# MIND-MATTER INTERACTIONS – ON THE ROLLERCOASTER FROM DATA TO THEORY AND BACK AGAIN

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## Abstract

Since the foundation of the Society for Psychical Research in 1882, the question whether mind could directly interact with matter without the aid of an intermediate causal chain of action was deemed decisive. It would speak for a world-view that allows for consciousness as a unique entity, not only as derived from matter. It is therefore not surprising that this question stood in the center of theory, empirical observations and experiments in parapsychology ever since. The database of the Princeton Engineering Anomalies Research (PEAR) Lab that focused on this question has therefore been a pillar of this strand of research. It started to shake with the large, unsuccessful, multisite replication of Jahn et al (2000) and the Bösch, Steinkamp & Boller (2006) meta-analysis of those data. Theorising by Walter von Lucadou already in the 90ies and followed up by von Lucadou, Walach & Römer in 2007 actually predicted the very sequence and patterning observed in these data. This theory assumes that mind-matter-interactions are generalised types of non-local entanglement correlations between physical and mental systems. Therefore, they are not to be treated as classical causal couplings, else time-reversal paradoxes would ensue. If treated as such they either need to break down or they shift direction. Following this reasoning, Walter von Lucadou introduced a different type of experiment with a meta-experimental approach. In such an approach no direct experimental evidence is attempted but only an indirect one. Here, non-local correlations are captured via a correlation-matrix, where a purported entanglement between mental and physical system becomes obvious in a set of variables producing a

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correlation matrix. The prediction, across experiments, then, is that the absolute number of significant correlations will be significantly above what is expected by chance, but that the actual cells that display significant correlations will shift unpredictably across experiments. Thereby the system maintains its general type of correlated state but the correlations cannot be used to code causal signals, observing the postulated boundary conditions. In this chapter I sketch the theoretical situation, illustrated by data from the Bösch, Steinkamp & Boller (2006) data-set, as well as von Lucadou's original data and our recent replication.

## Introduction

### *The Historical Heritage of Parapsychology*

The rise of the natural-science model in the 17th and 18th century was accompanied with a double movement: The scientific enthusiasts were sure that the analytical method of physics and chemistry, together with mathematical modeling will eventually allow science to understand and explain all natural phenomena and to reduce those phenomena that were not seen as pertaining to the domain of science ultimately to natural and scientifically explainable phenomena. Lightning, for example, long understood as of divine origin, was explainable as electric discharge. And so scientific enthusiasm was soaring high in the 19th century, extending its wings to such phenomena as consciousness and the mind. Prototypical is the famous letter that Emil du Bois Reymond (1818-1896), famous professor of physiology at the Charité in Berlin wrote to his friend (Du Bois-Reymond, 1918)[1]: "Brükke and myself, we have conspired to make known the truth that in our organism there are only physical-chemical forces at work. And where those are not sufficient for explaining phenomena we will have to look for such forces, using the mathematical-chemical method, in their concrete mode of action. Or else we have to

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[1] p. 108, translation mine; original quote: "Brücke und ich, wir haben uns verschworen, die Wahrheit geltend zu machen, dass im Organismus keine anderen Kräfte wirksam sind, als die gemeinen physikalisch-chemischen; dass, wo diese bislang nicht zur Erklärung ausreichen, mittels der physikalisch-mathematischen Methode entweder nach ihrer Art und Weise der Wirksamkeit im konkreten Falle gesucht werden muss, oder dass neue Kräfte angenommen werden müssen, welche, von gleicher Dignität mit den physikalisch-chemischen, der Materie inhärent, stets auf nur abstossende oder anziehende Componenten zurückzuführen sind."

assume other types of forces, which, however, are similar to the chemical-physical ones, inherent in matter, and can always be reduced to attractive and repulsive forces." What du Bois-Reymond describes here is the first known testimony of natural science researchers to attempt to reduce mental and physiological phenomena purely to material interactions and physical-chemical forces, or similar ones. He wrote this letter in his youthful years of studies, when he distanced himself from his teacher Johannes Müller, in 1839, when he began studying medicine together with Brücke, Freud's future teacher of physiology. Only 33 years later, in 1872, when he was well known and well reputed, he gave his memorable speech in Leipzig before the Society of Natural Researchers, where he took back his bold statement of youthful times and proclaimed his famous "ignoramus et ignorabimus": we do not know the nature of the mind and we will never know.

However, this personal turn of du Bois-Reymond remained an individual retraction of an older researcher. Science as a collective movement took up not only the sentiment of the young researcher but made it a program, quietly and implicitly assuming: Mind and conscious experience will ultimately be explainable in terms of material and chemical interactions. Modern day neuroscience is predicated on such sentiments and thus, this materialist stance, expressed by du Bois-Reymond in the heydays of scientific optimism, is well and alive, perhaps more so than ever (Churchland, 1986; Dennett, 1991; Edelman & Tononi, 2001; Metzinger, 2003; Tononi, 2004). Thereby, the Cartesian program of mechanising nature has finally reached its consummation by mechanising what Descartes saw as ultimately different, the mind, which in modern theories is also seen as a very complex material system that can be understood as a series of computations produced by the chemico-electrical activities of neurons.

Already in the early days of scientific enthusiasm in the 19th century a counter movement was formed by those researchers that were not satisfied with the common stance of implicit materialistic analysis of all natural events, even the mind and consciousness. The foundation of the Society of Psychical Research in the UK in 1882 was such a clear counter-movement

(Society for Psychical Research, 1882)[2]. Here, researchers gathered that tried to empirically counter the materialist dominant model by providing empirical evidence for the fact that minds actually can influence matter directly, or that mental events happen outside or independent of a body. Therefore they studied mediumistic phenomena and gathered spiritualist accounts. The goal was clear: to prove scientifically that the mind can influence matter directly, and hence is an independent, irreducible entity. Thus, the long history of parapsychological research can, in a way, be seen as a tradition of research demonstrating independent influences of consciousness in our physical world, and by the same token of causal and ontological independence of consciousness. Thus, the long tradition of mind-matter-interaction research has to be seen against this background. Slowly, it matured from naturalistic case series and collections of well documented anecdotes and observations to experimental studies in the laboratory. Initiated by J.B. Rhine of Duke University, others followed suit and by the end of the last millenium most academic parapsychological research, in as much as it existed, was experimental laboratory work.

