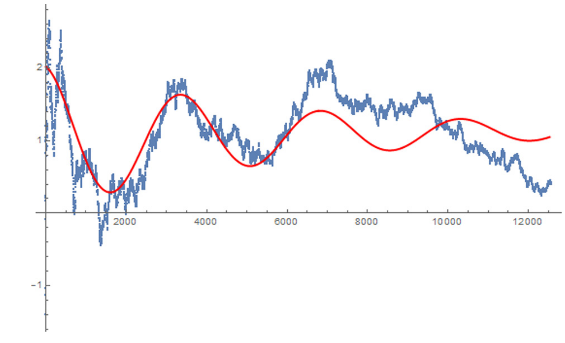

FIGURE 4 | Approximated harmonic oscillation function for the data from all 12,529 participants.

Parameter Estimation for the Simulation

A simulation was performed to create a control data set for experimental trials without any form of observation. 12,571 data sets were created by running the experimental sessions without any observer being present. Procedure, apparatus, and experimental design were the same as in the human observation condition.

Results

The simulated data were submitted to a Bayesian analysis testing the difference of the average mean score of positive stimuli against chance. A one-sample Bayesian *t*-test was performed revealing a mean score of positive stimuli of $M = 50.00\%$ ($SD = 4.99$) with a BF_{01} of 13.78, indicating strong evidence for the H_0. The sequential analysis can be seen in **Figure 5**.

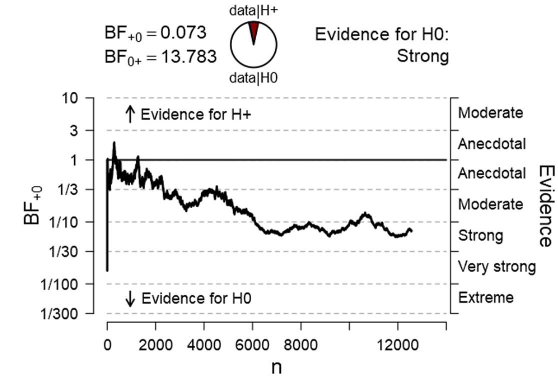

FIGURE 5 | Sequential Bayesian one-sample *t*-test analysis of the percentage of positive pictures obtained by the simulation.

In addition, the same parameter estimation for the dampened harmonic oscillation equation reported above was also performed with the simulated data. The z-transformed accumulated data were submitted to the parameter estimation again with curve-fitting algorithms provided by the mathematical software tool Wolfram Mathematica Version 11.1.1.0[8]. The approximated function found for the simulation was:

$$y = 0,359445\cos(0,000763727t + 3,93937)$$

$$-0,0000966587t + 0,85242$$

The minimal mean error variance obtained was 0.09. A graphical display of this function together with the cumulative empirical z-scores can be seen in **Figure 6**.

As can be seen from the graph, simulated data can be approximated by a dampened harmonic oscillation function. This is no surprise, since real random effects should initially alternate and with further accumulation asymptotically drift to the zero line. However, in this case, the likelihood for substantial further alternations strongly decreases with additional data generation.

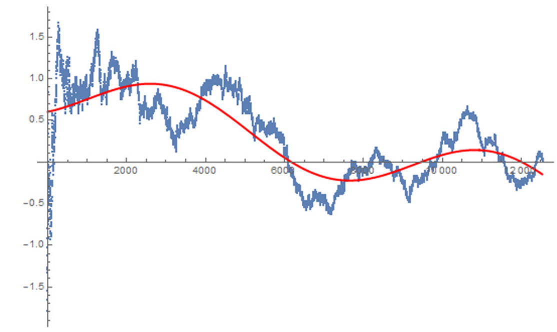

FIGURE 6 | Sequential Bayesian one-sample *t*-test analysis of the percentage of positive pictures obtained by the simulation.

Comparing Human and Simulated Data

The human and the simulated data should – if the harmonic oscillation assumption is true – differ mainly in the frequency parameter ω. Real effects should produce more pronounced oscillations than artificial data. To explore this, we compared the 95%-confidence intervals for both frequency scores and

[8]http://www.wolfram.com/mathematica/

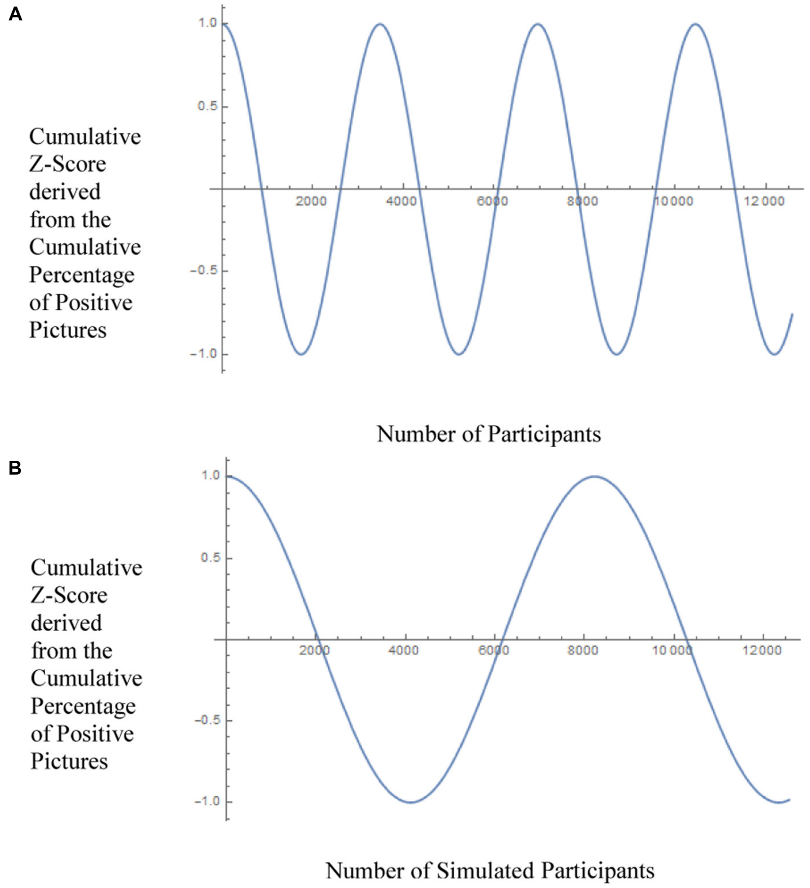

FIGURE 7 | Frequency of the oscillation for real **(A)** and simulated **(B)** participants.

found indeed that they did not overlap. The frequency score ω obtained with the human data was ω = 0.0018058 with a 95%-confidence interval ranging from [0.00179767; 0.00181392] and the frequency for the simulated data was ω = 0.000763727 with a 95%-confidence interval ranging from [0.000755895; 0.000771559]. Thus, oscillations are much more frequent in the human data than in the simulated control data. This difference is also illustrated in **Figures 7A,B**. This graph only reflects the frequency score when all the other parameters are held constant.

The raw data of the results presented in this manuscript (excluding the personality variables) can be found under: https://open-data.spr.ac.uk/dataset/role-conscious-observation-quantum-randomness-dataset.

Discussion

In the additional analyses, specific trends in the micro-PK data of our study were investigated. Based on the original explanation for decline effects in PSI, data first presented by von Lucadou (2006, 2015) who assumed a complementary relation between novelty of an effect and its confirmation, Maier and Dechamps (in press) in a re-analysis of their original micro-PK effects proposed that such effects should decline in a systematic way through the interplay between PK-effect and entropy. Specifically, the time course of micro-PK effects should closely match a dampened harmonic oscillation. The pattern of human-related micro-PK oscillations should be different from data obtained without observation. This proposition was tested with the data obtained in the study here. Interestingly, as predicted, the oscillating pattern was different for human as compared to simulated data. The frequency score thus appears to be a good indicator for micro-PK and – assuming that the postulated systematic decline mechanism is true – might be a much better indicator for non-random deviations than the overall mean score obtained in any micro-PK experiment. Future research should focus on systematic decline effects of this nature rather than on normative deviations from chance. Admittedly, at the beginning of this study, this hypothesis and the theoretical background did not exist. It was developed at the end of the data collection from Maier and Dechamps (in press) and applied to the data collected and described here on a *post hoc* basis only. However, we think that it provides a good basis for future research not only on micro-PK but on PSI in general. For now, it is not considered as evidence for micro-PK in the present data. Rather, the goal here was to inform the community about this promising development.

An alternative explanation for this null effect or for the oscillating pattern might also be found in experimenter effects on micro-PK that are specifically tied to the Bayesian approach. The Bayesian sequential analysis demands a continuous monitoring of effect changes due to its stopping rule. The experimenter who is repeatedly watching the updated mean score might develop drifts in his beliefs and by doing so incidentally causes effect changes across time. Varvoglis and Bancel (2015) discuss such experimenter effects in PK research in which the experimenters are considered hidden participants. We are not sure whether this would fully explain the non-existence of the effect or its oscillation, but in future research an "experimentally and theoretically blind" data analyst or an automatic analysis procedure that simply indicates when the stopping criterion is met could be used.

CONCLUSION

This study was introduced as a high quality and decisive test for micro-PK. Although several meta-analyses found evidence for micro-PK (Radin and Nelson, 1989, 2003; Bösch et al., 2006), the bulk of the scientific community was not convinced by this form of data aggregation. Rather, they took Carl Sagan's position arguing that 'extraordinary claims require extraordinary evidence.' Brugha et al. (2012) identified a "single high-quality, well-reported study" as one such potential form of extraordinary evidence. We have tried to deliver such a study. The quality features we aimed for were: high power (using a very large sample size), representative sample, high-quality randomization, sophisticated stimuli, objective presentation procedures and high standards on participants' compliance. All these requirements were met from our team and with the aid of Norstat, a professional polling agency. The results obtained were indeed decisive. Clear and strong evidence for a null effect was found. Thus, micro-PK was not existent in the data. This supports the arguments raised against micro-PK by many skeptics in the field (e.g., Alcock, 2011). It has to be noted that in our study we focused on unconsciously affected intentional states of the observers by using a rather indirect manipulation of our participants' goals during the picture presentations. The majority of micro-PK studies however have been performed with explicitly induced intentional states. It is unclear how such a manipulation would have affected our participants' behavior in our study design. Having no such comparison condition is a limitation of our study in terms of generalizability and should be addressed in future micro-PK research.

We would like to emphasize, that the conclusion of "evidence for no effect" is only true when referring to the average mean score of positive stimuli. No deviation from randomness was indeed found with this score. A closer inspection of the temporal change of the effect on the other side revealed some potentially systematic regularity that was not present in the simulated data and can thus hardly be explained by random fluctuations alone. It seemed that the effect in its temporal development across participants behaved like a dampened harmonic oscillation and the amount of oscillations found with human compared to simulated data clearly differed. Maier and Dechamps (in press) explained the existence of such a data pattern through the occurrence of a mechanism called entropy that counteracts the original micro-PK effect. Their mutual interplay most likely produces a dampened harmonic oscillation. If this, admittedly speculative, assumption is true, future PSI research involving quantum RNGs should not focus on significant deviations from chance, but rather should explore oscillating patterns across time and compare these with simulated data. This would be a more fruitful approach than fighting a basic premise in quantum mechanics and it would fit the law of conservation of energy and therefore avoid theoretical paradoxes within science.

In addition, such an oscillating pattern could also be true for standard psychological experiments that involve unconscious processing. Also, for these studies, from a physical point of view, effects are produced effortless and automatic and should therefore also violate the laws of energy conservation and entropy. This should also lead to entropic declines during replication attempts and might also result in an oscillating pattern of effect change. The replication crisis could thus to some extent be also influenced by these mechanisms. We encourage researchers who were working on unconscious processing to analyze their original data and replication attempts accordingly.

Descartes, a famous and well-respected 17th century mathematician and philosopher, was convinced of the existence of micro-PK when he stated that a gambler's optimistic attitude can bias the outcome of a gambling game toward success. In light of our empirical finding, we would say that he was right only to a certain extent. Indeed, the optimistic gambler might initially achieve higher gains, but then he also has to pay the price of higher losses. Gains and losses during the game will then alternate and approach the chance line at some point. The net earnings will be zero despite the optimistic attitude, but the wins and losses during the game will be more pronounced than in a neutral mood.

AUTHOR CONTRIBUTIONS

MM developed theory and hypotheses, designed the study, ran the study, analyzed the data, wrote the first draft; MD designed the study, ran the study, analyzed the data, revised the first draft; MP designed the study, ran the study, revised the first draft.

REFERENCES

Alcock, J. (2011). Back from the future: parapsychology and the Bem affair. *Skeptical Inquirer*. 35, 31–39.

Atmanspacher, H., and Filk, T. (2012). Contra classical causality violating temporal bell inequalities in mental systems. *J. Conscious. Stud.* 19, 95–116.

Atmanspacher, H., Römer, H., and Walach, H. (2002). *Weak Quantum Theory: Complementarity and Entanglement in Physics and Beyond*. Available at: http://arxiv.org/pdf/quant-ph/0104109v2

Bem, D. J., Utts, J., and Johnson, W. O. (2011). Must psychologists change the way they analyze their data? *J. Pers. Soc. Psychol.* 101, 716–719. doi: 10.1037/a0024777

Born, M. (1926). Quantenmechanik der Stoßvorgänge. *Z. Physik* 38, 803–827. doi: 10.1007/BF01397184

Bösch, H., Steinkamp, F., and Boller, E. (2006). Examining psychokinesis: the interaction of human intention with random number generators–a meta-analysis. *Psychol. Bull.* 132, 497–523. doi: 10.1037/0033-2909.132.4.497

Brugha, T. S., Matthews, R., Morgan, Z., Hill, T., Alonso, J., and Jones, D. R. (2012). Methodology and reporting of systematic reviews and meta-analyses of observational studies in psychiatric epidemiology: systematic review. *Br. J. Psychiatry* 200, 446–453. doi: 10.1192/bjp.bp.111.098103

Byrne, P. (2010). *The Many Worlds of Hugh Everett III*. Oxford: Oxford Univ. Press.

Davidenko, D. (1990). *Ich denke, also Bin Ich: Descartes Ausschweifendes Leben [English: I am thinking, therefore I am: Descartes' excessive life]*. Frankfurt: Eichborn.

de Leeuw, J. R. (2015). jsPsych: a JavaScript library for creating behavioral experiments in a Web browser. *Behav. Res. Methods* 47, 1–12. doi: 10.3758/s13428-014-0458-y

Etzold, E. (2004). Ist die Existenz von Psi-Anomalien beweisbar. *Z. Anom.* 4, 14–24.

Filk, T., and Römer, H. (2011). Generalized quantum theory: overview and latest developments. *Axiomathes* 21, 211–220. doi: 10.1007/s10516-010-9136-6

Greenstein, G., and Zajonc, A. G. (2006). *The Quantum Challenge: Modern Research on the Foundations of Quantum Mechanics*, 2nd Edn. Boston, MA: Jones and Bartlett.

Hameroff, S. (2012). How quantum brain biology can rescue conscious free will. *Front. Integr. Neurosci.* 6:93. doi: 10.3389/fnint.2012.00093

Hameroff, S., and Chopra, D. (2012). "The 'Quantum Soul': a scientific hypothesis," in *Exploring Frontiers of the Mind-Brain Relationship. Mindfulness in Behavioral Health*, eds A. Moreira-Almeida and F. Santana Santos (New York, NY: Springer), 79–93. doi: 10.1007/978-1-4614-0647-1_5

Hameroff, S., and Penrose, R. (1996). Orchestrated reduction of quantum coherence in brain microtubules: a model for consciousness. *Math. Comput. Simul.* 40, 453–480. doi: 10.1016/0378-4754(96)80476-9

Ioannidis, J. A. (2016). The mass production of redundant, misleading, and conflicted systematic reviews and meta-analyses. *Milbank Q.* 94, 485–514. doi: 10.1111/1468-0009.12210

Jahn, R., Dunne, B., Bradish, G., Dobyns, Y., Lettieri, A., Nelson, R., et al. (2000). Mind/machine interaction consortium: PortREG replication experiments. *J. Sci. Explor.* 14, 499–555.

Jahn, R. G., Dunne, B. J., and Jahn, E. G. (1980). Analytical judging procedure for remote perception experiments. *J. Parapsychol.* 44, 207–231.

Jahn, R. G., Dunne, B. J., and Nelson, R. D. (1987). Engineering anomalies research. *J. Sci. Explor.* 1, 21–50.

JASP Team (2017). *JASP (Version 0.8.2)[Computer software]*. Available at: https://jasp-stats.org/

Maier, M. A., Büchner, V. L., Kuhbandner, C., Pflitsch, M., Fernández-Capo, M., and Gámiz-Sanfeliu, M. (2014). Feeling the future again: retroactive avoidance of negative stimuli. *J. Conscious. Stud.* 21, 121–152. doi: 10.1037/a0021524

Maier, M. A., and Dechamps, M. C. (in press). Observer effects on quantum randomness: Testing Micro-psychokinetic effects of smokers on addiction-related stimuli. *J. Sci. Explor*.

Penrose, R. (1989). *The Emperor's New Mind Concerning Computers, Minds and the Laws of Physics*. Oxford: Oxford University Press.

Penrose, R. (1994). *Shadows of the Mind*. Oxford: Oxford University Press.

Penrose, R., and Hameroff, S. (2011). Consciousness in the universe: neuroscience, quantum space-time geometry and Orch OR theory. *J. Cosmol.* 14, 1–17.

Radin, D. (2006). *Entangled Minds: Extrasensory Experiences in a Quantum Reality*. New York, NY: Simon and Schuster.

