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***Mind and matter correlated in a matrix.
Replicating a new model***

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Doctor of Philosophy in Psychology

To

University of Edinburgh

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**Dedicated to my parents,
Gina and Fernando Borges
With Gratitude and Love**

&

**To my husband, Paulo
With Infinite Appreciation
for his Inspiration & Support**

Declaration

I, Ana Beatriz Leal Borges Rapazote Flores, declare that this thesis has been executed by myself and that it contains no material previously submitted for the award of any other degree. All work that was not of my composition is acknowledged in the text.

Signature

[Ana Flores]

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Lay Abstract

Empirical reports about unexplained psychical phenomena are often described. An example of one of these phenomena is Psychokinesis (PK), defined as the use of psychic abilities that facilitate the interaction between a person and a physical system without the use of any known physical interaction. PK is also known as the interaction of mind and matter. These manifestations are called paranormal and not treated as scientific, despite all experimental research to date.

The difficulty in studying PK and other paranormal experiences is several. The first challenge is related to the fact that experiences manifest in daily life without previous warning, which makes difficult to researchers to study them in loco. The second issue is linked to creating the experiences in laboratory to allow to measure the phenomena. The third problem is, to replicate results achieved, over and over again. As replicability of such manifestations have shown to be difficult due to the nature and little knowledge of the phenomena. However, replication is the base to establish a field as scientific therefore, is explored in the thesis.

To overcome the difficulties in studying paranormal manifestations a new methodology was developed by Walter von Lucadou. The method argues to be a solution to the problem of replication in Parapsychology and could benefit other fields of science such as Psychology, and others. The new method, called correlation matrix method (CMM) uses principles from physics,

namely from quantum physics. The model consists in correlating psychological behaviours produced by participants with events produced by a random number generator to explore whether participants can mentally influence the performance of the random number generator.

Physics has shown interest on the topics of Psychology and Parapsychology since very early times and, this influence lasts to the present. This contribution and knowledge exchanged between the scientific fields will be shown in the present work. The new CMM method was tested in five studies to explore its requirements and validity. The theoretical background of the theory, the experiments performed, and the findings achieved will be explained in detail.

Thesis Abstract

The thesis explores whether mind can interact directly with matter, i.e., with a physical system, without the use of any known physical interaction. The concept, called psychokinesis, is yet an unexplained phenomenon.

The study of paranormal manifestations has been arduous due to the difficulty in replicating its findings. To address the problem Walter von Lucadou developed a method called Correlation Matrix Method (CMM) that endeavours to explain it. CMM is supported by the Model of Pragmatic Information (MPI) and Generalised Quantum Theory. These theories based on principles from quantum physics were translated by analogy into a general quantum theory to be applied to the field of psychology. Links established between physics, psychology and parapsychology are then explored in the thesis.

The CMM method consists of correlating psychological behaviours produced by participants with the behaviour of a random number generator, to investigate whether participants can mentally influence the random number generator.

Previous experiments conducted by von Lucadou and Walach showed significant results. This thesis replicates the former experiments in five studies to test the reliability of CMM. The first two studies were exact replications of the original studies by Lucadou and Walach. The same random number generator (RNG), software program and protocol were used in the replications. Study 3, whether the number of participants was relevant against the number of sessions produced. In study 4 and 5 a new type of RNG, was introduced to compare with the

performance of the original RNG. A new method for control and for data analysis were introduced and compared with the original.

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The progress of science is strewn, like an ancient desert trail, with the bleached skeleton of discarded theories which once seemed to possess eternal life.

Arthur Koestler

CHAPTER 1 Theoretical Issues

1.1. Introduction

The thesis revolves around the topic of mind-matter interaction. Whether mind without the aid of an intermediate causal interference, could directly relate with matter. This definition permits to consider mind as an independent unity originated from unknown sources.

The subject of mind-matter interaction has been one of the main topics of study in experimental research and empirical observation in Parapsychology, under the name of Psychokinesis (PK). Its investigation remains popular until today, since the foundation of the Society for Psychical Research in 1882.

Although, PK effects have been noted, there is no consensus on the genesis of the concept.

A theoretical model, Weak Quantum Theory (WQT) was developed by Atmanspacher, Romer and Walach (2002), with the specific aim to work on a new approach to study PK and other unexplained paranormal phenomena. The WQT brings by analogy notions from Physics, to explain the interaction between mind and matter. With the assumption that the interaction is based on non-local correlations. The WQT contributed as a theoretical background to the Correlation Matrix Model (CMM). The CMM is being developed by von Lucadou since 1986. Both approaches based their foundations in principles of Physics, namely, concepts of entanglement and complementarity from Quantum Theory, that could make a scientific understanding possible.

The Model of Pragmatic Information (MPI) (Kornwachs & von Lucadou, 1985) complements WQT and CMM. It introduces a system theoretic perspective using the concepts of complementarity and entanglement as well as the role of information. According to the authors of MPI unexplained phenomena such as PK, for example, can be explained by transmission of information through synchronistic manifestations or non-local correlations (explained in detail in the MPI session).

CMM can be explained as exploring whether correlations resulting from a quantum system in an entangled state, are able to measure observables that are part of one system and the

whole (this will be explained in more detail in the CMM session). On other words, CMM correlates psychological variables produced by the participant with physical variables produced by a random number generator. The experimental session is than compared with a control session running without participant. The difference in number of significant correlations in both sessions will show the manifestation or not of PK.

The main aim of this thesis is to provide further data, testing the Correlation Matrix Method (CMM) assumptions in mind-matter interaction. I will be as close as possible to the definition of the concepts, deriving from Quantum Physics and do my best effort to integrate them in an easy way to be of accessible understanding and to connect them to Psychology.

Following, I introduce Parapsychology (paranormal phenomena) and some areas of research, keeping the main focus on PK. I present that there are two different perspectives to look at paranormal phenomena, as causal effects and non-local correlations and introduce the aim of this thesis, which is to perform independent replicates of CMM studies.

1.2. Approach to experimental Parapsychology

Parapsychological phenomena have been studied for a long time (von Lucadou, 1985, Walach et al. 2006; von Stillfried & Walach, 2006 a; b). Topics such as psychokinesis, telepathy and precognition have been subject to scientific experiments for more than a century (Bauer, 1984; Rao & Rao, 2001; Parker & Brusewitz, 2003).

Despite all the research efforts in the field, there is still much debate on the existence or non-existence of the phenomena. The reason for such an impasse can be either on the results of the evidence produced, or on the lack of theoretical understanding that connects the phenomena to mainstream scientific reasoning.

In regard to PK, some relevant studies are worth to mention. Radin & Nelson (1989) reviewed in a meta-analysis, empirical evidence from the domain of mind-matter interaction. The control condition revealed results conform to chance expectation, on the other hand, the experimental conditions showed unequivocal non-chance effects ($r=0.802$) ($Z= 1.645$). The results were interpreted as suggesting being consistent to the views that some kind of interaction with random physical systems had manifested. Relevant studies worth to mention are Radin & Ferrari, 1991;

Milton, 1993; Milton & Wiseman, 1999a; b; Storm & Ertel, 2001; Radin & Nelson, 2003a; b; Bösch et al., 2006.

Parapsychology also focuses on precognition, for example: Honorton and Ferrari, 1989; Steinkamp et al., 1998.

And in regard to distant mental interaction, Schmidt et al., (2004) and Roe, Sonnex and Roxburgh (2016) are significant examples. The studies by, Standford and Stein, 1994; Bem and Honorton, 1994; Milton, 1997; Honorton et al., 1998; Steinkamp et al., 1998, are examples in regard to telepathy and extrasensory perception.

However, a considerable number of studies have been unsuccessful in replicating previous significant results (Bem, 2011, Schmidt et al., 2001)). It is important to mention the lack of a stable experimental setup that allows for producing replications of the observations, and also the fact that existing models are in conflict with the current theoretical models of scientific knowledge, if they favour a subtle-causal approach. The current scientifically accepted model would have difficulty accommodating such a thing as a subtle influence of a new, as yet undiscovered, force.

1.3. Replicability Concerns

Authors in the field have been discussing the replicability problem, including Braud, (1985), von Lucadou (1991b); Beloff; Haraldsson and Houtkooper, (1995); Atmanspacher and Jahn, 2003; Dunne and Jahn, 2003; Kennedy, 2006; Walach et al., 2009.

The topic of replicability can be interpreted by exploring two different perspectives. On one hand, it can be argued that researchers who tend to accept PK as true consider that the experimental circumstances caused effects to decline. Justifications offered are often boredom of participants or of the researcher himself or herself, due to repeating the same experiment many times.

In the same line of thought, there are researchers or participants that are considered 'gifted' or 'psychic' who justify the circumstances by explaining that the capacities they have were 'given' for special and circumstantial use to benefit others and were not meant to be studied, as it is considered distrusting the 'special ones' who gave them the 'gift' and as such offensive.

On the other hand, there are researchers who question the existence of the phenomena. They simply use the lack of replication as being due to the fact that the phenomena do not

exist, is not real. Often their arguments for the fact that some studies are successful are that those results are based on statistical artefacts or pure chance (Alcock, 2003).

Moreover, another justification in this line is that the significant effects are due to publication bias, as studies presenting more significant results have a higher probability of being published when compared to studies with negative results. This justification can mislead on the effect size (Bösch et al. 2006). Successful replications also verified (Tressoldi, 2011; Mossbridge et al., 2014).

Finally, there is an argument based on a flawed methodology, that either the researcher or the participants replicating a successful study used fraud to not replicate the original results.

The debate uses arguments presented from both perspectives. The fact is that neither of the positions presented, provides consistent and sufficient explanations for replication issues in PK studies. If one labels those two opposite classes of researchers as “believers” and “sceptics”, it seems plausible to consider that each of them has concentrated on their own perspectives and maintained their views. Whether this assumption is true, both sides can be considered to be biased in their own analysis and support the opposite viewpoints.

Considering a different approach, suppose the main question is, 'is there a support for the phenomenon if it is real?' Instead of discussing its existence or non-existence about it, causal explanations can offer doubts, or even be fraudulent. Can a causal event justify a precognitive dream linking the situation dreamt about with the one that happened for real? Can significant results regarding mental intention interact with a physical process due to causal circumstances? The argument to be made here is not in the sense that cause cannot explain parapsychological phenomena. But rather the aim is to explore whether a different perspective can bring a new contribution, as these are questions of interest for the topic of the thesis.

1.4. Replication, Theoretical Issues

Considering the research mind-matter interaction, PK, and the classical view, that a direct influence should be causal, consistent and replicable. Facts should be analysed and questioned.

The Princeton Engineering Anomalies Research (PEAR) Laboratory hold a considerable data base on the research developed. The laboratory itself adopted the model of causality to test it (Walach & Jonas, 2007). The first studies hold

successful results (Jahn & Dune, 1987, 2001). As a consequence, the largest independent consortium with the purpose to carry out independent replication was created with laboratories in Freiburg and in Giessen, Germany. The protocol was designed by all parties and applied de same way by all members. The big data base created from this consortium gave no results on statistical expectation, and predefined outcome (Jahn et al., 2000). The replication failed. It could be argued that predefinition as regular local cause seems not to work. Hypothesis on the existence or influence of PK can be raised. On the other hand, it can also be questioned whether a non-local model could be an answer.

From debating relevant issues related to replication problem, arises the opportunity to explore the model of entanglement correlations and generalised non-locality.

Since the models GQT, MPI, CMM, have their roots in physics, it is crucial to introduce the history behind the models.

On one hand, as it is going to be shown, different words and concepts are used with the same meaning depending in which scientific field they are used. Also, there is an historical evolution that helps to understand and to bring together the methods focus of the thesis.

For last, it is relevant to show how the fields of physics and psychology worked to closely to study the interaction of mind and matter.

To deal to the reproducibility problem, von Lucadou developed the Model of Pragmatic Information (MPI) which complements the Correlation Matrix Method and also contributes to support the WQT. In 2014, the WQT was updated into Generalized Quantum Theory (GQT) by Walach et al. It argues that parapsychological manifestations are not causal effects, rather their existence is due to non-local correlations that drive parapsychological manifestations. The main argument to be tested is that non-causal correlations manifesting in linked meaningful random events, could contribute to the understanding of the mind-matter topic.

Despite, the fact that some similarities can be noted between non-local quantum correlations and some parapsychological phenomena this does not prove that parapsychological phenomena are real. However, it might contribute with an explanation related to observation, as it could help in understanding the replication difficulties, (von Lucadou and Poser, 1997; von Lucadou and Zahradnik, 2001).

As already mentioned, General Quantum Theory and the Model of Pragmatic Information address the replicability issue of experimental data in parapsychology. They do so, introducing the concept of entanglement correlations or synchronistic events as a possible explanation (von Lucadou et al., 2007).

1.5. Exploratory approach to solve replicability issues

The model of entanglement correlations was developed from the observation of patterns on the experimental data. The MPI and WQT authors theorised that the interactions between mind and matter could be explained as correlations, resulting from types of non-local entanglement, happening between mental and physical systems, but not by causal direct effects. Assuming, the interaction of mind and matter as non-local, classical explanations, which have deterministic perspectives, might not be able to explain the phenomena. Based on this argument, the core of the Generalised Quantum Theory, GQT, allowed the authors to explore those interactions through a new perspective.

As entanglement correlations, the mind-matter interactions need freedom to manifest. However, the classical perspective, due to a deterministic assessment, would break those interactions or

make them change course, due to the lack of freedom (explained in a chapter focused on the models). The authors assumed this position to be true, working from the assumption they are dealing with entanglement correlations.

von Lucadou introduce the Correlation Matrix Method (CMM). The experimental evidence is looked after an indirect way, in which the entanglement and non-local correlations are expected to manifest in a table matrix.

Psychological and physical variables are considered systems. Their assumption of entanglement correlations occurring between mind-matter or psychological and physical variables shows their interaction on the cells of a table matrix.

1.6. Summary

The studies performed in this thesis replicate previous studies that were firstly carried out by von Lucadou (1986, 1987, 1993, 1995, 2006) and then by Walach, Horan, Hinterberger, von Lucadou (2019)¹. Those studies reported significant results demonstrating CMM successful. The difference between von Lucadou and Walach studies was the number of variables for the matrix correlation. While von Lucadou's had a matrix with 18x27

¹ Study realised in 2014 and published in 2019

cells, Walach created more variables for a 45x45 matrix. Detailed information will be explained in the respective chapter.

Additionally, the interest fostered by von Lucadou through CMM in parapsychology, contributed to his approach to the problem that replications in the field conduct to a decline effect in the results (Schmidt, 2007). Hence, In the field of parapsychology, studies when replicated tend to have their results declining (Dunne & Jahn, 2007).

Furthermore, CMM explores whether the correlations resulting from a quantum system and an entangled state, are able to measure variables (observables) that pertain to parts of the system and the whole. In physics, where this process has already been proven, entanglement correlations do not transmit information, nor do they have causal influences (Römer, 2003, 2004). The formalism needed to a broader practical application of the model is described in general quantum theory (GQT) section (Atmanspacher et al., 2002). As a note, it is important to refer that what is proven in Physics it is not considered to be able to apply with certainty to this model.

I reinforce that the main experimental component of this thesis consists is replicating the original CMM studies, to contribute to

its improvement. Rather than the concepts of psychokinesis and experimental difficulties in replication in parapsychology.

The two models, MPI and GQT, and its applications in the CMM use ideas adopted from physics, which, is argued can be applied to parapsychology. Furthermore, the models' knowledge can be extended to studies in psychology, counselling, psychotherapies, etc.

The purpose of testing concepts from physics adapted by analogy into the new theoretical models can be useful to several fields of science. The concepts of complementarity and entanglement are undoubtedly becoming popular.

Due to the successful studies on the correlation matrix, an International consortium was created to discuss the experimental methodology.²

This thesis project benefited from participating in this meeting. I participated in the consortium meetings, discussing methods and strategies to improve the model, variables to use and methodological analysis. A protocol discussed between all members was written and uploaded to the *Open Science Framework* website to be accessible to all (available upon request).

² Matrix International consortium, Capri, 2017

The dissertation outlines the theoretical models through reasoning and experimental analysis. The limitations and weaknesses of this will be outlined below. It is important to note that the author is not seeking arguments in favour of, or against any of the theories presented, but only discussing facts in order to help improve the understanding of the method and the extent of its applicability. In my understanding, this will make the best contribution possible to improving knowledge available in the field and give most honest accounts for improvements.

The following chapter is called “The Encounter between Psychology and Physics”. The aim is to show how the two distinct fields of science have indeed been integrated for almost a century. It discusses the fact that physicist Nobel Laureates, as well as borrowing terms from Psychology, like e.g., complementarity, have also worked together, and contributed to developing therapeutic approaches. Their personal stories are considered interesting to the point to share them in a chapter, not only due to their work with psychology, but also because of their interest in developing parapsychology, and the importance of acknowledging idea of synchronicity. Synchronicity, was a

term from psychiatry, used by Jung was adopted by physics in the name of entanglement³.

It describes the synchronicity theory, (also called entangled events) and understands parapsychological experiences as 'meaningful coincidences or correlations happening between those coincidences. These experiences are mediated by correspondences and meaning, as in an unknown way they carry an important message from one person to another, as in MPI, (model pragmatic information described in chapter 3). It is demonstrated that usually, this transference of significance occurs during situations, which contributes to the openness and understanding of the meaning being transferred. The synchronistic phenomenon proposed and used in this work has the same meaning as the non-local entanglement correlations from CMM (chapter 3).

Note: The PhD candidate refers to herself in the present thesis in the first person of the singular.

³ Physicists Nobel Laureates proposed introducing concepts from quantum physics, namely complementarity and entanglement, into psychology. The concept of complementarity was first used by William James and then used by Niels Bohr. Furthermore, Jung's concept of synchronicity, which is still used today, was developed with the contribution of Wolfgang Pauli. Both, physicists and psychologists were interested in the field of parapsychology and contributed to bringing the topic into the realm of public discussion.

CHAPTER 2 The encounter between psychology and physics

I should like to say that it seems that there must be very deep connections between soul and matter and, hence, between the physics and the psychology of the future, which are not yet conceptually expressed in modern science. Such deep connections must surely exist, because otherwise the human mind would not be able to discover concepts which fit nature at all.

Wolfgang Pauli to Ralph König, 10 April 1946

2.1. Introduction

This chapter intends to reconcile two distinct disciplines, psychology and physics, and to show how they have worked together for almost a century. These two disciplines borrowed concepts from each other and shared ideas. This can be traced to a little-known relationship between two famous concepts from the respective disciplines: Carl Jung's 'synchronicity', and 'complementarity' that was made popular by Niels Bohr. These terms were both first used by psychology and then used by

physics Nobel Laureates, Wolfgang Pauli and Niels Bohr. Through psychotherapy, psychology explored and described the effect of synchronicity, which was later studied by Wolfgang Pauli. The idea of complementarity is well accepted and experimentally proven in physics, and was initiated with the father of Psychology, William James among others. Other sources were the psychologist Edgar Rubin who developed the famous vexing images, like the vase and the face illusion, and the Danish philosopher Harald Høffding (Rosenfeld, 1963; Walach & Römer, 2000).

This chapter investigates the development of these two sciences alongside one another and explores their progress together. It is interesting to note how Physicist Nobel Laureates, such as Wolfgang Pauli and Niels Bohr, understood the importance of studying synchronicity and complementarity phenomena under the umbrellas of parapsychology and psychology. Considering whether the topics were within their domain, this vision is deep and unrestrained.

The concept of synchronicity explored in this chapter, is shared by the Correlation Matrix Method and Model of Pragmatic information, that involves interpreting 'paranormal phenomena not as a result of a causal influence of mind on matter [...] but as meaningful coincidences, correlations not produced by causal interaction [...] but mediated by correspondences of sense and

meaning' (von Lucadou, Römer & Walach, p.51, 2007). This fits with the synchronicity theory that was first outlined by C. Jung and W. Pauli (Jung, 1952, Atmanspacher, Wiedenmann, & Amann, 1995). The ideas developed through the collaboration of Jung and Pauli form the theoretical foundation to the experiments in this thesis.

2.2. Carl Jung and the emergence of the concept of synchronicity

Jung was interested in paranormal experiences and considered that these could be interpreted in a similar way to synchronistic experiences or situations that provide information or insights considered important to the subjects involved in the experience (Jung, 1965). He argued that the circumstances or context in which such situations manifest often give rise to strong feelings and emotions in the subject experiencing them, which is what gives them meaning (Jung, 1973).

Various studies refer to Jung views about psychic events as synchronistic experiences. The concept of synchronicity was first introduced by Carl Jung and later developed with the contribution of physicist Wolfgang Pauli (Atmanspacher, 1995). Jung defined synchronicity as 'meaningful coincidences' or correlations

mediated by the correspondence between outer reality and inner meaning. These correlations are considered as non-causal correlations and take place within non-traditional systems under certain conditions. In physics they are studied by quantum physics and known as entanglement correlations.

Carl Jung and Wolfgang Pauli's development of the concept of synchronicity resulted from long discussions between both, and the process evolved from an empirical observation to an interpretative postulate. Their main point of interest was to understand the influence of mind on matter and their relationship. Based on their conversations, Jung and Pauli published the book 'Synchronicity: an acausal connecting principle' (1952)⁴, which also developed notions exploring the possibility of certain situations being connected with one another, either by causality or by meaning.

They reached the conclusion that synchronistic situations are facilitated by relations created between sense and meaning. This conclusion, in turn led them to extend their theories.

⁴ The book is a joint publication, although Jung is normally noted as a single author, it also contains a chapter by Pauli and they are both noted.

2.2.1. Definition of synchronicity

Jung presented the notion of synchronicity in the sense of “meaningful coincidences”, as ‘the simultaneous occurrence of two meaningful but causally unrelated events’ (Jung, 1960, p.441), or as ‘coincidences in time of two or more causality unrelated events which have the same or similar meaning’ (p.551). He considered the concept of circumstance with no causal relationships to be fundamental to the investigation of related situations and coincidences. He was in particular drawn by the fact that coincidences manifested themselves with apparently no causal circumstances but held nonetheless a specific meaning for the person experiencing them. This concept was then one he worked on and developed throughout his career, modifying it in particular due to its application and due to his continuing dialogue with Pauli over 30 years.

Jung had had paranormal experiences and studied them in his MD thesis. Later, he developed the concept of synchronicity to understand them. The concept and Jung’s enthusiasm arguing about paranormal had a strong influence on Arthur Koestler, who decided to explore the concept deeply in a book, entitled ‘The roots of coincidence’ (1972).

Jung introduced the concept of synchronicity from a psychoanalytic perspective. The relevance of what he called “meaningful coincidences” was shown to have a role in the patient’s therapeutic process. His challenge in his professional therapeutic practice was to deal with situations in which meaningful events, which were part of the therapeutic process, manifested with apparently no causal relationship with the problem itself (1972). It was his professional experience that made him introduce alterations to the definition of the concept of synchronicity (Donati, 2004).

Based on this concept of synchronicity, Jung argued for the existence of paranormal phenomena. The book ‘Synchronicity and the Paranormal’ (1997), starts:

“The culmination of Jung's lifelong engagement with the paranormal is his theory of synchronicity, the view that the structure of reality includes a principle of acausal connection which manifests itself most conspicuously in the form of meaningful coincidences. Difficult, flawed, prone to misrepresentation, this theory none the less remains one of the most suggestive attempts yet made to bring the paranormal within the bounds of intelligibility. It has been found relevant by psychotherapists, parapsychologists, researchers of spiritual experience and a growing number of non-specialists.

Indeed, Jung's writings in this area form an excellent general introduction to the whole field of the paranormal" (p. 1).

The study of paranormal manifestations contributed to Jung developing the concept of synchronicity, as the association between reality and meaningful coincidences. With the aim to understand the paranormal he introduced a new impulse to the study of paranormal phenomena which worked as a resource used by psychotherapists dealing with paranormal situations (Roxburgh, et al., 2015; 2016). His writings are considered a good overview to the field of the paranormal.

In another book called 'Synchronicity: An Acausal Connecting Principle', Jung argued that the experiences were difficult to explain on conventional grounds. He gives the example of Extra Sensory Perception (ESP, when someone claims to receive information not gained by recognised physical senses but felt with the mind). Jung argues that just using known human resources is not enough to explain the situations in which meaningful coincidences happened (example of the scarab beetle in a next section). The situations manifest as a phenomenon of energy, like a transference between mental states and physical occurrences. For him, such a synchronistic event, would be sufficient to exclude a causal explanation as the effect or the

situations could not be explained as anything but a phenomenon of psychic energy. Consequently, ESP could not be an issue of cause and effect; rather, it must be something related to time that could happen simultaneously. This situation of happening at the same time, was termed “synchronicity” to describe a hypothetical factor similar to causality as a principle of explanation (Jung, 1973).