### *The Implicit Assumptions of the Experimental Paradigm and the Problem of Absolute Presuppositions*

By adopting the experimental stance, parapsychologists also adopted the implicit presuppositions underlying it. One of the most important philosophical insights of the 1930ies and 40ies with multiple and independent sources can be summed up as follows:

*Any system, whether formal or of a natural language, must, by necessity, make assumptions or stipulate presuppositions that cannot be again vindicated by the system itself.*

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[2] "It has been widely felt that the present is an opportune time for making an organised and systematic attempt to investigate that large group of debatable phenomena designated by such terms as mesmeric, psychical and Spiritualistic. From the recorded testimony of many competent witnesses, past and present, including observations recently made by scientific men of eminence in various countries, there appears to be, amidst much illusion and deception, an important body of remarkable phenomena, which are primâ facie inexplicable on any generally recognised hypothesis, and which, if incontestably established, would be of the highest possible value (The SPR, 1882, S. 3)."

This structure of the necessary self-referentiality of theoretical systems has been observed and proven true by Gödel for mathematics (Gödel, 1931), by Wittgenstein for language as such - and then admitted by Carnap for all scientific theoretical models - (Wittgenstein, 1958, orig. 1953) and by Collingwood for any theoretical-philosophical system (Collingwood, 1998, orig. 1940). Collingwood coined the term absolute presuppositions for such assumptions that are necessary for a system to be operative, but rarely reflected upon, discussed or made explicit. This terminology was later adapted by Thomas Kuhn into what he termed "paradigm" (Kuhn, 1955): an implicit working model of scientific operations, including a set of accepted methods and standards, assumptions and truisms that are taken for granted, predicated on a world model that is assumed to be true until a new model is stipulated that overthrows in a paradigmatic revolution this old paradigm. Independent of the theoretical leaning one wishes to adopt, the structure is always the same: we have to make assumptions and stipulate presuppositions in order for any scientific model to work.

The presuppositions made by the "scientific" model are rarely explicitly discussed and very often taken for granted by those "doing science". Among them are the following:

- The assumption that systems can be analytically separated and studied in isolation. What we learn from those separated systems can be then put together to a mosaic of the whole: the analytical assumption.
- The assumption that the most important and the relevant section of the world is described by material and energetic interactions: the materialist assumption.
- The assumption that all causes are local and regular; they are mediated by contiguous contact and interaction of material particles that convey the energetic interaction, and by the same token that causes from a distance have to be and can be analysed in terms of local chains of particle interactions: the localist assumption.
- The assumption that the world is regular, at least those parts of the world that are relevant for us. Stretches in time and in space are uniform: the regularity assumption.

This is neither a comprehensive nor an exclusive list, but sums up what to me are the most problematic assumptions of the currently accepted model when it comes to the understanding of mind-matter-interactions. By doing experiments in the framework of science, parapsychology subscribed to these assumptions, probably unwittingly and also involuntarily. Every psychokinesis (PK) experiment that tries to document a direct influence of mental events on material events assumes that there is some sort of "influence" that is mediated by some sort of agent – a "PK force", some sort of radiation or similar regular influence –, can be enacted and replicated by others and documented by stringent experimentation.

Since conventional science is often also fraught with sources of errors and mistakes, it has become part of the standard procedure to not only do an experiment, but to repeat it, ideally by different experimenters and in different locations or under different circumstances to probe for causal stability and generalisability (Schmidt, 2009). Thus, part and parcel of the scientific protocol is a replication of experiments and the postulate of independent replicability of results. Even though this ideal is often not met, even within mainstream science, it is being raised as a standard, whenever unconventional challenges are voiced (Sheldrake, 1998a, 1998b, 2013).

Parapsychologists adopted this model and have tried to conform to it. Thus, they conceived of mind-matter-interactions in terms of field-models of consciousness where consciousness fields interact with material fields in regular but as yet unknown ways (Jahn & Dunne, 1987, 2001; Radin, 1997a). World models, however, have, in general, at least two functions: They guide our attention and teach us, what to expect. More importantly, perhaps, they also tell us what to implicitly ignore. Thus they shape what we are able to perceive in a very concrete way. This is certainly useful to some extent, as it helps us reduce the complexity of the world into a set of useful and workable partitions. But when it comes to science it also hinders our activities, as we are unable to see phenomena that do not fit the expected model. This can actually be reconstructed from the way our brain and our perception works: We are, to some extent, prediction engines (Gray, 1990, 1995). We predict what is to expected and change our world model according to mismatches with this prediction. However, whatever lies completely outside of the predicted range of phenomena will not even be seen, unless it is very salient, very dissonant, or unless the observer is very astute and keen.

A classical historical example for this guiding and structuring role of a world model is the discovery of the heart-beat by William Harvey, physician to the English king, around 1618. Harvey did not believe the standard opinion that was derived from Aristotle's physiology that was slightly edited by Galenos, Celsus and some other authorities in antiquity. This model held that the heart was a convection warmer, warming the blood that was again cooled by the brain. Thus it explained circulation, and there was no place for a pumping heart. Only when Harvey discovered in vivisection experiments in dogs that the heart was actually moving and thus pumping blood he developed the concept of the heart being a pump that propelled the blood through the circulatory system, and hence producing a distinct sound, the heart-beat. When Harvey published this finding, an outcry was heard throughout Europe. One of the spokesmen of medicine and philosophy, the Venetian Emilio Parisano, wrote: "There is no one in Venice who can hear a heart beat" (Parisano, 1647, p 107).