Radin, D., Nelson, R., Dobyns, Y., and Houtkooper, J. (2006). Reexamining psychokinesis: comment on Bösch. Steinkamp, and Boller (2006). *Psychol. Bull.* 132, 529–532. doi: 10.1037/0033-2909.132.4.529

Radin, D., and Nelson, R. D. (2003). "Research on mind-matter interactions (MMI): Individual intention," in *Healing Intention and Energy Medicine*, eds W. B. Jonas and C. C. Crawford (London: Harcourt Health Sciences), 39–48.

Radin, D. I., and Nelson, R. D. (1989). Evidence for consciousness-related anomalies in random physical systems. *Found. Phys.* 19, 1499–1514. doi: 10.1007/BF00732509

Rhine, J. B. (1944). "Mind over matter" or the PK effect. *J. Am. Soc. Psych. Res.* 38, 185–201.

Römer, H. (2004). Weak quantum theory and the emergence of time. *Mind Matter* 2, 105–125.

Scheier, M. F., Carver, C. S., and Bridges, M. W. (1994). Distinguishing optimism from neuroticism (and trait anxiety, self-mastery, and self-esteem): A reevaluation of the life orientation test. *J. Pers. Soc. Psychol.* 67, 1063–1078. doi: 10.1037//0022-3514.67.6.1063

Schmidt, H. (1970). A PK test with electronic equipment. *Parapsychology* 34, 175–181.

Schrödinger, E. (1935). Die gegenwärtige Situation in der Quantenmechanik. *Naturwissenschaften* 23, 807–812. doi: 10.1007/BF01491891

Turiel, T. P. (2007). Quantum random bit generators. *Am. Stat.* 61, 255–259. doi: 10.1198/000313007X223225

van Elk, M., Matzke, D., Gronau, Q. F., Guan, M., Vandekerckhove, J., and Wagenmakers, E.-J. (2015). Meta-analyses are no substitute for registered replications: a skeptical perspective on religious priming. *Front. Psychol.* 6:1365. doi: 10.3389/fpsyg.2015.01365

Varvoglis, M., and Bancel, P. A. (2015). "Micro-Psychokinesis," in *Parapsychology: A Handbook for the 21st Century*, eds E. Cardeña, J. Palmer, and D. Marcusson-Clavertz (Jefferson NC: McFarland & Company), 266–281.

von Lucadou, W. (2006). Self-organization of temporal structures—A possible solution for the intervention problem. *AIP Conf. Proc.* 863, 293–315. doi: 10.1063/1.2388760

von Lucadou, W. (2015). "The model of pragmatic information (MPI)," in *Extrasensory Perception. Support, Skepticism, and Science: Theories and the Future of the Field*, Vol. 2, eds E. C. May, S. B. Marwaha, and J. H. Fallon (Santa Barbara, CA: Praeger), 221–242.

von Lucadou, W., and Römer, H. (2007). Synchronistic phenomena as entanglement correlations in generalized quantum theory. *J. Conscious. Stud.* 14, 50–74.

Wagenmakers, E.-J., Wetzels, R., Borsboom, D., and van der Maas, H. L. J. (2011). Why psychologists must change the way they analyze their data: the case of psi: comment on Bem (2011). *J. Pers. Soc. Psychol.* 100, 426–432. doi: 10.1037/a0022790

Conflict of Interest Statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The reviewer JJ and handling Editor declared their shared affiliation.

4. Paper 3: Testing the Oscillatory Nature of Micro-Psychokinetic Observer Effects on Addiction-Related Stimuli

Dechamps, M. C., & Maier, M. A. (2019). How Smokers Change Their World and How the World Responds: Testing the Oscillatory Nature of Micro-Psychokinetic Observer Effects on Addiction-Related Stimuli. *Journal of Scientific Exploration, 33*(3), 406-434. doi:10.31275/2019/1513

Journal of Scientific Exploration, Vol. 33, No. 3, pp. 406–434, 2019 0892-3310/19

RESEARCH ARTICLE

How Smokers Change Their World and How the World Responds: Testing the Oscillatory Nature of Micro-Psychokinetic Observer Effects on Addiction-Related Stimuli

Moritz C. Dechamps
Markus A. Maier

Department of Psychology, Ludwig-Maximilians-University, Munich, Germany
moritz.dechamps@psy.lmu.de

Submitted March 15, 2019; Accepted April 29, 2019; Published September 30, 2019

DOI: https://doi.org/10.31275/2019/1513

Abstract—According to standard quantum theory, the occurrence of a specific outcome during a quantum measurement is completely random (see Bell 1964). However, some authors refer to revised versions of quantum mechanics (e.g., Walker 2000, Penrose & Hameroff 2011, Mensky 2013, Stapp 2017), and propose that the human mind can actually influence the probability of such outcomes. Empirical support for this idea has been provided by micro-psychokinesis (micro-PK) research, which shows a small but significant overall effect (see Bösch, Steinkamp, & Boller 2006). However, attempts to replicate specific findings have often failed (e.g., Jahn et al. 2000), a critique that is not exclusive to psi paradigms. In an attempt to explain these failures, von Lucadou, Römer, and Walach (2007) established a theoretical model predicting unsystematic variations of such an influencing effect across replications, resulting in a decline of a predictable effect in micro-PK data over time. Maier, Dechamps, and Pflitsch (2018) slightly expanded this theory by proposing that the temporal variation of such an effect follows a systematic pattern, which can be tested and used for prediction making. In this research, we generated such a prediction using data from two previous studies that initially demonstrated a strong micro-PK followed by a subsequent decline in the effect over the course of 297 participants (Maier & Dechamps 2018); we then put it to the test with a preregistered additional set of newly collected data from 203 subjects. We compared these results with 10,000 simulated datasets (each set with an N = 203) each comprising random data. Three tests were applied to the experimental data: an area under the curve analysis, a local maximum fit test, and an endpoint fit test. These tests revealed no significant fit of the real data

regarding the predicted data pattern. Further analyses explored additional techniques, including an analysis of the highest-reached Bayes Factor (*BF*) over the course of the experiments, the overall orientation of the *BF* curve, and its transformation into oscillatory components via a Fourier analysis. All these methods allowed for statistically significant differentiations between experimental data on the one side, and the control group and simulation data on the other. We conclude that the analyses of the temporal development of an effect along these lines constitute a fruitful approach toward testing non-random and volatile time trends within micro-PK data.
Keywords: micro-psychokinesis—observer effect—mind–matter—quantum measurement

Introduction

The relationship between the mental and the physical worlds, between mind and matter, remains a fascinating enigma to this date. Recently, advanced theories have tried to shed light on the mutual interactions of these worlds by incorporating ideas pertaining to an inherent connection of quantum theory and consciousness (see Atmanspacher 2004). A quantum state is characterized by peculiar properties, such as the superposition of multiple states or the possibility of entanglement. The transition from a quantum to a classical state is associated with the measurement of the quantum system. Whereas orthodox quantum mechanics mostly denies that mental aspects play a crucial role in the measurement process (see Greenstein & Zajonc 2006), some researchers argue that consciousness, or other mental concepts, contribute a much more relevant part in this transition (e.g., Penrose & Hameroff 2011, Mensky 2013, Stapp 2017, see also von Neumann 1932, Wigner 1963, Walker 2000).

According to some of these models, the quantum state can be interpreted as a pre-real possibility space, which interacts with both classical physical states and their corresponding representations within the conscious mental world (Filk & Römer 2011, Atmanspacher & Filk 2012, Stapp 2015). Quantum measurement, the moment when one of many superposed possibilities becomes real according to classical physics, is equally considered as a transference of knowledge from unknown into consciously known knowledge. If a measurement is characterized by the conscious processing of a classical outcome, quantum-specific effects must therefore operate within a pre-conscious realm (Penrose & Hameroff 2011, see also Penrose 1989, 1994, Hameroff & Penrose 1996, Hameroff 2012). Accepting this possibility, Jung and Pauli (see Atmanspacher 2012) even argued that conscious observation during quantum measurements itself does not cause the physical transition from quantum to classical states; rather, conscious observation of a measurement result co-occurs with the manifestation of a classical state in the physical world. Standard orthodox quantum theory predicts the occurrence of specific measurement outcomes with a probability function that is ontic in nature. Comparatively, some authors argue that the measurement interaction is not unidirectional, but that information can flow from observer to the observed system, consequently biasing the probability distribution (e.g., Walker 2000, Stapp 2015).

Although consciousness is crucial to these considerations, the origin of such a bias must be located in the transition from a subconscious to a conscious state of mind. Studies showing directional psi effects of subjects not consciously intending them support this claim (Stanford 1976, Stanford, Zenhausern, & Dwyer 1975). Maier and Dechamps (2018) extended the idea that this reality-shaping effect is non-intentional (Stanford 1990) and goal-oriented (Schmidt 1974) by characterizing the underlying unconscious motivational states.

Accordingly, these states, which translate their drives via emotions (e.g., fear or hope) into conscious realizations, provide the object of the influencing mechanism. For instance, if an individual has an unconsciously grounded motive to smoke, their corresponding desire is emotionally laden with the fear of not having enough nicotine in their body. This deficit-oriented fear translates into an expectation of never receiving enough of the desired substance. When such an addicted person interacts with a quantum system that is connected with two equally likely realities—one that corresponds to their motive, and the other being neutral regarding their motive—their desire will influence the measurement of that quantum system. Accordingly, this will lead to an increased likelihood of experiences corresponding to the implicit belief; a consequence that standard quantum probability would not allow. In other words, under such circumstances the unconscious mental constitution of an observer would create classical realities that include their conscious observations that accord with the individual observer's inner emotional desires. This would represent a truly self-fulfilling prophecy.

This idea is congruous with results yielded by micro-psychokinetic (micro-PK) research. Micro-PK can be described as mental influences on inanimate and probabilistic systems that produce effects that are only detectable through statistical means (Varvoglis & Bancel 2015). Typically, this involves studies measuring the influence of observers on random target systems, such as random number generators. Several meta-analyses have aggregated data from hundreds of micro-PK studies and found substantial overall effects resulting from observer influences (Radin & Nelson 1989, Bösch, Steinkamp, & Boller, 2006). The high heterogeneity of the effect sizes raises concerns for some critics; however, Varvoglis and Bancel (2015) conclude that despite some publication bias quite possibly being present, an unrealistically large file drawer would be needed to annul the results (see also Radin et al. 2006).

Nevertheless, micro-PK research has to grapple with recurrent difficulties, arguably the most important of which is the lack of successful direct replications (e.g., the replication of the PEAR landmark study; Jahn et al. 2000). This evasive nature of psi effects has not gone unnoticed within the psi research community (e.g., Bierman 2001, Kennedy 2003), and has furthermore confronted us with challenges during an attempt to replicate a promising first study on micro-PK (Maier & Dechamps 2018).

In this set of two consecutive studies, we originally aimed to investigate a possible mind–matter interaction by experimentally linking the outcome of a random event to a psychologically meaningful experience. Studies focusing on a relaxed mental state of effortless intention usually generate better results than those focusing on an intentional and deliberate influence on randomness (e.g., Braud & Braud 1979, Debes & Morris 1982). Accordingly, we designed our independent variable using a primarily unconsciously driven state: the desire for cigarettes within regular smokers. Through these means we ensured that we integrated the subject's implicit mental state into the design.

In the first study, we compared the effects of participants with a pronounced drive—regular smokers—on the output of true random number generators (tRNGs) with the effects of non-smoking, and therefore unmotivated, participants. Depending on the tRNG's outcome, pictures pertaining to the drive and need (e.g., people smoking) or pictures not pertaining to this need (e.g., a chair) were displayed to the passively observing participants. We then tested whether the distinctive mindset of regular smokers led to a bias in the quantum measurement process and, subsequently, to a non-random distribution of addiction-relevant stimuli.

In Study 1, 122 smokers and 132 non-smokers were presented with 400 trials. We hypothesized that the specific mental attitude toward cigarette-related content within smokers would lead to a deviation in the number of smoking pictures from that of random chance; accordingly, no deviation from chance was expected concerning the non-smokers.

Data were analyzed using a Bayesian approach (see Wagenmakers et al. 2011), which updates the support and evidence for either hypothesis with each new data point by pitting their likelihoods against one another. This subsequently allows for sequential testing, which involves adding and continuously analyzing data until a pre-specified stopping criterion has been met. We decided upon a Bayes Factor (*BF*) of 10 as a stopping rule, which corresponds to strong evidence toward a given hypothesis. Concerning a prior probability, we decided to use a Cauchy distribution centered on

TABLE 1
Mean Number of Cigarette Pictures and *BF* for Both Subsamples in Studies 1 and 2

	SMOKERS			NON-SMOKERS		
	N	**M (SD)**	**BF_{10}**	**N**	**M (SD)**	**BF_{10}**
Study 1	122	196.7 (9.87)	66.06	132	200.5 (9.86)	0.16
Study 2	175	200.3 (10.38)	0.09	220	199.0 (10.34)	0.30
Studies 1 & 2	297	198.8 (10.31)	0.61	352	199.6 (10.11)	0.12

zero with an r of 0.5, i.e. $\delta \sim$ Cauchy (0, .5), as proposed by Bem, Utts, and Johnson (2011). At the beginning of this research there was no clear prediction regarding direction of the effect, and so a two-sided approach was chosen.

The final Bayesian *t*-test analysis with 122 smokers yielded a *BF* of 66.06 toward H_1; this means that it was 66 times more likely to obtain the data when the alternative hypothesis was true than when the null-hypothesis was correct. Smoking participants saw an average of 49.18% addiction-related stimuli (‘cigarette pictures’), a percentage substantially below the expected chance value of 50%, thereby representing a very strong effect. Concerning the non-smoking subsample of 132 participants, the Bayesian *t*-test yielded a *BF* of 6.13 (=1/0.16) toward H_0; this indicates moderate evidence for a null effect (see Table 1). These remarkable results point to a need-specific micro-PK effect within those participants who experienced a subconsciously active but deficit-oriented desire toward the relevant stimuli. The results are in line with the reasoning of the emotional transgression model, as outlined above (see also Maier, Dechamps, & Pflitsch 2018). This model emphasizes the importance of implicit beliefs—in this case an unconscious experience of a lack of nicotine—when influencing the actualization of a corresponding outcome as part of a micro-PK experiment. This deficit translates into craving and addictive actions on one side, and into a subconsciously active mental pattern centering on ‘not having enough’ (of the addictive substance) on the other. Consequently, this unconscious fear leads to a self-fulfilling prophecy: The lack experienced by the smoker ‘establishes’ a confirming reality that misses smoking-related content. Accordingly, the consciously experienced classical reality corresponds to the unconscious inner beliefs of the observer.

After these initially promising results, we decided to perform an exact replication of the experiment to further substantiate the observed effect. The pre-registered replication[1] used the same procedural details as those of the first study. Surprisingly, our expectations were not met, and Study 2 did not replicate the findings of Study 1. For smokers, Study 2 revealed strong evidence toward the null hypothesis (BF_{01} = 11.07); comparatively, for non-smokers Study 2 revealed moderate evidence in the same direction, replicating the findings of Study 1 (see Table 1).

We faced a dilemma at this point, as the data yielded by Study 2 suggested there was no replicable effect of the smoker subsample on the number of cigarette pictures. Still, the effect development of the smoker and non-smoker subsamples seemed to differ immensely over the course of both experiments. This was particularly obvious when concatenating the data of both studies, as is allowed with Bayesian sequential testing. The two-sided one-sample *t*-tests showed a remarkable development within the smoker subsample. The *BF* begins to rise after about 80 participants, quickly surpassing the threshold of (very) strong evidence, reaching a climax of BF_{10} = 421.2 at participant number 134, shortly after commencing the second study. Soon a dramatic decline began to appear, countering the effect and eventually leading to an overall *BF* lower than 1, indicating evidence toward the null hypothesis. This extraordinary change in effect across times was found only within the smoker subsample. Contrarily, the non-smoker subsample showed a steady and consistent decline toward H_0 from the beginning (see Figure 1).

Given the apparent differences of the temporal changes in the sequential *BF*s of the two subsamples, we speculated as to the presence of a systematic time-dependent micro-PK effect, despite the lack of replication. As mentioned earlier, decline effects are somewhat prominent, especially in psi research (e.g., Bem, Palmer, & Broughton 2001, Radin 2006). Accordingly, it seems as if for these—and potentially other effects—different methodological approaches might be used other than the replication of original results. As the temporal development of the effect is so clearly identifiable among the data, we decided to focus on this temporal change. Of particular interest was the onset and development of the effect decline and whether a systematic pattern could be described here (see also Maier, Dechamps, & Pflitsch 2018).

This decline of initially strong effects—referred to as the statistical equilibrium effect, the balancing effect, the differential effect, or the first-timer effect, among other names; we refer to this pattern as the "Nemesis effect" (in reference to the ancient Greek goddess of retributive justice)—seems to pervade many psi studies, within both our lab and others.