2.2.2. Approach to Psychology

In 1902 Carl Jung was awarded his MD in medicine by the faculty of medicine at the University of Zürich with a thesis on the psychology of occult phenomena. He continued his studies, specialising in psychiatry. A fascination with Freud’s psychoanalysis led Jung to establish a closer relationship with Freud. This professional friendship lasted until 1913, when Jung stopped following Freud’s psychoanalytic approach. He then turned to the idea that the personal psyche is grounded in archetypes and historical roots. Jung focused his approach on the unconscious, studying texts from the fields of anthropology and alchemy; anything that could not be verbalised in clear analytical language was of significant interest to him.

Jung developed his therapeutic approach by reflecting on the psyche which led him to conclude that the psyche cannot be imputed to an individual's development alone, as individual psychological expressions are not acquired by the person but inherited. Jung's psychology, known as analytical psychology, also as 'complex psychology', is grounded on the idea of the world's collective personality or collective unconscious. The subjective, individual psyche is partially explained and understandable through the collective experiences of humankind in the past and psychological interconnectedness in the present (Jung, 1935). Jung defined three levels by which to distinguish and study the human psyche: the conscious, the personal unconscious and the collective unconscious. The collective unconscious integrates instincts and other independent forces called archetypes. The term archetypes were borrowed from Plato's idea of the "eidola" or "forms" (Barnes, 1945). Jung argued that archetypes are shared by all mankind and they can be found in all preserved important records.

Jung originally understood archetypes as psychic phenomena, but with time he began considering the unconscious as a field involving material and non-material aspects and he considered the nature of the archetype as "psychoid" instead of psychic (Jung, 1969). He explained this change in perspective by stating

that the psyche and matter are part of the same world, are in permanent contact with each other and impacted by the same transcendental influences. Thus, under all circumstances, it is possible that psyche and matter are two different aspects of one and the same thing. In the work *On the Nature of Psyche*, Jung raised the possibility of a united reality where psyche and matter are 'two different aspects of the same thing' as 'they are included in one and the same world'. This possibility develops from the existence of a synchronistic situation (Donati, p.712)

The conscious and unconscious psyche come together in an individual personality called the "self". This self is an archetype embodying the unity of an individual with the goal of developing the psychic process. Jung described this individualisation method in his *Psychology and Alchemy* treatise, stating that the psyche has a way of looking for its personal purpose in a way that is independent of external influences (Jung, 1968).

2.2.3. Applied synchronicity

Jung noted that there was a psychological transformation in his patients who were facing synchronistic experiences. In this regard, there is the example of the story of the golden scarab beetle. One day during a therapeutic session, a patient was

telling a story of dreaming of a golden scarab. Jung tried to explain that a scarab was an old Egyptian symbol of death and rebirth pointing out that the patient might need to let go of her overly intellectual stance. The patient did not understand Jung's point, when suddenly he heard a noise of something tapping on the windowpane. To his surprise it was a rose beetle, a scarabaeid beetle, very alike to a golden scarab. He understood and presented the episode as a synchronistic one that helped the patient resolve her conflict and finally understand her dream (Jung, 1952).

His explanation of the successful results for people experiencing synchronistic situations is grounded in the inner and outer event images of significant coincidences that can provide an entirely new perspective on the way a client responds to a situation. Usually, a deep involvement with the event brings meaning to the situation that is taking place (Mansfield & Spiegelman, 1991). It was on the observation of this unexplained phenomenon that he created the term non-causal coincidences, a precursor to synchronicity. In 1930, Jung started to refer to this as the 'synchronicity principle' upon reflecting further on the archetypes (Jung, 1957).

Originally using the ideas of 'archetypes' and 'fundamental images' as synonymous, Jung later distinguished these into the archetype concept and the manifestation of images. This

demonstrates that his ultimate interest was the ultimate structure of reality, which cannot be studied empirically by the main scientific methods alone but needs theoretical conceptualisation as well.

The idea of archetype developed in Jung's work alongside that of synchronicity.

In the book 'On the nature of the psyche' (Donati, 2014, para. 417) Jung writes:

"The archetypal representations (images and ideas) mediated to us by the unconscious should not be confused with the archetype as such. They are very varied structures [...]. the archetype as such is a psychoid factor that belongs, as it were, to the invisible [...]."

In this regard, 'psychoid' seems to be the expression used to explain the archetype as a proper concept that is not exclusively part of either the psychical or the physical world. Thus, a psycho-physical nature is suggested for the archetype and its unitary possibility/existence points to the transcendental. In the fact the psychoid is the transcendental realm out of which the distinction of material and psychical phenomena arises.

In a letter to Michael Fordham (Jung, 1973, p. 343-4) Jung noted his enthusiasm for the metaphysical characteristics of the phenomena:

“I well understand that you prefer to emphasize the archetypal implication in synchronicity. This aspect is certainly most important from the psychological angle, but I must say that I am equally interested, at times even more so, in the metaphysical aspect of the phenomena, and in the question: how does it come that even inanimate objects are capable of behaving as if they were acquainted with my thoughts? This is, as the above formulation shows, a thoroughly paranoid speculation which one had better not ventilate in public, but I cannot deny my fervent interest in this aspect of the problem”.

Based on this comment, it can be argued that synchronicity is an empirical manifestation of the transcendental world.

2.3. Wolfgang Pauli and synchronicity

Wolfgang Pauli, a well-known theoretical physicist, was made a Nobel Laureate in 1945 for his work on the ‘Exclusion Principle’, also called the Pauli Principle. The principle states that in an atom two electrons cannot occupy the same quantum state

simultaneously. His work was predominantly developed in the fields of quantum mechanics and quantum theory, but he extended his main object of interest to other fields such as Philosophy, History, and Jung's Psychology. The work that Wolfgang Pauli developed with Jung was disclosed in the 1990s, which in turn enabled a better understanding of their innovative theoretical positions in both scientific fields, analytical psychology and physics. Both scientists shared the opinion that the physical and psychical realms should be viewed as separated systems and the unconscious should be considered as an important element of study (Atmanspacher & Primas, 1996).

Pauli's interest in synchronicity did not just emerge from a theoretical perspective, but also from his personal experiences of unexplained phenomena throughout his life. Anecdotes about his special relationship with electronic equipment were well known among the scientific community. There were reports of situations in which his presence near a laboratory would provoke a breakdown in the experimental equipment in unexplained ways. Weizsäcker (1949) and Jordan (1973) reported several episodes of the so-called "Pauli effect". The effect would be termed a psychokinesis episode according to parapsychology. Even his friend, Otto Stern, prohibited him from going into his laboratory (Fierz, 1979). For Pauli this was a serious problem, and he considered these events as synchronistic situations resulting

from the profound inner struggle between his rational and non-rational perspectives.

Pauli, along with Niels Bohr, Werner Heisenberg and Paul Dirac, developed quantum mechanics and quantum field theory, making a significant contribution in the living conscience of theoretical physics. Despite professional success he experienced mental health problems that he called his 'big neurosis' (Pauli, 1956). These struggles prompted him to seek the help of Carl Jung while Pauli was in his thirties.

Jung, being perceptive enough, did not treat Pauli himself but sent him to his own student Erna Rosenbaum, which allowed him to uphold a personal relationship with Pauli. Thus, their relationship developed from a professional relationship to a personal, professional and scientific one. After studying Jung's theoretical approach, Pauli attempted to understand them (Jung, 1968), publishing a few articles (Donati, 1994) on philosophical issues, the foundations of science and the limits of scientific methodology.

Pauli's interest in Jung's work was beyond the psychotherapeutic perspective. He envisaged making scientific advances on the subject of nature using Jung's elemental ideas. Pauli argued that the ideas resulted from a connection between outer reality and archetypal images and the unconscious holds ideas that are not transformed by the therapeutic approach; however, those ideas

will develop in connection with general life sciences (Pauli, 1954). Jung took an analogous position, arguing that the treatment of neurosis was an issue that should be considered beyond medical knowledge (Jung, 1968).

2.4. Carl Jung's and Wolfgang Pauli's perspectives on synchronicity

The interest of both scientists in the phenomenon of synchronicity, became evident quickly, and it marked the start of a fruitful collaboration. Due to this cooperation, Jung changed his perspective on how to study synchronicity. His approach that had mainly focused on empirical facts changed to an ontological and metaphysical perspective. To deal with the nature of the human being, an interpretation based on an archetypal perspective was added. On his side, as a result of this collaboration, Pauli revealed his philosophical interest in the unconscious. From their teamwork, the concept of synchronicity was accepted as a theoretical principle, which, together with causality, contributed towards a new scientific understanding.

Concepts from mainstream science were now being studied under philosophical aspects. Jung explored events associated by causality that may be connected by meaning. Thus, events linked

by meaning could have a different justification than causality. Pauli and Jung discussed that the conventional relationship between causal events due to cause-and-effect relationship is quite right and sufficient itself but needs complementing by a principle of acausal connectedness called synchronicity. This they envisaged similarly to the relationship between Space-Time and Energy, i.e., as complementarity, thereby broadening the view. There is nothing that is factually wrong with mainstream concepts, but there was a need to broaden them.

2.4.1. Pauli's contribution to Psychology

Pauli described experiencing an archetypal journey that manifested through the emergence of symbols (Lindorff, 1995). This personal experience contributed to developing Pauli's interest in dreams, which led him to investigate these with the help of his therapists.

Pauli highlighted the role of intuition in developing concepts and ideas beyond ordinary experiences, which are important in building a system of natural laws or scientific theory (Pauli, 1955). He searched for philosophical thoughts since the seventeenth century that could explain the relationship between matter and psyche. Pauli followed Jung's opinion that an

archetype should be the foundation of science and he encouraged other scientists to explore the idea.

Jung also involved Pauli as much as he could in his own studies of synchronistic events (1949). Pauli's contribution helped Jung clearly define his concepts. The two agreed on the importance of defining the principle of the interpretation of nature (Meier, 2001). However, they had a different perspective on the relationship between synchronistic and quantum phenomena. Jung cultivated the idea of an analogy between the concepts of synchronicity and quantum phenomena, whilst Pauli stated that the concepts were different, particularly because synchronistic phenomena are non-reproducible. Nonetheless, it can be argued that they 'both go beyond the framework of classical determinism' (Meier, 2001, p.55).

Pauli argued that experimental science is established based on the reproducibility of the experiments and, in quantum physics, in order for an experiment to be reproduced, statistical analysis has to be used, and thus natural laws are established.

He went further, stating that the correspondence of statistics in quantum physics seen from the synchronistic perspective is a "very weak generalization of the old causality" (Meier, 2001, p. 56). This point was discussed, and if on one hand, Jung involved Pauli as much as he could in his own studies of synchronicity on the other hand Pauli contributed helping Jung to define his

concepts. The two agreed on the importance of their collaboration for the progress of scientific knowledge.

To deal with the differences between synchronicity and quantum phenomena, Jung developed a second definition of synchronicity: a strict perspective of synchronicity that incorporates the psychical image linked to the psychical event. In this way, synchronicity could be interpreted as distinct from microphysical phenomena, where it would be possible to include the direct participation of the observer's psyche nor significant presence of 'meaning' that manifests and presents singularly. This dual perspective of synchronicity was accepted by Pauli as a global conception of reality (1950).⁵

2.5. A new Era

It can be argued that the dialogue between Pauli and Jung marked the beginning of a new stage in the modern era, in which quantum physics introduced the concept of complementarity and psychology presented the concept of holism. The two notions were conceptualised in such a way that they resembled each

⁵ The publication of correspondence between Pauli and Jung has contributed to the study of their work in Psychology and philosophy (Meier, 2001).

other. Pauli and Jung discussed deeply how to connect the two perspectives. Pauli focused on understanding the impact of the new knowledge brought about by the theories of relativity and quantum physics and their impact on the world of physics as well as the world of psychology. On his side Jung concentrated on getting an objective ground for his model of the psyche based on the new theories from physics. The psychophysical interactions were the common point of the discussions between the two theories.

Pauli openly shared his belief that the issue of the spiritual realm should be understood under the study of the psycho-physical problem (Pauli, 1952a). The article published together with Jung; The interpretation of the nature and the Psyche, demonstrates their views on the points they agreed on as well the views they did not share.

While Pauli's contribution to this joint work was on the influence of Archetypal Ideas on the scientific Theories of Kepler (Pauli, 1952b), Jung's contribution was called Synchronicity: An acausal connecting principle (Jung, 1952). This work was strongly influenced by Pauli, in terms of the choice of the theme in the final published version, which he revised several times and commented on (Jung, 1949).

Pauli's interest in synchronicity came not only from a theoretical perspective but also from his personal experiences of unexplained phenomena that accompanied him during his life.

2.5.1. Jung and Pauli's synchronicity

In 1947, Jung used the term synchronicity for those situations in which at least two events, apparently unintentional, happened supported by three circumstances:

A synchronistic event is constituted by two elements, one formed internally and the other externally.

An apparent causal relationship of close proximity of two events, which would normally not occur simultaneously.

Synchronistic events are related to each other by the meaning they share; frequently the meaning has a symbolic appearance.

The first condition defends that synchronistic phenomena are formed by two components, one psychological and another physical. These two perspectives were presented as a new idea; psyche and matter together had not been studied by other fields of research.

The second condition requires two traditional fields of science to re-evaluate their methodology in order to study synchronicity,

mainly the relationship between cause and effect of events happening in different moments.

The third condition focuses on the importance of meaning that builds a new or symbolic perspective of the event.

Pauli stood by his view that synchronistic events were meaningful correspondences. He defended synchronicity as an acausal experience that could not be set up deliberately. In the same way, the idea of chance could be interpreted as a set of significant communications. He speculated that chance could be understood as a type of natural law with the underlying aim to allow for meaningful coincidences not causally connected by events. (Pauli 1953c). In this discussion it became evident that there was a need for a measure to define and evaluate the meaningful events revealed as essentials (Meier, 1992). Jung, on the other hand, defended the notion that the criterion for the concept of meaningful correspondence should be discovered through individuals' behaviours and subjective experience. It is expressed in their way of communicating their understanding of what was happening and the meaning they attribute to it. After all: synchronistic experiences are only such, because people define them so in their experience. Seen from outside they are mere random parallel events.

Pauli and Jung opted not to define the concept of meaning but instead just to deal with its idea by generalising the concept and making it correspond to the concept of similarity, holistic order or simply correspondence. Pauli's strategy was to plan meticulous experiments to study synchronicity in non-psychological conditions, like as in a radioactive decay experiment. His approach was centred in a context of a limited detachment of the psyche of an observer and any observed event. These experimental ideas can be seen as early attempts to perform parapsychological studies on correlational relationships between individual meaning, intention and physical random events.

Jung's approach was different; he preferred to study synchronistic events only at a psychological level. Part of his studies included psychokinesis events as part of his interests in synchronistic manifestations. He envisaged that the concept from physics could be construed as a new interpretation (Jung, 1951). Jung's perspective comprised the involvement of the psyche of the observer in the experimental result.

To Pauli, the psyche of the observer should be studied as detached from the observed event. Jung opposed this view; he stated that the observer's psyche was absolutely part of the event under observation.

The two positions explore the topic of the role of the observer. How should he be studied and interpreted in the experiment? Will the psyche of the observer impact the situation being observed? Also, will the psyche of the observer have an impact on the synchronistic events under study?

In traditional quantum mechanics the question of the issue of the observer is still a puzzle. Only some theoretical approaches such as the Wigner-von Neumann (1932) perspective solve the problem by stating that the observer collapses the wave function. Nevertheless, the observer is an inanimate observer, or an observer apparatus. The apparatus has some attachment to the observed system. However, in modern physics the interactions between the observables under study can be minimised. On the other hand, considering a human psyche, a human observer, as an observable being studied, it is not part of the quantum mechanics model and as such has no place in the reality of physical definitions. Despite knowing these details when framing the concept, Pauli stated his opinion defending that mind was being studied, considering it as an unsolved problem (1954b). His concordance with the idea of the observer and psyche being studied as detached from each other was part of the strong influence he received from Kepler (Donati, 2004).

Again, Pauli and Jung joined together to study the effect and tried to understand the problem. They considered it in terms of the complementarity of statistical methods and synchronistic events. They showed that synchronistic events cannot be discovered by statistical methods as they are generally applied. They suggested the use of the concept of synchronicity to study the concepts of “momentum”, “space-time” and “causality”.

Parapsychology took their suggestion and ventured to delineate experiments following their suggestions. As Pauli defended, Parapsychology would be the best positioned field of research to study synchronicity events, despite it being a controversial field (Pauli, 1956b).

2.5.2. Exploring mind and matter as part of the same field

Pauli’s pioneering view that the psyche and matter should be considered as a whole, opened up a new perspective on the study of psychotherapy and the mind. The study of mind and matter as part of the same field began with Pauli and Jung’s understanding that psyche and matter should be considered as a complementary aspect of the same reality, the archetypes (Pauli, 1952; Jung, 1953). Their perspective points into the direction that archetypes

are part of the same field but outside psyche and matter. However, they influence both aspects of reality.

Internal and external physical events are influenced by the phenomenon itself rather than by their central significance. This distinction is crucial to understanding Jung's idea of "psychoid archetypes", revealing the psychological distinction of the concept.

Pauli was aware of the complexity of the concepts and wrote to Fierz (1948) expressing his concerns. He also defended the notion that psyche and physical should be studied beyond their ordering factors. He agreed that the concepts are ordering factors, "archetypes", but stated that they should not be defined as part of the psyche, but rather as inner images that are a psychic manifestation called archetypes, and consequently are expected to create and produce what happens in the material world as a law of nature.

The physical manifestations of archetypes should be the expressions of laws of the material world. As a consequence, each natural law should then have a correspondent natural law related to the inner archetype. The process should happen in reverse and be demonstrable, not necessarily immediately but in the same or a similar way. Images and symbols are part of Pauli's description and openness to a new theory.

Pauli stressed the fact that the field of physics does not accept or does not include concepts of judgment, emotions and feelings, i.e. the concepts studied by psychology. According to his understanding, archetypes manifest the natural law of the material world. He even referred to Einstein's observation on the necessity of completing the concept of quantum mechanics (Pauli, 1948b, 1954b); he added that the need to complete quantum theory was not at a physics level but rather at a level of understanding life.

2.5.3. Contributions to Psychology

Pauli delved into the holistic links between the inside and outside of the observer, which were not covered by science and could indicate synchronistic correlations between the inner state of one observer and another. He concluded that he had reached the point where he was aware of the dangers of such feelings and considered it important to have the ability to maintain the positive results and values of rationality. His perspective implies that important questions of the natural sciences are yet to be reconsidered. This re-evaluation involves the fields of psychology and physics in terms of discussing the issues of space and time, the correlation between the observer's psyche and the material object observed, the links between the inside

and outside worlds, and the position of the realms of the conscious and the unconscious, their roles and links. He argued that these topics could be studied by psychology but also by a new psychophysical scientific research field. Studying such topics is fundamental to the evolution of humankind in the view of both Jung and Pauli, because it raises important questions, and these questions are still without answer or consensus. What they did was to help to identify delicate issues and made them clearer and more open to discussion.

Accepting Pauli's argument on the necessity of studying the relationship between the external material world and the inner world full of the meaning given by the psyche, a scientific approach to this has been recognised. A complementary approach to studying mind and matter as inseparable realms but as complementary, considering both as part of the same underlying reality, is often considered theoretically, but putting this approach into practice is an ambitious project.

From their discussion and the many letters exchanged between Jung and Pauli over the years, ideas can be developed based on the concept of synchronicity. As a consequence of Jung and Pauli's discussions, their investigations surpassed the limit of single sciences such as physics and psychology and extended into the world of the philosophy of nature.

2.6. Complementarity: the unknown reality and its origin in Psychology

The connection between psychology and physics was also noted by Niels Bohr, who contributed to spread the concept of complementarity to other disciplines, while working with William James.

2.6.1. Niels Bohr's contribution to Psychology

The concept of complementarity was popularised by Niels Bohr to the degree that it is now the best-known term from quantum physics (Atmanspacher, 2012). Niels Bohr, who introduced the term into quantum physics adapted it from psychology and the work of William James (Rosenfeld, 1953, 1963).

Bohr considered that the problem of observation being studied by psychology, had similarities to the observation problem in quantum physics. He was familiar with William James's work and aware of the difficulties, psychology was encountering in studying and analysing the phenomenon of observation, in particular referring to the observation to differentiate subject and object in psychic experiences.⁶

⁶ To Jung the word Psychic refers to the inner part of the self, as a regulating system (like a body) that strives to maintain a balance between opposing qualities

In one letter exchanged with Meyerhof in 5 Sep 1936 Bohr says:

“as far as my comments on the psychic problems are concerned, it is first and foremost simply a matter of the purely formal analogy between, as I see it, the difficulty, acknowledged by all psychologists and so graphically presented by William James, of observation and analysis of psychic experiences and the state of affairs in atomic physics.”

James had defended that the best way to study consciousness and its products or objects should be by observation. In the process of observation, he argued, the psychologist is partly outside the mental state even when relating his or her own mental state. This is because the act of describing a state of the observation puts the person outside, whether or not they turn out to be the object of study. William James focused a relevant part of his work on the link between consciousness and its object, describing it as a ‘relation of knowing’.

The similarities between Bohr and James’ line of thought are clear. Bohr and James were both focused on the difficulties of the observation, Bohr in the process in physics, and James on the observation problem in psychology.

Bohr developed a pragmatic criterion of truth with the philosopher Harald Høffding, stating that their principle established several possibilities to manifest and unify experiences. Høffding coined the notions 'dynamic' to demonstrate that truth can modify with a person's experiences, and 'symbolic' to describe the analogy between idea and object. This is comparable to Bohr's perspective of wave and particle as symbols and his argument that physics is a method by which to organise and summarise personal experiences, (Bohr, 1929).

Bohr outlined the parallels between the situation in quantum mechanics and in psychology stated in his essay 'The Quantum of Action and the Description of Nature' (1929). In this, he interpreted more widely the theory of quantum mechanics. He began by describing the problem of analysing microphysics. This led him to the problem of the object and the subject in psychology. He assumed that both sciences deal with comparable conditions. (Bohr, 1929).

Bohr and Høffding discussed the problem of self-observation that the latter described in a book of psychology, referring to the importance of the process of observing and being observed as elements of consciousness and observing that the process of attention might create modifications at a psychological level to the one who observes, (Bohr, 1930).

The idea, similar to James' perspective described in his book *The Principles of Psychology*, was mentioned by Bohr because of the impact it had on him.

Bohr transcribed from William James 'Stream of Thought':

'In particular, the apparent contrast between the continuous onward flow of associative thinking and the preservation of the unity of the personality exhibits a suggestive analogy with the relation between the wave description of the motions of material particles, governed by the superposition principle, and their indestructible individuality.' (Bohr, 1930 p.103)

Bohr's description of measuring the transition of an atom is similar to Høffding and James' narrative when explaining the link between subject and object in the act of self-observation (Bohr, 1932).

However, James also describes the concept of complementarity related to personality disorders. In his *Principles of Psychology* (1890) James stated:

'it must be admitted, therefore, that in certain persons, at least, the total possible consciousness may be split into parts which coexist but mutually ignore each other and share the objects of knowledge between them. More remarkable still, they are

complementary.’ (p. 204). ‘...Few things are more curious than these relations of mutual exclusion....’ (p. 207)

He argued that in an individual with a split personality, consciousness could split into distinctive sub-personalities that co-exist side by side, but nonetheless disregarding each other. Knowledge is still shared between them, however, and the sum of the complementary states of consciousness forms the normal personality.

Both William James and Høffding applied the concept to the idea of free will and then they later used it to explain that the link between mind and matter might be explained by a complementary process. Bohr was enthusiastic in defending the analogies verified in quantum physics and other fields of science. He expressed the perspective that complementarity could contribute to psychology to understand the link between thought and feeling.

In conclusion, this chapter has elucidated the links that have existed between psychology and physics since the beginning of the twentieth century. With the development of the concept of synchronicity by Carl Jung, shared with Wolfgang Pauli, the concept was used to explore the relationship between mind and matter considering that both concepts could be part of the same

field. The notion of complementarity in turn began with William James, and was later used by Niels Bohr, contributing to the development of both physics and psychology. It could be argued that the way Jung and Pauli used the concepts of synchronicity and causality are similar to the way Bohr used the term complementary in quantum physics. These ideas helped to lay the theoretical foundations for the experiments that will be conducted in this thesis.