Clearly, mothers would have heard the heart-beat of their children and lovers those of their beloved. But as a phenomenon it was not known and thus, as a scientific fact it did not exist. For a scientific fact is always a phenomenon plus the requisite theory explaining or predicting it. And in that sense the heart-beat was not a fact, nor was it a common phenomenon perceived by the majority of people as such, because there had not been a theory for it.

This example demonstrates how world-models and absolute presuppositions, shape expectations and thus experience, and thus restricts our phenomenal range. What we do not expect by theory, we normally do not perceive, unless we are astute observers that are willing and able to suspend their theories and expectations at least for a certain amount of time.

## The Theoretical and Practical Failure of the Standard Paradigm

PK research is a good example of how the accomodation to an accepted paradigm actually ruins the credibility of the research if it tries to conform to the dominant world-model. This world model assumes that direct influences of mind on matter should be causal, and thus regular and replicable. The PEAR research program and other researchers actually adopted this model and tried to prove such a causal stability and influence (Walach & Jonas, 2007). Initially, it seemed reasonably successful (Jahn & Dunne, 1987, 2001). But the largest ever done independent replication, the consortium replication program in which the labs in Freiburg and Giessen in Germany together with the PEAR-lab in Princeton adopted the protocol of the PEAR lab and created the largest to date database of micro-PK data, was unsuccessful and came out flat negative on the predefined outcome, mean-shift from statistical expectation value (Jahn et al., 2000). Although secondary analyses were able to show that there was some anomalous signature in the data, presenting itself in deviations of the variance (Atmanspacher, Bösch, Boller, Nelson, & Scheingraber, 1999), and in non-linearity parameters (Atmanspacher, Ehm, Scheingraber, & Wiedenmann, 2001; Pallikari, 2001), this failed replication demonstrates that whatever is going on here cannot be conceptualised as a regular, local cause. Thus, in pulling together all the available evidence, Bösch, Boller and Steinkamp concluded that the PK-Effect in those REG-experiments can only be demonstrated statistically, if this large replication study is excluded, or if one operates under the assumption that no small studies with negative outcomes exist which is not a well defensible assumption given the ease with which such experiments can be run once they are set up (Bösch, Steinkamp, & Boller, 2006). Thus, the attempt to demonstrate causal independence and local influence of mind on material systems, using the database which gathered the largest amount of data, failed. Does this mean that PK influences do not exist, or that PK is an illusion, or that there are no direct couplings between mental and physical systems without an interactive mediation?

No, obviously this cannot be concluded from the data, although this is frequently done. What can be concluded is that there is no reason to assume a causal-local model to be operative. But might there be other models? Yes, we think so.

## An Entanglement Model of Generalised Non-Locality

Walter von Lucadou has long held that effects found in parapsychology are examples of non-local correlations between mental and physical systems, in case of PK or clairvoyance, or between mental and mental systems, in case of telepathy or precognition (Kornwachs & Lucadou, 1979, 1985; Lucadou, 1994, 1995, 2001; Lucadou & Kornwachs, 1980). Part and parcel of this theoretical stance is that there is no signal-transfer process between systems, but only correlative parallelisms. And because entanglement correlations are non-local, they cannot be used to transfer signals, and if they are so used, they break down (Lucadou, Römer, & Walach, 2007). And this is the reason, why experiments in parapsychology fail in the long run, and, at the same time, parapsychological effects seem to be quite ubiquitous in lived experience and the real world. This needs some explanation.

Einstein's model of Special Relativity holds that every signal in the universe can maximally travel at the speed of light, i.e. roughly at 300.000 km per second (Reichenbach, 1957). This framework also defines time. For time is laid out by the forward-traveling light cone, as it is called, i.e. light, or other types of radiation, that is radiated out from a source covers an ever wider cone as it travels, and it needs time for the travel. This is why some of the stars in a long distance are actually already gone, when we see their extinguishing light in the supernova explosion, as the light might have taken several million years to travel the distance. Whatever is connected by such light or radiation cones is called "locally connected", i.e. in direct causal relationship. All our scientific causal models presuppose such a causal structure.

Now there is a different structure of non-local relationship known from quantum mechanics (QM)[3]. Schrödinger discovered it in the formalism of QM already in 1935 (Schrödinger, 1935). The discovery was this: QM is formulated in a way that within a quantum system all elements are only jointly clearly defined, and individually only as probability waves. As soon as a measurement takes place, a particular variable is measured to have a certain value. It is unclear which value this will be, but QM predicts the probability to receive a value of this particular magnitude. Now, if we have a conjoint system, the system is only defined as a whole. Its elements remain undefined until measured. So we have here a complementarity between the global variable, the clear definition of the

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[3] Whenever I say "quantum mechanics" I mean the physical theory proper. When I refer to a theoretical group of models I say "quantum theory" to delineate it from the physical application.

system and its state, and the local variables, the maximally undefined state of its local variables. It is called complementary, because there is maximal incompatibility between these states of full definition and probability description. Because this is so, the single elements of the system remain undefined, but highly correlated. If one of these elements is measured, the potential of all probabilities collapses instantly into a defined value. Which one this will be is unclear. However, once it does, it is immediately clear from the theoretical structure, which value a corresponding variable will be measured at. There is clear theoretical predictability, but no local-causal interaction between those parts of the system. This structure has been called "entanglement" by Schrödinger. Einstein opposed it. Because he saw clearly that it undermines the deterministic and local structure of the physical world (Einstein, Podolsky, & Rosen, 1935).