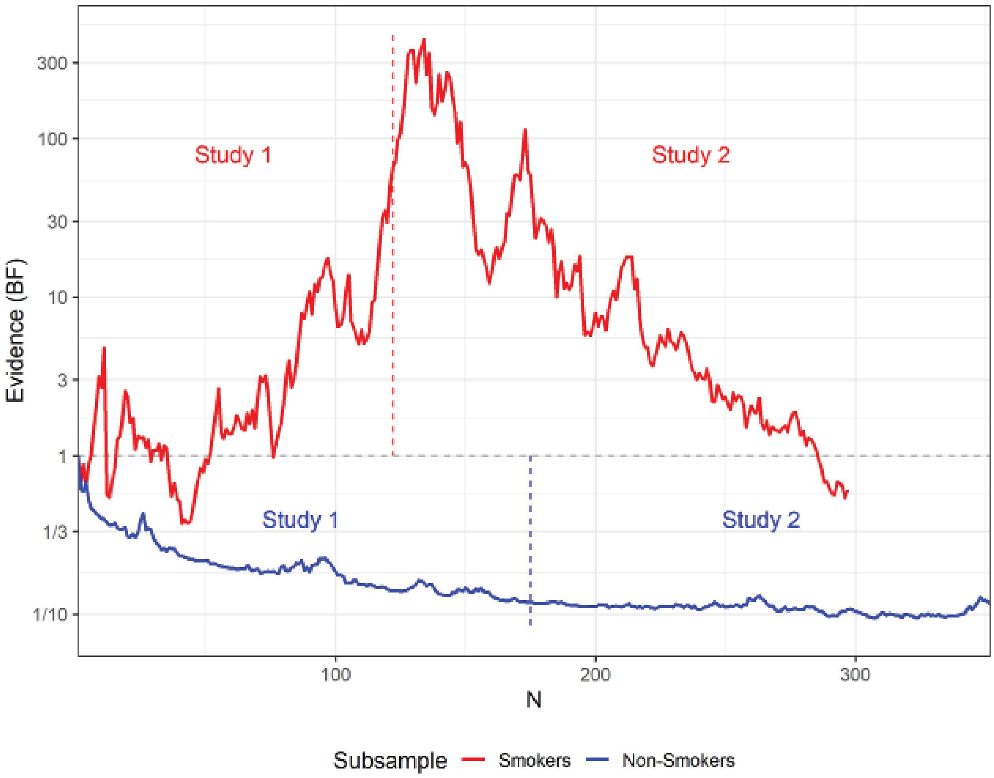

Figure 1. Sequential Bayesian analyses of mean number of cigarette pictures for smoker (top curve, red line) and non-smoker (bottom curve, blue line) subsamples. Dotted lines indicate the transition from Study 1 to Study 2 within both subsamples.

Explanations for this effect, along with selective publication and increasing study quality (both do not apply here), include several psychological variables, for example subjects becoming tired or bored with the task. However, between-experiment declines of effects, as is often the case, cannot be explained through these mechanisms (for an overview, see Bierman 2001). Another psychological explanation revolves around unconscious belief systems toward supernatural phenomena. Since implicit beliefs seem to play a crucial role in the characteristic or direction of a reality-shaping influence, Eisenbud (1992) reasoned that an unconscious motivation to live in an orderly world might be responsible for a decline of paranormal effects (see Braude 2016).

Von Lucadou, Römer, and Walach (2007) addressed the phenomenon of declining effects theoretically and provided an elaborated explanation in their Model of Pragmatic Information (see also von Lucadou 2006, 2015). Pragmatic information is meaningful for a closed system and provides an opportunity for entropy-reducing change (see Weizäcker 1974). The authors considered this kind of pragmatic information as a prerequisite for the emergence of nonlocal correlations within closed psychophysical systems, which underlie most psi effects (von Lucadou 1995, Walach, von Lucadou, & Römer 2014). Psi effects can be understood as entanglement correlations that are mediated not through causal signals, but rather as a consequence of a specific configuration of a system's mental and material components (von Lucadou, Römer, & Walach 2007). Any artificial setups allowing the use of such pragmatic information within entanglement correlations for signal transmission—something that would be feasible if psi effects were robust and replicable—would lead to a reduction of pragmatic information and, therefore, to an unsystematic disappearance of psi effects in later replication attempts. This would satisfy the important Non-Transmission Axiom (NT Axiom) of quantum mechanics (Atmanspacher, Römer, & Walach 2002, von Lucadou, Römer, & Walach 2007). The NT Axiom is supposed to prevent physical paradoxes such as faster-than-light signal transfer (see also Einstein, Podolsky, & Rosen 1935) and ensure that natural order is abided (Walach, von Lucadou, & Römer 2014). Von Lucadou, Römer, and Walach (2007) condensed the factors responsible for the decline in the following formula:

$$I = R * A = B * E$$

Here, the amount of pragmatic Information (I) increases with higher proportions of Novelty (E) and Autonomy (A), and decreases with higher proportions of Confirmation (B) and Reliability (R). Replication studies involve low levels of novelty and autonomy as they often involve the specification of a clear prediction and are, therefore, unlikely to contain a sizable amount of pragmatic information; i.e. they are without unambiguous results (Etzold 2004, Walach, von Lucadou, & Römer 2014). In sum, the Model of Pragmatic Information (MPI) predicts that exact replication attempts of psi effects based on non-locally correlated systems need to decline in the original dependent variable and possibly reappear unpredictably in other variables of the system (so called 'displacement'). This would also be true for micro-PK effects and may provide an explanation for the elusiveness of such phenomena (von Lucadou, Römer, & Walach 2007).

Maier, Dechamps, and Pflitsch (2018) (see also Maier & Dechamps 2018) also refer to the MPI to explain their results, though they revised its predictions regarding the decline of psi effects. Instead of adopting the assumption regarding the unsystematic disappearance of the effect per the original MPI, these researchers proposed a systematic temporal change of micro-PK effects (and psi effects in general). This revision is based on the idea that evidence for micro-PK constitutes a severe violation of the Second Law of Thermodynamics because a chaotic system, such as a random quantum event, becomes more orderly under micro-PK without the investment of energy. Such a system therefore decreases in entropy over time. Consequently, with increasing evidence for micro-PK, the onset of an entropic countereffect is proposed. We assumed that this entropic countereffect manifests as soon as the information resulting from mentally induced deviations from quantum randomness reaches a certain threshold of experimental evidence. Once this original effect—and the evidence for such an effect—has weakened, the countereffect also loses power, allowing the micro-PK effect to reappear again. This interplay between effect and countereffect should lead to a distinctive pattern when analyzing the effect's temporal development.

In a recent publication reporting the results of two micro-PK studies using smokers and non-smokers—and the time course of these effects across the studies (Maier & Dechamps 2018)—we proposed a way to study a systematic variation of the effects by analyzing their temporal change. Within the aforementioned publication we argued that psi effects will display a systematic interplay of effect and countereffect in the form of a dampened harmonic oscillation. We then applied this idea to the smokers' data from Studies 1 and 2. To do this, we plotted the effect as a cumulative z-score and used a curve-fitting algorithm, with the software Wolfram Mathematica Version 11.1 (https://www.wolfram.com/mathematica), estimating a dampened harmonic oscillation as an approximation of the raw data. Furthermore, an extrapolation of this function was then used to predict the future time course of a third set of data with that of prospectively collected micro-PK data (the study reported herein). For this purpose, the extrapolated continuation trend of our calculated curve should constitute a rough estimate for the development of the effect within this future dataset (see Figure 2).

From this curve extrapolation, a prediction for the next 200 participants can be derived: After a temporary local maximum (technically a local minimum, as the effect is negative), the effect will reappear, though with a lower effect size and then decline once more to a value similar or slightly more negative than the initial end-point value. The local maximum should appear around subject number 410–450 and should lie between a z-score of −2.5 and −3. We decided to look at several test statistics to test for the quality of our prediction among the experimental data compared with 10,000 simulated datasets:

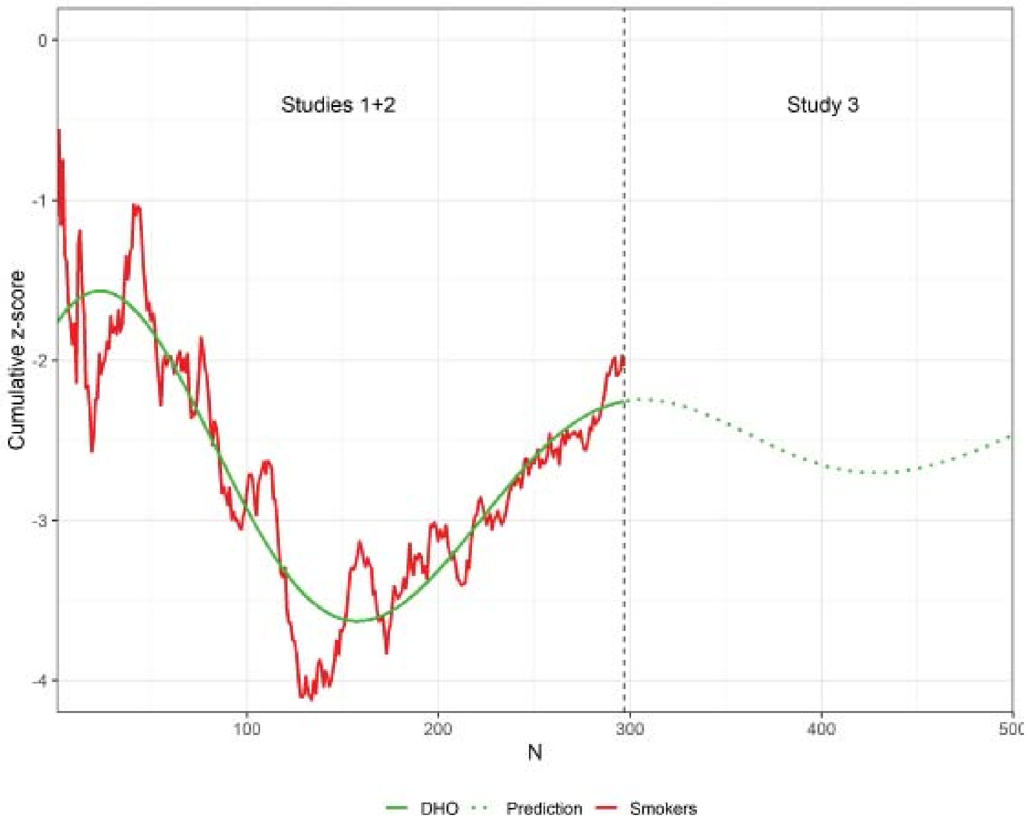

Figure 2. Cumulative z-score of the smoker subsample (jagged curve, red line), fitted dampened harmonic oscillation (DHO) (smooth curve, green line), and prediction (dotted curve) for the following 203 participants.

1) The area between the experimental data curve and the prediction.
2) The Euclidian distance of the local maximum compared with that of the prediction.
3) The Euclidian distance of the end point compared with that of the end point of the prediction.

Methods

This study was pre-registered at the Open Science Framework (OSF) (https://osf.io/ac839). It was conducted in accordance with the ethical requirements of the American Psychological Association (APA). All materials and procedural decisions were identical to those of Studies 1 and 2 (Maier & Dechamps 2018).

Consent

All participation in this study was voluntary, and written consent was obtained from all participants prior to their involvement. Interested participants were given an individual explanation about the purpose of this study once they had completed their tasks. The procedure used in this study was approved by the ethical board of the Department of Psychology.

Participants

Participants were added until a total of 500 smokers had been reached, including all participants from Studies 1 and 2. This resulted in a total of 236 tested participants for this study; of these participants, 203 were smokers and were included in this analysis accordingly (102 female, 101 male; mean age = 33.1 years, *SD* = 14.44). Participants were recruited via several means, including through the Department's announcement board, handouts in psychology classes, Facebook university groups, and direct contact with the experimenters. Participants who were enrolled in the university's psychology bachelor's degree classes were able to acquire credits as part of their program. For this study, we explicitly recruited 'smoking participants'.

Participants were asked to provide information about their smoking behavior. Only those participants who reported that they were a 'regular cigarette smoker' (at least 1 cigarette per day) were considered for inclusion in this study, mirroring those inclusion criteria applied for Studies 1 and 2. Of the 33 excluded subjects, 3 claimed to be strict non-smokers, 23 stated they were casual smokers, and 7 described themselves as smokers of other tobacco products (e.g., pipe). Additional questionnaires were the same as those used in Studies 1 and 2, namely the German version of the Fagerström Test for Nicotine Dependencies (FTND-G) (Schumann et al. 2003), and a questionnaire assessing the subject's attitude toward smoking. Here, participants were asked to respond to ten statements about smoking, indicating their level of agreement toward each one positively (e.g., "smoking is fun") or negatively (e.g., "smokers smell bad"). The questionnaires were not part of our hypotheses and therefore were not considered further.

Materials

Software and Computers. The study was conducted using three mobile testing stations comprising a notebook, a tRNG, and the experimental software. All notebooks used for this study were prepared in an identical fashion. The experimental software was programmed in C#, and translated the tRNG output into a display of either a smoking-related ('cigarette') picture, or a neutral picture (e.g., objects of daily use). The stimuli were presented in the center of the screen on a black background with a size of 500 × 400 pixels, corresponding to roughly one-quarter of the overall screen size.

Stimuli. All smoking-related pictures were taken out of the Geneva Smoking Photographs (GSP) set (Khazaal, Zullino, & Billieux 2012), a normative database providing 60 addiction-relevant photographs for nicotine and tobacco research. A set of 10 pictures was chosen from this database, providing variation in terms of product, smoking behavior, and tobacco-related cues (e.g., cigarette packs, ashtrays, smoking individuals, etc.).

All neutral pictures were taken from the International Affective Picture System (IAPS) (Lang, Bradley, & Cuthbert 1997), a dataset providing an experimental set of 1,169 digitized photographs rated on arousal and valence on a 9-point scale. A set of ten pictures displaying everyday objects and geometric forms was chosen from this dataset. These pictures were rated neutral (mean valence = 4.90, *SD* = 1.09), and unexciting (mean arousal = 2.61; *SD* = 1.86).

Generation of quantum randomness. Randomness in the form of superposed quantum states was provided by a quantum random number generator (Quantis-v10.10.08) as developed by the company ID Quantique (http://www.idquantique.com/random-numbergeneration/quantis-random-number-generator). This tRNG generates quantum states by emitting photons aimed at a semi-conductive, mirror-like prism, similar to the well-known double-slit experiment. Photons have an equal chance of being deflected or passing through the prism to be registered by one of two sensors. Upon measurement, the photon's superposition vanishes, and it is found on either route with a 50% probability. Depending on which sensor registers the photon, a "0" or "1" bit is created and passed to the computer via a USB interface. The Quantis tRNG has passed all serious tests of randomness (e.g., NIST SP800-22 Compliance) and is considered one of the most effective sources of randomness (Turiel 2007).

Experimenters

Informally trained research assistants were used as the experimenters for this study; their task was to find 203 participants who were regular smokers. The experimenters only had rudimentary knowledge about the aim of the experiment and were blind toward the specific hypothesis at the point of data collection.

Procedure

Participants were tested in different environments without distractions or other persons present. At the beginning of the experiment, written instructions were read to the participants:

> Thank you for participating in this experiment! In the first part of the study you will sit in front of the computer and look at pictures. I know that this can be very tiring, nevertheless I ask you not to get distracted and that you focus your attention on the computer for the whole period of this part of the study. It is *absolutely necessary* for this experiment that you look at the pictures! This will take approximately 10 minutes. Of course, you can quit the experiment at any time, should you feel uncomfortable.
>
> As soon as you have finished, a message will appear on the screen. Please let me know, so I can prepare the computer for the second part of the experiment, which will be a questionnaire. Filling it out will take about five more minutes. All data will be collected anonymously.
>
> Do you have any questions?

After participants' potential questions were answered, the experimenter opened the software and instructed participants to start with the presentation of the pictures when they felt ready. Subsequently, the experimenters sat aside and distracted themselves mentally to exclude possible interference with the experiment itself, only occasionally checking on the participants.

Participants attentively watched a series of 400 picture trials displaying either an addiction-related or a neutral stimulus on each trial, depending on the output of the tRNG. Stimuli were chosen by sampling without replacement during a ten-trial block. After every 10^{th} trial, all pictures had the same probability of being chosen again. This process ensured that, over the course of the experiment, each stimulus had the same probability of being displayed and affecting a participant. Participants first looked at a centered cue (700 msec), then at the addiction-related or neutral stimuli (400 msec), and finally at a black screen (400 msec). This process was repeated 400 times and took approximately 10 minutes (see Figure 3).

After the completion of the stimulus presentation, participants were asked to fill out the questionnaire using the computer's web browser.

Derivation of the Prediction

Data from Studies 1 and 2 were transformed to cumulative z-scores in order to derive a prediction. First, standard deviation was calculated for each of the 298 data points:

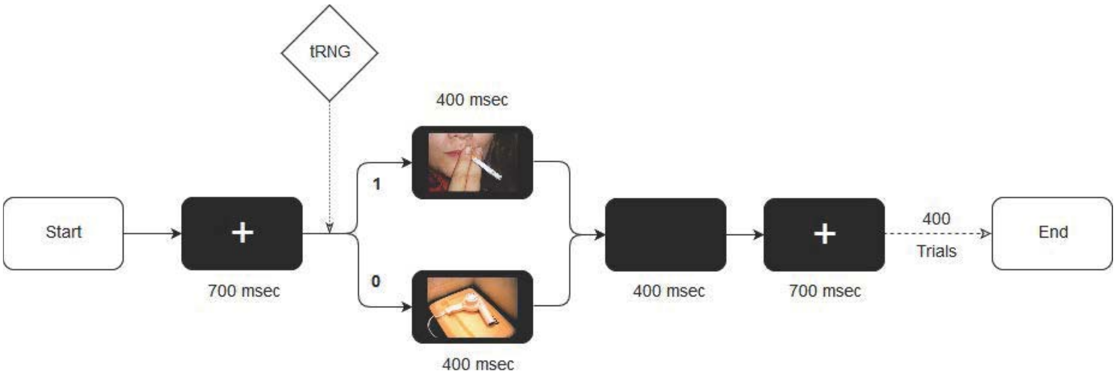

Figure 3. Experimental procedure: Schematic flow chart for a single trial.

$$SD_n = \sqrt{t \times n \times p \times (1 - p)}$$

where t is the number of trials ($t = 400$), n is the number of subjects from 1 to 298, and p is the probability of a hit for a single trial ($p = 0.5$). Subsequently, the difference between the cumulated number of hits (number of smoking-related pictures) from the expected value for each data point was transformed in units of standard deviations:

$$z_n = \frac{\Sigma_1^n M_{obs} - \Sigma_1^n M_{exp}}{SD_n}$$

The resulting dataset was then plotted and a nonlinear model fit applied using the function of a general dampened harmonic oscillation:

$$y(n) = ae^{-\beta n}\cos(\omega n + \varphi) + mn + h$$

The software used for the curve fit (Wolfram Mathematica 11.1) required boundary values for the model fit; hence, the following boundaries were given:

$$\begin{aligned} -5 &< a < 5 \\ 0 &< b < 0.01 \\ 0 &< \omega < 0.1 \\ 0 &< \varphi < 2\pi \\ -5 &< m < 5 \\ -5 &< h < 5 \end{aligned}$$

After it had been ensured that none of the fitted parameters were near a constraint boundary, the goodness of the fit was evaluated by a variance estimation using the mean squared error. It was ensured that no other relevant combination of constraint boundaries would produce a lower variance estimation than the attained variance of *Var* = 0.065, and, therefore, a better fit to the experimental data. The final model produced the following estimates:

	Estimate	**Standard Error**	**Confidence Interval**
α	1.53484	0.0472682	{1.44197,1.62771}
β	0.0031827	0.000182361	{0.0028244,0.00354099}
ω	0.0191355	0.000296296	{0.0185534,0.0197177}
φ	6.00159	0.0599918	{5.88372,6.11946}
m	0.00193325	0.00014269	{0.0016529,0.00221361}
h	−3.02286	0.0423804	{−3.10613,−2.93959}

Therefore, we used a damped harmonic oscillation of the following kind to produce the prediction for this study, from $N = 298$ to $N = 500$ (see also Figure 2).

$$y(n) = 1.53484\, e^{-0.0031827}\, n \cos(0.0191355\, n + 6.00159) + 0.00193225\, n - 3.02286$$

This predictive function was described in the pre-registration stage, as well as in the original Maier and Dechamps (2018:288) article.