The next chapter will continue presenting the concepts that are the main structure for this thesis, showing the similarities between the concepts discussed in this chapter with the ones found in the theories presented.

CHAPTER 3 Presenting the main theoretical framework: GQT, MPI & CMM

3.1. Introduction

This chapter further develops the concepts that provide the main grounds for the theories underlying the experiments in this thesis, namely: The Generalised Quantum Theory (GQT), the Model of Pragmatic Information (MPI) and the Correlation Matrix Method (CMM).

A brief historical note on the topic of mind and matter will open the chapter. I will present a philosophical introduction on Plato and Descartes' perspectives on the mind-body and mind-matter issue and how it links with the concepts of complementarity and entanglement discussed in the previous chapter and that form part of the background of CMM.

This opening is followed by the introduction of the Weak Quantum Theory (WQT). The WQT developed in 2002 evolved through new interpretations of the main concepts into the Generalised Quantum Theory (GQT). The concepts of entanglement and complementarity that helped to shape the format of WQT and GQT are then explored and defined. The main notions of General

Quantum Theory: system, state, observable and measurement, are outlined.

The chapter continues by presenting the theoretical background of the Model of Pragmatic Information that classifies itself as a sub-section of the Generalised Quantum Theory. The MPI takes the narrative further into the Non-Information -Transmission axiom (NT-axiom), as well as to the laws and requirements that make up the Model of Pragmatic Information. The chapter continues with the Correlation Matrix Method, CMM, which leads to exploring the concept of organisational closure.

The links between the three theories, GQT, MPI and CMM are outlined, demonstrating how the three models claim to provide an answer to the mind and matter problem, and more broadly, an answer to parapsychology's replicability problem?

GQT is the first theory to be introduced because is the main support to the other two models (MPI and CMM). Due to the complexity of the three models and how they are intrinsically connected, the order chosen to present them contributes to an easier understanding. Examples from everyday life are given to illustrate the main concepts and facilitate their understanding. Moreover, I will not resort to mathematical formulas that support the theoretical ideas as those go beyond the scope of the thesis.

3.2. Mind-matter and mind-body related to complementarity and entanglement

3.2.1. Introduction

This brief historical summary on mind-body and mind-matter is of interest because it complements the topic of the thesis. Moreover, it also highlights how the topic has endured over the centuries which emphasizes its actuality and the need to continue its study. However, the historical section was introduced for being considered a relevant piece of information to complement the topic of the thesis. The historical perspective is not the main aim of the discussion, rather it acknowledges the discussion since Descartes and Plato.

3.2.2. Descartes and Plato's philosophy of mind and body vs mind and matter

The relation between mind and matter is a topic that has been fascinating philosophers since the time of ancient Greece, from Plato in 342 BC to Descartes in the seventeenth century, up until today (Primas, 2009). The topic has been kept alive with discussions and arguments being exchanged, reflecting a diversity of opinions and theoretical approaches, between mind

and body and mind and matter (Atmanspacher, 2012; von Stillfried & Walach, 2006).

To Plato, mind and body were two different realities independent and separable. Aristotle (1968), shared Plato's point of view on defining mind and body distinct from one another. He defended the idea of metempsychosis, which had been originated by Pythagoras. The concept means the migration of the soul from one body to a new physical body when the person passes away. The process of metempsychosis was considered part of the evolutionary process of humanity (Hart, 1996). Descartes (1641) described the idea of mind and body as a 'dualistic' perspective, based on the notion that mind and body are different qualitative substances opposing to monism in which mind and body are part of one combined being (Atmanspacher, 2003; Walach, 2005).

The concept of causality does not allow for interactions between the two realities: mind and body. Descartes did not explain the interaction between mind and body but developed a theory on "mind-body dualism" (Murdoch, 1987; Pais, 1991). Dualism could justify the interaction between what Descartes called *res cogitans* and *res extensa*. With no argument that the mind, the nature of which is to think, is absolutely different from the body, the extended non-thinking part, is not possible for one to exist without the other (Descartes, 1976). Descartes' causal interaction between mind and body is still discussed today

(Flage, 2019; Faye, E, 2016; Scott 2016). The problem is exposed in the following way: if the mind can cause one part of the body to move, such as by raising one arm, how can the body's organs provoke feelings in the mind if their natures are different? According to Descartes, causality is not an answer to the causal interaction between the above examples.

Considering the two ontologically different substances, *res extensa* and *res cogitans*, the main question to the problem is: how can they influence each other or interact with each other? Descartes saw the problem but could not solve it; his proposed solution to have a special organ, the pineal gland, is for one wrong and apart from that not a solution, as it does not explain how two completely different things can interact.

For this reason, the question continued to be discussed.

At his time, Spinoza (2016; Nadler, 2018) and later Leibniz (2015) tried to solve the dilemma by a kind of dual aspect model: extended and mental aspects pertain to the same substance as two aspects of reality. That is, in a way, an early complementarity stance.

Interestingly, the topic of causality related to the study of the mind and body was also discussed by other philosophers such as Primas (2003).

These philosophical ideas influenced the development of Weak quantum theory, which explores how to integrate the concepts of complementarity and entanglement as an answer to the problem (Walach & Römer, 2000).

The question of whether mind and matter interaction is real, raises the need to define how this interaction works and in what it consists. One way of answering this issue is that they are complementary aspects of one reality, as matter and mind do not have the same properties (von Stillfried & Walach, 2006)

Envisioning mind and matter as correlations through the synchronicity/entanglement perspective, indicates correlations between mind and matter as a possible reality (Atmanspacher, 2012). Reflecting that these correlations are not consequence of causal interactions between mental and material fields, a dualistic framework where mental states are not caused by material states, and vice-versa could be feasible in a dualistic perspective (Primas, 2007).

Such psychophysical correlations were debated between Pauli and Jung mostly from 1949 to 1951 while discussing the framework of synchronicity. This point is presented in chapter 2.

3.3. From Weak Quantum Theory to Generalised Quantum Theory - An outline of the GQT

3.3.1. The beginning of WQT & GQT

GQT had its beginning as Weak Quantum Theory (WQT) and was hypothesised by Atmanspacher, Römer and Walach in 2002. WQT emerged from the conviction that a successful theory such as Quantum Theory could be applied to other fields of science, as explained in the introduction.

The theories exploring the effects of mind-matter interaction, or PK, had their origin in concepts of classical physics. The classical process accepts the transmission of information as a local cause or an influence to generate PK (Bauer, 2007). However, this interpretation of explaining psi through local causes, did not explain the empirical database, which demonstrates that psi manifestations happen independently of time and space, showing that classical physics could not be the answer (Walach et al., 2014).

The interpretation of Psi effects explained as local principles, means that they cannot produce consistent Psi manifestations (Lucadou et al., 2007; Walach et al., 2014)

To apply quantum concepts to other disciplines, the authors of GQT considered that it would be helpful to broaden the concepts of quantum theory, which would facilitate its acceptance and understanding by other fields of research (Filk & Römer, 2011). The initial idea behind the weak quantum theory was as the name expresses, taking the relevant concepts and to weaken the axioms from physical quantum notions so they could be applied in a more 'flexible' way. However, the applicability of the theory to other fields showed that the term 'weak' was not the most appropriate as it was considered that the challenge for applying quantum principles to other fields relied more on the capability of opening up the axioms in the sense of making them more generalised rather to weaken them. The introduction of more generalised axioms contributed to the development of the theory evolving then into what is now called Generalised Quantum Theory, getting a stronger emphasis on its features (Atmanspacher, Filk, & Römer, 2006; Filk & Römer, 2011; Walach, von Lucadou & Römer 2014).

The possibility to use tools from quantum theory in fields other than physics, was appealing to other areas of science. For example, a relevant tool that would contribute to the study of mind would be to implement a measure. Measurement is a key tool in science. The fact that a measurement might be able to

influence a variable during the process of measurement, modifying its own state, is called a non-classical measurement and is the defining feature of a quantum system (Filk & Muller, 2007). However, this kind of measurement has not been discussed, for example, in the social sciences, or in psychology, due to the lack of a theory, although it might be relevant even there. Quantum measurement-like tools would, therefore, provide new opportunities also to other fields of science. Considering the example of a psychotherapeutic session wherein a patient undertakes an introspective exploration on a personal issue, which might alter the patient state of mind or feelings, or a hypnotic session, where afterwards the person may have a different understanding of the issue reported before the therapeutic session. These situations suggest that psychology in the psychotherapeutic framework would benefit from the application of a quantum-like measurement according to Atmanspacher, (2002, 2006). Furthermore, another aspect to consider is a sequence or order in which clinical events happen and its influence on the patient outcome (Walach, Römer & von Lucadou, 2014).

This perspective directly follows Niels Bohr's demonstration that the order in which quantum states are measured influences the outcome. (Bohr, 1966, Atmanspacher & Römer, 2012). GQT is relevant due to its theoretical framework which builds its

concepts in a way to make them applicable beyond physics. The approach opens up a new possibility to study psychology, parapsychology and other fields of science (Walach, et al. 2014).

3.3.2. The structure of Generalised Quantum Theory

GQT adopts four notions that are part of classical and generalised quantum physics. Those notions are system state, observable and measurement which will be detailed below, (Filk & Römer, 2011; Atmanspacher, Filk & Römer, 2006; Walach & von Stillfried, 2011). These concepts are also used in Generalised Quantum Theory and were transformed by analogy from the original concepts from Quantum Theory.

System: the notion of a system refers to information (Kornwachs and von Lucadou, 1989). A system can be anything that when isolated from everything else, can be studied on its own. One example of a system can be a university, which has departments that are integrated with each other, with buildings, students, etc. The method used in physics to describe a system can, according to Filk and Römer (2011), be widened to include the possibility of describing subsystems inside one system. This mechanism allows to include subsystems to incorporate in the larger system in the definition of system used within GQT (Atmanspacher, et

al., 2006). This approach will be reflected on the MPI and CMM. According to them any piece of reality that can be isolated from its environment, can be an object of investigation. It is implicit that a system has the ability to exist in different states. Moreover, it is also stated that there is a connection between the system and the knowledge of the observer about the system.

State: A state describes the organisation of properties of a variable in a phase. Whilst a system is something that is supposed to exist in diverse conditions without losing its characteristics, pure states and mixed states can be distinguished. It is considered that pure states hold the maximal knowledge and mixed states hold incomplete knowledge (Atmanspacher & Römer, 2012; von Lucadou, 2015).

Observable: an observable is defined as any part of the system that can be studied within a more or less significant form. Understanding the meaning of an observable is vital (Filk, 2013). There are global observables that relate to a system as a whole and local observable that relate to subsystems. As an example, an observable could be, for instance, the university, (Walach, 2014). An object that is part of a system that can be observed, i.e. measured, is meaningful and produces a useful result and is called an observable. There are observables that are compatible,

and thus their state can be determined simultaneously without influencing each other. And there are observables that are incompatible. Observables A and B are *complementary* or *incompatible* in relation to their measurement, if the order in which they are measured matters. This means that observables cannot commute with each other, because the measurement of one observable influences the measurement of the other observable. An example of this would be assessing a patient's psychological state through questionnaires. Giving the patient the questionnaire before or after the therapeutic session will alter the measurement and the assessment of the patient. Observables are compatible, as opposed to complementary when the measurement is interchangeable, which means that the order in which the measurement of the variables is made does not influence the result, or in other words, the measurement does not influence the measured observable.

Measurement: observables are measured in order to understand what belongs to the observable. For example, observable A is measured to study what belongs to it, and when arriving at result A its factual validity can be considered. The significance of factual validity is related to the system. One example of this is the agreement among groups of human beings. When measuring the behaviour of A, the result can be related to a specific state

Z, or the measurement can be dependent on other factors or states that are not exclusively Z.

The process of measurement, even in physics, is not completely successful (Römer, 2004). In the case of GQT, in which the focus is on systems, the generalised measurement is mainly a cognitive process and pertains to cognitive processes. As such, cognitive psychology could use the field of physics in this measurement based on applicable systems to explain cognitive processes (Atmanspacher et al., 2002). As an example, the variables *A* and *B* explained above as observables, can be considered complementary if, when they are being measured, the sequence of their measurement is relevant. In that case they can be called *complementary* or *incompatible*. *A* and *B* are called *incompatible* if it is not possible to measure their precise values at the same time simultaneously. Thus, the state of the system depends on the order the measurement is taken and the corresponding results. Another way of putting this is saying observables *A* and *B* are incompatible if measuring *A* changes the state of *B* and vice-versa.

The same observables *A* and *B* are *compatible* when they are *not complementary*, which is to say that the measurements are interchangeable, they do not interact with one another. If observables are compatible, we can treat them classically and we do not need a quantum theoretical framework to deal with

them. The quantum type framework of GQT has been developed to deal with incompatible observables, which are likely also relevant in psychology. In GQT, A and B do not need to be compatible but will often be complementary, (Walach et al., 2014).

If we are dealing with observables that are non-complementary, this means that the order in which the observables are measured is not relevant, and the observables are called compatible. Filk and Romer (2011) introduced a new interpretation of the GQT and noted that the existence of an action of observables on states was suggested. In their new formulation they simplify the process, weakening even further the axioms of GQT, which, according to the authors, can bring benefits. This new introduction allows GQT to use an action of all observables and states.

3.4. Introducing notions of complementarity and entanglement

3.4.1. Framing the concepts

According to GQT, the concepts of complementarity and entanglement of quantum theory were intended to be 'weakened' to allow its use in some non-physical contexts. By weakening the

concepts of complementarity and entanglement they continue to be definable, which means that the concepts in themselves are general enough to be applied to other fields (Atmanspacher et al., 2002; Filk & Römer, 2011).

The concepts of complementarity and entanglement are explained without their mathematical formulas as mentioned previously. The meaning of complementarity and entanglement are looked at from the philosophical, psychological and psychophysical perspectives. In the next subsection the notion of complementarity is explained followed by the notion of entanglement.

3.5. The notion of complementarity

Complementarity can be explained as a situation in which objects holding opposite properties cannot be observed and measured at the same time. However, the concept creates limitations in its understanding as it seems to go against what is natural in everyday life: that one cannot observe something and measure it at the same time. Complementarity is an important concept that supports the GQT suggesting a way to create the link between quantum and fields of science outside physics.

The concept of complementarity was made well-known by Bohr as explained in chapter two. It was used to describe the relationship between contradictory notions that seem to have an opposed relationship. The characteristics of the concept seemed to show that they complemented each other. This idea of contradictory or opposite notions that complement each other prompted Bohr to relate this to the Chinese Yin-Yang symbol and the inscription: “*contraria sunt complementa*” – translate as ‘opposites are complementary’. One example of complementarity also related to entanglement and frequently used by Bohr was the study of light. Bohr, used pairs of photons, that spin in opposite directions to show that somehow, they communicate at a distance without the use of any known method. This conclusion, the measurement of communication between particles is main point of interest to GQT which is a direct consequence of complementarity.

It is interesting to note that the example most used by Bohr, the double slit experiment, in which he considered whether there were complementary properties between one wave and one particle, one can observe them but not measure them simultaneously. As Bohr (1934) himself put it:

The analogies with some fundamental features of the quantum theory, exhibited by the laws of psychology, may not merely make

it easier for us to adjust ourselves to the new situation in physics, but it is perhaps not too ambitious to hope that the lessons we have learned from the very much simpler physical problems will also prove of value in our endeavours to obtain a comprehensive survey of the subtler psychological questions. [...] it is clear to the writer that for the time being we must be content with more or less appropriate analogies. Yet it may well be that behind these analogies there lies not only a kinship with regard to the epistemological aspects, but that a more profound relationship is hidden behind the fundamental biological problems which are directly connected to both sides. (p. 20)

Particles and waves are concepts from classical mechanics, which notes that being a particle and a wave at the same time is impossible. Consequently, it is not possible to measure all of the properties, either of the wave or the particle, at a specific moment (Bohr, 1966). Bohr argued that objects embedded with complementary principles from quantum mechanics do not have inner properties independent of being identified by a measuring device. It is the type of measurement that determines which property is shown (Bohr, 1961).

Later, Einstein and Bohr discussed their ideas about quantum mechanics equations given/ being used in a wide of variety of fields for everyday use, from physics to engineering, and to

chemistry and biology. The success of modern technology depends on the principles of quantum mechanics. However, its method of working remains a mystery. Due to the fact that principles of quantum mechanics work over and over again and in replicable ways, scientists do not question the lack of 'natural common sense' when applying them. There is no description of what happens to a physical system, only about the way a physical system interacts with another. Authors extrapolate from this and argue that the essence of reality is an inexpressible system, questioning whether reality could be a sum of interactions and correlations, according to Rovelli (2016). In the field of parapsychology, the opposite can be argued; there is some knowledge of what happens, but not of how it happens. GQT aims to supplement concepts that by analogy allows the field of parapsychology in between others to apply similar rules as those of physics to the mind, considering it as a system.

3.6. Concept of generalised entanglement

The concept of generalised entanglement is presented to describe another argument of GQT. An example of an entangled particle is a pair of photons. In quantum physics entangled particles continue to couple so the measurement of a property of

one particle affects the other even if at a distance and even if there is no possibility for a causal signal to convey the effect of the measurement; this was called 'spooky action at a distance' by Einstein in 1935. As a principle of quantum physics, one photon/particle exists in all potential states simultaneously until the moment it is observed or measured; from this moment onwards, the observed/measured photon assumes one state and instantaneously the other coupled photon, even if it is situated at a distance, assumes the opposite characteristic in the case of spin measurement. The pair always exhibits spin in opposite directions, but the directions which anyone assumes is only defined by the observation itself. Entanglement or quantum entanglement happens when pairs of particles relate to each other. Those particles have the characteristic that one cannot be measured and explained separately from the other. Therefore, one particle or group of particles has to be described holistically as related to the other, even when the particles are separated by a distance or in time⁷ no matter what that distance is. This notion of entanglement is crucial for the experiments replicated in this thesis. Entanglement correlations (or synchronistic manifestations/ correlations) are the measurements taken in the psi task performed in the studies. According to the author of

⁷ This is also true for temporal entanglement, a fact that can be used to explain precognition.

CMM, von Lucadou, entanglement correlations are created by organisational closure of a system. As I will discuss in greater detail in a later section, the notion of organisational closure is a form of connection created between the elements of a system, in this case the participant and the machine, a psi task performed on the laptop. One could also speculate that the researcher is part of the system as well, due to the involvement in receiving the participant, explaining the study, etc., and thus contributing to facilitate the establishment of organisational closure.

Resuming, the existence of entanglement correlations (Lucadou et al. 2007) depends upon whether a system: (1) is organizationally closed (as explained in the appropriate section below) to its external environment; (2) includes a subsystem; (3) that is described by variables and observables; (4) part of a global observable or system as a whole; (5) which subsystems or local observables, (6) can be complementary or incompatible to each other.

3.7. Model of Pragmatic Information - MPI

3.7.1. Introduction

The Model of Pragmatic Information (MPI) was developed by Walter von Lucadou and Klaus Kornwachs (Kornwachs & von Lucadou, 1985; von Lucadou, 1985, 2006, 2015).

The notion behind the model, called pragmatic information, is the condition for the model to explain the manifestation of non-local correlations (synchronistic manifestations/correlation) as part of a system. The notion of system is defined in section 3.3.2. as something that can be isolated from its surroundings and can be studied on its own. "System" is part of the notion of information. The term pragmatic information belongs to the information theory. It was introduced by Ernest Ulrich von Weizsäcker and has been used by several authors, namely Kornwachs and Lucadou (1985, 1986), Atmanspacher and Scheingraber (1992) and beim Graben (2006). The Model of Pragmatic Information intends to define the quantity of information that a message conveys, or that is transmitted, looking at the impact it has on its receiver.

The two main characteristics of the MPI are the results of two variables: novelty and confirmation. As an example, to better

explain the idea, one should consider the same person reading a new book in their native language and in a foreign language. Interpreting the situation from the perspective of the Model of Pragmatic Information, the case in which the person reading the book can interpret the information gives the individual confirmation of the content of the book (= confirmation). Nonetheless, reading the book also contains some novelty to it (= new book) which is significant as well. Moreover, the meaning obtained the first time the reader reads the book in his/her native language will be stronger, due to the novelty (= novelty), whereas novelty without any confirmation whether the book in a foreign language was not well understood, has no pragmatic information value.

The information that the receiver gets from the message is measured according to its context. The act of measuring permits one to quantify the *effect* of the information exchanged, where the amount of information can be calculated by being the information that is understood. One can affirm that the size of the effect is proportional to the meaning of information, as a product of novelty and confirmation. It is interesting to note here, that this is also a multiplicative relationship of incompatible observables; this makes up the analogy between MPI and GQT.

Thus, it is possible to widen the context defining that a change in variable A allows a change in B which is a related variable. This interpretation sustains that A affects B and because of that effect there is meaning for B . This is the same theoretical structure as in the model of GQT, where a measurement of one observable influences the value of the other measured observable. Indeed, the core concepts of MPI, novelty and confirmation, are also incompatible observables.

3.7.2. Main characteristics of the MPI

The MPI quantifies the meaning of the given information, starting from the assumption that that meaning can be measured. Moreover, the important information coming from a system can be used to measure the meaningfulness of the information belonging to the system.

The measurement is quantitative and starts with the assumption that it is possible to quantify the content of relevant information. Considering that the information is important and meaningful, it should be possible to measure its importance in a quantifiable form. This is an assumption of the model.

The relevance of the notion of pragmatic information was pointed out by Kornwachs (1996). He comprehended the importance of having deeper knowledge about the concept of information itself,

as well as its definition for a better understanding of the concept of pragmatic information. He argues that the pragmatic model relies on the concept of information, which interacts in a meaningful way between systems. He plays with the words to reinforce his perspective. Systems are the foundations, the crucial base of information, and information creates systems. Kornwachs argues for the possibility of the two concepts being 'two sides of the same coin'.

The MPI characteristics are also extended to include the concepts of entanglement and complementarity from the Generalised Quantum Theory (presented in section 1 of this chapter) (Lucadou 1994, Filk 2010). Moreover, the model incorporates concepts of structure and function.

The fundamental presupposition of the model states that nature should be explained as structure and the MPI can be explained in a similar way. Nature has a structure similar in form to the manifested structure described in quantum theory.

According to Walach et al. (2014), psi phenomena can be seen as similar in meaning to quantum phenomena, namely through the concepts of complementarity and entanglement.

3.7.3. Laws of the MPI

The MPI can be framed within two laws:

1st: psi phenomena are non-local entanglement correlations in socio-psycho-physical, self-organising, organisationally closed systems, which are induced by the pragmatic information, creating the system.

2nd: Any attempt to use a non-local correlation as a signal transfer makes the non-local correlation vanish or change the effect in an unpredictable way (e.g. the effect may show up in a different variable, which was not under consideration beforehand; this is known as the “displacement-effect”).

The second law is a result of an aspect of the MPI that von Lucadou considers to be the most important part of the model, called Non-Transmission axiom (NT-axiom) (Lucadou, 1984, 1987, 1998, 1995, 2001, 2002; Lucadou, Römer & Walach, 2007). This principle states that entanglement correlations cannot be used for any signal transfer or causal links (Lucadou, 2015). For physical entanglement correlations this can be formally proven. For the generalised case it is a reasonable assumption. For this reason, the NT- axiom has to be accepted as an axiom.

The NT-axiom plays a role in the MPI, by stipulating that the origin of psi phenomena are entanglement correlations and not signals. The entanglement correlations result from the meaning, that is, from the information created by the situation or system. In the example of the experiments described in chapter 5 and 6,

the meaning was created during the experimental session, by the relationships developed between the researcher, the participant, and the machine, the random number generator. These allowed the entanglement correlations to manifest when the participant was performing the task.

3.7.4. Non-Transmission- axiom

In this section, I discuss how the MPI's axioms are operationalised in an experiment. The theorem part of the quantum information theory states that during the process of measurement of an entangled state, the observer cannot measure a total subsystem and communicate the information to another observer related to the measured result. The non-communication is a postulate that explains how at a quantum level during the measurement of entangled particles, correlated information is generated that cannot be used for signal transfer. The setup of any experiment based on MPI therefore has to prevent the production of a signal according to the MPI and GQT. This means that psi effects cannot be tested directly. This idea applied to the experimental setting, states that according to the NT-axiom no predictions can be made as to which cells entanglement correlations will occur. A prediction to where the

significance occur would violate the axiom and make the effect fail to manifest (Lucadou, 2007). This is the theoretical argument for why traditional experiments fail to replicate, because psi is treated like a signal

The “Non-Transmission axiom” part of the MPI assumes that psi phenomena are not signals but entanglement correlations. Those correlations are created by the “meaning” or pragmatic information of the situation (Lucadou 1984, 1987). Another assumption of the MPI is if psi is treated as a causal signal, this leads to the decline-effect (Lucadou, 1983, 1989, 2000b, 2001). Psi should, therefore, be treated as entanglement correlations, or a synchronistic situation. This is in clear contradiction to most psi research that implicitly assumes a subtle causal influence model of a purported “psi-signal” or “subtle causal” influence. Assuming that structure and function are bases of the MPI, as stated previously, they should be considered as complementary observables in the system being studied. This means that different results are obtained depending on the order of the measurement; if the structure is measured first and the function in second, this gives a different result than if the function is measured before structure. One example is, if one gives a group of students a well-being test and they are also asked to watch a boring movie in a hot room, the answers would be different

depending on whether the test is performed before or after the group watches the movie.