As a thought experiment one could conceive of a quantum system that is spread out over the universe, say one light-year across space. If one part of the system was measured on earth, then the other part measured on Alpha Centauri would immediately collapse into a corresponding state, known to the measuring scientist on Alpha Centauri. It is as if the particles had communicated in a mysterious way and bridged the one light-year gap in no time, contradicting locality, being non-locally correlated.

The debate was only solved, when, following a joint-probability argument developed by John Bell (1987), and a concretisation of the thought experiment by Bohm, an experimental set-up was realised that allowed for testing the prediction of QM experimentally. It was realised by a beam-splitting crystal that splitted one photon into an entangled system of two twin-photons. These twin photons are individually undefined in one of their properties, for instance the polarisation angle of each photon. The polarisation angle is the angle at which a photon vibrates as it travels. But they are conjointly defined regarding the sum of these angles. If polarisation measurements are conducted, typically the analyzers are oriented at certain angles, known from theory to produce many or very few measurements. Now, QM predicts that the jointly measured polarisation angle has to be highly correlated, i.e. if we adjust the polarisation angle to be measured at one photon to a value highly unlikely then the angle measured at the other photon will be one corresponding to the first one and more photons with correspondingly more probable angles will be measured, and vice versa. That is to say the polarisation angles measured will be correlated. Exactly which angle will be exhibited by an individual photon cannot be predicted. But if a certain angle is measured in one analyser, then a corresponding angle will be measured in the other analyser (This is a short exposition; a more precise and elaborate description can be found in Nikolaus von Stillfried's PhD thesis, which is available online (N. v. Stillfried, 2010).

Classical physics would predict that the two measurements should be uncorrelated. QM predicts that the photons are entangled, if they are produced by the same source and hence have to be treated as belonging to one quantum system. Experimental data vindicated QM in a series of tests starting with the famous experiments by Aspect and colleagues (Aspect, Dalibard, & G., 1982; Aspect, Grangier, & Roger, 1982), and could be demonstrated even over macroscopic distances several kilometers apart, if the system is appropriately isolated against interactions (Salart, Baas, Branciard, Gisin, & Zbinden, 2008). It has been shown in comparatively macroscopic systems (Lee et al., 2011), and it could also be demonstrated that entanglement can also work "backwards in time" (Ma et al., 2012).

Thus from a physical point of view it is quite clear that non-locality and entanglement is a physical fact at the level of true quantum systems. Although other interpretations are possible, this seems to be the majority view in the physics community. A lot of technological applications that are being developed depend on this phenonemon: quantum computing and quantum encryption being just two prominent examples. What is impossible from a physical and theoretical point of view is to transmit "causal" signals non-locally, i.e. against the arrow of time. If this were possible, we would run into time-reversal paradoxes that have been analysed in the 70ies: We then could telegraph into the past and hire a killer who could kill our grandmother which would make it impossible for us to be around and telegraph in the first place (Fitzgerald, 1971). The emphasis is here on "causal". While it is perfectly possible to have non-local correlations that reach into the past and into the future, from a theoretical point of view, it is not possible to use those correlations as if they were causal.

What does "causal" and "signal" precisely mean? "Causal" means, in our current physical view, that we can measure an interaction between two systems that is based on interaction particles, such as photons or the like. A “signal” means that we can encode a message of at least one byte, say “1” or “0”, or “yes” or “no”. A causal, local signal would be one that is always and repeatedly available to transmit an information using physical interaction vectors, such as particles. Thus, ideally, a causal, local signal can be used at will. A non-local, causal signal would be one that could be used to transmit a signal across the time barrier, as it would be faster than light. So far, no interaction particles have been measured to my knowledge that can do this. And if it were possible, we would indeed run into time-reversal paradoxes. Thus, “non-local” and “causal”, or “non-local” and “signal” are contradictions in terms. Non-local signals can only be theoretically construed under certain conditions, for instance complex field models, and would therefore require a profound rewriting of our physical textbook knowledge. It is not impossible, but difficult, and the mainstream community has some aversions against such proposals, as science aims to be parsimonious and is conservative in principle (Walach, 2010; Walach & Schmidt, 2005).

Now it is very important to understand that parapsychological research within an experimental paradigm is actually the attempt to nail a non-local signal as a causal one. This is so, because direct experimentation is always, by definition, an attempt to isolate a cause. If parapsychological effects were due to such non-local causes, it would create all the problems described above. One could envisage to set up a series of experiments that are direct replications. One uses the outcome of the first experiment to define a signal, for instance “measurement above mean” as “1” or “below mean” as “0”. As soon as in the second experiment a measurement below the mean is found, the signal code “0” is registered. This could then, at least in principle be used to code a signal and a message which is based on a non-local system. And this constitutes a violation of special relativity. This seems to be prohibited by nature (Lucadou, Römer, & Walach, 2007). And this is obviously the reason why the problem of experimental validation of PSI effects mainly becomes visible as a problem of replication. It is not the case that experiments fail for the first time, on the contrary. The deviations are often very large in first-time experiments (Bem, 2011; Schmidt, Schneider, Binder, Bürkle, & Walach, 2001). And very gifted researchers such as Dean Radin have practically made a principle out of it to never repeat an experiment in exactly the same way. Apparently, the replications often "fail" in the sense that the original effects are difficult to reproduce, often reverse themselves into negative directions opposite to the deviation predicted (Ritchie, Wiseman, & French, 2012). And this is what makes critics skeptical (Alcock, 2003). Understandably so, as long as parapsychologists insist that their effects are of a subtle causal nature.