Data Analysis

To determine whether the experimental data of this study fits the prediction, we decided to look at three key characteristics. Firstly, if the courses of the empirical and the prediction curves are similar, the area between them should be minimal. We therefore decided to calculate the area under the curve (AUC) of both the experimental data and the prediction before using their difference as the first test statistic.

Secondly, harmonic oscillations are generally characterized by a systematic upward and downward movement with local minimum and maximum points. Our prediction shows such a local maximum (a maximum for negative effect, so technically a minimum) at $N = 429$ and predicts a z-score of $z = -2.70$. We then used the Euclidean distance of the local maximums of the experimental data and the prediction as the second test statistic.

Thirdly, we decided to look at the last cumulated data point, since it contains the most precise information about the effect. To test how well our harmonic oscillation predicts the final z-score, we decided to use the Euclidean distance of the end points of the experimental data and the prediction as a third test statistic.

Since no theoretically derived criteria were available that indicated at which respective scores these statistics could be defined as being statistically significant, we decided to compare our results with those obtained from 10,000 simulations. Simulation data were generated using the same tRNG device employed in the original study. For each simulation, 203 × 400 bits were generated and summed up in the same fashion as in the experimental dataset; this produced 10,000 instances of a purely random development of our data that we could compare with our actual experimental data.

Main Results

Of the 236 subjects, 203 self-identified as regular smokers and were added to the overall analysis, which also included smokers' data from Studies 1 and 2. The total mean for cigarette pictures was *M* = 199.1 (*SD* = 10.11). This is slightly below chance value and, therefore, in the same hypothesized direction as in the first two studies. A Bayesian analysis revealed a BF_{10} = 0.40, which corresponds to anecdotal evidence toward the null hypothesis. Accordingly, in looking at this average score no substantial deviation from chance was found. It must be remembered that we did not hypothesize a consistent effect for the data in this study but rather a specific development of the effect curve.

The z-score plot of the experimental data started slightly above the prediction value, before rising toward zero until it reached a z-score of −1.58 at *N* = 380. Subsequently, the effect can be seen to increase once more, reaching a local maximum at *N* = 475 with a z-score of −2.60. Finally, the last data point at *N* = 500 equals *z* = −2.35, which is slightly more negative than at the beginning of Study 3 (*z* = −2.06; see Figure 4).

Area under curve. The area between the prediction and the experimental data curve was found to be 85.22. Of all 10,000 simulations, 18.71% revealed a smaller area between them and the prediction (Mean *AUC* = 157.48, *SD* = 74.03). Figure 5 shows the distribution of AUCs.

Local maximum (turning point). The local maximum, or turning point, of the experimental data is equivalent to the highest absolute z-score; this was identified at *N* = 475 whereby z_{max} = −2.60. To measure the distance to the predicted turning points, x- and y-coordinates were standardized to fit in a 1 × 1 square, i.e. the lowest value was transformed so that it was equal to 0, and the highest so that it was equal to 1. This ensured that both

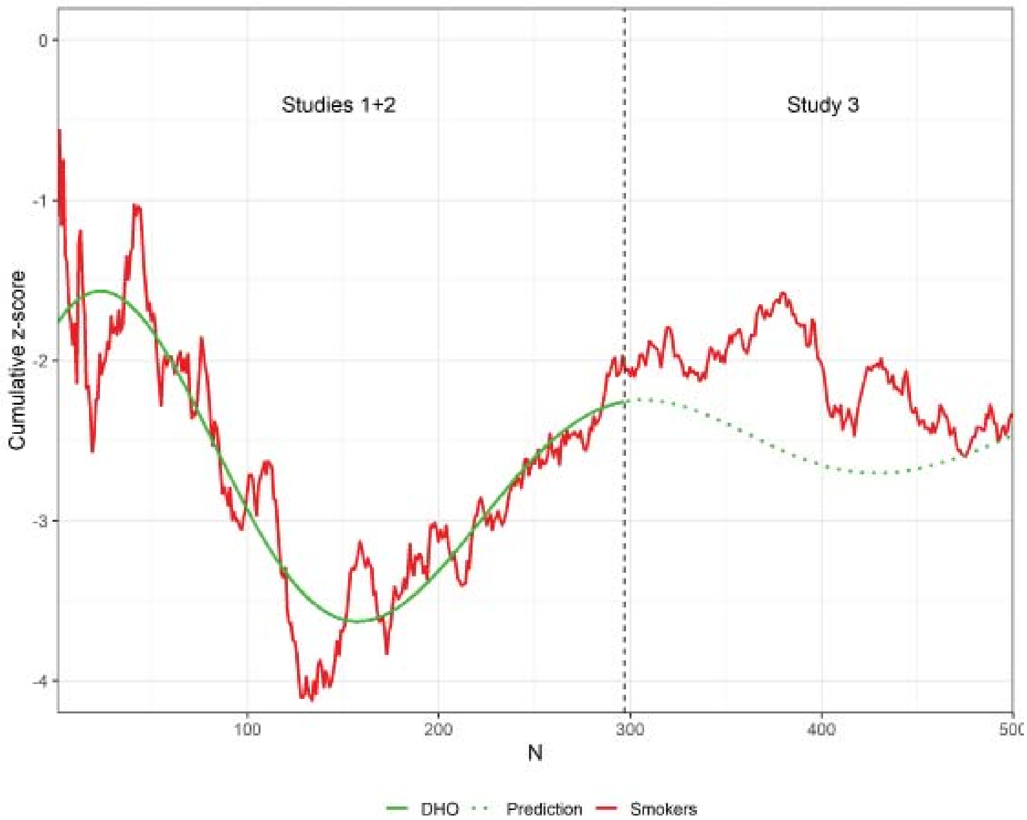

Figure 4. Results of Study 3 were transformed into cumulative z-scores and compared with the prediction, the extrapolation of the fitted dampened harmonic oscillation (DHO).

distances—value of the z-score and the subject number—were accounted for in equal parts. The transformed distance between the turning points of the experimental data and the prediction was $d_{trans} = 0.23$.

In sum, 19.42% of simulations showed a smaller distance for their turning points to the prediction (mean $distance_{trans} = 0.44$, $SD = 0.19$) (see Figure 6).

End point. The final z-score of the experimental data lies at $z = -2.35$; this is 0.11 points above prediction. Of all simulations, only 5.28% showed a smaller distance to the prediction (mean distance = 0.90, $SD = 0.62$).

Discussion of the Main Analyses

The results of our confirmatory analyses of Study 3—which combined data from Maier and Dechamps (2018) with the newly collected data described herein—revealed a mixed picture. For two of the three analyses applied, roughly 1/5 of all simulations showed a closer match to our prediction

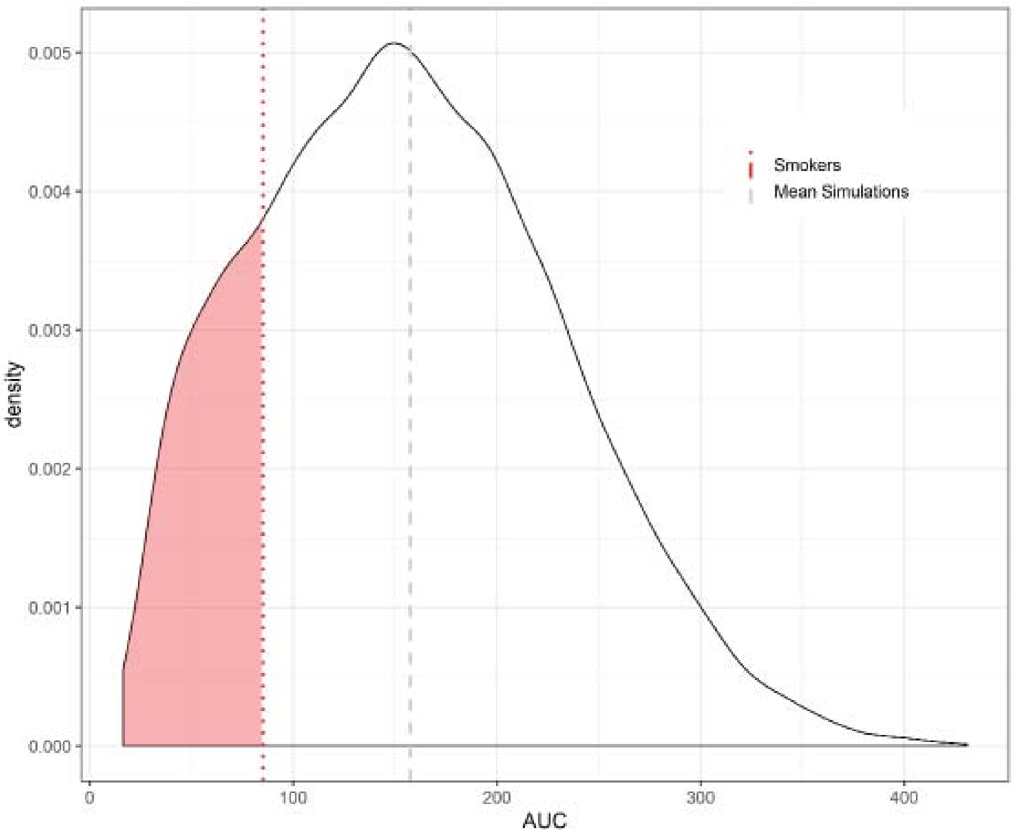

Figure 5. Distribution of the area under the curve between the simulations and the prediction. The shaded red area (gray in the print journal) indicates the proportion of simulations with a smaller area, i.e. a better fit than the experimental data.

function than the actual experimental data. This includes the area between curves, as well as the occurrence of the local maximum or turning point.

Descriptively, it seems that the general trend—a temporary increase of the effect that declines toward the end of the study—is present in the data. As can be seen in the median simulation in Figure 7, a truly random dataset should move toward $z = 0$. In contrast, while the experimental data do indeed temporarily increase in effect, the highest effect is found 46 subjects later than predicted. The final cumulative z-score, the end point of the curve, is met pretty well by the experimental data. Only 5.28% of all simulations lie closer to the prediction, which correctly predicted a more extreme value than the initial z-score.

Even though the experimental data are closer to the prediction than most simulations, they do not stand out in a statistically significant way. A closer look at the characteristic of the prediction increases the plausibility

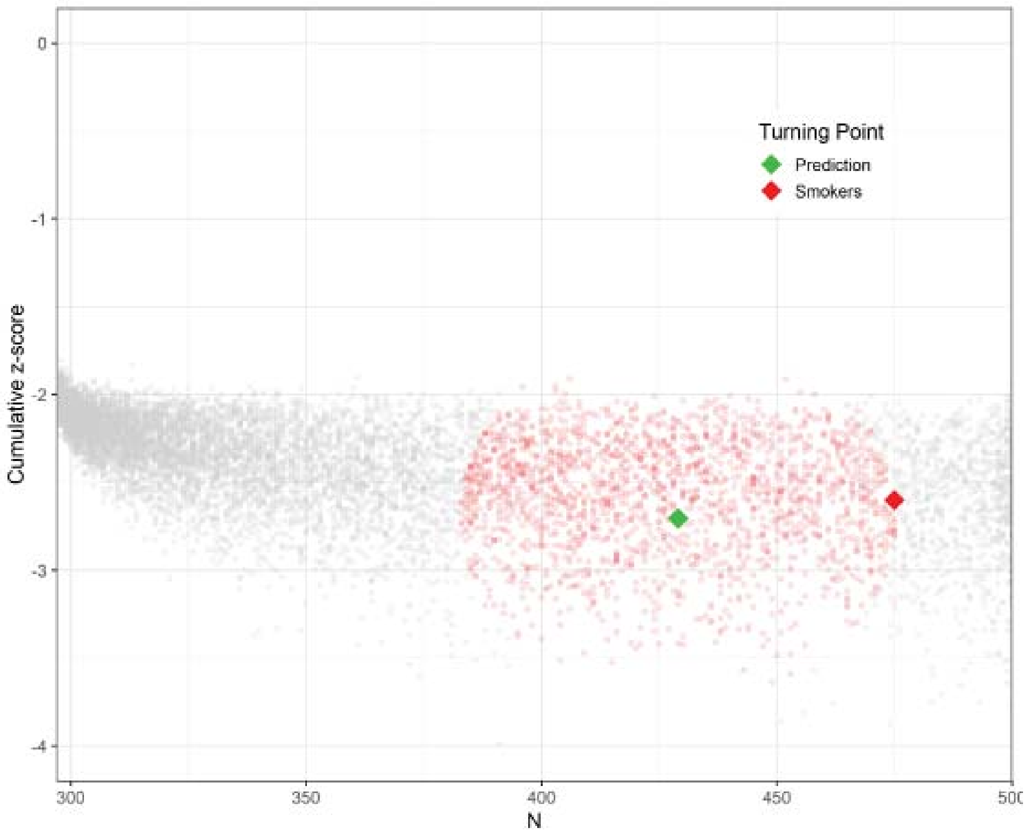

Figure 6. Overview of the turning points (local maxima) of all simulations (top rhomb is green and rhomb to the left is green; bottom rhomb is red and rhomb to the right is red). Red dots (brighter dots between 375 and 475) indicate simulations with a turning point closer to the prediction than to the experimental data.

of this finding. Although the prediction shows a subtle oscillating pattern, the development is not notably protuberant, meaning that it may not be sufficiently distinctive to be able to reliably distinguish between random and non-random data. Therefore, it remains inconclusive as to whether the temporal development of a micro-PK effect follows the pattern of a dampened harmonic oscillation closely enough to derive a prediction about its future progress.

Exploratory Results

Since the pre-registered confirmatory analyses of Study set 3 yielded no definite results, we decided to further explore the unambiguously extraordinary effect development of the smoker subsample over the course

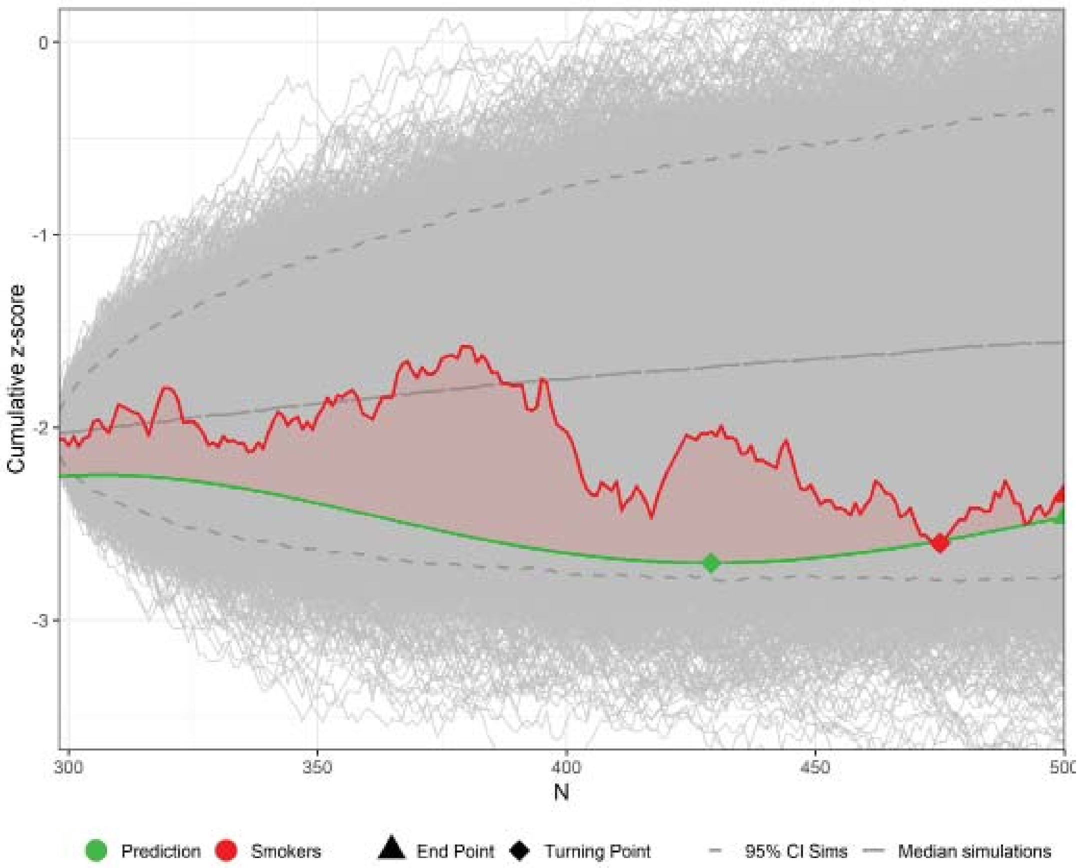

Figure 7. Overview of all confirmatory analyses conducted for Study 3. Here, the gray lines represent random simulations; their median is the center, gray, long-dashed line, while the outer, gray, short-dashed lines represent the borders in which 95% of all simulations lie. The red line (top curve) represents smokers' experimental data, and the green line (bottom smoother curve) the prediction. The red shaded area (darker gray shading) visualizes the area under the curve between the experimental data and the prediction. The rhomb represents the turning point and the triangle the end point for both the experimental data and the predictions.

of all 500 participants. Arguably, the best indicator of evidence of an effect at any moment is the *BF*. This test statistic can be used sequentially and gives a precise estimate of the probabilities of two competing hypotheses at every data point. The *BF* is consistent, meaning that it will give a more precise answer the more data it considers, even if the null hypothesis is true (Rouder et al. 2009).