3.7.5. MPI key concepts

The main MPI concepts used to measure the structure and function of a system are as follows: pragmatic information [I], novelty [E], confirmation [B], autonomy [A], reliability [R], temporal dimensionality [D], and minimum action [i].

Examples of the concepts are the following:

I: measures pragmatic information: the data acquired by an information measured by its performance on a system. The information produced by the experimental session is all relevant to the model, as it the relevant information transmitted in the system, between the sender and receiver.

D: measures temporal dimension: measures the connection between temporal events that are part of the history of the system. The history of the events produced during the experimental session are measured as being part of the system.

R: measures reliability measures the observed phenomenon that is anticipated on the system. Data produced during the experimental session should be trustworthy as it is part of the system

A: measures autonomy: relates to the observation that cannot be expected in the system.

B: measures confirmation: confirmation is the part of pragmatic information that is already known by an observation of the system. Participant when performing the task should understand the task that is performing.

E: measures the novelty: the amount of pragmatic information of an observation that is that is new for the system. The experimental design, when replicated should always have a new element introduced. Novelty helps to keep the interest or equilibrium of the system.

i: measures the minimum action: is required to perform the minimum action on the system when it is being measured. Experimental task should be simple and quick. It allows to record participants intuitive action.

As described in the introduction of the chapter, the main theories underlying the experiments in this thesis are to be presented in this chapter. The MPI and its main characteristics, laws and the NT-axiom were here described. The section ends with the description of the MPI key concepts. The following section focuses on the CMM, which has its foundations in the GQT and the MPI which is also the model I am testing in the studies described in chapter 5 and 6. The definition of CMM takes us to

the concept of organisational closure which is part of the next section.

3.8. Correlation Matrix Method (CMM)

As stated previously, CMM is based on the MPI and GQT and was developed to test GQT and MPI by using a correlation matrix technique.

The CMM technique was created to measure psychological variables and physical variables throughout the experimental session. After the data produced is correlated all together and shown on a matrix table. The psychological variables are measured during the psi task and afterwards they are correlated with the physical variables created by a random process that produces random events during the experimental session. The correlations obtained from both data sets are then counted and the ones considered as significant are highlighted in the matrix table.

According to the QGT and MPI the assumption is that psi is not a signal but a non-local entanglement correlation manifesting through the correlations created between psychological and physical variables. Psi, can also be called a synchronistic correlation or synchronistic manifestation of mental influences. Thus, CMM is developing with the aim to be used as a tool for

psychological therapy, counselling as to other areas of research. At a parapsychological level, the model proposes to contribute to the difficulty of replicating findings and avoiding the decline effect of the results when the same study is successively replicated.

The task given to the participants explores whether mind interferes with matter by asking the participant to influence a display by intention alone. For the task a display shown on a laptop screen and driven by a random number generator moves randomly after the participant presses a key on a laptop keyboard. In parapsychology, this phenomenon of mental influence over a physical system without physical interaction is called micro-psychokinesis (Varvoglis, 2016).

3.8.1 Correlation Matrix Method

The classical psi experiments are designed under the implicit assumption that psi is a kind of signal, and thus the experimental paradigm contains several psychological variables, such as questionnaires, and mainly one dependent psi-variable (Jahn & Dunne, 1987). The matrix-experiment, CMM, however, is designed under a different experimental paradigm, namely, that psi is an entanglement correlation. Here we have not only a set

of several psychological variables but also a set of physical variables, resulting in the experimental matrix of psychological versus physical variables. Both sets of variables correlate among each other. Additionally, there exists a control-matrix which uses the participants' psychological variables however, the random computer program runs 'alone' the psi task without participants. The program uses each participant psychological data and new independent random data is created for each participant's psychological data. This is the original control developed by von Lucadou. A permutation analysis as statistical evaluation tool was added as a novelty in this thesis. Both methods, are explained in chapter 5.

The entanglement effect is measured by the difference of the number of correlations within the two matrices, the experimental and the control.

The MPI predicts that the entanglement can also produce a loss of correlations in the control-matrix and, furthermore, additional correlations among the physical variables. This is a requirement of the NT- axiom (von Lucadou, 2006, 2015) explained in more detail in chapter 5.

3.8.2 Organisational closure (OC) in the experimental set-up of CMM

According to MPI, the behaviour of a non-classical system is related to the circumstances of its observation. That is to say that the observer, participant, and observed, machine, RNG in the case of the studies performed in this work, create an 'organisationally closed' system just by exchanging pragmatic information, meaningful information, that creates a link between the participant and the experiment. This link is called organisational closure and it is argued by Lucadou (1984,1987, 2002 2015) that it is what produces entanglement correlations, or using another terminology, synchronistic correlations, between the observer and observed.

The challenges with the experimental set up of the CMM can be defined as follows:

- 1) to establish the direct link between organisational closure, the observer and the observed system, participant and machine, avoiding predictions about the variables.
- 2) to determine that non-local correlations arising in the system are due to the organisational closure. That is, to seek assurance that other physical influences from the observer are not responsible for correlations in the system. Furthermore, that the observer's behaviour and psychological processes can be related to the level of motivation of the subjects, influencing the level of organisational closure.

3) to guarantee that the machine (RNG) is adequately secured against external influences.

3.8.3 Organisational closure and its application

Organisational Closure is a concept that explains the limits of systems that was presented by Francisco Varela and Maturana (1981, 1991). The concept describes that certain types of relationships or interactions that are essential parts of an organisation or structure could be called a system. They named this system as organisational closure. Varela stated that the property of closure was typical for certain types of systems. One example of a closed system is a group that somehow relates in its meaningful parts. It creates meaningful or organisational ties that makes them organisationally closed. Moreover, this is a property that makes them able to produce unique transferences of information, just by circulating among the closed system. Maturana and Varela (1961) argue that these organisationally closed systems that are composed by organisationally closed structures are common in living organisms. An example of an organisationally closed system in the field of biology is the cellular part of an immune system or following the same line of thought one example from psychology would be consciousness.

The organisationally closed system is a unity with a specific identity that works together in a structured way interacting to regenerate the system as a unity (see Varela, 1981)

The effects of observation are interactions of this kind, specific characteristics of the system, when it comes to applying the Generalised Quantum Theory (von Lucadou, 2006). Since organisationally closed units are considered closed systems they exist in entangled states. Jung regarded synchronistic situations as entangled states (Cambray, 2014)

A relevant point for discussion continues to be whether the quantum characteristics of the system explained by General Quantum Theory are related to our knowledge only, i.e. to epistemic states, or to the underlying reality, i.e. ontic states and such is validated by the theory.

An organisationally closed system is considered a significant part of the GQT because entanglement correlations among apparently separated systems cannot be ignored or excluded with confidence (Filk, 2014). One example of a small system can be a single person. A person can manifest psychosomatic experiences and somatise a symptom.

These experiences are sometimes reported as synchronistic or parapsychological experiences and in GQT they can be explained, such as in a manifestation of complementarity between mind and body as a part of the whole of the person.

In the cases of dealing with not just a single person but several persons one may say that they are dealing with more complex systems, where several physical parts/things manifest as telepathic, psychokinetic or precognitive phenomena. As per Carl Jung the world was the biggest system that it was possible to imagine (Meier, 2001; Zabriskie, 2014). One can explore the concept of GQT applied to the world as a unified system in terms of complexity searching for entanglement correlations in such an organisationally closed system. But it is likely more promising study such correlations in smaller, experimentally more accessible systems that are complex and meaningful enough.

Synchronistic experiences manifest normally at a level of the more complex systems just mentioned.

Synchronistic manifestations are conventionally expected when a system is organized in an entangled state. This can be done with the system in a state called the eigenstate, where a measurement of A defines the state of the system where A produces meaningful results. For example, a closed system composed by several individuals is complex because it has several systems, i.e., persons, (each person is a system). An observable part of the system, A , could be measuring the level of emotion in their connection, their relationship or commitment as a part of the family bond.

Continuing with a family as an example of an organisationally closed system, *A* can be considered as an observable that has the function of measuring the emotional level of the family attachment or friendship.

Also, if exploring in the family an entanglement state, also called synchronicity event; local observables as part of the system can be observed because the correlations between the local observables can be measured. For a measurement to be taken there is a *sine qua non* condition, namely that the state is observed.

Entanglement correlations are considered non-local and hence are not bound by space or time. Therefore, synchronistic events can happen across a large distance or across temporal divides, such as in precognition. The example that Jung gave of the golden scarabaeus, described in chapter 1, 1.2, is an example of a synchronistic or non-local manifestation resulting from a meaningful situation in a non-local system. Synchronistic correlation is not related to the object and its location but exclusively to its meaning.

The Model of Pragmatic Information requires an explanation of the phenomenological meaning of the synchronistic circumstances. The model suggests an operationalisation of the

concept of “meaning” by presenting the ideas of ‘novelty’ and ‘confirmation’ (Weizsäcker, 1974; Lucadou, 1998). Referring back to Varela’s concept of organisational closure and Weizsäcker’s concept of pragmatic information, Lucadou (1986) explained how to operationalise them in his experimental correlation technique integrating them with GQT.

In conclusion and recapitulating the concepts due to their importance in the CMM, the notion used to explain the limits of natural systems, called organisational closure (OC) was defined by Varela and Maturana (1972, 1980), who first used the idea to explain the self-maintaining biochemistry of living cells. By definition, an organisationally closed system, due to its nature, interacts with its own components.

The conditions for the organisational closure are:

- 1) self-organisation; and
- 2) the system having self-stabilising properties.

Psi effects are considered by von Lucadou (1984, 1991b) to be meaningful non-local entanglement correlations between a living system and other (causally) separated systems.

Entanglement correlations are patterns inside an organised system that are created by pragmatic information and measured from the outside. Moreover, non-local means that the observable is not dependent on time and distance (e.g., the importance of a

personal relationship is relevant no matter how far apart partners are in time or space).

The concepts underlying the experiments in this thesis are now all introduced. A goal of this project was to validate the CMM. The next step in that process was to certify the software used to test the model. The CMM software was developed by von Lucadou. A validation process was developed by me and the process published in a journal. It follows in the next chapter 4, before introducing the experimental replication study 1 in chapter

CHAPTER 4 EDINBURGH SOFTWARE VALIDATION TEST FOR RESEARCHERS IN PSYCHOLOGY

4.1. Introduction

The following chapter is composed by an article written by the author as part of her PhD project. One of the tasks of this PhD project was to validate the software program developed by von Lucadou which was used in all five experiments. In addition, I wrote my own analysis software in R language with the help of the computational biologist P. Rapazote-Flores, following the protocol describing the method I was replicating. (Appendix 1).

It is important to emphasize that I learned to program in R language from scratch, my previous knowledge in any programming language was null. I developed the R software program with help, according to Walach and von Lucadou's protocol. The analysis program in R was validated according to the protocols described in this article.

My commitment to my validation made me believe I could write and publish an article on this topic. The aim is to reach other psychologist researchers, who could take advantage of this process. In fact, individually developed software,

when validated, creates a more professional approach to the scientific field, giving more confidence to the results achieved. Validation brings clarity to the research project, also contributing to an easier replication of the projects.

The article that follows, was submitted and accepted by the peer-reviewed *Open Science Journal of Psychology* and is entitled 'Edinburgh software validation test for researchers in psychology'. After being revised on the 3rd and 9th October it was accepted for publication on the 11th October 2018. The journal is a peer reviewed journal. The article aims to provide information for students and researchers on the importance of validating individually developed software for scientific purposes, thereby encouraging the process. Moreover, it is based on the International norm for Software Testing ISO/IEC/IEEE 29119, from the International Organization for Standardization (ISO).

I would like to draw attention to the fact that there are many templates and ways of performing an academic software validation. The one presented in this article is just one example that intends to contribute to helping researcher colleagues improve their work, by implementing the process of validation at an academic level operating an easy and paced format. It is not the purpose to present the exposed

validation steps as compulsory. Also, these steps are not imposed or requested by the international institutions that regulate the software validation, the ISO. They serve mainly as recommendations and have to be adapted to each particular project, despite the mains templates created and can be easily adapted to new projects.

The validation of software is something new in the field of Psychology, (Koul, A., Becchio, C., & Cavallo, A. 2018).

Many hours were spent engaging with the process with the hope of contributing not only to the CMM project but also to the introduction of this new tool to psychology, parapsychology and other fields of science. I hope this contribution brings awareness to its benefits.

Due to the journal formatting I was not able to original format while copying it to this section, however it can be found following the above link.

<http://www.openscienceonline.com/journal/archive2?journalId=740&paperId=4824>

Authorization was received from the editor to have it shared in this thesis.

4.2. Article - EDINBURGH SOFTWARE VALIDATION TEST FOR RESEARCHERS

Edinburgh Software Validation Test for Researchers in Psychology

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Abstract

Software validation test is recognised essential by international organisations responsible for their supervision and validation. The academic field, namely Psychology, does not use a validation test as an obligation. Psychology researchers are often required to develop their own software. However, it is not expected its validation. Also, personal software testing is often an unknown procedure. Moreover, Psychology researchers are not familiar with the protocols and reports part of the process. There is a gap between research personal software and their validation. The advantages of the validation procedures are various. Validation test contribute to produce high quality research in a consistent way, to help to adhere to the predicted costs and the schedule of the project. The present article aims to call the attention for the lack of validation in the software used in Psychology research. Furthermore, describe the validation process and provide exemplificative tools. The importance of developing protocols during the research process, prepare a manual, a plan research detailed, a description of requirements and writing installation notes, have been demonstrated to be essential for successful research projects. The present article reveals what the test of validation consists of, how it can be implemented and its benefits.

Keywords

Validation, Test, Software, Protocol, Psychology

1. Introduction

Personal software developed by researchers and students for academic experimental studies is not usually formally validated. Academic professionals often have support from university IT departments specialising in establishing, monitoring and maintaining information technology, systems and services. Despite all that these departments could provide, based on their knowledge and support of the process of the researchers' validation software, in reality this does not happen. Thus, the process of the validation of developed software by academic individuals is not common practice.

This article acknowledges the institutional international norm that rules on the process of software validation: ISO/IEC/IEEE 29119. It does so by presenting the process in easy steps to be implemented at academic levels. It is very likely that to some researchers the content and steps presented in the article are not new and are already put in practice [4, 2]. However, to others, they may be novel and

serve as a helpful tool. Developing protocols for experimental studies can improve their reliability. This will also allow scientific articles mentioning that they designed and followed their own protocol to be more easily shared with other researchers that intend to replicate in 'ipsis' form (an exact study replication) the original study [7, 8]. The validation protocol illustrates transparency in the set up and main phases of the study, as well as consistency and trust in the results presented [3]. The main goal of introducing a validation test is to open new avenues to more easily replicate others' studies and make all the steps of the experimental software process used to collect data in experimental studies clear.

Sometimes, when writing up reports of all experimental phases, a small detail can make a big difference, helping get the project easily on track, and producing a more reliable piece of science. The emergence of new tools to write up individual experiments has also contributed to researchers writing personalised programs to perform statistical analysis [9]. Academic research has been developing daily [11].

Modern hardware and software allows each researcher to write their own analysis using available software packages that contain mathematical principals, statistical formulas, etc. [13]. The benefits of having tools available to all to write their own analysis programmes, such as Psychopy and R language to name only a couple, is vast and positively recognised. However, caution is needed and all available tools should be used according to standardised models, so making them available to all is recommended. It is proposed that this norm should be used as a guideline, combining needs from researchers and projects or requests from university department rules. The norm should be tailored according to an interactive process with the aim of satisfying the needs of the experimental study and those of the researcher.

2. Benefits of a Software Validation Test for Students and Researchers

In the final years of their study, university students are often required to write software programmes for their individual research. However, verification and validation of individuals' academic software is not common practice and rarely is performed [14, 5]. The test proposed by this work was developed in the Department of Psychology at the University of Edinburgh, as part of a PhD thesis. Most of the observations refer to needs, difficulties and challenges that are consistent within the social sciences. Is important to consider this validation protocol as a first approach to implement norms that can validate students' personal software, with potential application beyond experimental studies in psychology and its statistical analysis [13]. In the past few years, there has been an extensive amount of discussion on replication in psychology. Identifying the performance of the researchers and quality of software used to perform the experimental studies, as well analysing the studies' results can make a positive contribution [12].

The Test Protocol outlined in this work intends to serve as a tool available to researchers to identify steps needed to give order, to develop and run their studies. It is also intended to highlight the importance of being able to register all ideas and steps in a well-defined format [6]. This could be done by recurring to the templates shared here, or others that best suit the needs of the project. The software validation process, as a new process, is not common practice in academic research, as explained above. There is a lack of information on this practice, which, if adopted, can also benefit understanding differences in results verified in replicated studies, whether the case in question is due to a faulty software or even to the use of different outputs and goals of the software. The test contributes to identifying the origin of the differences or modifications in results obtained from exact study replications.

Another positive point is that the validation protocol, with all steps specifically defined in advance, allows a new researcher, even one external to the project, to start working

on it just by following the protocol. The protocol of each experiment can be shared and the validation steps executed by different researchers from different groups. If inaccuracies are found, they can be more easily addressed.

3. Development

The significance of software validation has led to the creation of an internationally agreed set of standards for software testing to be used by developer organisations in all areas of the industry (Heiberg, E., et al, 2010). These norms aim to implement internationally recognised levels of accepted standard tests that can be uniform, tested and are widely accepted. The validation of software is described and regulated by the International Software Testing ISO/IEC/IEEE 29119. The ISO or International Organization for Standardization is an international standard-setting body composed of representatives from various national standards organisations recognised by the state members.

Test standards are intended to help people understand and use software, facilitating the application in practice. They are relevant to defining concepts used in the software, describing theories, application procedures, documents needed and techniques performed. The test is tailored according to an interactive process. The main aim is to satisfy the needs of the researcher. It is proposed that this norm is used as a guideline, combining the software with needs or requests from university departments or solely those of research projects.

The test is divided into three standard testing phases:

- (1) to consider the test policy from the organization using the above norm;
- (2) to take into account the software management process;
- (3) to run dynamic testing on the software.

4. Commercial Challenges

Validation of software has already been implemented in some areas of industry, such as pharmaceutical companies, food producers, cosmetic manufacturers, etc. The supervision of these rules falls to the agencies responsible for enforcing regulations on these areas of commerce to account for good practices and the Food, Drug and Cosmetic Act. Software validation ensures vital specifications are met and requirements correctly fulfilled.

As validation is carried out, researchers write their own methods of analysis using the software available [1]. However, sometimes the software is developed to be applied in one specific field and the mathematical formulas underneath are not able to be successfully applied to other disciplines [15]. The description of the software is often general and has a commercial goal. Companies that sell software to be used in science regularly refuse to give specific details on the programming, such as the algorithms used. One specific example of this is related to companies creating their own algorithms to program a random number of generators, but they do not share them when they sell the device. This creates uncertainty about the software used and

the device performance. The justification given by the companies is essentially commercial, related to fear of allowing the software to be copied and no longer saleable. This argument can be understood from the commercial point of view, but it does not satisfy the scientific rigour and quality standards for open information and explanation of statistical analysis and results.

Reliable science requires procedures to ensure consistency in projects, models, process application and adaption of the software projects when needed in different domains and topics. This perspective contributes to team work on a project and adapting to a model to manage the progress of a different or new project experiment with new variables to establish in keeping the same protocol from previous studies or by implementing new ones to be replicated.

5. First Approach to ISO Tests

The ISO norm stipulates several steps to be accomplished as part of the normative institutional framework. Example tests can be named as:

- (1) Test process model
- (2) Test management processes
- (3) Test planning processes
- (4) Test monitoring and control processes
- (5) Dynamic test processes

These tests are mainly focused on the organisation and management process and on the dynamics of all documents produced during each stage of the process.

The best way to presenting the ISO/IEC/IEEE 29119 Software Test is by explaining its aims, to justify the software validation needs and it provides the background for the validation performed in the present study. After presenting the fundamental law, ISO, that defines and predicts the validation of software testing, I can delineate and suggest based on the protocols I have, checking according to the international rules: ISO/IEC/IEEE 29119 Software Testing [10]. The purpose of exploring this norm is also to establish and delineate templates that show how to record all software testing information produced in each phase. The norm requires the existence of one template per phase and per group when it is being developed in more than one laboratory or by different developers or researchers, or by a single individual, when just one person does the work. The information registered serves to implement the standard test.

The goal of defining an international standard test technique is based on the importance of covering software test design techniques that can be applied during the process of implementation by and within any institution or research group. The test design technique has the purpose of collecting evidence that the requirements previously defined have been met. The test techniques can also be designed to suit the specific needs of the organisation or system implementing the test. Testing software should be adapted to conform to the academic project developed by individual students and researchers who have developed their own software or used existing software without being aware of the

importance of processing their validation.

6. Protocols

Again, these protocols are simply an example, but these are elaborated below.

6.1. User's Manual

The user's manual is a global document covering the main aims of the project and all relevant steps and essential requirements for the successful development of the project. This document should be an easy-to-follow list of functionalities. The manual should identify aims, materials, purpose, people (researcher(s) and participant(s)), how the process/project works, who can help to improve it, who developed it, to whom it is directed, how to get information and the input and output of the software.

6.2. Planning the Project

This protocol defines the plan of the experimental software project. It is important to categorise all steps of the validation process: who is doing the validation, documents used to certify the validation, who keeps them and where they are kept. If more than one person works on the process, their intervention should be described and the leader responsible named. A description of the situations accepted for each project and situations considered to exclude, rules, limitations, criteria for error, circumstances that allow corrections or resolutions, etc. The list part of the planning should be as extensive as possible, predicting templates to be added if necessary.

6.3. Description of Requirements

The protocol that describes the requirements for the software validation should apprehend the entire context of the project in order to properly organise the elaboration of the plan.

6.4. Apparatus Set-up Protocol

This protocol defines all the necessary steps for installation of the software. The protocol is clear, easy to understand and able to be followed by any person with minimum knowledge of programming software. The protocol is now ready and all steps defined. Is time to set up the protocol, implementing it or installing, executing the program and registering the specifications, reporting any incident or unexpected feature, checking the incidents, modifying and checking them again, reporting the results, and retesting if needed.

6.5. Installation Comments

A short report describing the installation protocol in 4 should be written with comments of situations raised during the installation. As part of the verification process, the researcher should install the same software on at least two other different laptops to confirm they work properly on all

of them. The researcher can also ask a colleague to follow the protocol and install the program on a new laptop. The installation of the software is marked as successful for validation purposes if this is the case.

6.6. Assessment Protocol

The present test protocol consists of running all programs, and afterwards checking with the files produced by the software to see if they correspond with the files produced. Different combinations should be tried and their evidence described. Sometimes screenshots of the different steps are sufficient evidence to gather for the protocol, or even print reports of results. This information will be part of the assessment protocol.

6.7. Assessment Information

The assessment information is an iterative step. It demonstrates how the different steps can be used according to the needs and the specificities of the project. The plan for

the project leads to setting it up, installing, testing its management details by monitoring measures defined and writing reports on all procedure stages. The process of monitoring, control and report can lead to detecting faults, updating details and revising previous features of the project. A report should be written stating the procedure and the results.

6.8. Final Report of Validation Process Including all Steps

It not expected that errors or anomalies will be found at this stage after all the above steps are taken. However, it is the understanding of the researcher that verification and validation of all software used as part of any study that aims to be scientifically reliable should follow standard procedures to assure the validity of the same. This report includes all previous validation steps.

Protocol template

Table 1. Template for one protocol, namely Description of requirements. The table should be bigger to have enough space for all descriptions and comments. Each protocol should be in one different table. Other options that not a table can be used. The number of columns and lines should be adapted to the research project being developed.