The fact that long series of experiments approach a null-effect has to date only be verified with the micro-PK meta-analyis of Bösch, Boller & Steinkamp (2006). Other meta-analyses have been able to verify effects over an ensemble of studies (Mossbridge et al., 2014; Schmidt, 2012; Schmidt, Schneider, Utts, & Walach, 2004; Storm, Tressoldi, & Di Riso, 2012; Tressoldi, 2011). But if it is true that PSI-effects are non-causal and non-local in nature then no amount of direct experimentation will be able to distil an effect out of systems in the long run. We would expect the effect to decline over time, which is a signature that can be found in the Bösch, Boller & Steinkamp (2006) data. Figure 1 displays a correlation analysis between effect sizes and time when the study was conducted or published (data courtesy Holger Bösch-Hartmann). Although the correlation is small, it is clearly visible and negative. Over time the regression line touches the zero-point, and we would expect that the same will be the case for other experimental paradigms.

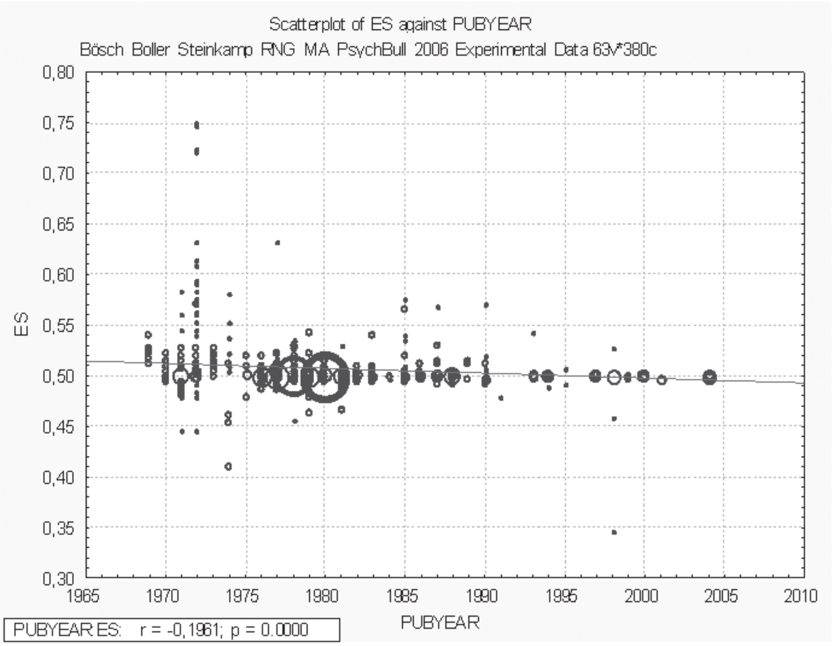

**Figure 1.** Scatterplot of correlations between micro-PK study-effect sizes and time. The vertical axis displays effect-size where 0.5 is the mean chance expectation, i.e. an effect-size of zero. The horizontal axis gives the time when the study was conducted/published. Data according to and by courtesy of Bösch, Boller & Steinkamp (2006). The size of the bubbles represent the size of the experiments.

This is, why we think that a non-local model, conceptualising PSI-effects as non-local correlations is both easier to join with mainstream theoretical models, fits the experimental findings better and is true to the phenomenology. Such a model would see PSI-effects as the expression of non-local correlations within systems and between systems. They can be very real, they can also have an effect in people's lives or generate meaning. They can even be used in defined frameworks that are not controlled and not causal. Some healing practices, such as homeopathy or shamanic healing, would be examples in our view (Walach, 2003, 2005). And some gifted people can possibly more often than others use such correlations for meaningful interactions, such as diagnosing disease, or sensing future dangers, as has been testified phenomenologically multiple times in the ethnographic literature (Kale, 1995; Müller, 1987; Rose, 1956; Sax, Quack, & Weinhold, 2010). But as soon as one would use these effects to generate technology from it that is meant to operate reliably on a quasi-causal principle the effects would dwindle away or break down.

To use an example: One might be able to use PSI in individual cases to warn of dangers. Anticipatory responses to threatening stimuli have been demonstrated experimentally (Hinterberger, Studer, Jäger, Haverty-Stacke, & Walach, 2007; Mossbridge, Tressoldi, & Utts, 2012; Radin, 1997b) and make a lot of sense in an evolutionary frameworke (Sheldrake, 2013). However, constructing a technical device out of it that would use, say, the autonomic response as measured by the electrodermal activity to warn a soldier of danger, as in (Mossbridge et al., 2014), will be doomed to failure in the long run, although certainly initially spectacular effects are to be expected.

So the difference between a causal non-local model of PSI and a non-local entanglement model of PSI is not that the one works and the other does only sometimes. The difference is constituted in the theoretical structure presupposed. While a causal model of PSI presupposes a signal that is unkonwn to our standard physics and has to travel faster than light, contradicting special relativity, an entanglement model is more parsimonious and presupposes "only" that a generalised form of non-locality exists that is, however, not causal in structure. Thus, phenomenologically such correlations will be observable, but technologically they won't be of use reliably. They can be used comparatively reliably, as long as their presumed causal structure is not probed. That is, why we prefer telephones over telepathy.

### *A Model of Generalised Entanglement*

Now what would such an entanglement model look like? It actually follows from a very simple assumption. If we assume that the general structure of QT is relevant not only for the physical realm, as in QM proper, but also potentially in other types of systems, then we will have to use a generalised form of QT which, by its very structure, predicts a generalised form of entanglement. What does that mean, and why would one want to do that?

We have asked ourselves: What is the minimal definition of any system or description to need a quantum theoretical description rather than a classical one? And it turns out: the one and only one requirement is that a theory can handle incompatible or complementary operations or variables (Atmanspacher, Römer, & Walach, 2002). And the stipulation is: Incompatible operations or variables are relevant also in other areas than in the quantum mechanical realm proper. In QM they are well known and well defined: measuring position and measuring momentum are such incompatible operations. You cannot measure position with a high precision and momentum at the same time with a similarly high precision. If you do that, you lose your knowledge about momentum, and vice versa. This is what the Heisenberg uncertainty relationship in essence is about.