For this reason, we decided to take a closer look at the temporal change of the *BF*s of both subsamples (smokers and non-smokers) before comparing

TABLE 2
Results of Confirmatory Analyses of Study 3 in Comparison with 10,000 Random Simulations

	Result	% of Simulations with a Better Result
Area under curve	85.22	18.71
Turning Point	0.23	19.42
End Point	0.11	5.28

them to another set of simulations. These simulations were generated in the same way as before, though on this occasion contained 200,000 bits for a total of 500 data points (400 trials × 500 subjects per simulation). Again, we generated 10,000 simulations using the tRNG device, summed up the bits, and calculated two-sided sequential Bayesian *t*-tests with a prior of $\delta \sim$ Cauchy (0, 0.5) (see Figure 8) (Table 2).

Highest *BF* reached. As can be seen in Figure 8, the smoker subsample ($BF_{10} = 421.22$ at $N = 134$) peak is remarkable. Only 0.21% of all simulations showed a higher *BF* at any point. This is in stark contrast to the non-smoker subsample, which resembles a nearly perfect null curve and at no point rises above a value of 1 in the H_1 direction (as do 40.56% of all simulations).

***BF* Energy**. The overall orientation of the curve is also of interest, much like the highest peak. The overall area between the baseline at *BF* = 1 and the empirical sequential *BF* curve above and below that line, where deviations above *BF* = 1 receive a positive sign and below a negative sign, can be described as its *energy* (see Figure 9). For the smoker subsample, this area was: $AUC_{\text{Smokers}} = 7981.73$, this is surpassed by only 0.15% of all simulations (mean *AUC* = −291.96, *SD* = 1485.19). Non-smokers show an Energy of $AUC_{\text{Nonsmokers}} = -323.35$, which is surpassed by 95.95% of simulations cut after the non-smoker N of 385 (mean AUC for these simulations is −208.28, *SD* = 1375.05).

Frequency Spectrum analysis. The Energy of the curve does not account for periodicity as a characteristic, however. As this is the core idea of the Maier, Dechamps, and Pflitsch (2018) revision of the MPI, which postulates systematic variations of micro-PK effects over time, we then applied an analysis of periodicity to our dataset. One such way to gain a deeper understanding of the oscillative nature of our empirical *BF* curve

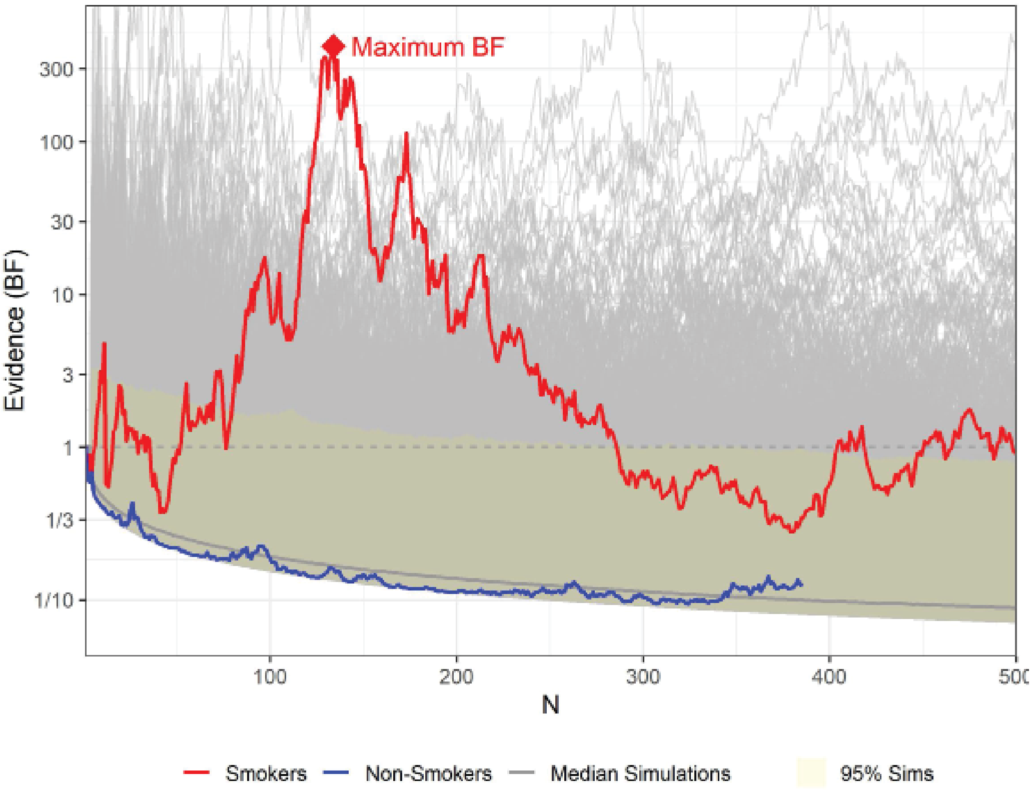

Figure 8. Sequential Bayesian analyses of both subsamples (Studies 1–3) in comparison with 10,000 simulations comprising random data (muted gray lines). Overall, 95% of simulations are located in the yellow area (the slighter lighter gray shading roughly under 1); the median of the simulations is represented by the single bottom gray curve line (near the bottom).

is by applying a Fourier transformation. This analysis converts a time-dependent function to a representation of its composited frequencies and can be understood as a harmonic analysis of the input. The resulting curve—the Fourier transform—shows the amplitude of all frequencies comprising the original input sequence (Penrose 2017). Accordingly, high amplitudes indicate the presence of pronounced periodic elements within the original curve.

A fast Fourier transformation (FFT) was conducted on the sequential Bayesian analysis of both subsamples, as well as on all 10,000 simulations. Simulations that were used for the comparison of the non-smoker subsample to the smoker subsample were cut after $N = 385$ data points. Sampling rate was 1/N in each case. The transform shows the amplitude at every point of the sampling rate. As it is symmetric, only the first half of the transform is considered. Remarkably, the spectrum analyses of the subsamples differ

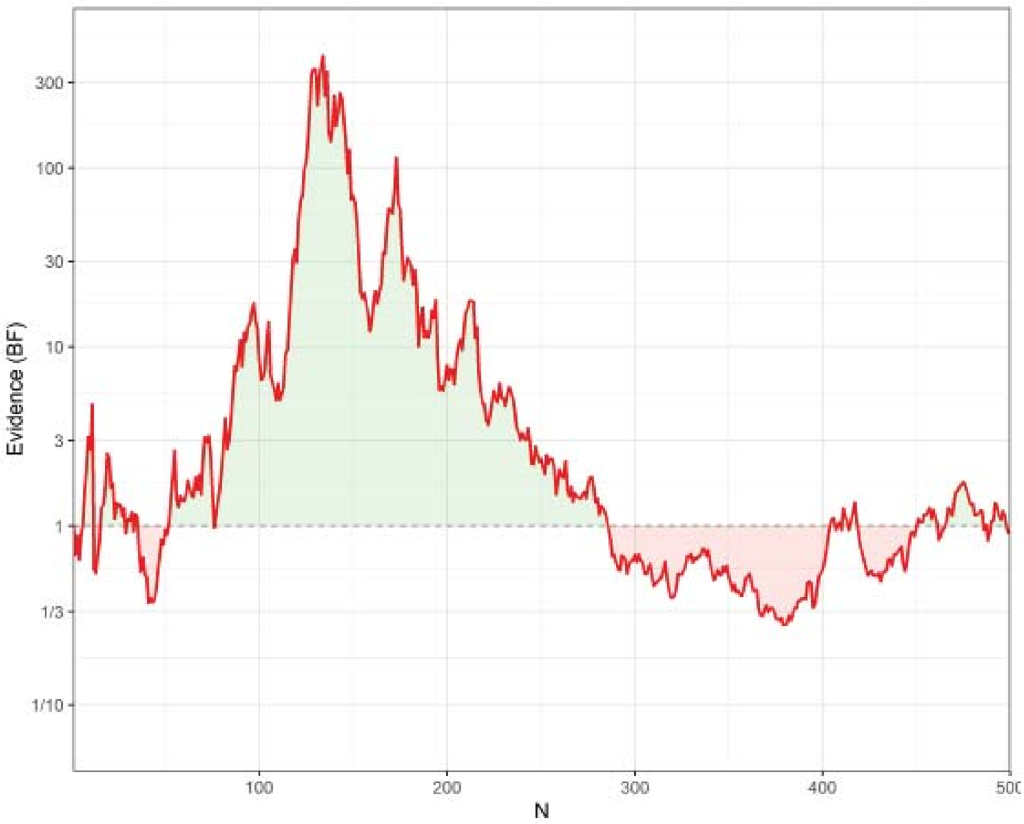

Figure 9. Representation of the curve's Energy. Parts below BF = 1 (red [lighter gray shading]; direction toward H_0) are subtracted from parts above 1 (green [darker gray shading]; direction toward H_1).

tremendously: The smoker subsample shows a very high amplitude at almost every frequency (see Figure 10a for the first 50 frequencies); comparatively, the non-smoker subsample shows very small amplitudes (Figure 10b). Compared to the simulation data, 245 of 250 frequencies (98%) of the transform of the smokers' data have a higher amplitude than 99% of all simulations, while all frequencies (100%) have higher amplitudes than 95% of simulations. Comparatively, none of the frequencies of the non-smoker subsample show an amplitude in the top 5% of simulations.

Discussion of Exploratory Results

All exploratory analyses revealed very promising results in their ability to distinguish between the smoker and non-smoker subsamples and simulations. The latter illustrated that the occurrence of a BF_{10} of 421.22 over the course of the data collection stage is quite exceptional; indeed, it can only be expected with a probability of about 0.21% using truly random

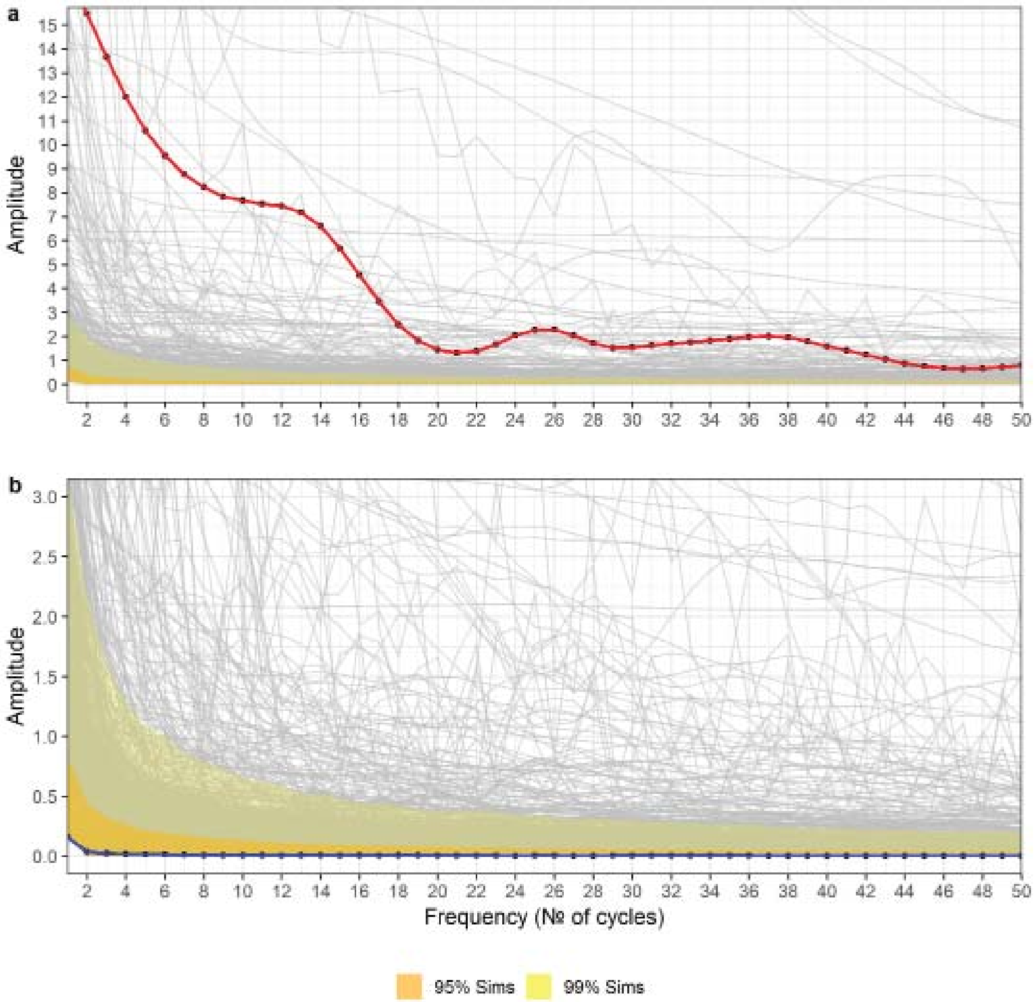

Figure 10. FFT of Bayesian sequential analyses of the smoker subsample (red [dark curve on the top graph a]) and 10,000 simulations, and the non-smoker subsample (blue [dark line on the bottom graph b]) and 10,000 simulations. The orange (95%) and yellow (99%) areas (near the axes) represent the simulations' empirical confidence bands (darker and lighter shadings near the bottom of the graphs).

data. The *BF* is designed so that it yields more precise information as more data are added. This strategy reaches a limit, though, when the tested effect is not consistent in its strength but volatile, as might be the case with psi effects.

Considering this, it might be fruitful not only to consider a single *BF*, but also to closely examine its development. The difference of the sums of all *BF*s going in the direction of either hypothesis may also provide valuable information; this is calculated by subtracting the correspondent areas from one another, and can be described as the curve's energy. The energy of the sequential Bayesian analysis of the smokers' data is even more unusual than its highest *BF* and is surpassed by only 0.15% of all simulations. Conversely, non-smokers' energy resides in the bottom 5% of simulations. This *BF* curve is, therefore, oriented remarkably strongly toward the direction of the null hypothesis. The data seems to be 'more random' than most random datasets.

Finally, from our perspective, it is important to account for the possibility of an oscillating nature regarding psi effects. Effects like micro-PK might be possible in general; however, they are likely being counteracted by an opposing force at some point. This interplay should present itself as a periodic pattern of the effect (Maier, Dechamps, & Pflitsch 2018). As a Fourier transformation is able to extract the harmonic structure of an input signal, it might therefore be suitable as an instrument to reveal such non-random oscillating patterns. A remarkable difference can be noticed when this is applied to the sequential Bayesian analyses of both subsamples and their corresponding simulations; the amplitudes of the frequencies—meaning their significance in comprising the input signal—show a much higher value in the smoker subsample. When compared with 10,000 simulations, this transform features amplitudes in the top 1% in nearly every frequency. This means that it is highly unlikely to be obtained from a truly random *BF* development.[2] Comparatively, the non-smoker transform on the other hand shows a pattern similar to a typical null-effect simulation, and does not stand out in any way.

General Discussion

A certain degree of experimental evidence for psi effects is unquestionable (Cardeña 2018). Nevertheless, successful replications of psi effects, such as micro-PK effects, are scarce, which is demonstrated exemplarily in the first two studies of this experiment (Maier & Dechamps 2018). It seems that these effects evade classical detection through replication. Different ideas about the elusive nature of psi have emerged, one example of which is the No-Transmission Axiom of the Model of Pragmatic Information (von Lucadou, Römer, & Walach 2007). The authors of this model conclude that psi effects in general cannot be tested with specific predictable outputs and are, therefore, not accessible to reproducibility-oriented research (von Lucadou 2006).

A more tangible equivalent to these considerations is grounded in the quantum nature with which psi effects are usually brought into connection. A systematic deviation from quantum randomness violates the No-Communication theorem and the Second Law of Thermodynamics because information is created from nothing and could be used to transmit signals.

This temporary decrease in entropy could lead to an onset of a counter-mechanism whose task it is to restore randomness, dwindle the information away, and increase entropy. There is one critical difference from the MPI, however: We predict that the interplay between effect and countereffect leads to a systematic pattern in the development of the effect itself; in principle, this is something that can be predicted and tested (Maier, Dechamps, & Pflitsch 2018, Maier & Dechamps 2018).

Our first instinct was to assess the z-score as this embodies the standardized deviation from a given value: in this case, from chance. We hypothesized that effect and countereffect should balance in a form comparable to a dampened harmonic oscillation and applied a correspondent curve-fitting algorithm to experimental data showing a rise and decline of micro-PK. In doing this we derived a prediction about the behavior of the cumulative z-score of future data. At this point, no definitive conclusion can be drawn regarding the goodness of the prediction. Experimental data of 203 further participants in the micro-PK study fitted the prediction better than most simulations according to three different test statistics; however, they did not stand out in a significant way. This is potentially attributable to the lack of distinctiveness, a characteristic that makes it easy for random data to match the prediction.