Test Software Experiment X	Description of requirements	Second testing to correct any that did not work as expected previously
Test description	Here one should describe context of the project	
Verified Requirement	Whether the requirements verified or not,	
Initial conditions	Describe all of them	
Tests inputs	Try different inputs	
Data collection actions	Describe how and what to collect data	
Tests outputs	Behaviours of the software	
Expected results and criteria	It worked as expected, or a different outcome happened	
Test procedure	Satisfy, good, etc	
Step number	Operator actions	
1		

7. Reasons to Validate Academic Software

The application of this norm is intended to validate the process of the research during the phases. First, if it is necessary to repeat one part of the program for the research, there is no risk in doing so as the process is already written down. Second, it is helpful in cases that researchers get someone to help them, as often happens, with researchers accepting students to help them as part of students' projects during their undergraduate or even at higher levels of study. In this situation, the student has all the information written in protocols, which allows them to understand the project and begin working, saving time for the main researcher. Third, the time spent planning the research and writing the research proposal or grant for the project can be used just by adding a few more details that are, again, going to save time in the future. Fourth, having the software project validated and written helps the owner use it more quickly in future experiments. Fifth, it would be very helpful for the researcher to have all protocols for the case in order to share it with

other researchers so as to replicate their experimental studies. This last reason is one of the most important.

The validation process is able to consistently produce quality research. The ISO/IEC/IEEE 29119-5 [10] applies to individual scripts and documentation, which includes individual academic projects. Software testing is of increasing interest to organisations as they understand the crucial role played by the quality of software produced and reliability of their results. Pressure is falling on IT organisations to deliver more products.

The organisation of the validation process comprises the management rules of the validation process, namely the phases of planning, control and conclusion [3]. As an introduction to the validation process, is important to be clear that the process is an interactive process. The steps described do not need to be used in the presented order, but as best suits the project. The steps are also not exhaustive; they are designed to be implemented in a project, defining its environment, looking at the execution and careful maintenance and reporting incidents.

8. Considerations on Validation Metrics

- (1) It is important to consider that results can be misinterpreted during the validation process.
- (2) New details can arise that are unexplained or not expected. The situation has to be dealt with according to the specific software and aim of the project.
- (3) The researcher or programmer should take into account new situations, environmental situations, unexpected behaviour of the software, as well as the individual's programming and validating the software. They should be open to not thought-of circumstances that can manifest. Openness is key.
- (4) Human intervention is the most crucial. This is related to the researcher or developer. Software validation requires knowledge to thoroughly comprehend the project and apply it properly.

9. Recommendations

- (1) It is important to let the software be flexible to adapt according to each person's project.
- (2) It should be simple, which facilitates faster performance.
- (3) To allow clear results to enable a better understanding of the software potentialities and adaptations to update to new projects, or replications of projects by other independent researchers.

10. Conclusion

It is good practice to document decisions taken during the process of designing a scientific project, taking notes of the software plans, writing the discussion main points, the goals of the project, implementation and process improvements. Good documentation of all experimental processes, i.e. the psychology software being developed to execute the experimental study, could benefit the actions performed, improving its effectiveness and assessing the performance through analysis.

This paper discussed the importance of verification and validation of individuals' independent software and the advantages of introducing these analysis programmes as they are used to produce science and the process, from the simplest research project developed by academic students to senior researchers.

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4.2 Conclusion

This article elucidated the need for a validation test to be applied by students and researchers, to their own developed software. The article started by identifying in general the reasons for the need for software validation, being followed by explaining the benefits of the process. From helping to delineate all the research process in advance, by testing the steps established. Implementing validation protocols that are accessible to any researcher can contribute for example, to keeping the project within deadlines and budget. The development of a validation process identified the main standard phases and afterwards the commercial challenges. These can be enumerated as the lack of information provided by software companies that develop their own programs to profit from them, and as such do not provide the information often required by the researchers in order to explain their own projects in detail. One example of this situation happened with the commercial random number generator used in studies 4 and 5 of the present thesis, which detailed information on the algorithms that create the randomness were not provided as are considered intellectual property of the company that developed them.

The validation presented followed the International Software Testing ISO/IEC/IEEE 29119 as the most relevant and commonly used by International Organisations for standard software. An example of the main important protocols is given and explained, together with a template. As mentioned in the article, templates and protocols should be defined according to each specific project and the ones described are credible examples. The article makes recommendations to researchers and students that decide to follow the validation process, concluding with the good practice in regard to designing scientific projects, which should be made available to other researchers and facilitate the replication of projects.

CHAPTER 5 First Replication of CMM - Study 1

5.1. INTRODUCTION STUDY 1

The key motivation for this thesis is to produce data to validate the findings of previous matrix experiments.

Empirical results demonstrating PK outcomes are assumed by some researchers to be due to bias or experimental errors (Alcock, 2003), notwithstanding, a strong record of evidence in the field that have been already revealed (Cardeña, 2018). Still, a meta-analysis has shown some significance for PK (Bösch, et al., 2006; Storm, et al., 2012; Schmidt, 2012). It can be argued that the different interpretation of PK effects can be due to a lack of a theoretical accepted theory. Moreover, is also relevant that attempts to replicate studies have often failed (Jahn et al., 2000; Ritchie et al. 2012).

Researchers studying paranormal, and PK in particular, have mainly assumed a causal model, justifying the phenomena as a transference of information as a causal effect or 'signal'. The theories studied in this thesis, GQT, MPI, CMM, have an opposite understanding, arguing the phenomena is not causal, but simply a correlation. A correlation originated by the general arrangements of the systems (variables) or a common measure

of variables acquired by correlations. Using quantum entanglement correlations by analogy, the concepts of systems and sub-systems from physics are used to build the grounds of the theories. It is assumed that quantum entanglement correlations cannot be used as signals (Lucadou et al. 2007).

To prove the theory, it was set-up an experimental study, in which a correlational system operates between a participant and an RNG. It is argued that the intention of a participant, due to the nature of the framework, originates a correlation between himself or herself and the machine, a technical system. The interaction from psychological and physical systems creates entanglement correlations.

A matrix with 2025 cells (45x45) was constructed to measure the correlations produced between both participant and RNG during the performance of a task. First studies were developed by von Lucadou (1986, 1987) and later Walach et al. (2019). In the experimental session participant interacts with the RNG, while in the control session the computer runs the session alone with the psychological information from the participant. The number of significant correlations created during the experimental session should be more than the ones produced with the computer alone. Because the information (intention) of the participant should interact with the system, RNG, according to MPI.

The bond created with participant, called organisational closure is crucial to develop the nature of the entanglement correlation (the way pragmatic information manifests). The process is going to be explained in detail in the next sections.

5.2. METHODS

5.2.1. Design

This study is the first of a series of replications that is intended to explore Correlation Matrix Method. A protocol that consists in correlating psychological variables produced by a participant (keystrokes) with physical variables produced by a RNG with and without a participant performing a task. It is expected that the number of correlations produced during the experimental session is higher than the number produced during the control session when the participant is not part of the experimental setting.

In study one, participants were told that they could do as many experimental sessions as they wished. They decided when they wanted to stop participating.

5.2.2. Participants

For study one, participants were recruited mainly among friends and members of a university club. Data was collected at the university Women International Club and at the researcher's house. In both places, a quiet room with a table was allocated for the experiment. Participants were left alone for the duration of the experimental session and told where they could find me when they had finished the session or in case of any doubt.

There were no criteria in terms of requirement such as age or specific background. Anyone willing to contribute could participate in the study. Some participants offered because they were friends and were willing to help, while others offered because they were interested in the topic.

For friends, my place was an option. A room were prepared to receive participants with similar conditions as the ones provided at the university. I intended to have a broad range of participants in terms of diversity in age, professional experience, etc., doing the experiment in an unformal environment. For this study 49 participants were recruited, 68.2% female and 31.8% male, contributing with 213 sessions. From the 49, 5 participants were excluded: one decided to stop during the first sub-run because she could not make the bands move in the desired direction and felt frustrated; another participant felt bored and decided to stop

after the first run, a third participant in the middle of the session realised that was late to get to the train, the other two participants simply did not complete the experiment without justification.

The session began with a 10-minute conversation with the participant, to make them feel comfortable and to explain the aim of the study. Participants were explained the details of the experimental task in a relaxed environment. A written description of the study was given and was complemented by an oral explanation. Then, they were asked to sign a consent form before starting the task. Some participants asked for a demonstration before the start of the session, which were provided until they feel ready to start the session; for others it was enough to show them pictures of the fractal they were going to see during the experimental session. Participants were treated in a friendly way at the same time they were made to feel important for contributing to a scientific study.

The age of the participants was taken in intervals of ten years, as it was used the original protocol to perform an exact replication. The mean of the ages is not calculated as it would not give us important information. The age was asked just to create a bond between participant and the experiment. Table 5-1 shows the participants' ages by gender. 30 females and 14

males took part, giving a total of 44 participants. The average contribution per participant was around 4 times each. Participants below 30 years old represented 52% of the total participation, 68% were females.

Table 5 - 1 Displays the number of participants, their age taken in intervals of 10 years and their gender, for study 1.

Age group	Female	Male	Total participants	% Participants per age group
20-30	13	10	23	52.3%
31-40	9	1	10	22.7%
41-50	5	2	7	15.9%
51-60	1	0	1	2.3%
61-70	0	1	1	2.3%
71-80	2	0	2	4.5%
Total	30	14	44	100.0%
% Total	68.2%	31.8%	100.0%	

5.2.2.1. Organisational closure

Wherever the meeting place, participants were always welcomed by the researcher in a friendly environment in order to make them feel comfortable. Tea, coffee or water was offered, as well as a chocolate bonbon to ensure that a good empathic mood was established between the researcher and the participant. Even when participants did not accept anything that was offered, they retained the sensation of welcome and appreciation. In the end they were thanked for contributing with their time to help the researcher with her experiment. It was relevant to recruit participants without any payment being involved, just a thank you, as it was very important to have participants who were committed to the topic of the experiment itself, whatever they believed about mind-matter interaction. This contributes to create the organisational closure requirement of the CMM. It was explained to participants that their own beliefs were not important but, rather, what mattered for the experiment was their focus and commitment to following the instructions and performing the experiment accordingly.

5.2.3. MATERIALS

5.2.3.1. Apparatus - Original RNG

The original RNG developed by Walter von Lucadou was engineered according to his instructions. The ones used in Walach's study (2019) were also re-engineered under von Lucadou's instructions but at the University of Viadrina. I, as mentioned previously, used one of Walach's RNG that had been used in previous studies. The characteristic of von Lucadou's RNG is that the random source was built in the SID (Sound Interface Device). The SID is a synthesiser chip that works autonomously from the rest of the laptop. The SID has its own clock and produces three independent acoustical wave forms as a random number generator noise waveform. The random events produced by the chip are as follows:

The noise waveform is created using a 23-bit pseudo-random sequence generator, i.e., a shift registers with specific outputs fed back to the input through combinatorial logic.

This process permanently produces a pseudo random number of eight bits, with a frequency of 4kHz.

After each key press the 8-bit number is read out in order to produce the random sequence.

The frequency of the computer clock is about 1 MHz. The maximum access frequency for the Basic programme for the 8-bit random number is about 20 Hz. Hence, the random process depends on:

- 1) the clock of the SID;
- 2) the clock of the computer; and
- 3) the moment of the key presses.

Due to the fact that the clock on the laptop and the clock of the SID are independent, this was expected to create a random sequence, although the random source is a 'fortune's wheel' type. The random sequence of the experiment that was created by the 8-bit random number was a Markov-chain, as used in previous experiments.

The RNG output was smoothed by a Markov-chain window with lag 1 that made the appearance of the output look more like a natural process and slowed the change process.

The noise-current of a Zener-diode was used as the random source. The equivalent voltage of the noise-current was amplified and measured by an analogue-digital converter, which was read out by the USB-interface of the computer.

To produce the Markov-chain the momentary 12-bit number (voltage) R_{i+1} was compared with the previous one R_i . A decrease of the momentary voltage was indicated as a "1" and

an increase as a "0". If no change of the decay rate occurred, the event was omitted.

5.2.3.2. Markov-Chain process

To produce a Markov-chain event the momentary 8-bit number R_{i+1} was compared with the previous one R_i . A decrease of the momentary decay rate was indicated as a "1" and an increase was indicated as a "0". If no change to the decay rate took place, the event was omitted.

$R_{i+1} > R_i = \text{"0"}$

$R_{i+1} < R_i = \text{"1"}$

$R_{i+1} = \text{"no result"}$

The procedure of the Markov-chain results is shown by the following matrix:

$$\begin{pmatrix} p(1 \rightarrow 1) & p(1 \rightarrow 0) \\ p(0 \rightarrow 1) & p(0 \rightarrow 0) \end{pmatrix} = \begin{pmatrix} \frac{1}{3} & \frac{2}{3} \\ \frac{2}{3} & \frac{1}{3} \end{pmatrix}_8$$

Important to refer that the Markov Chain even though is here explained, it was not used in the experimental setting as a

⁸ Formula retrieved from Thomas Filk oral presentation Capri (2017)

measure itself. The Markov function in the experiment has the purpose of showing the transition of the bands in a slower mode, using lag one, what makes the process more natural. The idea surrounding the purpose of this experimental setting is to make the process as natural as possible to translate the order of nature itself.

5.2.3.3. The Display and random process

All studies used a graphic presentation of a spiral fractal Mandelbrot as shown in figure 1. A spiral coloured in red and blue bands was positioned in the middle of the screen, as presented in figure 4.2; it then moved in a random way. The red band moved one step forward towards the centre of the spiral when a “1” was produced by the random number generator, and it moved outwards if a “0” was produced. This apparatus shows to be successful due to the colours. It was arranged a fractal with bright colours moving in a spiral figure to help participants become interested and enthusiastic about the performance of the experiment.

Each random event began with the pressing of one key, the shift key from the keyboard, the right or left. Only these two keyboard keys were programmed to work during the experimental session;

the shift keys the left and right were the only keys working during the experimental session in the keyboard. Participant was told to press the right shift key with the right hand and the left shift key with the left hand. Pressing both keys at the same time was also an option to activate the random process automatically, but participants were not informed of that. The subject was instructed to mentally try to influence and control the movement of the bands following the same direction of the arrow appearing at the top of the spiral.

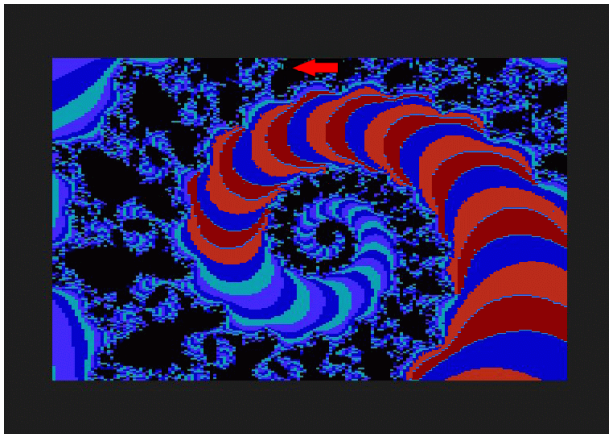


Figure (a)

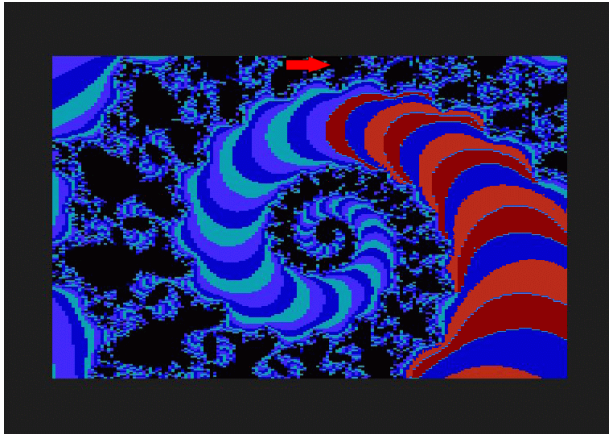


Figure (b)

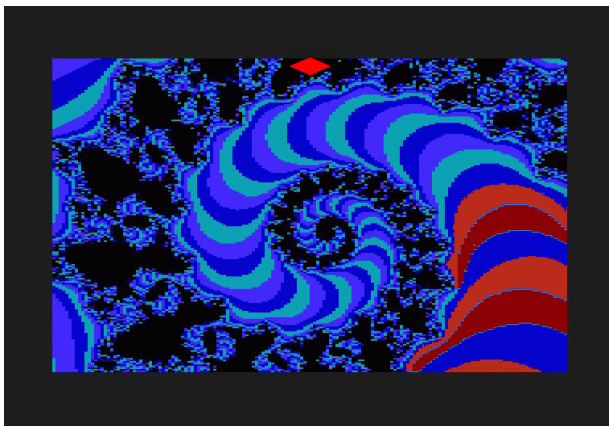


Figure (c)

Figure 5- 1 figure (a) shows the fractal with the arrow pointed left, while figure (b) shows the arrow pointing right. Figure (c) has the rhombous on top of the fractal.

Figures a, b, and c are the figures that appear on the laptop screen during the experimental session. The arrows and rhombus are the instructions for the participant to follow when trying to mentally to influence the movement of the fractal. Participants

are expected to influence the movement of the bands in the direction as the arrows.

5.2.4. Materials and human resources; experimental set-up

5.2.4.1. Introduction

This sub-section describes the experiment steps following the same order of the study. The description begins by revealing the requirements for setting up the laptop and the RNG.

5.2.4.2. Introduction to materials and preparation of the laptop and RNG

A room was made available, with a table and a chair for the participant. The equipment was set up on the table. The experiment required the laptop and RNG to be prepared before the participants' arrival, as the RNG should be working already. The laptop used in all of the experiments was an Asus running with Windows XP. This laptop was allocated to the experiment and was exclusively used to collect data for these studies.

The random number generator (RNG) common to all studies was the same used in Walach's study (2019). Since the aim of the thesis was to carry out an exact replication of the original studies, I used the material and protocols from the original studies.

5.2.4.3. Details of the installation

The installation process is written in detail in a specific protocol to describe all steps.

Once the Original RNG had been installed, it was plugged into the laptop, and the laptop was then plugged into a socket with the battery fully charged. The laptop should stay plugged in during the experiment. von Lucadou's argument for having the RNG working on its own for at least half an hour before starting to collect data and, to have it plugged during the experiment, was that it helped to stabilise the voltage of the channels to avoid interference on the RNG.

With the RNG installed in the laptop a short cut was created and put on the home screen for simplicity for the researcher to test and start each experimental session. To turn on the RNG, a double press on the icon opened a screen and eight bars

corresponding each one to a channel of the RNG. The columns displayed the random movements created per channel.

This was the test that had to be performed before each experimental session to check that the RNG with all its channels was working properly. After confirming that all of the channels were working properly, they were left to work on their own for as much time as possible. Though half an hour was the time recommended. The movement of all channels could be seen working and their data was recorded in all of the studies. For the five replications only, data produced by channel four was analysed. This decision to analyse channel 4 as a variable was random and was pre-registered. Again, I chose previously to analyse the same channel as the original studies to produce an exact replication. Although, all channels were tested and no differences in behaviour were found. This explains the reason for the choice of the same variable excluding any choice made based on the channel's performance.

The researcher was supposed to start one experimental session before the participant's arrival to test whether the software was working properly

It was decided from the start that only one laptop would be used to collect data as there was only one original RNG.

5.2.5. Introduction to variables

Variables are all described in this section. The variables are psychological and physical and are identified by two letters or one letter and one number. They repeat along the matrix table respecting their order on the experiment. Variables are numbered from one to nine representing each variable per run.

5.2.5.1. Definition of all Experimental Variables

There are five physical variables:

TR: number of times the output of the Markov-chain of the RNG yields “1” during one run.

DT: number of steps by which the fractal displays deviate from the goal.

KR: deviation of the theoretical autocorrelation from the experimental autocorrelation calculated over 10 steps.

ZT: mean voltage output of the RNG at the fourth channel. All eight RNG channels were measured but it was defined a priori to use the mean of the fourth channel.

ZV: standard deviation of the voltage output of the fourth channel.

The physical variables appear in the matrix table as follows: TR1, DT1, KR1, ZT1, ZV1, corresponding to the run number 1, TR2, DT2, KR2, ZT2, ZV2, ... TR9, DT9, KR9, ZT9, ZV9 correspond to run number 9.

The number after the variable letters identifies the number of the run.

There were also five psychological variables:

T1: number of right shift key presses.

T2: number of left shift key presses.

T3: number of double presses.

DR: mean time between key presses.

DV: variance of time between key presses.

In the matrix table the psychological variables appear numerated as follows; T11, T21, T31, DR1, DV1, for the first run, T12, T22, T32, DR2, DV2, for the second run.... T19, T29, T39, DR9, DV9. The number following the variable identification identifies the number of the run same for the physical variables.

5.2.5.2. The physical variables

TR counts the number of times the RNG produces “1” ($TR(I)$, $I = RN$ “run-number”). This value is registered on a file produced during the experimental session called “Bewertung_name.csv”. The file presents the cumulative values of the variable.

KR, is in the analysis program, ($KR(I)$), is a variable that measures some of the differences between the theoretical autocorrelation and the experimental correlation achieved in one sub-run, for 10 steps.

DT is defined in the following way: $DT(I) = \text{SUM}(I = 1, RL)$ (TT). TT is the display position and refers to the hits regarding the display. DT is the sum of the number of “open steps”; for example, towards the left the band can move from cell 17 to 28 and so $DT = 17, 18, 19 \dots 28$. Towards the right the band has open possibilities to move from cell 1 to 11, so $DT = 10, 9 \dots 1$. With “centre” it is taken as the inner interval: cell 1 to 28 is DP (TT) = 1, 2 ... 28. This variable is calculated in the following way: for “centre” $DT = DT + \text{ABS}(TT)$ measuring the absolute deviation from the centre; “left” $DT = DT + (17 - TT)$ referring to the

distance from the left maximal position point + 17; “right” DT = DT + (10 + TT) measuring the distance from the right optimal position -10; this is added up for each run.

RT is the mean value of the measured voltage of channel 4.

RV is the standard deviation of RT.

For each experimental session, the sum of hits T and the sum of hits K for all sub-runs constituted additional physical variables, which is why they are not considered independent variables. The experiment consisted of executing the nine sub-runs one after another; the physical and psychological variables depend on the time that is measured on the ordinal scale of 1-9, not in real time. The last two physical variables present an indication of the physical measure of the experimental session. The result of the described structure displays the data in a matrix correlation with all of the psychological and physical variables, consisting of $45 \times 45 = 2025$ cells.

There are five physical variables per experiment per nine sub-runs, making a total of 45 psychological variables: $5 \times 9 = 45$

5.2.5.3. The psychological variables

T1 consists of the sum of the number of key presses for the right shift key per run.

T2 consists of the sum of the number of times the left key was pressed.

T3 counts the number of times both keys, right and left, were pressed at the same time.

DR is the mean value of the duration of each trial in a sub-run.

$DR = 1/RL * \text{SUM} (\text{Timestamp} (I + 1) - \text{Timestamp} (I)).$

DV is the standard deviation of DR.

These numbers were recorded during the experimental session and calculated in a file called Log_name.csv.

There are five psychological variables per experiment per nine sub-runs, making a total of 45 psychological variables: $5 * 9 = 45$

5.2.6. Structure of the data

The structure of the data was defined as follows:

The decision of the software producing “zero or one” is called **trial**. The trial is based on input from the participant, consisting of pressing a shift key, and from the RNG, and is represented as a visual feedback; the red band moves towards the right or left as a consequence of the RNG decision.

80 trials or button presses make up a **sub-run**. There are three conditions for the sub-run: to influence the trials towards the right (R), left (L), or keep it centred in the middle (M).

Three sub-runs, (each of which has a separate condition (80 trials to the left, 80 trials to the right, 80 trials in the middle), make up a **run**.

Three runs (R, L, M - R, L, M - R, L, M) make up one experiment or experimental session.

When the same participant performs more than one experimental session, the following sessions were recorded as an independent experiment and is evaluated independently.

The computer program for the experiment calls PSI.2. It creates two files per experimental session: one file named

“Log_name.csv” composed by one line as header plus 720 lines, each saving the data per each trial: 80 trials * 9 runs = 720 trials registered in 720 lines in an excel sheet; and second, a file called “Bewertung_name.csv” made up of one line with headers plus nine lines with the sum of the runs, plus one line with the totals. Incomplete files were excluded from the analysis.

Analysis of the data followed von Lucadou (2006) protocol and program in Basic that I updated writing it in R language.