The formal expression for that is that in QM, in fact in every QT that is dealing with such incompatible variables or operations, you have to use a non-Abelian algebra. An Abelian algebra is the one that is used to model classical theories. In it we have a law of commuting operations: whether you take first 2 and multiply by 3 or the other way round is irrelevant. The result is always 6. The formal expression for that is $a*b - b*a = 0$. If you insert “2” and “3” for “a” and “b” you can immediately see that this is true. This is the formal expression for the fact that in a classical situation the sequence of operations is irrelevant, or that measuring one variable does not influence the measurement of the other. You can use laser optics to measure the momentum of a cannon ball and then its position or vice versa. The measurement will neither disturb the cannon ball, nor will the sequence of the measurements make a difference, exactly because the measurement has not disturbed the ball in its trajectory.

Now in any quantum type situation this is different. The measurement disturbs what is measured, and hence the sequence of measurements is not irrelevant. The formal expression is given by a non-Abelian type of algebra: $p*q - q*p > 0$. Inserting “2” and “3” makes immediately clear that this is a strange situation. It is in fact the formal representation of a Heisenberg-type uncertainty relationship. It arises because in QM it is important what we measure first, since a measurement of a particle’s location will blur our knowledge about its momentum, and vice versa. Another way of putting this is saying that complementarity is at the heart of every quantum type theory. Complementarity means incompatibility of variables or operations. More precisely, we call complementary those observations and operations that are incompatible – in QM even maximally incompatible – yet need to be applied conjointly to describe a fact – for instance light – or a measurement situation. As we have seen in the description of physical entanglement above, complementarity is also at the root of entanglement. More precisely, entanglement is a certain type of complementarity, namely the complementarity between a global observable of a system, for instance the global polarisation angle of a two photon system which is defined, and a local observable, for instance the concrete values of its elements that are undefined until measured.

Thus, from generalising QT it follows that also entanglement should have a generalised counterpart:

*Whenever global descriptions of a system and local descriptions of parts of that system are complementary, we would expect non-local correlations between those systemic elements.*

We could thus use generalised entanglement as a theoretical concept to understand phenomena like PSI, which are clearly non-local, but not causal. But is there a scope for such a postulate? Does complementarity or incompatibility also play a role in the world of us mortals? We think it does. Agreed: it is well defined as a concept only in the physical realm proper. But phenomenologically it is also important in our lived experience. Here are a few candidates for complementary pairs, which we need to describe things or situations (Stillfried & Walach, 2006; Walach & Stillfried, 2011; Walach & von Stillfried, 2011):

The human being is always conjointly separated and in communion or community, socially speaking. He or she is also himself or herself a systemic assembly or conjunction of separate elements, psychologically and physiologically. Complementarity exists between the description "community" and "individuality" or "union" and "separability". Other potential candidates for such pairs of complementary descriptions might be

- actuality and potentiality
- freedom and structure
- confirmation and novelty
- knowledge and uncertainty
- love and hatred
- good and evil

to name but a few.

To be sure, there needs to be a thorough philosophical analysis to clarify these concepts and answer the question whether they are truly incompatible or complementary. What is important here is that complementary pairs are not just nominal opposites but incompatible descriptors. While an opposite of a term can be expressed as the logical negation of that term, a complementary notion cannot. For instance, the opposite of love is indifference, not hatred. The opposite of actuality is non-existence, and the opposite of confirmation is denial, and so forth.

So whenever we have a system that can meaningfully be separated from its environment and this system contains single separable elements, our model predicts non-local correlations between those systemic elements. This model can be used to reconceptualise PSI (Lucadou, Römer, & Walach, 2007), and this will be more concretely done in a separate publication.

If this is true, what does this mean for experimental research?

## Nailing Jelly: The Experimental Quest for PSI and a Potential Solution

If our stipulation is correct that PSI is real, but not a causal signal, then classical experimentation will fail in the long run, and has failed PSI already, as we have seen. But is there a chance for a novel type of experiment to capture the effect? After all, physics has experimentally demonstrated entanglement. In order to answer the question, we need to understand how the physical entanglement experiments are different from what has been done in PSI research so far.

Physical experiments test a correlation of two seemingly independent data streams of, say, polarisation measurements of twin photons in two analysers, against a theoretical expectation. The expectation is derived from two competing theoretical assumptions, expressed by Bell's inequality. Details are not important at this point. Entanglement is experimentally proven, if Bell's inequality is violated, because it describes the boundaries which correlations need to conform to, if the two data streams are classical and thus uncorrelated. PSI experiments do not have such a theoretical backbone. Hence they need a direct experimental set-up, whereby the standard against which to test is generated by the experimental procedure itself, the control condition. But this set-up automatically constitutes the potential for coding a signal, as described above: A replication experiment could use the outcome of the previous experiment for such coding. This is impossible in classsical physical entanglement experiments, and there is a formal proof that physical entanglement correlations cannot be used for causal signal transfer, provided by Hartmann Römer as an appendix to our von Lucadou, Römer & Walach (2007) paper[4].

This is the reason, why Walter von Lucadou has devised an indirect experimental micro-PK procedure in analogy to the physical situation. The analogy consist of the following elements:

- There is no direct experimental control condition to gauge a deviation of the mean shift against, and mean-shift of hits – a classically conceived PSI-PK effect – is not the target of the experiment.
- This avoids even the potential coding of a signal.
- The target outcome is a matrix of correlations between physical variables of the system and psychological variables of the operator.
- Since the matrix is large the system has many degrees of freedoms to exhibit the effect.
- The outcome measured is the number of significant correlations in the whole matrix. As there is no precise prediction about the positions of significant cells of correlations within the matrix, no signal can be derived. And replication experiments do not force the system into a causal framework.
- In any experiment and replication experiment we would expect that roughly the same number of significant correlations will be visible, but the correlations will appear in unpredictable cells. Thereby the experiment will demonstrate the entanglement between the operator and the physical system, but since there is no chance of encoding the signal, the experimental condition will be able to preserve the correlations. Should new variables be added to the system, the effect might even benefit from this and become stronger.