Subsequently, we aimed to find other ways of assessing the development of the effect on a post hoc basis. We decided to favor the sequential Bayesian analysis to the cumulative z-score because the former represents more sophisticated information regarding the state of effect at every point of the experiment. We felt that the evidence toward one of two hypotheses better matches the knowledgeable information of the presence of an effect, which should comprise the basis for the interplay with the entropic countereffect. This development went hand in hand with new methodological possibilities that arose during the course of the experiment, specifically the extraction of individual *BF*s and the execution of FFTs.

Analyzing the development of the *BF* has proven to be a very promising approach using the data from this series of experiments. The maximum *BF* expresses the climax of the initially present micro-PK effect, whereas the curve's energy gives an indication of the overall distribution of the *BF*s with regard to the competing hypotheses. Both these methods could reliably distinguish between an experimental sample and a control group or simulated data at a 1% level. In particular, we would like to emphasize the method of a Fourier transformation of the sequential Bayesian analysis. This approach assesses the existence of a periodicity in the data, which is the fundamental idea behind an interplay of effect and countereffect. The transform of the experimental sample showed a behavior that fully supports this claim. The remarkably high amplitudes seen for nearly every frequency suggest the presence of a strong oscillative element only in the dataset where micro-PK is expected. The transform stands out from both the control group and random simulations. Meanwhile, all three methods have been applied to a different high-power and within-subject, micro-PK study; once again, they show very promising results (Dechamps & Maier 2019).

Psi effects such as micro-PK repeatedly present us with scientific challenges. This circumstance has led some people to conclude that the classical epistemological standpoint—which demands the replication of results to establish a proof—is not applicable within such a context. While we agree that current standard methods might not be suitable when securing comprehensive evidence for volatile effects, such as psi, we propose a way out without giving up testability and predictability. The goal, therefore, must be to move away from only considering end results and toward a closer investigation of temporary change and the development of psi effects themselves.

Notes

1 Study preregistration is available at https://osf.io/wn5b7

2 A Bayesian binomial test revealed an 'infinitely high' *BF* toward the hypothesis, indicating that the proportion of top 1% frequencies is far higher than the 1% chance base rate.

References Cited

Atmanspacher, H. (2004). Quantum theory and consciousness: An overview with selected examples. *Discrete Dynamics in Nature and Society*, *2004*(1), 51–73.

Atmanspacher, H. (2012). Dual-aspect monism à la Pauli and Jung. *Journal of Consciousness Studies*, *19*(9–10), 96–120.

Atmanspacher, H., & Filk, T. (2012). Contra classical causality violating temporal bell inequalities in mental systems. *Journal of Consciousness Studies*, *19*(5–6), 95–116.

Atmanspacher, H., Römer, H., & Walach, H. (2002). Weak quantum theory: Complementarity and entanglement in physics and beyond. *Foundations of Physics*, *32*(3), 379–406.

Bell, J. S. (1964). On the Einstein Podolsky Rosen Paradox. *Physics Physique Fizika*, *1*(3), 195.

Bem, D. J., Palmer, J., & Broughton, R. S. (2001). Updating the Ganzfeld database: A victim of its own success?. *The Journal of Parapsychology*, *65*(3), 207–219.

Bem, D. J., Utts, J., & Johnson, W. O. (2011). Must psychologists change the way they analyze their data? *Journal of Personality and Social Psychology, 101*(4), 716–719.

Bierman, D. J. (2001). On the nature of anomalous phenomena: Another reality between the world of subjective consciousness and the objective world of physics. In *The Physical Nature of Consciousness* edited by P. Van Loocke, Amsterdam: John Benjamins, pp. 269–292.

Bösch, H., Steinkamp, F., & Boller, E. (2006). Examining psychokinesis: The interaction of human intention with random number generators—A meta-analysis. *Psychological Bulletin*, *132*(4), 497–523.

Braud, L. W., & Braud, W. G. (1979). Psychokinetic effects upon a random event generator under conditions of limited feedback to volunteers and experimenter. *Journal of the Society for Psychical Research*, *50*, 21–32.

Braude, S. E. (2016). Jule Eisenbud. *Psi Encyclopedia*. London: The Society for Psychical Research. https://psi-encyclopedia.spr.ac.uk/articles/jule-eisenbud

Cardeña, E. (2018). The experimental evidence for parapsychological phenomena: A review. *American Psychologist*, *73*(5), 663–677.

Debes, J., & Morris, R. L. (1982). Comparison of striving and non-striving instructional sets in a PK study. *Journal of Parapsychology, 46*(4), 297–312.

Dechamps, M. C., Maier, M. A., & Pflitsch, M. (2019). *Enhancing Micro-PK through Altering Primes.* Manuscript in preparation.

Einstein, A., Podolsky, B., & Rosen, N. (1935). Can quantum–mechanical description of physical reality be considered complete? *Physical Review*, *47*(10), 777.

Eisenbud, J. (1992). *Parapsychology and the Unconscious*. Berkeley, California: North Atlantic.

Etzold, E. (2004). Ist die Existenz von Psi-Anomalien beweisbar. *Zeitschrift für Anomalistik*, *4*, 14–51.

Filk, T., & Römer, H. (2011). Generalized quantum theory: Overview and latest developments. *Axiomathes*, *21*(2), 211–220.

Greenstein, G., & Zajonc, A. G. (2006). *The Quantum Challenge: Modern Research on the 544 Foundations of Quantum Mechanics* (second edition). Boston: Jones and Bartlett.

Hameroff, S. (2012). How quantum brain biology can rescue conscious free will. *Frontiers in Integrative Neuroscience*, *6*(1), 93. https://doi.org/10.3389/fnint.2012.00093

Hameroff, S., & Penrose, R. (1996). Orchestrated reduction of quantum coherence in brain microtubules: A model for consciousness. *Mathematics and Computers in Simulation*, *40*(3–4), 453–480. https://doi.org/10.1016/0378-4754(96)80476-9

Jahn, R., Dunne, B., Bradish, G., Dobyns, Y., Lettieri, A., Nelson, R., Mischo, J., Boller, E., Bösch, H., Vaitl, D., Houtkooper, J., & Walter, W. (2000). Mind/machine interaction consortium: PortREG replication experiments. *Journal of Scientific Exploration, 14*(4), 499–555.

Kennedy, J. E. (2003). The capricious, actively evasive, unsustainable nature of psi: A summary and hypotheses. *Journal of Parapsychology*, *67*(1), 53–74.

Khazaal, Y., Zullino, D., & Billieux, J. (2012). The Geneva Smoking Pictures: Development and preliminary validation. *European Addiction Research*, *18*(3), 103–109.

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (1997). International affective picture system (IAPS): *Technical Manual and Affective Ratings. NIMH Center for the Study of Emotion and Attention,* pp. 39–58.

von Lucadou, W. (1995). The Model of Pragmatic Information (MPI). *European Journal of Parapsychology*, *11*, 58–75.

von Lucadou, W. (2006, October). Self-Organization of temporal structures—a possible solution for the intervention problem. In *American Institute of Physics Conference Proceedings*, *863*(1), 293–315.

von Lucadou, W. (2015, July). The Correlation Matrix Method (CMM)—A New Light upon the Repeatability Problem of Parapsychology. *Proceedings of the 58th Annual Convention of the Parapsychological Association and the 39th SPR International Annual Conference,* University of Greenwich, July 16–19, 2015, London, UK.

von Lucadou, W., Römer, H., & Walach, H. (2007). Synchronistic phenomena as entanglement correlations in generalized quantum theory. *Journal of Consciousness Studies*, *14*(4), 50–74.

Maier, M. A., & Dechamps, M. C. (2018). Observer effects on quantum randomness: Testing micro-psychokinetic effects of smokers on addiction-related stimuli. *Journal Scientific Exploration, 32*(2), 265–297.

Maier, M. A., Dechamps, M. C., & Pflitsch, M. (2018). Intentional observer effects on quantum randomness: A Bayesian analysis reveals evidence against micro-psychokinesis. *Frontiers in Psychology*, *9*, 379.

Mensky, M. B. (2013). Everett Interpretation and Quantum Concept of Consciousness. *NeuroQuantology*, *11*(1), 85–96.

Neumann, J. V. (1932). *Mathematische Grundlagen der Quantenmechanik*. Berlin: Julius Springer.

Penrose, R. (1989). *The Emperor's New Mind Concerning Computers, Minds and the Laws of Physics*. New York: Oxford University Press.

Penrose, R. (1994). *Shadows of the Mind: A Search for the Missing Science of Consciousness*. Oxford: Oxford University Press.

Penrose, R. (2017). *Fashion, Faith, and Fantasy in the New Physics of the Universe*. Princeton: Princeton University Press.

Penrose, R., & Hameroff, S. (2011). Consciousness in the universe: Neuroscience, quantum space-time geometry and Orch OR theory. *Journal of Cosmology, 14*, 1–17.

Radin, D. (2006). *Entangled Minds: Extrasensory Experiences in a Quantum Reality*. New York: Simon and Schuster.

Radin, D. I., & Nelson, R. D. (1989). Evidence for consciousness-related anomalies in random physical systems. *Foundations of Physics*, *19*(12), 1499–1514.

Radin, D., Nelson, R., Dobyns, Y., & Houtkooper, J. (2006). Reexamining psychokinesis: Comment on the Bösch, Steinkamp and Boller (2006) Meta-Analysis. *Psychological Bulletin, 132*, 529–532.

Rouder, J. N., Speckman, P. L., Sun, D., Morey, R. D., & Iverson, G. (2009). Bayesian *t* tests for accepting and rejecting the null hypothesis. *Psychonomic Bulletin & Review*, *16*(2), 225–237.

Schmidt, H. (1974). Comparison of PK action on two different random number generators. *The Journal of Parapsychology*, *38*(1), 47–55.

Schumann, A., Rumpf, H. J., Meyer, C., Hapke, U., & John, U. (2003). Deutsche Version des Fagerström-Test for Nicotine Dependence (FTND-G) und des Heaviness of Smoking Index (HSI-G). *Elektronisches Handbuch zu Erhebungsinstrumenten im Suchtbereich (EHES). Version*, *4*.

Stanford, R. G. (1976). A study of motivational arousal and self-concept in psi-mediated instrumental response. *Journal of the American Society for Psychical Research*, *70*(2), 167–178.

Stanford, R. G. (1990). An Experimentally Testable Model for Spontaneous Psi Events: A Review of Related Evidence and Concepts from Parapsychology and Other Sciences. In *Advances in Parapsychological Research 6* edited by S. Krippner, Jefferson NC: McFarland, pp. 54–161.

Stanford, R. G., Zenhausern, T. A., & Dwyer, M. A. (1975). Psychokinesis as psi-mediated instrumental response. *Journal of the American Society for Psychical Research*, *69*(2), 127–133.

Stapp, H. P. (2015). A Quantum–Mechanical Theory of the Mind–Brain Connection. In *Beyond Physicalism* edited by E. F. Kelly et al., Lanham: Rowman and Littlefield, pp. 157–193.

Stapp, H. P. (2017). *Quantum Theory and Free Will*. New York: Springer.

Turiel, T. P. (2007). Quantum random bit generators. *The American Statistician*, *61*(3), 255–259.

Varvoglis, M., & Bancel, P. A. (2015). Micro-Psychokinesis. In *Parapsychology: A Handbook for the 21st Century* edited by E. Cardeña, J. Palmer, & D. Marcusson-Clavertz, Jefferson NC: McFarland, pp. 266–281.

Wagenmakers, E.–J., Wetzels, R., Borsboom, D., & van der Maas, H. L. J. (2011). Why psychologists must change the way they analyze their data: The case of psi: Comment on Bem (2011). *Journal of Perssonality and Social Psychology, 100*, 426–432.

Walach, H., von Lucadou, W., & Römer, H. (2014). Parapsychological phenomena as examples of generalized nonlocal correlations—A theoretical framework. *Journal Scientific Exploration*, *28*(4), 605–631.

Walker, E. H. (2000). *The Physics of Consciousness.* Cambridge: Perseus.

Weizsäcker, E. V. (1974). Erstmaligkeit und Bestätigung als Komponenten der pragmatischen Information. *E. v. Weizsäcker (Hrg.): Offene Systeme I*, 82–113.

Wigner, E. P. (1963). The problem of measurement. *American Journal of Physics, 31(1)*, 6–15.

5. Overall Discussion

5.1. Findings of the empirical studies

5.1.1. The importance of meaning in the measurement process

The goal of the empirical studies presented here was to examine mind-matter interactions via micro-psychokinetic experimental paradigms. Conscious observers were confronted with the results of a supposedly random and non-predictable quantum experiment carried out in a quantum based true random number generator (RNG). The RNG's output was translated into psychologically meaningful stimuli to ensure an intrinsic connection to the subjects' implicit core beliefs. In papers 1 and 2, we hypothesized the emergence of a non-local correlation between the subject's state of mind and their physical experience. This would result in a non-random distribution of realized quantum states and would therefore constitute a violation of quantum mechanics' randomness postulate. The results of these two studies indicate that such an influencing observer effect might exist to a certain extent. In paper 1, we compared participants with a specific meaningful mental configuration towards the results of the quantum measurement (smokers) to those with a neutral attitude towards them (non-smokers). In the first study, smokers saw less than the statistically expected amount of smoking-related stimuli. We interpreted this result as the consequence of a reality-shaping influential mechanism ensuring the parallelism of mental and physical aspects of reality moderated through a biasing of the probability distribution during quantum measurement.

Unfortunately, so far we can only speculate on the nature of this influencing effect; different quantum mechanical interpretations give rise to different possibilities. In TI, the wave function is interpreted as the product of two determining factors, one retarded wave emitted by the quantum system and one advanced wave sent back in time from the measuring receiver (Cramer, 1986). The biasing might therefore originate in different configurations of advanced waves depending on the state of mind of the conscious observer. In QBism, measurement is seen as an inherently subjective process in which an agent is updating their prior belief about the quantum system. Since the probabilities generated are dependent on the individual previous experience (the *prior* in Bayesian terms), proponents of this view postulate them and therefore the quantum states themselves to be personal (Fuchs, 2014). The previous experience that constitutes the individual prior also determines the subjects' implicit core beliefs; especially regarding a psychologically potent topic like addiction, it is not hard to imagine a different experiential history and therefore a different belief about how reality is going to evolve between addicted and not addicted agents. Other theories suggest different mechanisms (Mensky, 2013; Penrose & Hameroff, 2011; Stapp, 2017; Walker, 2000; see also Millar, 2015) Admittedly, the empirical results cannot give indications towards the exact mechanism of the effect.

Nonetheless, they indicate the importance to extend quantum theory to include a biasing through subjective meaningful content into the measurement process.

5.1.2. How to test an elusive effect

However, additional studies we conducted demonstrated that there is more to the story. Surprisingly, the results indicate that with more data added, the randomness-biasing micro-PK effect vanishes. Naturally, one explanation is that the initial effect was just a chance finding. Considering the substantial amount of empirical data that supports micro-PK (see Cardeña, 2018), the initially very strong evidence towards an effect in paper 1, and the prominent appearance of decline effects in the literature, we still felt obliged to take a closer second look at the data. Descriptively, the sequential Bayesian analyses reveal extraordinary temporal patterns of the experimental samples in comparison to control samples and randomly generated data sets. Several new statistical methods subsequently have been applied on a post-hoc basis to the temporal change of evidence towards the effect in paper 3.

The highest reached Bayes Factor represents the peak of evidence at any time during data collection and indicates the initial presence and strength of an effect. The overall orientation of the curve in regard to the border line of evidence towards the competing hypotheses at $BF = 1$ shows in which parts of the experiment the evidence becomes noticeable. A substantial amount of energy, i.e. a large proportion above $BF = 1$, suggests an atypical effect-induced course. Finally, a frequency spectrum analysis via a Fourier transformation discloses the periodicity of the evidence. High amplitudes of the transform are evidence for a pronounced oscillatory nature of the evidence curve. In paper 3, all these analyses support the impression that even though the initial effect declined, a discriminable pattern of the data, represented as a time series, can be observed and tested for. Consequently, we feel that in contrast to theories postulating an elusive effect, which is not verifiable in principle (Atmanspacher, 2012; Atmanspacher, Filk, & Römer, 2006; von Lucadou, Römer, & Walach, 2007), the analysis of the temporal change of the effect instead of its end result could constitute a way to consistently detect observer effects; It seems as if the decline is indeed systematic and not completely chaotic. The proposed analyses have proven to be suitable to identify this unusual interplay between effect and decline for smokers in paper 3 and have been successfully applied to the second paper in the meantime (Maier, Dechamps, & Schiepek, 2019) as well as to two additional micro-PK experiments (Jakob, Dechamps, & Maier, 2019; Maier, Dechamps, & Pflitsch, 2019). We propose to further assess the efficacy of these methods in future studies.

5.2. The Nemesis effect

The decline of an initially present effect is something we have encountered countless times both in small and in comprehensive experimental settings. We have termed this process 'Nemesis effect', named after the Greek goddess of retributive justice. The circumstances of its appearance have been the topic of many discussions. Assuming a dual-aspect framework of mind and matter as a basis for micro-PK effects, the source of the decline may lie in either one or even both these systems. Let's illustrate different reasonings for a basic example: A gambler throwing a die. Just like a quantum system, the physical system 'die' possesses inherent qualities that determine its behavior under ordinary circumstances. Its sides and areas are equal, its mass is distributed homogenously and thus all numbers have the same probability to be thrown. For a result to be obtained the die needs an interaction with an agent – that is the gambler throwing it. Through this interaction, a personal element enters the process. Some days the gambler might feel haunted by fortune and other days they are convinced to be dogged by bad luck. Let's imagine that, depending on the mental state 'lucky' or 'unlucky', through some subconscious action the gambler gives the die the right spin for it to be congruent to their implicit belief and therefore biases the results. Unfortunately though, this lucky streak will not hold indefinitely. On a lucky day, the gambler may throw ten 6's in a row, not believing his luck, before – from one moment to the next – not a single 6 is thrown until they leave the table.