5.2.7. Correlation measure

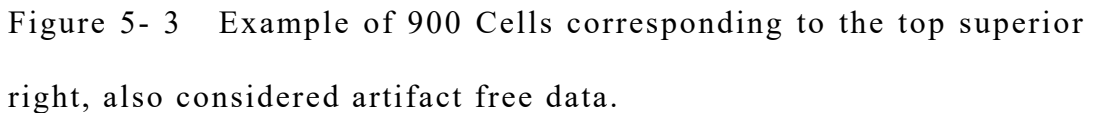
The psychological and physical variables of all experiments are displayed in a correlation matrix, and so ultimately the matrix displays the $45 \times 45 = 2025$ cells. Each cell corresponds to one data point for each experiment correlated. The correlation of the variable per cell is calculated using Spearman Rho (r) as the correlation measure. Cells displaying correlations with statistical $p < 0.05$ two-tailed are considered significant correlations.

5.2.7.1. Distribution of data on the matrix table

The final table matrix, which is the aim of the distribution of the data, is a table of 45 x 45 variables correlated with each other, producing a total of 2025 cells of data. This table, called a correlation matrix, can be divided into three parts, showing three different moments of the entire experimental sessions. Those three parts are: the top superior right containing 900 cells that correspond to future data, the central cells correspond to the present moment in which participants are performing the experiment. The third part is the bottom left side which cells could contain causal information because the participant already performed the session.

The data is distributed on the matrix in the same order of the runs performed by participants. The physical data goes on the top of the matrix and the psychological data on the left side of the matrix.

Study 1	PHYSICAL VARIABLES																				213 sessions																			
	TR1	DT1	KR1	ZV1	TR2	DT2	KR2	ZV2	TR3	DT3	KR3	ZV3	TR4	DT4	KR4	ZV4	TR5	DT5	KR5	ZV5	TR6	DT6	KR6	ZV6	TR7	DT7	KR7	ZV7	TR8	DT8	KR8	ZV8	TR9	DT9	KR9	ZV9				
T	-0.080	-0.096	-0.068	-0.039	-0.005	0.010	-0.056	0.012	0.076	0.011	-0.073	-0.003	0.069	-0.032	0.025	-0.036	0.115	0.049	0.045	-0.032	0.056	-0.010	-0.074	-0.010	-0.040	-0.094	0.051	0.112	-0.075	-0.092	0.002	-0.032	-0.016	0.045	-0.019	0.111				
P	T21	-0.006	0.037	0.062	-0.038	-0.125	0.047	0.014	0.061	-0.001	-0.061	-0.101	0.067	0.111	0.026	0.064	-0.034	0.052	-0.011	0.022	0.083	0.038	-0.012	0.040	-0.043	-0.037	0.055	0.065	-0.013	0.010	-0.014	-0.004	0.037	0.008	0.011	0.061	0.044			
S	T31	0.025	-0.110	0.083	-0.029	0.096	0.106	-0.052	0.089	0.127	0.003	-0.048	0.014	-0.021	-0.119	0.035	0.048	0.071	-0.107	-0.066	-0.067	-0.037	0.126	0.074	0.016	0.086	0.040	0.027	-0.023	0.060	0.128	0.052	-0.079	-0.113	0.035	0.070	-0.062			
Y	DT1	-0.003	-0.026	-0.085	-0.033	-0.072	-0.039	-0.036	-0.044	0.106	0.039	-0.038	0.073	0.107	0.099	0.029	-0.029	-0.095	0.027	-0.034	-0.086	0.086	-0.103	-0.100	0.027	0.100	0.046	-0.087	-0.093	0.015	0.014	-0.038	-0.065	0.017	-0.094	0.068				
C	DT1	-0.042	0.049	-0.110	-0.092	0.028	-0.057	-0.062	0.010	-0.023	-0.045	0.087	0.033	0.021	-0.128	0.081	0.032	0.017	0.008	0.016	0.049	-0.006	-0.087	-0.020	-0.082	-0.017	-0.035	-0.049	0.071	0.046	-0.021	-0.027	-0.059	0.025	0.067	0.048				
H	T12	0.116	-0.108	-0.062	0.101	-0.007	-0.082	-0.075	-0.038	0.087	0.092	0.082	0.048	0.021	-0.017	-0.060	0.027	0.097	0.083	0.040	-0.031	-0.054	-0.059	0.034	-0.127	0.037	0.014	-0.005	-0.059	0.019	-0.031	0.023	0.041	0.056	-0.011	-0.055	-0.069			
O	T22	-0.092	0.110	0.044	0.021	0.027	0.058	0.013	0.081	-0.077	-0.017	-0.130	-0.057	-0.051	-0.034	0.012	-0.011	-0.033	-0.040	-0.042	-0.024	0.023	0.098	0.051	-0.018	0.034	-0.030	0.101	0.030	0.052	-0.033	0.040	0.050	-0.033	-0.020	-0.038				
L	T32	-0.122	0.107	0.054	-0.116	-0.029	0.089	0.091	-0.022	-0.033	-0.095	-0.056	-0.033	0.037	-0.087	0.089	0.049	-0.016	-0.059	-0.103	0.004	0.041	0.021	0.029	-0.017	0.109	0.012	-0.038	0.019	0.023	0.022	-0.012	-0.015	-0.037	-0.101	0.036				
O	DT2	-0.054	0.015	-0.034	-0.041	-0.022	-0.014	-0.096	-0.051	0.040	-0.010	-0.014	0.077	-0.035	-0.083	0.042	0.091	0.102	0.023	-0.044	-0.072	-0.070	-0.097	0.047	0.094	-0.124	-0.056	-0.046	0.107	0.094	0.000	-0.091	0.013	-0.021	0.038					
G	DT2	-0.064	0.058	0.040	0.012	0.031	-0.029	-0.066	-0.084	-0.090	-0.048	-0.029	-0.006	0.018	-0.117	-0.065	-0.095	-0.065	0.092	0.097	0.011	-0.122	-0.024	-0.128	-0.048	-0.079	0.036	0.031	0.108	0.006	-0.120	-0.091	-0.051	-0.100	-0.109					
I	T13	0.046	-0.032	-0.127	-0.017	-0.091	-0.042	-0.051	-0.111	-0.081	0.061	0.068	-0.075	0.013	0.050	0.027	-0.001	-0.091	0.042	-0.031	-0.055	0.053	-0.016	0.001	-0.047	0.077	0.003	0.011	0.046	0.025	0.060	-0.070	-0.090	-0.121	0.069					
C	T23	-0.039	0.034	0.113	0.020	0.056	0.032	0.038	0.100	0.085	-0.032	-0.055	0.062	-0.019	-0.020	0.001	0.005	0.049	-0.028	-0.037	0.029	-0.068	0.036	0.127	0.046	0.086	0.114	-0.116	-0.007	-0.011	0.058	-0.064	-0.012	-0.046	0.099					
A	T33	-0.089	0.080	0.082	0.113	-0.099	0.130	0.119	0.062	0.084	0.024	-0.075	-0.057	-0.067	0.019	0.066	0.002	-0.022	0.061	0.102	0.015	0.051	0.014	-0.046	-0.010	0.112	-0.111	-0.045	0.038	-0.046	-0.020	0.030	0.014	0.097	0.027					
L	DT3	-0.011	-0.009	-0.076	-0.008	-0.118	-0.056	-0.041	-0.039	0.068	0.069	-0.009	0.031	-0.007	0.052	-0.025	-0.100	0.070	0.026	0.016	0.051	-0.072	-0.116	-0.060	-0.093	-0.128	0.127	0.107	-0.093	-0.063	0.033	-0.108	-0.115	0.022						
DT3	0.009	-0.010	-0.045	-0.074	-0.069	-0.028	-0.050	-0.033	0.027	0.074	-0.011	0.006	-0.042	0.100	0.043	0.022	0.100	0.038	0.017	-0.059	-0.046	-0.126	-0.025	-0.079	-0.055	0.090	0.090	-0.078	0.013	0.011	0.127	-0.045	-0.089							
V	T14	-0.089	0.101	-0.116	0.066	-0.025	-0.021	-0.017	-0.107	-0.122	0.002	0.103	0.030	0.060	0.012	0.023	-0.027	0.063	0.010	0.008	0.020	0.074	0.130	-0.068	0.020	-0.045	-0.031	0.086	-0.091	0.038	0.096	0.074	0.061	0.011	0.008					
A	T24	-0.019	0.024	-0.041	-0.021	0.041	0.021	0.037	0.053	-0.072	0.035	0.020	-0.037	-0.063	-0.051	0.039	-0.090	-0.027	0.023	0.055	0.097	-0.058	0.033	-0.013	-0.041	0.013	0.035	0.071	0.040	0.094	-0.012	-0.019	0.022	0.036	0.043					
R	T34	0.091	-0.104	0.124	-0.078	0.019	0.032	-0.044	0.112	0.003	-0.087	-0.031	-0.026	-0.026	-0.017	0.110	-0.064	-0.052	-0.059	-0.121	0.015	0.062	0.090	0.040	-0.125	-0.118	-0.118	-0.054	-0.106	0.076	0.023	-0.022	-0.008	-0.043						
I	DT4	-0.023	-0.013	0.006	-0.011	-0.119	-0.077	-0.101	-0.080	-0.019	0.024	-0.007	0.105	-0.051	0.109	-0.046	-0.113	0.106	0.110	0.109	0.012	-0.018	-0.086	0.007	-0.081	-0.087	0.064	-0.105	-0.109	0.006	0.054	-0.019	0.062	-0.021						
A	DT4	-0.021	0.024	-0.026	-0.074	-0.005	-0.073	-0.121	-0.024	-0.024	-0.111	0.034	0.074	0.004	-0.053	0.085	-0.064	-0.002	0.015	0.070	0.085	0.098	0.033	-0.127	-0.033	-0.046	-0.038	-0.106	0.024	0.110	0.124	-0.081	-0.094	0.077	0.102					
B	T15	0.051	-0.087	-0.013	0.050	-0.004	-0.050	0.001	0.079	0.082	0.075	0.047	-0.062	-0.006	-0.040	-0.014	-0.013	0.011	0.112	0.023	0.116	-0.099	0.025	0.012	-0.011	0.055	0.003	-0.060	-0.120	-0.030	0.031	0.030	-0.007	0.046	0.098					
L	T25	0.000	0.039	-0.013	-0.028	0.028	0.014	-0.035	-0.032	-0.112	0.044	-0.046	-0.023	-0.055	-0.114	0.002	-0.098	0.092	-0.109	-0.073	0.033	0.053	0.112	0.090	0.073	0.029	-0.006	-0.056	0.005	0.124	0.084	0.025	-0.026	0.032						
E	T35	-0.060	0.081	0.014	-0.041	0.004	0.090	0.036	0.067	-0.017	-0.109	0.046	0.083	0.007	0.054	0.034	-0.007	0.007	-0.097	-0.011	0.116	0.080	-0.011	-0.027	0.039	-0.060	-0.004	0.032	0.019	-0.025	-0.040	0.019	0.075	0.076						
S	DT5	-0.042	0.020	-0.066	-0.003	-0.050	-0.032	-0.072	-0.069	-0.071	-0.010	0.039	-0.033	-0.128	-0.041	0.076	-0.084	-0.082	0.117	0.125	0.114	-0.037	-0.095	-0.052	-0.098	-0.094	0.028	0.074	-0.124	0.054	0.014	0.046	-0.054	0.018						
DT5	-0.016	-0.009	-0.033	-0.014	-0.010	-0.044	-0.067	-0.066	-0.051	0.056	0.019	-0.076	-0.082	-0.063	0.110	-0.086	-0.089	0.030	0.127	0.111	0.114	-0.068	-0.087	-0.077	0.007	0.064	0.025	-0.090	-0.096	0.117	0.094	0.077	-0.009	0.011						
T16	-0.009	-0.009	-0.109	-0.047	-0.047	-0.045	-0.073	-0.062	-0.007	-0.041	0.081	0.039	-0.074	0.064	0.039	-0.039	0.089	0.124	0.031	0.011	-0.011	-0.127	-0.046	-0.040	-0.008	-0.083	0.119	0.118	-0.126	-0.082	-0.083	0.023	-0.000	-0.082						
T26	-0.043	0.065	0.094	0.016	0.073	0.058	0.057	0.030	0.067	-0.008	-0.045	-0.011	0.064	0.000	-0.030	0.040	0.091	0.023	0.074	-0.069	-0.008	-0.027	0.096	0.083	0.086	0.035	0.105	0.084	-0.129	-0.095	0.066	0.095	0.051	-0.029						
T36	-0.046	0.020	0.032	0.115	0.020	0.047	0.115	0.100	0.092	-0.054	0.048	-0.107	-0.110	0.062	-0.121	-0.036	0.021	0.082	0.072	0.062	0.011	-0.026	-0.027	0.072	-0.070	-0.068	-0.042	0.138	-0.042	0.028	0.085	-0.035	-0.007	-0.085						
DT6	-0.011	0.004	-0.104	-0.020	-0.014	-0.097	-0.049	-0.034	0.014	-0.029	-0.020	-0.009	-0.009	-0.009	-0.100	0.119	0.105	0.083	0.081	-0.057	-0.024	0.020	-0.109	-0.070	0.127	-0.123	-0.103	0.032	0.082	0.034	-0.121	0.019	0.005							
DT6	-0.058	0.011	-0.060	-0.048	-0.087	-0.120	-0.022	-0.056	0.006	-0.017	-0.075	-0.073	0.111	-0.016	0.062	-0.073	-0.061	0.016	0.072	0.067	-0.023	0.062	0.011	0.026	-0.093	-0.057	0.077	-0.076	-0.084	-0.063	0.016	0.057	0.001							
T17	-0.066	0.098	-0.060	-0.001	-0.021	-0.052	-0.067	-0.077	0.066	0.006	-0.081	0.095	0.057	-0.038	-0.009	-0.059	0.073	0.065	0.051	-0.103	-0.108	-0.073	-0.108	-0.018	-0.012	-0.044	0.120	-0.026	-0.016	-0.043	-0.054	0.017	0.081	-0.101						
T27	-0.047	0.047	-0.003	0.057	-0.022	-0.085	-0.028	-0.011	-0.032	-0.038	-0.011	0.054	0.042	-0.010	-0.027	-0.091	-0.002	-0.024	0.011	0.06																				



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all psychological variables collected. This data is accepted by critics and opponents to this model.

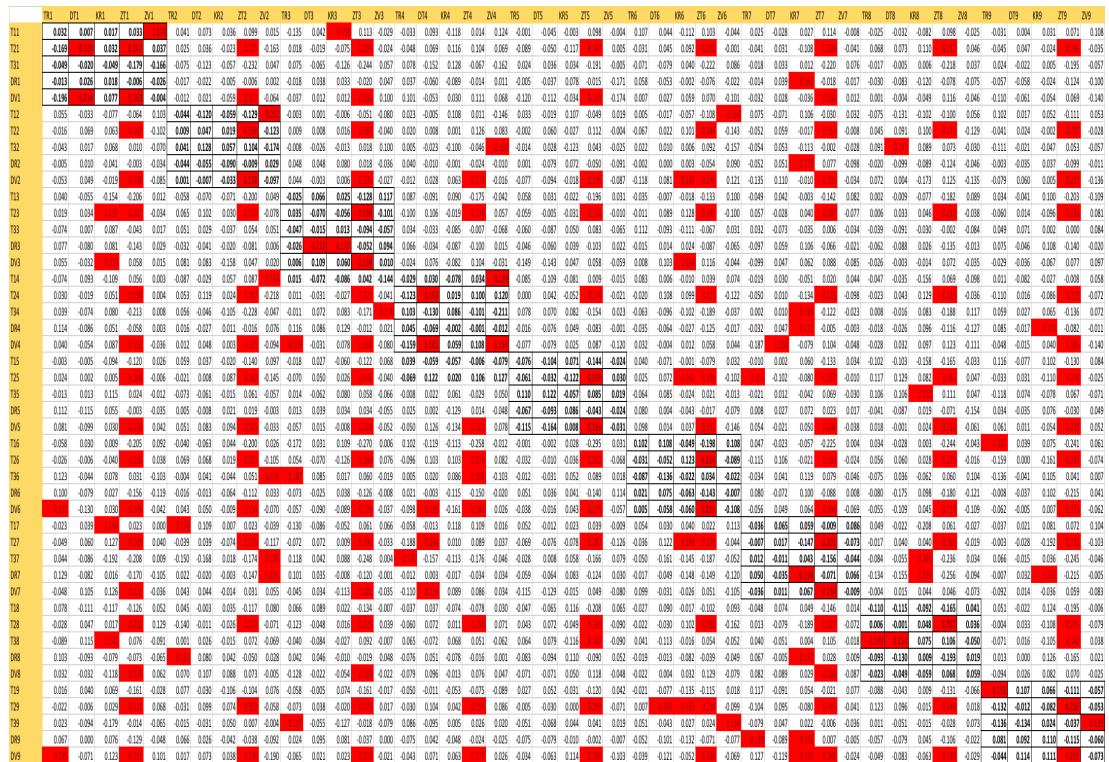


Figure 5- 4. the cells marked in black represent the present moment in which participant is performing the task. It comprehends nine blocks that correspond to 9 runs, 3 runs with the arrow pointing left, 3 pointing right and 3 with the rhombus.

The central diagonal column, with the borders signalled in black, designate the present moment of participant performing the task,

pressing the keyboard keys and trying to mentally influence the movements of the fractal. These blocks, the central diagonal include 225 cells, the number of presses per participant per session.

5.2.7.2. Structure of the data, Introducing Correlation & Permutation method

The correlation and permutation methods are exemplified in this section for better understanding of the reader. It is important to make clear that the correlation method using Spearman rho was part of the replication protocol, since the beginning of the study. However, after the Matrix consortium (Capri, 2019), the decision to use a permutation of the data made possible to run both analysis to all studies the decision was not part of the original protocol. This is the reason why the permutation method is explained in conjunction with the correlation method.

The participant performs 9 runs per session. The arrow points <- , --> , <>, this process as explained above repeats 3 times, $3 \times 3 = 9$. These 3 repetitions are considered replications of each other. The 9 runs are exact replications of the three sets of three

runs. Thus, the experimental session is made up of nine replications.

200 participants perform 9 runs each, which means that 200 participants * 9 runs create 1800 values per variable, ($200 * 9 = 1,800$). Let's consider the first psychological variable, T1, which counts the number of right presses, thus we have 1,800 values for variable T1.

There are two ways to do the control set, the original process in which the computer runs the experimental session alone with the RNG producing random events, and the permutation. The control process involves all 10 variables. Data from both controls are processed to correlate data between all variables. The analysis method applies the same way as with the one with raw data. In the end the number of significant variables is counted for each ranking.

Consider the first physical variable TR that counts the number the RNG produces '1', following the same rational we end up with 1,800 values produced by this variable. We correlate 1800 values from T11 with 1800 values from TR1. These values are correlated between each other and the final value fills in the first cell top left of the matrix.

This process repeats for all variables per each of the 9 runs for the 10 variables. All values end correlated with all. That gives

the name to correlation matrix because to understand them better they are expose in a matrix.

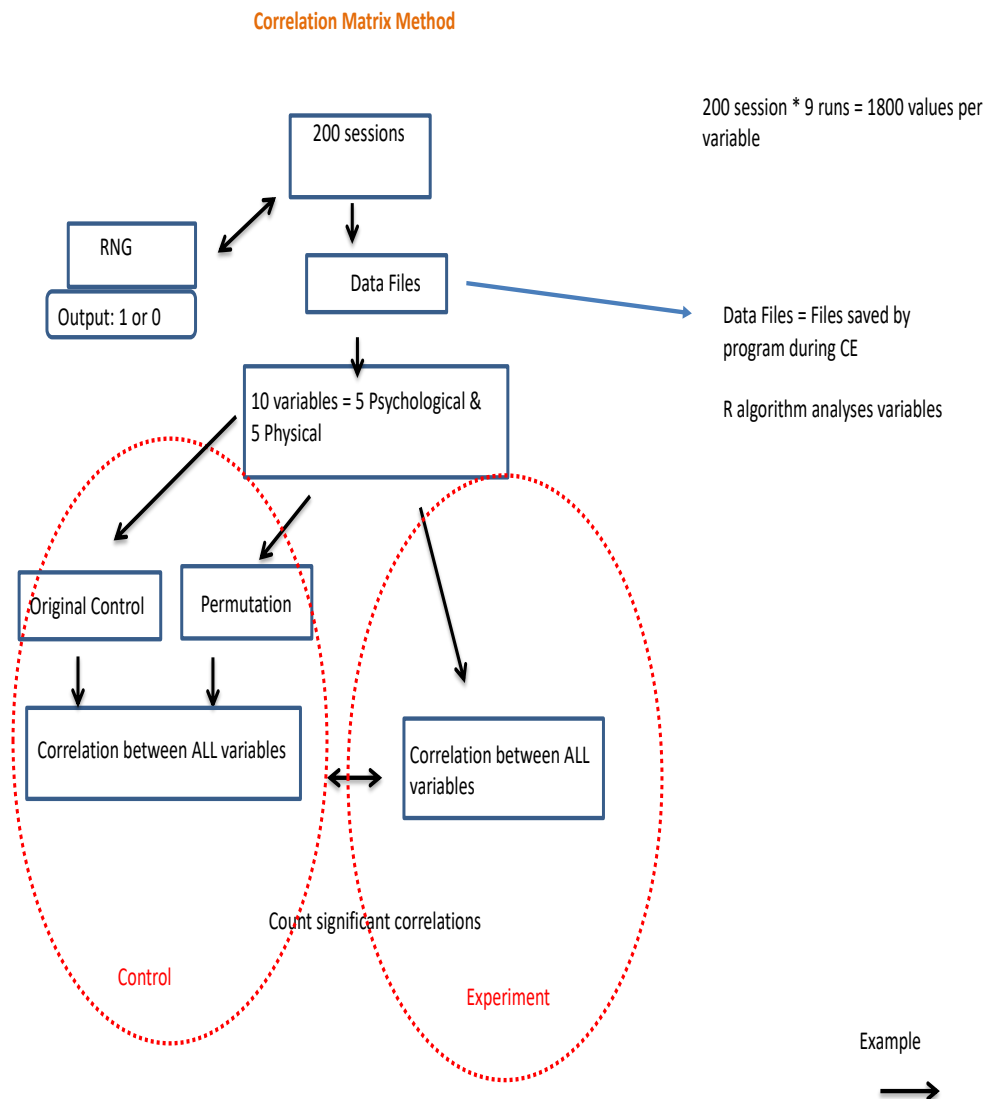


Figure 5- 5 Exemplification of the Correlation Matrix Method

T11 and TR1 are variables from the study. The nine numbers separated by lines show 9 runs each per session. The program of analyse in R correlates the 200 session values. The values produced by session 1, 2 and 3 in T11 and TR1 are correlated using Spearman Rho, producing one value that goes into the matrix. Two values are randomly chosen by an algorithm written in R to create a random choice to choose one value from a random position in one variable to swap with another value from other values from a different set but the same variable other. The algorithm is part of the R programme and incorporates the new values for a new analysis, this is the permuted values. This process of permutation of the values was repeated 10.000 times per variable. This process allows the original values belonging to the dependent variables to change place randomly 10.000 times, making then random in their position. The 10.000 permutation gets rid the dependencies from the original data set.