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[4] Specialists might argue that quantum teleportation is just such a usage. But here it is important to realise that it always relies on the existence of a second, classical channel that defines the meaning of the data stream.

Walter von Lucadou has conducted altogether five studies with that set-up, and all but one produced a significant number of correlations (von Lucadou, 1986, 1995; 2006; see Table 1).

| Study | N sig corr | N subj | Psych Var | Phys Var | Numb corr | Z | E |
|---|---|---|---|---|---|---|---|
| Lucadou 1986 | 75 | 299 | 24 | 23 | 552 | 5,1325603 | 0,218 |
| Lucadou 1991 | 28 | 307 | 16 | 8 | 128 | 3,1035636 | 0,274 |
| Radin 1993 | 32 | 1 | 16 | 23 | 368 | 2,6340387 | 0,137 |
| Dataset 2 | 39 | 386 | 27 | 18 | 216 | 6,2253021 | 0,423 |
| Dataset 3 | 11 | 386 | 27 | 18 | 216 | 0,0441511 | 0,003 |
| Innov Set 3 | 21 | 220 | 27 | 18 | 216 | 2,2517051 | 0,0153 |

**Table 1.** Previous Studies with the Correlation-Matrix Approach; number of significant correlations, number of subjects in the experiment, number of psychological and physical variables, number of correlations and according z-score and effect-size.

*The Replication of the von Lucadou Matrix-Experiment*

Hence we set out to replicate this design. We started from scratch, implementing the whole experiment anew, by reprogramming the display and the experimental procedures. The REG-devices were newly built by the workshop of the University Hospital in Freiburg according to von Lucadou's specifications. The sampling of the REG-devices was smoothed by a Markov-window with lag one. A Markov-chain with lag one is a time series with one degree of auto-correlation or memory, i.e. each value is correlated with the preceding one. This creates a time series with a small memory effect, and this is how many natural processes, for instance the weather, behave. Thus, although the process is purely random, the appearance is more natural to the observer. The sampled process was used to steer the growth or shrinkage of a fractal spiral (see Figure 2) that was displayed on a computer screen to the subjects.

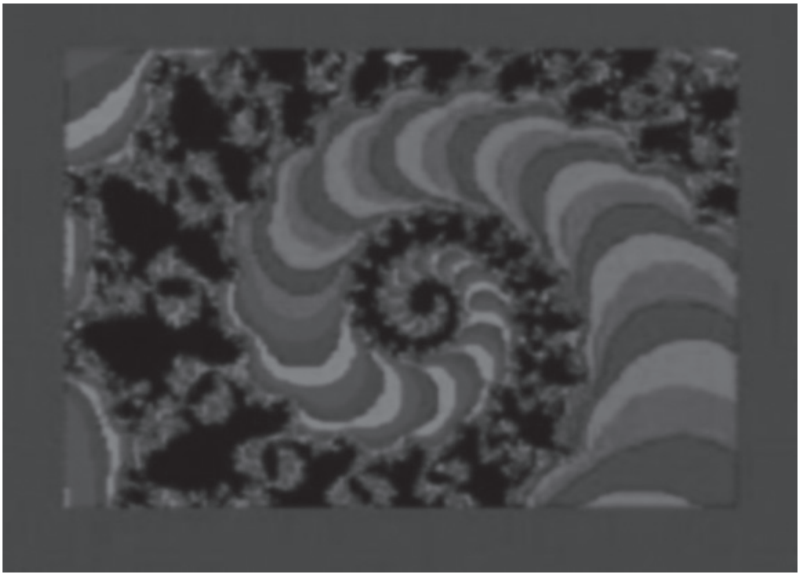

**Figure 2.** Display of the Fractal on a Computer Screen. On top of the screen an arrow would point to the left, or to the right, or to the center to indicate the direction toward which the operator should try and "influence" the growth ("arrow right") or shrinkage ("arrow left") of the fractal, or the instruction to leave it stable ("arrow center").

On top of the screen an arrow would point to the left, or to the right, of to the center to indicate the direction toward which the operator should try and "influence" the growth ("arrow right") or shrinkage ("arrow left") of the fractal, or the instruction to leave it stable ("arrow center"). This was the experimental instruction to operators. Each of these subruns ("left", "right", "center") consisted of 80 trials, and three such subruns of 80 trials completed one run. Three repeated runs constituted one experiment. An operator was requested in an information sheet and in an ensuing oral instruction to "influence the display mentally, by the power of their will or imagination" to achieve the desired direction of the fractal. They were told that they could use the left and right shift keys to move the experiment forward and potentially "influence" the behavior of the machine. In fact what happened was that the shift keys only moved the sampling process forward one step but was otherwise unconnected to the behaviour of the system.

The physical variables derived from this experiment were, for each sub-run:

1. deviation from randomness (the classical "mean shift" of REG experiments")
2. largest deviation from ideal outcome (difference between largest deviation and ideal target, i.e. a variance measure)
3. deviation of the data stream from Markov-chain behaviour
4. mean-voltage at REG output
5. standard-deviation of mean-voltage at REG output

The psychological variables derived from this experiment were, for each sub-run:

1. number of left key presses
2. number of right key presses
3. number of double key presses
4. time to run the whole sub-run (mean time between button presses)
5. standard-deviation of the time to run the sub-run

Thus, each sub-run created 5 physical and 5 psychological variables, and since 9 such subruns constituted one experiment we have, for every experiment, a matrix of 45 physical by 45 psychological variables, yielding a correlation matrix of 2025 cells.