Now, what could have caused this dramatic change of behavior? Typical psychological explanations for a decline include tiredness or boredom of the participant (see Bierman, 2001), however inter-subject decline effects argue against those. Conversely, a different explanation fits very well to the previous ideas about the workings of mind-matter interaction: A different implicit belief might become stronger at a certain point, namely the desire to live in an orderly and consistent world, where natural laws are abided (Eisenbud, 1992). Psychoanalyst Jule Eisenbud argues there might even be an unconscious resistance or defense to psi in the sense of a basic fear of the possibility of omnipotence (of thought). Even though the gamblers belief to be a lucky child is dominant for a certain amount of time, at some point the unconsciously active motivation to live in a world that makes sense and on whose rules you can rely on might take over control and make the gambler give a different kind of 'spin'. Since this motive is quite meaningful as a core concept of one's role in the universe, in virtually every case it will eventually gain the upper hand.

Comparatively, a decline could also be rooted in the physical domain of the process. A consistent biasing of probabilities without a physical cause would violate a handful of natural laws from quantum mechanics' no-signal theorem to the second law of thermodynamics. A fair die does not allow any prediction about the next number thrown and therefore is a consistently random system. In terms of the MPI its *pragmatic information* is characterized by high levels of confirmation (the results do not add new information to what is already known: every number has the same probability to be thrown) and reliability (the behavior, i.e. the probability distribution does not change). However, if the die and the gambler are entangled via the meaningful implicit belief of the gambler that influences the unus mundus, a biasing of the die's results may be observed. This would lead to a shift of the pragmatic information towards novelty (new information consisting of the increased probability to throw a 6) and autonomy (unexpected behavior of the die). A decline is subsequently predicted when this behavior has been observed so many times that a reliable confirmation of it is expected anew, inevitably leading to a decrease of the novel and autonomous outcomes once more (von Lucadou, 2015).

As stated in paper 2, a physical correlate to this interplay could be based on the second law of thermodynamics, which states that in a closed system entropy will always increase. A purely random distribution possesses more entropy than a biased one, which means that in the case of a micro-PK effect information is created ("6 is more likely than the other numbers") where there used to be none ("no prediction about the next number can be given") – a violation of the second law[1]. This corresponds to the first shift of pragmatic information. Since this state is in direct contrast to arguably one of the most basic laws of our world, it cannot persist indefinitely. An entropy-increasing counter-effect may set in at this point equalizing the original effect and ensuring that the information is lost again and the die behaves the way 'it's supposed to do'. Induced correlations would therefore correspond to a temporal decrease in entropy that is met with a randomness-restoring entropic counter-effect.

Interestingly, the Nemesis effect seems to appear not only on an individual subject-level but depending on the definition of the target system over the course of one or even many experiments. While the MPI and entropy explanation account for the considered system, a psychological reason for the decline must be based on a collective subconscious belief and therefore shared implicit knowledge about the system's state. If there is a series of lucky gamblers playing the same game, it might come to pass that the first ones successfully apply their implicit belief to be lucky onto the dice. However, at some point the collective knowledge about the bias obtained so far leads the following gamblers, without any explicit experience of that information, to destroy the lucky effect and to restore a shared consistent world[2].

5.3. Future directions and implications

Future research of this general topic could further investigate the nature of the Nemesis effect. It might be worthwhile to pursue the question whether its origin is psychological, physical, or both. The onset of an entropic counter-effect may even constitute the physical correspondent to an implicitly based psychological explanation. To follow up on the existence of the latter, the subject's implicit desire to live in a consistent world could be tested or manipulated. For example, a statistical fact could be established in a way that it is integrated into the subject's implicit belief system. Subsequently, the underlying probabilities could be

[1] In this simplified example, actually the second law is not violated, since the gambler adds energy to the system through his addition of a 'spin'. It would be though, if the biasing was the result of a purely mental state.

[2] An idea towards how shared implicit knowledge might arise can be found for example in Kastrup (2018).

changed (e.g. by using a biased RNG) to examine whether the subject's expectations influence the actual probabilities in a way that they match the earlier established 'subjective truth'. Other implicit beliefs could be manipulated as well, e.g. by using a quasi-experimental design before and after a psychotherapy, during which the belief is worked through and changed accordingly. Considering this, possible experimenter effects should also be further researched at some point. Especially under the light of possible psychologically based decline effects, one must ask the question to what extent the (implicit) expectations of the experimenters (and study authors, and readers of the paper, etc.) play a role (see e.g. Walker, 1975). Investigating experimenter effects must include advanced study designs such as a triple-blind setup or the blurring of study results. It might be the case that ambiguous and not clear cut study results give way for circumventing the onset of a decline induced by secondary observers. At the same time, these results will most likely not convince a skeptic of the presence of a psi effect.

Even though paper 3 proposes ways to test for psi effects and their subsequent decline by analyzing the change of effect via various means, there is still work to be done regarding the concrete characteristic of this interplay and the meaning of the test results. For that reason, we plan to create a standardized Fourier measure, in which the frequencies between experiments will be comparable. It will be interesting to see, which (ranges of) frequencies will be most characteristic for similar paradigms. Maybe a 'psi-frequency', a 'micro-PK-frequency' or some other domain-specific frequencies can be found. A general effect-decline-interplay of high-powered studies will most likely be represented by lower frequencies that comprise 100s of participants, since a certain threshold of evidence must first be gathered. Due to the usually (very) small effect sizes in psi research, this will require a non-negligible minimum sample size. Nonetheless, studies analyzed with this method so far showed high amplitudes in higher frequencies as well. Further emphasis should also be put on the onset of the decline. We assume that it is dependent on the amount of evidence generated by the data towards the effect (which in our cases is represented by the *BF*), but it seems there is also an impact of the effect size and therefore the steepness of the *BF* curve, as well as possibly other variables. In paper 2, we proposed a way to predict the further course of an effect by matching a dampened harmonic oscillation to the cumulative *z*-score. However, this approach relies on a substantial amount of data including both times of effect and decline and therefore does not seem suitable to predict the onset of the decline. To do so, a model should be set up incorporating at least the evidence gathered and the estimated size of the effect, or better yet, including even more experimental parameters, such as expected sample size, prior beliefs about the effect, expected impact of the findings, and others. Moreover, the strength of the decline should be analyzed. Does it comprise a simple regression to the mean due to the absence of the original effect, or can an antagonistic counter-effect be found that levels out the effect even faster? The latter would lead to an even more pronounced pattern of up- and downward movement; a participant skilled in psi abilities would be characterized by a very volatile result stream, residing above but also below chance.

Single-case studies are currently carried out and might provide an answer. Finally, the cessation of the decline should be addressed. Will the original effect reappear and if so, at what point and to what degree? Another high-powered study is currently performed and might provide some indication towards these questions.

A final aspect to consider in future research is the definition of meaningful events that are able to elicit induced correlations. Although many micro-PK experiments have focused on deliberate and intentional tasks, there are ideas and empirical data for nonintentional responses as well (e.g. Schmidt, 1974). One example is Stanford's (1974) psi-mediated instrumental response model, which emphasizes the need-relevance of these responses and proposes the occurrence of spontaneous and subconsciously motivated psi effects. This mechanism resembles the impact of implicit core beliefs and a further assessment of the strength and direction of an effect provoked by these inner states could be fruitful. Research questions that could be addressed include the qualities of needs or beliefs, which elicit the strongest psi effects and the direction of these effects. As paper 1 made clear (smokers saw *less* cigarette-pictures) the direction is not a direct consequence of our needs but is mediated through subconscious processes (deficit-oriented needs lead to an anxious attitude) and probably is translated through emotions (fear of not having enough nicotine). This relationship is based on the communication between the conscious self and the (at least partially) unconscious system that can interact with the rest of the system. A meaningful and therefore efficacious communication is most likely characterized by an emotional connotation.

Several implications can be derived from these findings. It seems, man does indeed forge his own destiny, at least to a certain extent. We do not only construct our experience and perception of reality through subjective processes but influence the physical world we live in indirectly through our state of mind. These findings contradict a physicalist world view and the causal closure of the physical. Nevertheless, we are not experiencing an all-encompassing power of the mind in our day-to-day lives but an elusive effect that is difficult to pin down. In an empirical setting this is apparent in the difficulties reproducing study results, a consequence of an often observed decline of the effect. Can this psychogenic influence still be used to improve one's life? Firstly, the findings emphasize the importance of a healthy and beneficial self-concept. A positive and optimistic attitude will increase the likelihood of positive experiences – within the limitations mentioned above. It is crucial though, that these beliefs work on an unconscious implicit level and are phrased efficaciously. Deficit-oriented 'craving' implies a lack and will lead to a further shortage of the needed content. Instead, a blissful and deserving 'wishing' for something congruent to one's already established self-concept should prove more expedient. Psychological trainings that address establishing contact to one's unconscious desires and beliefs and articulate them in a beneficial way could be of support. An alternative could be constituted by a more mechanical activation of specific implicit content, e.g. via priming of the desired states (see Maier, Dechamps, & Pflitsch, 2019). Finally, there might be ways to transfer the subconscious access to the manifold unus mundus or implicate order into our explicit system. This would be similar to a training of intuition and consist of ways to improve one's sensitivity towards the (quantum) possibilities being hold and acting accordingly. Research focusing on anomalous cognition like precognition (Bem et al., 2015; Honorton & Ferrari, 1989; Storm, Tressoldi, & Di Risio, 2012), presentiment (Mossbridge, Tressoldi, & Utts, 2012), Ganzfeld (Storm, Tressoldi, & Di Risio, 2010) or remote viewing (Dunne & Jahn, 2003; Milton, 1997) provide promising indications to this approach. A process that describes how this explication could work can be found in Mensky (2011).

As has become clear, consequences and implications of mind-matter interactions are far-reaching not only for physical and philosophical principles, but also for the way we are living our day-to-day lives. Researchers in this field must therefore place a great deal of emphasis on methodically clean and dogma-free research. This procedure is regularly put to the test by the difficulties of reproducibility that seem to be incompatible with basic research principles. By showing alternative evaluation possibilities that not only include, but also focus on the reasons behind these difficulties, this dissertation hopefully can provide an approach to get to the bottom of this profound topic nonetheless. The methods presented here and an interdisciplinary approach might be the way to move beyond the 'pre-scientific stage' regarding the workings of mind and matter in Pauli's time:

> Die finale Betrachtungsweise muss in der Produktion der 'Hintergrundphysik' durch das Unbewusste des modernen Menschen eine Zielrichtung auf eine künftige, Physis und Psyche einheitlich umfassende Naturbeschreibung erblicken, von der wir heute aber nur eine vorwissenschaftliche Stufe erleben. […] Ich [werde] versuchen, zu erläutern, wie ein Physiker als Folge dieses Begriffes von diesem Hintergrund aus notwendig in die Psychologie gerät. Da ich Physik und Psychologie als komplementäre Untersuchungsrichtungen betrachte, bin ich sicher, dass ein völlig gleichberechtigter Weg existiert, der den Psychologen […] in die Physik führen muss. (Pauli, 1992, p. 177)

References

Bem, D., Tressoldi, P., Rabeyron, T., & Duggan, M. (2016). Feeling the future: A meta-analysis of 90 experiments on the anomalous anticipation of random future events. *F1000Research*, *4*, 1188. doi:10.12688/f1000research.7177.2

Bierman, D. J. (2001). On the nature of anomalous phenomena: Another reality between the world of subjective consciousness and the objective world of physics. In P. Van Loocke (Ed.). *The Physical Nature of Consciousness* (pp. 269–292). Amsterdam: John Benjamins.

Cardeña, E. (2018). The Experimental Evidence for Parapsychological Phenomena: A Review. *American Psychologist*. doi:10.1037/amp0000236

Cramer, J. G. (1986). The transactional interpretation of quantum mechanics. *Reviews of Modern Physics*, *58*(3), 647-687.

Dunne, B. J., & Jahn, R. G. (2003). Information and uncertainty in remote perception research. *Journal of Scientific Exploration, 17*, 217–241.

Eisenbud, J. (1992). *Parapsychology and the Unconscious* (revised edition). Berkeley, CA: North Atlantic Books.

Fuchs, C. A. (2014). Introducing QBism. *New Directions in the Philosophy of Science*, *5*, 385-402.

Honorton, C., & Ferrari, D. C. (1989). “Future telling”: A meta-analysis of forced-choice precognition experiments, 1935–1987. *Journal of Parapsychology, 53,* 281–308.

Jakob, M.-J., Dechamps, M. C., & Maier, M. A. (2019). *You get what you are: The Effect of Unconscious Needs on Micro-Psychokinesis.* Manuscript submitted for publication.

Kastrup, B. (2018). The universe in consciousness. *Journal of Consciousness Studies*, *25*(5-6), 125-155.

von Lucadou, W. (2015): The Model of Pragmatic Information (MPI). In E. C. May & S. Marwaha (Eds.). *Extrasensory Perception: Support, Skepticism, and Science: Vol. 2: Theories and the Future of the Field* (pp. 221-242). Santa Barbara, CA: Praeger Publications.

Maier, M. A., Dechamps, M. C., & Pflitsch, M. (2019). *Correlations between Quantum States Reductions and Conscious States of an Observer*. Manuscript in preparation.

Maier, M. A., Dechamps, M. C., & Schiepek, G. (2019). Reply to Grote H. (2018). Commentary: Intentional Observer Effects on Quantum Randomness: A Bayesian Analysis Reveals Evidence Against Micro-Psychokinesis. Manuscript submitted for publication.

Mensky, M. (2011). Mathematical Models of Subjective Preferences in Quantum Concept of Consciousness. *NeuroQuantology, 9*(4). doi:10.14704/nq.2011.9.4.488

Mensky, M. B. (2013). Everett Interpretation and Quantum Concept of Consciousness. *NeuroQuantology, 11*(1), 85–96.

Millar, B. (2015). Quantum theory and parapsychology. In E. Cardeña, J. Palmer, & D. Marcusson-Clavertz (Eds.), *Parapsychology: A handbook for the 21st century* (pp. 165-180). Jefferson, NC, US: McFarland & Co.

Milton, J. (1997). Meta-analysis of free-response ESP studies without altered states of consciousness. *Journal of Parapsychology, 61,* 279–319.

Mossbridge, J., Tressoldi, P., & Utts, J. (2012). Predictive physiological anticipation preceding seemingly unpredictable stimuli: A metaanalysis. *Frontiers in Psychology, 3,* 390. doi:10.3389/fpsyg.2012.00390

Penrose, R., & Hameroff, S. (2011). Consciousness in the universe: Neuroscience, quantum space-time geometry and Orch OR theory. *Journal of Cosmology, 14,* 1–17.

Schmidt, H. (1974). Comparison of PK action on two different random number generators. *Journal of Parapsychology, 38*(1), 47–55.

Stanford, R. G. (1974). An experimentally testable model for spontaneous psi events: I. Extrasensory events. *Journal of the American Society for Psychical Research, 68*(1), 34-57.

Stapp, H. P. (2017). *Quantum Theory and Free Will.* New York: Springer.

Storm, L., Tressoldi, P. E., & Di Risio, L. (2010). Meta-analysis of free-response studies, 1992–2008: Assessing the noise reduction model in parapsychology. *Psychological Bulletin, 136,* 471– 485. doi:10.1037/a0019457

Storm, L., Tressoldi, P. E., & Di Risio, L. (2012). Meta-analysis of ESP studies, 1987–2010: Assessing the success of the forced-choice design in parapsychology. *Journal of Parapsychology, 76,* 243–273.

Walker, E. H. (1975). Foundations of Paraphysical and Parapsychological Phenomena. In L. Oteri (Ed.) *Quantum Physics and Parapsychology.* New York, NY: Parapsychology Foundation.

Walker, E. H. (2000). *The Physics of Consciousness.* Cambridge: Perseus.