It is important to mention that the calculation of the new correlation for the new matrix was done after the permutation process. The permutation process happened 10.000 times inside each variable. Because variables have different measures, they cannot be mixed. Highlighting that each 1800 values used in the example, per variable will change place 10.000 times

PERMUTATION Example values of 2 variables and 3 Correlations

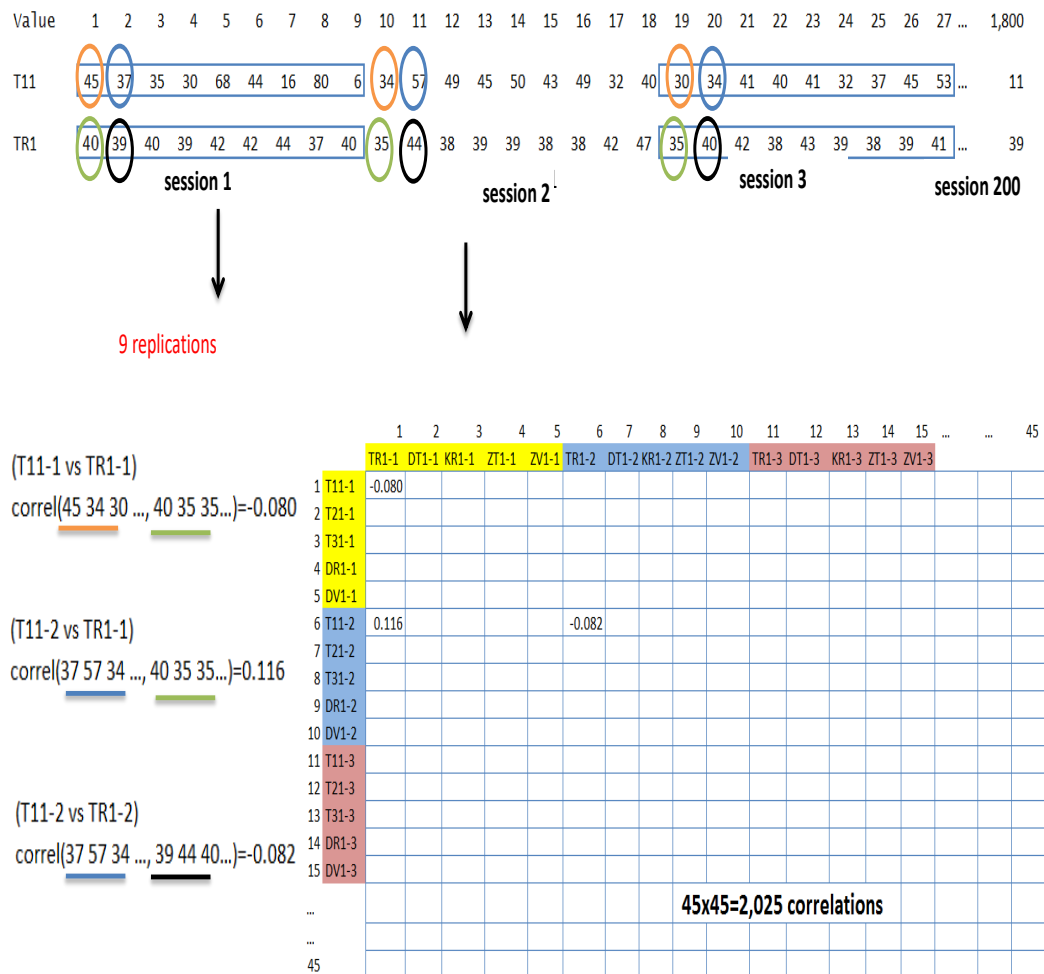


Figure 5- 6 Example of how to calculate 3 correlation values to the matrix table.

These three values in the figure, correspond to true values from study 1. They exemplify how values from the experimental session are analysed and introduced in the matrix table.

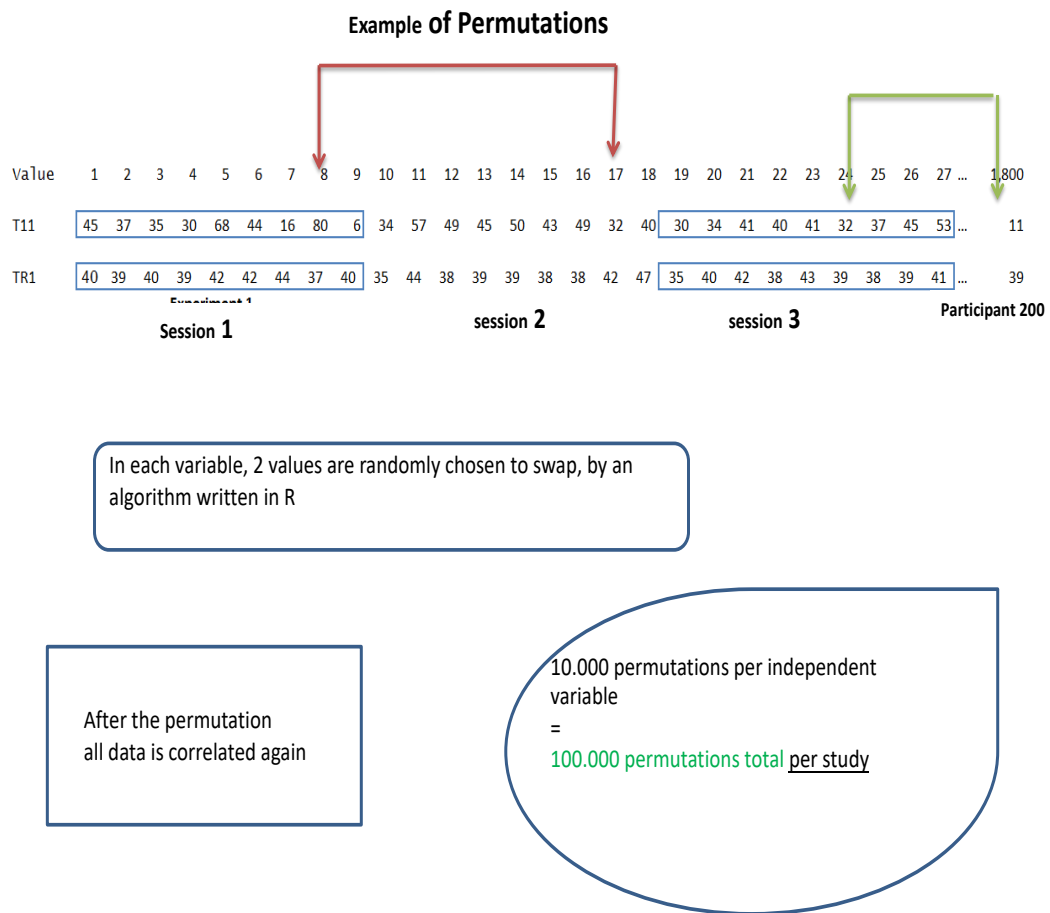


Figure 5- 7 Demonstrates how the permutation method, shuffling process, was performed in the study.

After the permutation process had been finished, all of the data were correlated again as raw data and new correlations produced, to fill in the matrix were produced following exactly the same analysis process described earlier.

The threshold $p = 0.05$ (two tailed) was defined as the first to consider as significant.

5.2.8. PROCEDURE

Participants were given a short questionnaire to fill in with their demographics. The questionnaire was not intended to obtain information itself, but instead served as a tool to get the participants involved in the system. According to the theory being tested, this involvement had the goal to creating a bond with the participant, to establish organisational closure within the system. The questions were about age, measured in a gap of ten years, education level and sex (M/F). This was followed by the questions: "I am left-handed" (Yes/ No); "I believe that human psyche can have a direct influence on matter" and "I believe I can influence chance" (both with a Yes/No/Don't know answer).

Participants were seated in front of a laptop with the output, a Random Number Generator (RNG) running a Markov-chain process. The laptop screen displayed a fractal that moved one band every time the participant pressed the shift key. The display moved towards the right or the left according to the decision of the RNG.

They were told that the study was composed of nine runs; one run consisted of 80 key presses with the arrow pointing to the left, 80 key presses with the arrow pointing to the right, and 80

key presses trying to keep the bands close to the centre. The three runs ($80 \times 80 \times 80 = 240$ key presses) were repeated three times, to make nine runs in total. At the end of the nine runs the participants received feedback on how they had performed. The test could take around 10-20 minutes, depending on their speed in pressing the keys.

Participants were asked to influence the movement of the fractal using their mind or intuition or any other term they preferred to use, in order to make the bands move in the direction of an arrow positioned at the top of the screen. The arrow pointed to the right, left or centre. The three positions of the arrow indicated the respective direction in which they should try to mentally influence the movement of the fractal. Through skilful pressing of the right or left shift key, it was expected from them to try to control the red band in the spiral as far as possible in the direction ($\rightarrow$) or ($\leftarrow$) following the arrow. When there was a rhombus ($\langle \rangle$) rather than an arrow, the red band should be kept as close to the centre as possible. The participants were to press the right or left shift key on the laptop keyboard based on their wish to help. Pressing the keyboard keys made the experiment progress, but the movement of the display was driven by a random number generator. At the end of the session a table appeared showing an evaluation of the performance.

The feedback was based on the cumulative difference between the hit rate of all “left” and all “right” sub-runs in a graphical bar indicating the direction and the deviation from zero.

It was not mentioned that they could press both shift keys at the same time, only to press the left or right as they wished. In the situation of pressing both keys at the same time, the next trial occurred automatically as long as a shift key was pressed again to allow the experiment to go further.

Participants were left alone and told where the researcher was in case, they had any doubts. They were also asked if they had understood all of the steps. The instructions ended by telling them: *“DON’T THINK TOO MUCH! WORK QUICKLY AND INTUITIVELY, ENJOY AND HAVE A GREAT TIME”*. The sentences were part of the written instructions and were repeated orally before they began the experimental session. When they had finished, they were asked if they had enjoyed the experiment or, for example, how they had found it; if it had been too long, if they had had fun, whether they were tired, etc. the purpose with the final talk is to let them share their opinion and deepen the organisational closure. In the end they were then thanked for participating.

The organisational closure was maintained and kept until the end of the experimental session because every time that was

logistically possible, the experimental control was performed. The prediction to test the CMM looks also at keeping the organisational closure as long as possible as this detail is one requirement of the success of the model.

Participants were allowed to decide by themselves how many sessions they wanted to contribute. It was observed that the number of contributions was due to their interest in the topic or a tentative aim to improve their performance.

5.2.8.1. Experimental hypothesis

The hypothesis predicted that this method of analysis would yield more significant correlations compared to the control sessions.

In the second hypothesis which was also exploratory, it was hypothesised that the number of significant correlations in the above-diagonal part of the matrix (the part where the psychological data were collected *prior to* the physical data) would be greater than the same correlation from the above superior part of the matrix (900 cells).

5.2.9. Ethics

The study was approved by the Psychology Research Ethics Committee at the University of Edinburgh with number 111-1617/2 in 12 December 2016.

The same approval was valid to study two and three as they were exact replications of the first study.

5.3. Study pre-registration

The number of participants for each study was previously decided in the pre-registration form, as well as the hypothesis and methods of analysis to be used. Additionally, the dates to start and to end collecting data, as well as the number of participants required (see appendixes 4-8)

According to the pre-registration protocol all data was firstly collected, and files were kept untouched. After finishing collecting the data, usually when the number of subjects pre-registered were achieved or deadline ended, the data files were opened all at the same moment. Files were then checked one by one for completeness. Incomplete files were deleted, only the

complete ones were saved in a folder for analysis. This rule was applied to all five studies.

5.4. Analysis

5.4.1. CMM analysis with Z score

As mentioned above, the method of analysis initially performed by von Lucadou was the Z test. This statistical method was imposed to him by a peer-review (1989). The Z formula was withdrawal from a book of Statistical Methods in Parapsychological Research, Handbook of Parapsychology (1977). Though, it so happens that the Z test formula needs two pre-requirements to be correctly applied:

- 1) the data to be normally distributed
- 2) data to be independent.

This is not the case in the set-up of the study. The psychological variables, number of button presses are dependent on each other. Moreover, the Z formula was used due to the imposition of the peer review, for the author to be able to get his paper published. Though, there is a similar Z test formula in several books of statistics from mainstream sciences. There is no reason,

in the opinion of sceptic physicist Thomas Filk (2017) ⁹ not to use the formula from mainstream statistics. To check for the differences that the two formulas could produce, both were used to analyse data from study 1 by the present author and by Thomas Filk, independently. The differences found were minimal. The changes were only manifested at the third decimal case of the study result, i.e., they were so small that they could be considered non-existent. The argument is raised as part of the work done in order to cover all aspects that could improve the CMM and its methodology.

Another point that I would like to raise is the fact that the statistical measure, Z even though is not the correct method to analyse the data set produced in the studies, is in fact the only method that allows to compare the results from this study with the first studies produced by von Lucadou and attest for the predictions of replicability of the CMM.

Following this line of thought, and because the first analysis performed for the three first experiments used this formula, I performed this analysis for an exact replication.

The formula was written as follows:

⁹ Oral presentation at the Consortium meeting in Capri in October 2016

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

CE = number of significant experimental correlations

CD = number of significant correlations of the permuted data

NC = number of significant correlations in the correlation matrix

$$Z = \frac{(CE - CD)}{\sqrt{2 \cdot CD \cdot \left(1 - \frac{CD}{NC}\right)}} \Rightarrow Z = \frac{(CE - CD)}{\sqrt{CE \cdot \left(1 - \frac{CE}{NC}\right) + CD \cdot \left(1 - \frac{CD}{NC}\right)}}^{10}$$

5.4.2. Z score and its relevance

The Z statistical test intends to examine if the mean of two populations is distinctive when variance values are known and there is a large sample size.

Also, the test aims to look at the type of hypothesis as a way to show if results from a test are valid and repeatable, saying that the hypothesis being tested is probably true or not true. In the present studies psychological data is independent from physical

¹⁰ Formula retrieved from von Lucadou (2006)

variables. The dependencies on the original study appear between the psychological variables, example button presses. Another requirement to apply the Z is the data set to be normally distributed. This requirement verifies in my data sets. Knowing the reasons that exclude the Z application for not being completely accurate, and the requirement of normal distribution that verifies, I show the results from my studies after running the permutation method, which randomise all data creating the right requirements to apply the Z score, (Appendix 8.12). However, being aware of the problem of dependencies between psychological variables.

5.4.3. STUDY 1

Data was collected in a total of 213 experimental sessions. Data files were only opened once the study was complete with all data collected and ready to start the analysis. The files were open all at the same time by the researcher i.e., me.

The method of analysis used for this study was the original method, the Z score. The Z score quantifies the relation existent between a group of values. The measure is based in terms of standard deviations from the mean. It intended to show the

difference between experimental data and the control data. This analysis is an exact replication of the original study.

Two years later the first Z analysis, a permutation analysis was introduced to replace the original method of control.

As my work is to do an exact replication, the analysis of the data should include the Z-score, even afterwards was shown that this method overestimated the results¹¹. The permutation was performed for being considered more reliable.

Being aware that it is being presented one analysis that is considered not to be correct, even though, the decision is to do so. Several scientific articles are published using the Z score analysis as explained in chapter 3. By applying the permutation method, an improvement in methodology is introduced in this work. The Z score should be considered just a measure of comparison with previous studies where it was used.

¹¹ As a senior colleague told me while discussing the best methodology for this experiment: “this is a new field of research, there is no perfect statistical method to measure mind with RNG events, whatever ones do is a step further in the process”.

The hypothesis pre-registered foreseen the employment of the original Z method. This Z showed to overestimate results with a $Z = 10.6$ at $p = 0.05$ as shown in table 6 -2 presented below.

From the experimental hypothesis for this study, hypothesis 1 is accepted as more significant correlations were produced in the experimental session than in the control condition with the original method used by von Lucadou.

Table 5.2 demonstrates the results for the full matrix with 2025 cells, using the original method of control. The same table. shows the full matrix, with the same experimental sessions, but using the permutation method analysis. It was decided to present in one table results from different analysis, for an easier comparison of the results. The decision was pondered and considered as thoughtful for a better comprehension regarding the presentation of the experimental results.

The p value threshold is considered as a sensitivity analysis to test for robustness of the results. The number of significant correlations is counted for the different p values thresholds and the respective Z as a measure of comparison. The thresholds go from $p=0.1$ to $=.0001$.

All the permutations performed used experimental data. Each variable is permuted 10.000 times, times 10 variables 100.000 permutations are produced in total per study.

According to the protocol and as a sensitivity analysis the true P-value is achieved by getting the difference between the number of significant correlations during the experimental session and the significant correlations counted with the permuted data. This difference is split by the number of permutations, 10.000, which gives the respective P-value

As a control, the number of correlations expected by chance are also performed to compare with the behaviour of the control method (RNG) used in the experiment.

It is interesting to see that the correlations expected by chance 101 for $p=.05$ are more than the ones produced by the original RNG working alone, 88 for $p=.05$. It would be estimated that correlations expected by chance would be similar to the control ones and in such way to be used as a control. However, the expected correlations can be with precaution, used as a second measure of control due to its difference to the ones counted during the experimental session, 365 for $p=.05$, and its statistical rational.

The P value shown in the last line of the table is the same from table 5-3 where permutations had been run. The decision to include them in the table is to show how the analysis performed along these three years improved. Also, it facilitates the observation and comparison of both analysis

Table 5 - 2 Results from 2025 cells, the entire matrix table. Number of significant correlations obtained in the experimental session, N correlations expected by chance, N correlations using original control and results obtained with original Z score.

P-value threshold	Pvalue 0.1	Pvalue 0.05	Pvalue 0.01	Pvalue 0.001	Pvalue 0.0001
(a) Experimental significant correlations	365	226	78	21	4
Significant correlations expected by chance	203	101	20	2	0
(b) ORIGINAL Control significant correlations	173	88	14	0	0
(a) - (b) Correlations Difference	192	138	64	21	4
Number cells	2025	2025	2025	2025	2025
Z	10.793	10.636	12.137	∞	∞
P value from table 6-3	0.019	0.014	0.006	0.002	0.004

The first line of the table presents a Pvalue threshold. The true p value result from the difference between a - b divided by 10.000, as the outcome of the randomization it gives the corresponding p value.

It shows the difference between Correlation Experimental session (CE) and Correlation Control session (CC), in the present case the permuted data. The calculation gives the following values for the p-value threshold (two-sided), (Walach et.al 2019). For the entire matrix, 2025 cells, the P values achieved are between $p=0.019$ and the more significant for a threshold of $p \leq 0.0001$ a $p=0.0005$.

Table 5-2 shows the Z scores from the original control method using the original Z formula. As one can see the values for a p value threshold of $p \leq .05$ corresponds a $Z = 10.63$, $p = 0.01 = Z = 12.13$, at a $p \leq 0.0001$. calling the attention that these values are achieved with the less appropriate measure because is dealing with dependent variables. This information should be in consideration for the next studies, where the original control will always be presented with the original analysis Z score.

$Z = \infty$ corresponding to a 4 significant correlation in the experimental session. To these overestimated values the Pvalue based on the 10.000 permutations were respectively at the

different thresholds $p=0.1=0.019$, $p=0.5=0.014$, $p=0.01=0.006$,
 $p=0.001=0.002$ and to $p=0.0001=0.004$.

Table 5 -3 Results 2025 matrix, 10.000 permutations P values & Z scores

	P value	P value	P value	P value	P value
P-value threshold	0.1	0.05	0.01	0.001	0.0001
(a) Experimental significant correlations	365	226	78	21	4
Significant correlations expected by chance	203	101	20	2	0
(b) Significant correlations from 10.000 permutations	226	130	28	0	0
(a) - (b) Correlations Difference	139	96	50	21	4
Number cells	2025	2025	2025	2025	2025
Z	6.937	6.154	6.728	∞	∞
((a) - (b))/10,000 Permutation P-value	0.019	0.009	0.005	0.002	0.0005

Table 5-3 follows the same structure as table 5-2. The difference between a) and b) is executed. The permutations work as the control data. The Z score is achieved by using the permuted values and is visible a significant drop in the results. With permutations the Z-score for the first p threshold is just around value 6, respectively $Z = 6.9$, $Z = 6.1$, $Z = 6.7$ $Z = \infty$

With the permutations the P values are still significant, in a decrescent order starting in $P = 0.1 = 0.019$, $p = 0.05 = 0.009$, $p = 0.01 = 0.005$, $p = 0.001 = 0.002$ and $p = 0.0001 = 0.00$

Following the results from the full matrix with 2025 cells, two tables presenting the results related to the diagonal superior of the experiment, composed of the 900 cells are presented

The significance of these 900 cells is explained in table 5.

Again, the two tables show the different methods of control used.

The tables are presented always in the same order, first the one with the original method of control used by von Lucadou, because that was the one performed first. The Permutation method even though it is part of the hypothesis two was developed much later.

Table 5 -4 Number of significant correlations counted for the top superior of the matrix table, 900 cells, compared with original control session

Pvalue threshold	Pvalu e 0.1	Pvalue 0.05	Pvalu e 0.01	Pvalue 0.001	Pvalue 0.0001
(a) Experimental cor	170	106	29	5	2
(b) Control ORIGINAL	80	39	5	0	0
(a) -(b)	90	67	24	5	2
Number cells	900	900	900	900	900
Z=	7.454	7.756	7.611	∞	∞

The number of significant correlations when analysing data from the top superior of the matrix table, the 900 cells that refer to future information. Data referred to the moment after participant had finished to perform the session, not possible to be contaminated by any artefacts, show significant results.

Comparing data from table 5-5 and 5-4, the original control produced less significant correlations than the permutation method. This happened to all sensitivity significances described

in the tables. For the top right of the matrix the original RNG produced more significant results than the permuted data.

Table 5 - 5 Number of significant correlations counted for the top superior of the matrix table, 900 cells, compared with N correlations obtained with 10.000 permutations as control

	Pvalue	Pvalue	Pvalue	Pvalue	Pvalue
Diagonal superior	0.1	0.05	0.01	0.001	0.0001
Experimental cor	170	106	29	5	2
10.000 permutations	113	68	3	1	0
Number cells	900	900	900	900	900
Z=	4.055	3.389	10.632	2.830	∞
Pvalue	0.011	0.006	0.0003	0.0001	0.0002

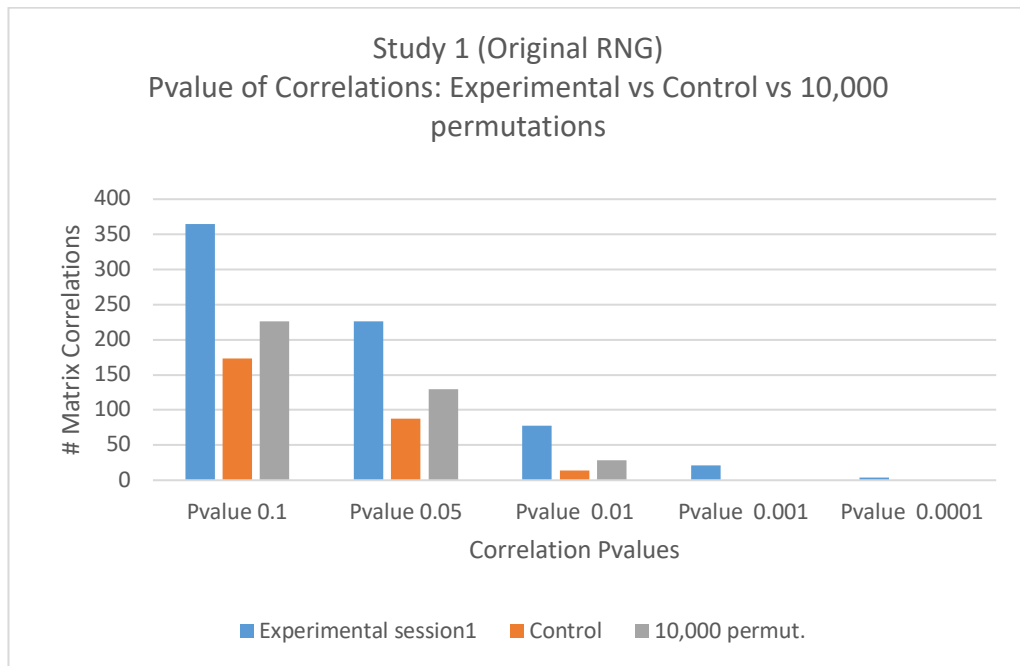


Figure 5 - 8: shows significant correlations for all significances from experimental session, original control and permuted data

The figure shows in a visual perspective the differences in the results obtained. The experimental sessions show, in all of the different value's thresholds, stronger results. While the original control demonstrates lower results when compared with the permuted data. The original control does not follow the re-arrangement of the permutation, this is, does not dilute the effects from the experimental data itself, but behaves like creating its own set of events, for $p=0.1$, $p=0.05$, 0.01 . the permuted data produces more significant correlations than the

original control. However, the experimental session is where the highest level of significant correlations is produced.

5.5. Discussion

Study 1 focused on replicating previous successful CMM studies. This replication also found evidence that psychological variables produced by an individual, when correlated with randomness produced by a RNG creates more significant correlations than in the control session, when participant is not participating in the task. Stringent significant levels to count the number of significant correlations were used ($p=0.001$, $p=0.005$, $p=0.0001$) to find that experimental sessions produced more significant correlations than in the control condition. Additionally, the top superior right of the matrix, reporting values from the correlation between psychological variables and future physical variables, confirmed the significant results.

Other considerations however should be discussed, starting with participants age and gender. Participants below 30 years old represented 52% of the total participation, 68% of the participants were females. However, that can be easily explained due to the places where the data was collected for the study, which was primarily a women's club. According to the data, the

contribution of the participants diminished with their age. It is a point to consider whether the number of significant correlations obtained in this study is due to the number of women contributing to the study.

The central diagonal cells marked in the figure 5-7., with the total 225 cells, designate the correlations produced during the moment participants are performing the experiment. It is argued by some parapsychologists that these correlations can include causal effects. To justify this argument, one has to consider that the significant correlations found in these 225 cells are originated as a consequence of the subject's strategy when performing the experimental session. The argument does not seem reliable because significant correlations happen as well in other parts of the matrix and not specifically related to the moment of performance.