Operators were recruited at conferences, meetings and seminars. We recruited 243 participants who competed 503 experiments. 103 experiments were provided by Walter von Lucadou in Freiburg, 400 by Majella Horan and Harald Walach in Frankfurt (Oder). Optional stopping was excluded by the rule that the experiment would stop when 300 participants are included or the 30th of December 2013 is reached, whichever occurred first. Data were not analysed until all data were in, the database was logged, and the evaluation protocol was deposited.

Immediately after each experiment, the system produced a set of empty runs to simulate the behaviour of the system at the experiment. The actual psychological variables of the operator were used to construct, together with the empty run, an according control run. Thus, each true experimental run was mirrored by a control run that consisted of automatically produced physical variables together with psychological variables of an actual subject that had not, however, produced the according physical data. By that procedure we were able to produce two kinds of controls: the ideal statistical situation, i.e. the number of correlations expected by statistical theory, following the theorem of big numbers, and an active control that simulates an experiment.

The analysis of the experiment is still ongoing and a publication is in preparation, hence we can here only describe preliminary data and results.

We calculated non-parametric correlations, used a two-tailed p-value of $p < 0.05$ (or one-sided p-value of $p <0.1$), as in previous experiments, and, as sensitivity analysis we adjusted the p-value to $p < 0.01$, and $p < 0.001$. We used the standard formula for the difference of significance of two correlation matrices (Figure 3) that yiels a z-score.

$$Z=(CE-CD)/\sqrt{(2*CD*(1-CD/NC))}$$

with CE= number of significant correlations in experimental condition
CD= number of significant correlation in control condition
NC= number of correlations in correlation matrix

**Figure 3.** Statistical formula that allows to estimate whether two correlation matrices are statistically different

We first analysed those variables that are also part of the previous experiments and found a significant difference between the correlation matrices for all significances tested. We then analysed the full matrix and in a first preliminary analysis we found a clear statistically significant result.

| p < | Significant Experiment | Correlations Control | Expected | Difference | z-Score |
|---|---|---|---|---|---|
| 0.05 (two-sided) | 476 | 415 | 205 | 61 | 2,38 |
| 0.025 ( “ ) | 278 | 199 | 101 | 79 | 4,17 |
| 0.005 ( “ ) | 94 | 44 | 20 | 50 | 5,39 |
| 0.0005 ( “ ) | 16 | 4 | 2 | 12 | 4,24 |

**Table 2.** Preliminary Results from Matrix-Experiment Replication using

What is interesting about these results is a two-fold structure: First, the effect-size, i.e. the z-score, is not reduced, as the criterion of how many significant correlations are counted in the the experimental and control matrix is increased. The second interesting observation is that increasing the significance criterion weeds out spurious correlations that affect the control matrix and likely also the experimental matrix. This can be seen in the fact that the number of significant correlations in the control matrix is gradually approaching the number of those correlations expected by theory. Since we test the difference score of correlations between control and experimental matrix this inflation of correlations does not affect our statistics. But it is to be expected, since some of the variables are highly correlated (e.g. the number of left and right key presses).

Thus, our replication seems to have borne out von Ludacou's prediction that the matrix approach will in fact allow for a reproduction of the effect, but at the same time not press it into a causal-local framework. Since our analysis is not finished yet, some caveat's need to be borne in mind:

Our experiment was one with an active zero-control, as demanded by Walleczek and as implemented by Yount and colleagues as one of the few experiments in the unconventional sector (Taft, Moore, & Yount, 2005; Yount et al., 2004). We achieved this by using an actual psychological set of variables and combining it with an empty run of the system. However, critics might still stipulate that the correlations observed might have been driven by some third event that happened at the time, and only if a robot with no intentions and no consciousness, driven by another random process would have conducted the control experiment would have there been a true control condition. While this is right from a purist point of view, it is obviously not realistic, and we hold that our control is the closest one can get to an active zero-control condition. Since our metric and statistics was build on the difference between the active and the control matrix, and since control data were engendered right at the same time, whatever might have affected the system – variances in power supply, field-effects, cosmic radiation, time effects, variances in the earth magnetic field and whatever else – has affected both data-streams in a similar way and will have been accounted for by our difference approach.

However, we will still want to calculate Monte-Carlo simulations to make sure that our data are not biased.

Also, some of our variables are highly correlated, such as the key-presses. We will want to make sure that this does not affect our data. But again the difference approach should have taken care of this.

Thus, as a preliminary conclusion we summarise that our replication of the matrix-experiment was successful and could demonstrate more significant correlations between a human operator and the behaviour of a REG-device than expected by chance. We interpret this to demonstrate two things:

First, PSI effects, in that case PK effects, can indeed experimentally be verified. Second, these effects seem indeed to be purely correlational in nature and have to be interpreted and conceptualised in analogy to quantum entanglement correlations. This is why we assume them to be generalised non-local correlations derived from a generalised type of non-locality or entanglement as predicted by our generalised quantum theory model. We would predict that any attempt to replicate our results will be successful, if the system is left free to move the effect around within the matrix, and it will fail if replication experiments try to predict the precise location of the correlations. This is so, because the latter would constitute the coding of a signal, which is prohibited by the No-Signal-Transfer theorem of our model. At the same time, this might also be an experimental way to distinguish between the two theoretical concepts.

Another way to elaborate on our model would be to probe to what extent the consciousness and intention of the experimenter is part of the experimental system. In a way, it is quite arbitrary to delineate the experiment as the coupling between the operator and the physical machine. Why would not the experimenter setting up the experiment, or the larger environment, within which it is conducted, also play a role? One could test that by having the same experiment run by different experimenters.

In conclusion, we seem to have indeed found an experimental set-up that allows us to capture PSI effects and their non-local nature by providing enough freedom for the system through a correlational approach. Thus, our results support the idea that PSI effects are indeed non-local and non-causal entanglement correlations between systems, as predicted by generalised quantum theory.

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