6. Zusammenfassung

Der Titel der Arbeit lautet zu Deutsch *Geist-Materie-Interaktionen und ihre Reproduzierbarkeit*. Der Kern von Geist und Materie und das Wesen ihrer Verbindung sind Themen, die Wissenschaftler aus unterschiedlichsten Disziplinen seit Jahrhunderten beschäftigen und immer wieder vor Rätsel stellen. Während unserer naiven Alltagserfahrung am ehesten das Bild des kartesischen Dualismus entspricht, also der Idee, dass alles Geistige und alles Materielle komplett getrennte Sphären darstellen, die in wechselseitiger Beziehung stehen, herrscht in der modernen Naturwissenschaft vorrangig das Bild eines Physikalismus. Diese metaphysische Position erklärt alle natürlichen Vorgänge, also auch Geistiges, durch physische Prozesse, stößt aber an einigen Punkten, speziell bei der Erklärung des Bewusstseins, an ihre Grenzen (Atmanspacher, 2014). Dementsprechend haben sich alternative Betrachtungsweisen entwickelt, unter ihnen die Zwei-Seiten-Lehre *(dual-aspect theory)*, welche Geist und Materie als zwei Aspekte einer zugrundeliegenden Substanz betrachten. Neben dem Quantenphysiker David Bohm (2000) entwickelten auch C. G. Jung und Wolfgang Pauli einen entsprechenden Ansatz, in welchem diese Substanz *unus mundus* genannt wird. Diese „eine Welt" ist nicht bewusst zugänglich, sondern drückt sich nach einer epistemischen Spaltung in einer (bewussten) mentalen und einer physikalischen Facette aus, welche nicht nur strukturell korreliert also parallel sind, sondern jeweils auch die unus mundus und damit ihr Gegenstück durch eine sogenannte *induzierte Korrelation* beeinflussen können. Die Autoren erklären damit das Auftreten von Synchronizitäten, also inhaltlich aber nicht kausal verbundenen Korrelationen, welche sporadisch auftreten und nicht reproduzierbar sind (Atmanspacher, 2012). Eine entsprechende nicht-lokale Verbindung von physikalischen Systemen ist aus der Quantenmechanik als Verschränkung bekannt, demzufolge versuchen sich weiterführende Theorien wie etwa die *Generalisierte Quantentheorie* (Atmanspacher, Römer, & Walach, 2002) mit einer Erklärung außergewöhnlicher Korrelationen zwischen Geist und Materie mit Hilfe von quantentheoretischen Prinzipien (Walach, von Lucadou, & Römer, 2014)

Die epistemische Spaltung kann demzufolge auf physikalischer Seite mit der quantenmechanischen Messung gleichgesetzt werden, in welcher nach statistischen Prinzipien ein Zustand aus einer Überlagerung von Möglichkeiten klassisch real wird. Verschiedene Interpretationen der Quantenmechanik liefern dabei unterschiedliche Ideen, was diesen Prozess konkret ausmacht und bedingt. Für einige Physiker ist die Messung gleichbedeutend mit einer bewussten Wahrnehmung (z.B. von Neumann, 1932; Wigner, 1963), manche gehen noch darüber hinaus und haben quantentheoretische Bewusstseinsmodelle formuliert (Mensky, 2013; Penrose & Hameroff, 2011; Stapp, 2015); der Übergang von Unbewusst zu Bewusst wäre somit nicht mehr nur parallel dem Übergang von Quantenzustand zu klassischem Zustand, sie wären auch intrinsisch miteinander verbunden. Theorien wie die Transaktionale Interpretation (Cramer, 1986) oder QBism (Fuchs, Mermin, & Schack, 2014) sprechen dem

Messsubjekt – in diesem Falle also dem bewussten Beobachter – dabei eine aktive Rolle zu. Die Wahrscheinlichkeitsverteilung des Quantenzustands könnte auf diese Weise subjektiver interpretiert werden als in der orthodoxen Quantenmechanik und von (impliziten) mentalen Prozessen des Beobachters, wie etwa dessen Erwartungen oder Vorerfahrungen, abhängen. Eine Veränderlichkeit des eigentlich unumstößlichen Quantenzufalls und somit die Grundlage für nicht-lokale Korrelationen auch zwischen geistigen und physischen Systemen wäre somit erklärbar – sofern ein bedeutungsvoller Zusammenhang zum Messobjekt bzw. dessen Konsequenzen besteht.

Empirische Forschung zu Geist-Materie-Interaktionen wird unter dem Stichwort *Mikropsychokinese* systematisch seit etwa den 1940er Jahren unternommen. In der Regel wird hierbei ein mentaler Einfluss auf Zufallssysteme, wie Würfel oder später (quantenbasierte) Zufallsgeneratoren untersucht (Varvoglis & Bancel, 2015). Metaanalysen der letzten Jahre fassen hunderte von Experimente zusammen und konstatieren einen kleinen, aber signifikanten Effekt (Bösch, Steinkamp, & Boller, 2006; siehe auch Cardeña, 2018). Nichtsdestotrotz scheitern hochqualitative Replikationsstudien immer wieder an der Reproduktion eines Effekts (z.B. Jahn et al., 2000). Einige Autoren sehen den Grund dafür in einer prinzipiellen Unvereinbarkeit eines Mikro-PK-Effektes mit grundlegenden Axiomen der Physik. So verbietet das No-Comunication-Theorem der Quantenmechanik, dass Messungen an verschränkten Teilsystemen zur Informationsübermittlung verwendet werden können. Eine psychogene Beeinflussung der Wellenfunktion eines Quantensystems würde dies aber ebenso ermöglichen, wie eine Abnahme der Entropie des Systems bedeuten, da von einem zufälligen, also chaotischen Zustand in einen nicht-zufälligen also geordneten Zustand übergegangen wird. Ohne Zugabe von Energie verstöße dieser Vorgang gegen den zweiten Hauptsatz der Thermodynamik. Pauli und Jung sowie die Autoren aufbauender Theorien schließen daraus, dass Geist-Materie-Interaktionen zwangsweise unsystematisch und unreproduzierbar sein müssen (Atmanspacher, 2012, Walach, von Lucadou, & Römer, 2014).

In mehreren Experimenten, die in insgesamt drei Fachartikeln zusammengefasst sind, haben wir die Plausibilität von Geist-Materie-Interaktionen untersucht und uns mit deren Reproduzierbarkeit auseinandergesetzt. Dazu haben wir uns mikropsychokinetischer Forschungsparadigmen bedient und Versuchspersonen mit potentiell bedeutungsvollen und unbewusst wirksamen Inhalten konfrontiert, über deren Auftreten oder Nichtauftreten das Ergebnis eines quantenbasierten Zufallsgenerators entschied. Der erste Artikel (Maier & Dechamps, 2018) umfasst zwei Studien, in denen Raucher und Nichtraucher eine Reihe von Bildern betrachteten, die entweder dem impliziten Suchtmotiv entsprachen („Raucherbilder“) oder diesem gegenüber neutral waren („neutrale Bilder“). Wir formulierten die Hypothese, dass bei Nichtrauchern eine im Mittel nicht vom Zufall unterschiedliche Anzahl von 50% Raucherbildern gezeigt würden, während Raucher durch die Bedeutung der Inhalte für sie einen unbewussten Einfluss auf den Zufallsgenerator ausüben würden, der sich in einem nichtzufälligen Mengenverhältnis ausdrückt. Die Abweichung vom Erwartungswert wurde mit Hilfe eines Bayesianischen Einstichproben-t-Test analysiert. Der in dieser Analyse resultierende Bayesfaktor *BF* gibt die Evidenz oder Überzeugung für oder gegen diesen Effekt an und berechnet sich aus dem Verhältnis der Wahrscheinlichkeiten, dass die Daten unter der Null- bzw. unter der Alternativhypothese entstanden sind. In der ersten Studie verzeichneten 132 Nichtraucher durchschnittlich 50.13% Raucherbilder, was einem $BF = 6.13$ in Richtung H_0 entspricht. Die 122 getesteten Raucher zeigten hingegen lediglich 49,18% Raucherbilder, eine Abweichung vom erwarteten Wert, die einem $BF = 66.06$ in Richtung H_1 entspricht. Es kann von einer sehr starken Beweiskraft für das Vorhandensein eines nichtzufälligen Effekts gesprochen werden (nämlich 66x so groß wie die Beweiskraft für einen Nulleffekt). Nach diesem vielversprechenden Ergebnis wurde eine präregistrierte Replikationsstudie mit einer diesmal gerichteten Hypothese („Raucher sehen *weniger* Raucherbilder") durchgeführt. 220 Nichtraucher zeigten ein ähnliches nicht vom Zufall unterschiedenes Bild ($M = 49.75\%$, $BF_{01} = 3.37$) wie zuvor, die 175 Raucher konnten mit 50.07% und einem $BF_{10} = 0.09$ jedoch nicht die Ergebnisse der ersten Studie reproduzieren.

Obwohl sich der Effekt nicht replizieren ließ, zeigte eine sequentielle Verlaufsanalyse der Daten eine starke Veränderung der Beweiskraft über die Zeit in der Raucherstichprobe, nicht jedoch bei den Nichtrauchern. Diese Beobachtung ist zwar mit Vorhersagen aus oben genannten Modellen vereinbar, die einen Informationsaustausch über nicht-lokale Korrelationen ausschließen, die außergewöhnliche Verlaufskurve lässt aber auch Vermutungen über eine Systematik innerhalb des offenkundigen Wechselspiels aus Zu- und Abnahme des Effekts zu. Sollte die fehlgeschlagene Replikation Folge eines temporären entropiezuführenden Gegenmechanismus sein, ließe sich eine Regelmäßigkeit in den Effektbewegungen über die Zeit feststellen. Der Effekt könnte nach Wiederherstellung des Zufalls erneut auftreten, ab einer gewissen Stärke wieder abfallen, etc. Das daraus resultierende Muster sollte der generellen Form einer gedämpften harmonischen Schwingung entsprechen. Eine entsprechende Annäherung an die kumulierte *z*-Transformation der Daten wurde berechnet und diente als Vorhersage für den künftigen Effektverlauf.

Artikel 2 (Maier, Dechamps, & Pflitsch, 2018) beschreibt ein weiteres Mikro-PK-Paradigma, welches online mit einer sehr großen Stichprobe Anwendung fand. In diesem präregistrierten Design steht ein allgemeinpsychologisches implizites Motiv im Mittelpunkt, das (fast) allen Menschen eigen ist, nämlich die Annäherung an positive und die Vermeidung von negativen Zuständen. Durch dieses generalisierte Motiv, das eine Vergleichsstichprobe überflüssig macht, konnte das Auftreten und der Verlauf des Effekts mit einer außerordentlich hohen Power getestet werden. Den 12 571 Versuchspersonen aus drei Ländern wurden hierbei in Abhängigkeit von einem über das Internet verbundenen Zufallsgenerator entweder positive

Bilder und harmonische Klänge oder negative Bilder und disharmonische Klänge präsentiert. Zuvor absolvierten sie eine Entspannungsübung, mit dem Ziel einer optimistischen und entkrampften Grundhaltung. Die Hypothese bestand in einer den Zufallsgenerator beeinflussenden Geist-Materie-Interaktion, welche zu mehr positiven Erlebnissen für die Probanden führen sollte. Das Endergebnis deutet mit 50.02% positiven Inhalten und einem BF = 10.07 in Richtung H_0 zwar auf keinen konsistenten Effekt hin, dennoch offenbart die sequentielle Verlaufsdiagnostik erneut ein auffälliges, durch Schwingung gekennzeichnetes Muster der Beweiskraft des Effekts. Dieser Eindruck wird durch den Vergleich der hochfrequenten an den Datenverlauf angepassten gedämpften harmonischen Schwingung zu einer niederfrequenten simulierten Vergleichskurve untermauert. Die Ergebnisse bekräftigen die Idee, dass der gesuchte Effekt sich womöglich eher durch systematische Variation als durch aussagekräftige Endergebnisse auszudrücken scheint.

Im dritten Artikel (Dechamps & Maier, 2019) wird schließlich die Hypothese überprüft, ob eine Vorhersage des Effektverlaufs anhand der abgeleiteten Schwingungsfunktion möglich ist. Zu diesem Zweck wurde die in Artikel 1 berechnete harmonische Oszillation des Rauchereffekts interpoliert und als Vorhersage für den Verlauf des kumulativen z-Werts für 203 neue Versuchspersonen verwendet, welche das gleiche Experiment wie in den ersten beiden Studien durchliefen. Die Passung der Vorhersage zum tatsächlichen Experimentaldatenverlauf wurde anhand verschiedener Prüfgrößen ermittelt und in Beziehung zu 10 000 simulierten Datensätzen gestellt. Hierbei zeigte sich ein gemischtes Bild; die Fläche zwischen den Kurven, sowie der Wendepunkt wurden von etwa 1/5 der Simulationen besser beschrieben, der Endpunkt von etwa 5%, was insgesamt einem nicht signifikant treffenden Ergebnis entspricht, zu einem gewissen Grad aber der fehlenden Ausgeprägtheit der Vorhersage geschuldet ist: durch ihren unmarkanten Verlauf ist sie auch für Zufallssimulationen leicht zu treffen gewesen.

Explorative Analysen aller 500 Raucher aus Artikeln 1 und 3 weisen wiederum auf einen Verlauf der Beweiskraft für den Effekt hin, der sich zwar nicht gänzlich überzeugend mit der Schwingungsfunktion vorhersagen ließ, sich in unterschiedlichen Analyseverfahren aber durchgängig signifikant von erneut durchgeführten 10 000 Simulationen unterscheiden ließ. So zeigten nur 0.21% der Simulationen einen höheren BF im Verlauf als der Experimentaldatensatz von BF_{10} = 421.22. Nur 0.15% der Simulationen zeigten eine höhere Energie der sequentiellen BF-Kurve, also die Fläche zwischen ihr und dem Grenzwert bei BF = 1, wobei Flächen unter dieser Grenze von den Flächen oberhalb abgezogen werden. Zu guter Letzt offenbarte eine Frequenzspektrumanalyse mit einer Fast-Fourier-Transformation eine außerordentlich starke Periodizität der Verlaufskurve, was durch Amplituden höher als 99% der Simulationen in allen Frequenzen ersichtlich wird.

Insgesamt deuten die Ergebnisse der hier präsentierten Studien auf das Vorhandensein eines unkonsistenten mikropsychokinetischen Effekts und damit einer Geist-Materie-

Interaktion hin. Die Abnahme des zunächst feststellbaren Effekts lässt sich durch die oben beschriebenen physikalischen Zusammenhänge oder auch durch psychologische Mechanismen erklären. So könnten die ursächlich wirkenden impliziten Überzeugungen (Mangel an Nikotin / entspannter Optimismus) ab einem gewissen Punkt durch den stärker werdenden Wunsch in einer widerspruchsfreien, Gesetzmäßigkeiten befolgenden Welt zu leben, ersetzt werden (Eisenbud, 1992). Im Gegensatz zum Postulat, dass ein solcher Effekt durch diese erzwungene Abnahme *(Nemesis-Effekt)* prinzipiell unreplizierbar und untestbar ist, legen die Daten der Studien eine Systematik im zeitlichen Verlauf der Beweisstärke nahe. Die hier dargestellten neuen Methoden scheinen sich sehr gut zu eignen, diese Systematik aufzuzeigen und könnten dementsprechend einen wertvollen Beitrag in der zukünftigen Erforschung des Zusammenspiels von Geist und Materie liefern.

Quellen

Atmanspacher, H. (2012). Dual-aspect monism à la Pauli and Jung. *Journal of Consciousness Studies, 19*(9-10), 96-120.

Atmanspacher, H. (2014). 20th century variants of dual-aspect thinking. *Mind and Matter*, *12*(2), 245-288.

Atmanspacher, H., Römer, H., & Walach, H. (2002). Weak quantum theory: Complementarity and entanglement in physics and beyond. *Foundations of Physics*, *32*(3), 379–406.

Bösch, H., Steinkamp, F., & Boller, E. (2006). Examining psychokinesis: The interaction of human intention with random number generators—A meta-analysis. *Psychological Bulletin, 132,* 497–523. doi:10.1037/0033-2909.132.4.497

Bohm, D. (2000). *Wholeness and the Implicate Order*. New York: Routledge.

Cardeña, E. (2018). The Experimental Evidence for Parapsychological Phenomena: A Review. *American Psychologist*. doi:10.1037/amp0000236

Cramer, J. G. (1986). The transactional interpretation of quantum mechanics. *Reviews of Modern Physics*, *58*(3), 647-687.

Dechamps, M. C., & Maier, M. A. (2019). How Smokers Change Their World and How the World Responds: Testing the Oscillatory Nature of Micro-Psychokinetic Observer Effects on Addiction-Related Stimuli. *Journal of Scientific Exploration, 33*(3), 406-434. doi:10.31275/2019/1513

Eisenbud, J. (1992). *Parapsychology and the Unconscious* (revised edition). Berkeley, CA: North Atlantic Books.

Fuchs, C. A., Mermin, N. D., & Schack, R. (2014). An introduction to QBism with an application to the locality of quantum mechanics. *American Journal of Physics*, *82*(8), 749-754.

Jahn, R., Dunne, B., Bradish, G., Dobyns, Y., Lettieri, A., Nelson, R., Mischo, J., Boller, E., Bösch, H., Vaitl, D., Houtkooper, J., & Walter, W. (2000). Mind/machine interaction consortium: PortREG replication experiments. *Journal of Scientific Exploration, 14*(4), 499–555.

Maier, M. A., & Dechamps, M. C. (2018). Observer Effects on Quantum Randomness: Testing Micro-Psychokinetic Effects of Smokers on Addiction-related Stimuli. *Journal of Scientific Exploration, 32*(2), 265-297. doi:10.31275/2018.1250

Maier, M. A., Dechamps, M. C., & Pflitsch, M. (2018). Intentional Observer Effects on Quantum Randomness: A Bayesian Analysis Reveals Evidence Against Micro-Psychokinesis. *Frontiers in Psychology, 9*, 379. doi:10.3389/fpsyg.2018.00379

Mensky, M. B. (2013). Everett Interpretation and Quantum Concept of Consciousness. *NeuroQuantology, 11*(1), 85–96.

von Neumann, J. (1932). *Mathematische Grundlagen der Quantenmechanik*. Berlin: Julius Springer.

Penrose, R., & Hameroff, S. (2011). Consciousness in the universe: Neuroscience, quantum space-time geometry and Orch OR theory. *Journal of Cosmology, 14*, 1–17.

Stapp, H. P. (2015). A Quantum–Mechanical Theory of the Mind–Brain Connection. In E. F. Kelly et al. *Beyond Physicalism* (pp. 157–193). Lanham: Rowman and Littlefield.

Varvoglis, M., & Bancel, P. A. (2015). Micro-Psychokinesis. In E. Cardeña, J. Palmer, & D. Marcusson-Clavertz (Eds.). *Parapsychology: A Handbook for the 21st Century* (pp. 266–281). Jefferson NC: McFarland.

Walach, H., von Lucadou, W., & Römer, H. (2014). Parapsychological phenomena as examples of generalized nonlocal correlations—A theoretical framework. *Journal of Scientific Exploration, 28*(4), 605–631.

Wigner, E. P. (1963). The problem of measurement. *American Journal of Physics, 31*(1), 6 – 15.