Causal effects can happen under the circumstance in which a participant is always pressing the opposite key from the direction of the visual feedback in the anterior step. For example, the arrow on the top of the fractal points to the right, so the participant task is to try to influence the bands to move towards the right, participant presses the right key, but the movement happens to the left, on the next trial participant presses the left key expecting

the RNG to behave again the same way, towards the right. If participant always presses the opposite key related to the previous step, the correlation produced will be antisymmetric between psychological and physical variables.

The 900 cells below the central part, are considered as plausible to include causal effects because they contain psychological data already collected. If artefacts were produced by the subject they are shown in this lower part of the matrix,

It can be argued that there is a small hypothetical possibility of the participant memorising or use any other kind of causal influence on the RNG.

Even though the argument seems exaggerated, that someone is able to memorise all possible future random decisions produced by the RNG even when pressing, is relevant to highlight it to bring more awareness on the details of the CMM. Considering the previous argument, even hypothetical, we have the superior right of the matrix that reflects the future sub-runs or “non-contaminated” cells, where correlations can be counted, and more significant correlations hold significant.

The Markov-chain method used in the RNG can be challenged if one always bets on the number (1 or 0) that is different from the last one. The person will win in at least $\frac{2}{3}$ of all cases. Of

course, the participant was not betting nor interfering with the Markov-chain process, but in fact the behaviour of the RNG is not completely unbiased. On the other hand, the difference in random choices from the RNG can be always random in a way that the formula does not apply. It seemed important to make this remark to help understand all of the details of the Markov-chain process (Filk, 2016, oral presentation Capri)

To the argument that pressing one key on the keyboard could interfere with the voltage and in consequence create an artefact, due to the autocorrelation variable, does not seem to be possible. Whether this situation was true that artefact should manifest systematically creating patterns in the different variables within

The main point to discuss in this first replication is whether the method of analysis is appropriate.

The argument that the Z score inflates the number of significant correlations and consequently the final result, has to be taken in consideration. The psychological variables are dependent between each other as explained in 5.8.1. However, following the von Lucadou's original protocol with the instructions on how to perform the Z-score, applying the Z formula I am doing an exact replication. Which is the purpose of this thesis. Of course,

improvements are always welcome and are the second aim of my thesis. The permutation was then applied as an improved method of analysis.

In this analysis the Z score was attained in two different contexts; in one the Z was performed using data from the original control following Lucadou's original control technique, on a second way the Z score was achieved by using the permuted data. For last, the Pvalue is obtained from the permutation. The purpose of getting these two Z values is first the 'wrong' Z was the analysis used in the past years, papers are published with this analysis and I myself did my first analysis, presentation and publication with it. The second analysis using the Z from permuted data is a correct statistical analysis (confirmed with Prof Jessica Utts). Even though the Z analysis 'wrong', I present the Z analysis to allow a comparison with the previous CMM studies that I am replicating. I would like to reiterate that the analysis with the 'wrong' Z was the one performed in the past years by von Lucadou and I myself presented in conferences the Z analysis. It is clear that the results from the second Z score, using the permuted data set, lowered the results, which is expected because data is independent, even though keeping its significance

It was argued that the Z score overestimates result in situations in which the variables are dependent or non-orthogonal. Von

Lucadou (2016) considers this argument to be true only in the situations where causal signals hold. In the example of using the same variable several times that argument would produce an $r = 1$. When the variables are completely independent the scenario would be $r = 0$. However, in both situations, the model predicts that the value of significant correlations will decline in the case of replications. For this reason, some novelty has to be introduced in each replication.

Following a more traditional method of analysis, and since some of the variables used in the experiment are dependent, the Z is used in my analysis as a measure for comparison with the previous experiments and to explore the method of analysis used for so many years.

However, after data is permuted, the dependencies between the variables fade and show up as random values. Under this circumstance the Z score was tested to explore the results and compare with the original ones.

The first analysis performed with the first three studies used the Z. It is explained in another part of this thesis that the measure was imposed to the senior author, von Lucadou (1989) by a peer review as the best measure to use with to test this new type of model, the correlation matrix.

Later, in the end of the second year of my PhD a new method, permutation, was considered more effective by the international group of researchers. Since part of my work of analysis used the Z score, I am presenting both analysis and showing the results from both methods. I consider the alteration of the method of analysis could be pondered as a progress and a contribution to a better understanding of the correlation matrix model and its development. Although, the main goal of the author's model is to achieve a way of identifying the differences between experimental and control sessions without any statistical method, as it happens in other fields of science such as physics, chemistry and others.

The results show that in all matrixes and at the diagonal superior, using von Lucadou's method or the permutation method, the experimental sessions produced more significant correlations than the control sessions in both situations.

Cannot be left without referring that it is possible that some correlations considered significant, are not true correlations for the effects of the study. This circumstance can happen if a participant develops his or her, own strategy and presses always the same key. This behaviour would create significant correlation but due to the participant technique, because she or he was not following the instructions given. It is considered for the analysis

that this kind of behaviour is exceptional and do not make the rule.

The analysis of the top superior right of the matrix, also reported significant correlations between the psychological variables when correlated to the future physical values which supports the findings in all matrix.

To the arguments that artefacts can have contributed to the significance of the results, an explanation on how I avoided them is due. All study was pre-registered, and all details previously defined before the beginning of collecting data. Data files were only open for analysis by me after finishing all data collection. The original RNG built according to Lucadou instructions were always sealed as I received it. The analysis program was written by me in R (see Appendix 10), following the original program from Lucadou in Basic. The program was re-written from scratch by Dr Thomas Filk in language C++, as an independent validation of my analysis (Appendix 11)

The issue related with the Markov-chain method, not being a purely random process, was checked and both analysis with the two different possibilities, having the Markov-chain creating pure random values were performed by myself and by Dr Thomas Filk.

The RNG worked based on a Zener diode, there was no algorithm creating random numbers, this avoided any classical influence of the system.

Finally, it was argued that successful results from Walach et al. (2019) were due to the number of times participants performed the experimental sessions. Some participants had contributed ten times each. This is an open argument to test in the next study.

In conclusion

The first point to highlight is that it is clear that the original Z overestimates results, due to the dependency of the variables.

Second point, with the data permuted, the dependencies disappear because all values of the matrix (even all values per participant) change place. So, the Z score could be used as a measure of comparison with the original Z, using now the permuted data, as well as to evaluate the methodological changes.

Third point highlights that the recommended method of permutation analysis was followed, and respective p-value achieved exactly as described in the protocol (Walach, 2017).

Being aware that some researchers do not rely on P values considering them not reliable (e.g., Dr Thomas Filk, see appendix 10), Others do prefer so.

This first study was an exact CMM replication, and validated Lucadou and Walach (2019) studies. The reason to report to both authors' studies, is that although von Lucadou created the entire set-up and CMM, his study is the original, but he used a smaller matrix with less variables. Walach (2019) replicated the study adding more variables, the ones I am using in this thesis as explained in more detail in the beginning of the chapter.

CMM argues to have solve the problem of replicability in Parapsychology. This statement requires to be tested again, to replicate the same study to look at whether a decline effect exists compared with this first study. Moreover, the number of contributions per participant requires caution in the next study. The argument will be tested by limiting the number of contributions per participant.

CHAPTER 6 SECOND AND THIRD CMM REPLICATIONS

6.1. INTRODUCTION to STUDY 2

This is the second study from this thesis, also a replication from the previous study, in which CMM was successfully replicated. The results showed that more significant correlations were produced during the experimental sessions with participants present, trying to mentally influence the fractal, than in the control condition with the same software running alone without participants.

It had been argued that the positive correlations, could be a consequence of the number of times some participants had contributed to the study, (e.g., Walach et al. 2019), as they could memorize the RNG randomness. In answer to this argument, this second study allows participants to contribute to a maximum of two sessions but in different days. This study intends to validate the results previously obtained with CMM and test the relevance of the number of contributions per participant.

6.2. METHODS

6.2.1. Design

The design of study 2 is the same as study 1. With the particularity that in this study, each participant is invited to participate one or maximum two times in the experimental sessions. If the participant choses to participate twice it has to be in different days. This particularity is the novelty in the study, as such the MPI requirement. After running the sessions, the MPI requirement of confirmation is verified by the participant's knowledge of the session.

6.2.2. Participants

In total, 105 participants contributed with 200 sessions. Seventy-three participants (73) female and thirty-five (35) male. Ages are reported by intervals and gender in table 6-6.

For this study, participants were mainly recruited from the Spiritual Centre, Arthur Conan Doyle centre (ACD centre), and at a Scottish church in Edinburg. The study was advertised in both

places as well as by word of mouth. The Centre is a spiritual centre and was expected to raise curiosity among the members in regard to contributing to the study. There was diversity in the range of participants recruited for this study.

The pre-registered protocol required to get 220 participants, or the number reached by the 30th April 2017, whichever came first. The study stopped at the 30th April, with 105 participants.

I was the main researcher, for this study. Temporarily, an international psychology student had joined the Koestler Unit for his final year project, at the time the second study was being performed. He helped collecting data for the experiment after adequate training was administered to prepare him to run the experimental sessions. The student took the laptop and RNG, for around two week and he collected data from 20 participants in his home using close friends and relatives as participants. These were the only participants recruited outside the previous mentioned places.

Table 6.1: Shows total number of participants, their age taken in intervals of 10 years and gender - study 2

Age group	Female	Male	Total participants	% Participants per age group
10-20				
20-30	29	7	36	34.3%
31-40	16	6	22	21.0%
41-50	13	9	22	21.0%
51-60	8	3	11	10.5%
61-70	7	4	11	10.5%
71-80	2	1	3	2.9%
Total	75	30	105	100.0%
%				
Total	71.4%	28.6%	100.0%	

Participants with age between 20-30 years old totalized 34% of the participants in the study. The second and third groups of age, totalised exactly the same number of participations, 22, though females contributed more when compared with males. In total, 71% of female participated against 28% of male.

6.2.3. Materials

Materials used are exactly the same as described for study 1.

6.2.4. Procedures

I collected data at a church room specially allocated for the study. Also had one room allocated at the university of Edinburgh just for this study, mainly receive participants recruited at the ACD Centre. The process of greeting participants, explaining them the experiment was equal to the previous study. The same procedure as described for study one was repeated in the present study

6.2.5. Experimental Hypothesis

Hypothesis 1 (exploratory hypothesis) replicates the method of analysis employed by Walach and von Lucadou the original ZDifference. It will be applied to the full matrix, and it is predicted that this method of analysis will yield greater proportion of significant correlations compared to the control sessions.

Hypothesis 2 (exploratory hypothesis) explores an alternative method of analysis that is applied to the section of the data that is not susceptible to causal correlation from RNG feedback influencing the psychological data.

it is hypothesised that the number of significant correlations in the above-diagonal part of the matrix (the part where the psychological data have been collected *prior to* the physical data) will be significantly greater than the number expected by chance. This analysis will be conducted using Z score and a permutation or simulation analysis.

6.2.6. Ethics

The studies were approved by the Psychology Research Ethics Committee at the University of Edinburgh with the following numbers:

Study number 111-1617/2 on 12 December 2016.

The study was pre-registered at the KPU registry with number 1031

Although this is an exact replication study, it is not pre-registered as confirmatory because the CMM is under

development by a research group and at the time of running this study, the method of analysis was still being discussed.

6.3. RESULTS

The number of significant correlations in the matrices are shown in p values variations: 0.1, 0.05, 0.01, 0.001 and 0.0001 (see chapter 5) to test for rigorousness.

It is observed in table 6-7 that in the experimental task there are three significant correlations at a $p = 0.0001$. For the same Pvalue variation it is not expected any significant correlation. Moreover, there was no significant correlations at the control session. This means that the results conformed between expected by chance and experimental control session. Though, the permuted data from all matrix, 45x45 matrix cells, permuted 10.000 times, got significant results for all different levels.

The permutation analysis got significant results at all intervals analysed, being the most significant at level Pvalue 0.0001 with a result $p = 0.0003$.

The Z values found with the original control is not significantly different from the Z values resulted from the

permuted data. Again, the last row of table 6-8 contains the Pvalue from table 6-9, making it easier to compare the different results.

The findings are shown in the tables below. The structure of the tables was explained for study 1, this follows the same organisational method.

The permuted data, 10.000 permutations, gives more security of the results obtained, as already explained. In this study, the number of correlations produced by the original control method was very similar to the number of significant correlations produced by the permuted data. Moreover, the Z score from both analyses, original and permutation, are very similar. This finding suggest that the permutation can replace the original control, for this study at least.

Table 6 - 2 Results from 2025 cell matrices, analysing original control, number of Spearman rho correlation coefficient significant at $p < 0.5$

P-value threshold	P value 0.1	P value 0.05	P value 0.01	P value 0.001	Pvalue 0.0001
(a) Experimental significant correlations	315	187	66	13	3
Significant cor. expected by chance	203	101	20	2	0
(b) Control ORIGINAL significant correlations	205	108	23	2	0
(a) -(b) Correlations Difference	110	79	43	11	3
Number cells	2025	2025	2025	2025	2025
Z	5.730	5.525	6.340	5.503	∞
((a) - (b))/10,000 Permutation P value	0.011	0.008	0.004	0.001	0.0003

Moreover, the number of expected by chance correlations are very similar with the number of permutations, the same holds for thresholds 0.001 and 0.0001.

Note that p values are originated from permutations, as true probabilities existing between the number of significant correlations counted during the experimental session against the permuted results.

For the criterion pre-defined significant correlations were found at $p=0.0001$.

Table 6 - 3: Shows results from 2025 matrix cells, analysis with 10.000 permutations, P values & Z score

	P value	P value	P value	P value	Pvalue
P-value threshold	0.1	0.05	0.01	0.001	0.0001
(a) Experimental significant correlations	315	187	66	13	3
Significant correlations expected by chance	203	101	20	2	0
(b) Significant corr from 10.000 permutations	207	109	20	2	0
(a) -(b) Correlations Difference	108	78	46	11	3
Number cells	2025	2025	2025	2025	2025
Z	5.602	5.431	7.273	5.503	∞
((a) -(b))/10,000) Pvalue	0.011	0.008	0.005	0.001	0.0003

The top superior right of the matrix, that includes the psychological variables, correlated with the physical variables produced after participant perform the experiment, called physical future data, also yield significant Z using the original control method. This Z score is the original formula replicated from von Lucadou's studies. The most reliable results are the ones obtained from the permutation analysis as explained in the permutation section.

Table 6 -1 Diagonal superior 900 cells with **original control**

Diagonal superior	Pvalue 0.1	Pvalue 0.05	Pvalue 0.01	Pvalue 0.001	Pvalue 0.0001
Experimental cor	123	72	28	5	2
Control ORIGINAL	80	37	4	0	0
Number cells	900	900	900	900	900
Z=	3.561	4.155	8.504	∞	∞

With the permutation method, the Z score only get significance at thresholds of 0.01, 0.001 and 0.0001, this for

the 900 cells that represent the top superior of the matrix, referring to the information that according to some authors are not possible to be contaminated by any circumstance, as such they are robust.

The number of significant correlations counted after the permutation is higher than the number of significant permutations produced by the original control.

Table 6 - 2 Diagonal superior, Permutation & Pvalue

Diagonal superior	Pvalue 0.1	Pvalue 0.05	Pvalue 0.01	Pvalue 0.001	Pvalue 0.0001
Experimental cor	123	72	28	5	2
10.000 permutations	111	54	10	1	0
Number cells	900	900	900	900	900
Z	1.860	1.786	4.047	2.830	∞
Permutation p values	0.008	0.0037	0.0004	0.0004	0.0002

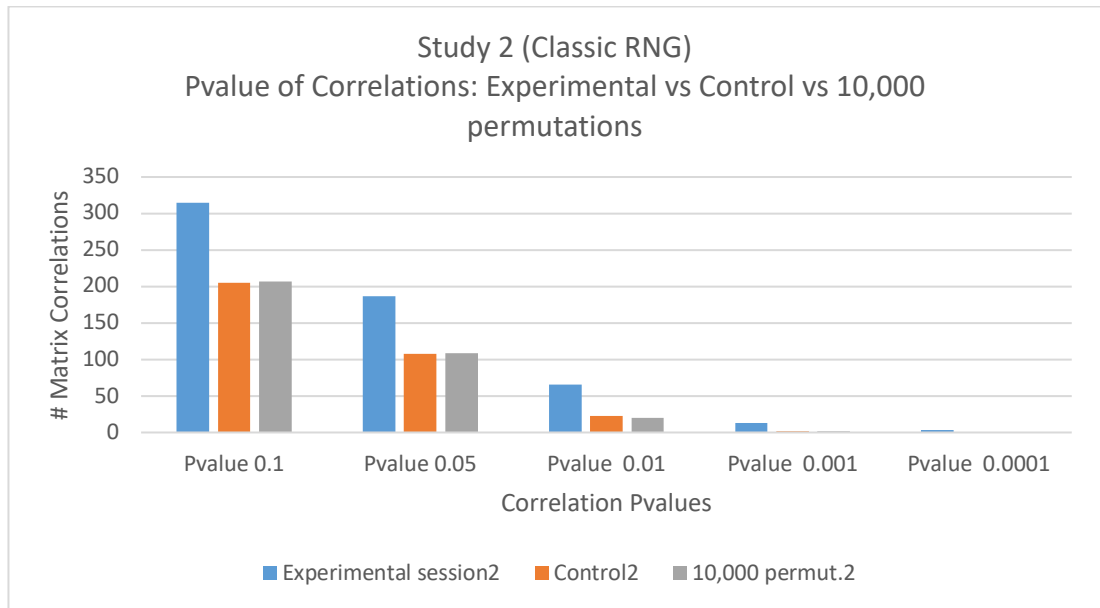


Figure 6 - 1 Represents in bars results from Correlations of experimental sessions using original control & permutation method

The graphic shows that the experimental sessions produce more significant correlations than the control sessions and the permuted data. Additionally, the original control and the permutations, count a very similar number, is not clear to a naked eye to observe the difference between them. Thus, for this study they can both work as control.

6.4. DISCUSSION

Study 2 proposed to validate the results obtained in study 1, where more significant correlations were counted during the experimental session with a participant interacting with a physical system an RNG, versus a control session where a RNG system produced randomness without the participant present. This study also tested whether the number of contributions per participant influence the significant number of correlations.

Study 2 differs from the study 1 in several respects. The novelty introduced in the study as required by MPI to avoid decline effect, was the number of times participants could contribute with experimental sessions. In this study each participant could participate maximum two times but in different days. From the results obtained, the number of times each participant contributed does not shows to interfere in the significant results.

Participants were recruited in different places, Churches and at ACD Centre. 70% were female and 30% male. Even though, advertisement was made in public places, male tend to not participate in the same way as female. Both genders

had same access to advertisement as well as to information about the study. Similarities with study 1 noted. Compared to Study 1, there was more diversity in terms of participants, age, maturity, different religious backgrounds, etc. this diversity did not show to produce significant relevance, because results were similar to the ones obtained in study 1.

This study was the second replication of CMM studies, replicating study 1. Significant correlations manifested in both studies. No decline effect verified. Moreover, the significant correlations appeared in different positions within the matrix table as argued by von Lucadou (2006).

The hypothesis pre-registered for this study have to be accepted as true because in all circumstances, full matrix and right superior matrix, counted more significant correlations during the experimental session than during the control session. The fact can favour the theory that when participants perform the experimental task a different behaviour happens with the experimental set-up.

The explanation given by GQT and MPI is that these correlations are not causal because they did not receive any

kind of influence from the participant, so they are 'non-local' correlations.

One finding in this study is that the number of significant correlations expected by chance is very similar with the number of correlations counted after the permutation analysis and even with the number of the original control sessions.

Also, significant correlations for the 2025 cells (table 6-8), with results obtained by permutation analysis confirm, like in study 1, that PK effect can be replicated.

According to the MPI the significant correlations manifested in different places of the table, (see annexe) than in study 1. This means that the effect behaves according to the Non-transmission axiom. It is not possible to predict in which matrix cells the PK effect, or significant correlations, manifests.

The number of experimental sessions required to consider the study a replication is 200 (von Lucadou, 1986). According to the author, 200 is the number that allows to obtain enough information from the experimental sessions.

His argument is based in his own studies and theoretical development of CMM.

The question whether the number of times each participant contributes to the study, according to the present data, does not affect the significant results. However, the question raised now, is whether the 200 sessions is the relevant number to obtain significance.

To test whether one single participant performing 200 experimental sessions could maintain the results from study 1 and 2 and bring some light to the question.

A third study was designed looking for confirmation about the importance of the number of contributions per participant. The study was also a replication of the two previous studies.

This detail is also the novelty required by CMM to acquire confirmation of information.

Note: All arguments discussed in study one (chapter 5) at the Discussion section, that also apply to this replication, are not going to be repeated again.

6.5. Study 3: A REPLICATION OF THE CMM WITH ONE PARTICIPANT

6.5.1. INTRODUCTION

The present study follows the aim of the two previous ones. First, to perform a new exact replication of the original CMM studies to challenge the validity of the correlation matrix method and the solution for the problem of replication. Second, it looks at the question whether the one participant performing 200 experimental sessions can produce statistical results found in past studies (von Lucadou, 1987 and Walach, 2019). Including previous studies 1 and 2.

This is a methodological question whether the relevance of the number of participants impacts the number of sessions performed. This question has been raised without answer. This study intends to bring light to this question at the same time to continue challenging the CMM paradigm with one more exact replication.

6.5.2. METHODS

Methods used are the same as described for study 1

6.5.3. Design

The design of this third replication is the same as described first in study 1 with the difference that there is only one participant in this study.

6.5.4. Participant

The present experiment had only one participant, the researcher, a 48-year-old female.

6.5.5. Materials

As described for study 1.

6.5.6. Procedures

In this study, I completed the number of sessions previously defined, 200 sessions, followed the instructions given to participants in previous studies.

Participant had a room allocated to run the experimental sessions. The laptop was set up on a table. All sessions were run with the participant alone in the room.

Participant started the session by reading aloud the information protocol that used to give to participants in study 1 and 2. Followed all steps to confirm the RNG working properly, etc.

The importance of creating and keeping organisational closure was kept in mind by the participant, i.e., a bond established between the participant and the system. Every time feelings of boredom or a lack of enthusiasm were felt, I finished the session and would continue at a different moment or another day.

As participant, I followed the same instructions from protocol and read it before performing each experimental session. The 200 sessions were performed as in previous studies during the period of two months.

6.5.7. Experimental Hypothesis

Hypothesis 1: to replicate the CMM method with only one participant.

H1- Exploratory hypothesis: it is predicted that one single participant contributing 200 experimental sessions, will yield greater proportion of significant correlations compared to the control sessions.

6.5.8. Ethics

The studies were approved by the Psychology Research Ethics Committee at the University of Edinburgh with the following numbers:

While study 3 was pre-registered in 05.07.2017 at the Open Science Framework. <https://osf.io/gfzbp/>

6.6. RESULTS

The exploratory study aimed to look at whether one single participant could obtain similar findings as to many participants. I was the single participant and contributed 200

experimental sessions. A greater number of significant correlations (291 for $p=.05$) were produced during the experimental performance than the number of correlations produced by the original control system (118 for $p=.05$) (table 6-11).

Table 6 - 3 : Shows significant correlations from study with only one participant, using the original control (Zscore) for 2025 cells.

P-value threshold	Pvalue 0.1	Pvalue 0.05	Pvalue 0.01	Pvalu 0.001	Pvalu 0.0001
(a) Experimenta l significant correlations	415	291	138	55	13
Significant correlations expected by chance	203	101	20	2	0
(b) Control ORIGINAL significant correlations	233	118	32	3	0
(a) -(b) Correlations Difference	182	173	106	52	13
Number cells	2025	2025	2025	2025	2025
Z (original)	8.962	11.605	13.356	21.245	∞

Original control produces higher number of significant correlations than the permuted method.

Table 6 - 4 One participant number of correlations obtained by 10.000 permutation

P -value threshold	Pvalue 0.1	Pvalue 0.05	Pvalue 0.01	Pvalue 0.001	Pvalue 0.0001
(a) Experimental significant correlations	415	291	138	55	13
Significant correlations expected by chance	203	101	20	2	0
(b) Significant corr from 10.000 permutations	183	86	18	23	0
(a) -(b) Correlations Difference	232	205	120	32	13
Number cells	2025	2025	2025	2025	2025
Z	12.715	15.974	20.000	4.745	∞
((a) -(b))/10,000) P Permutations P value	0.023	0.020	0.012	0.003	0.001

The number of significant correlations expected by chance were not significantly different from the number of correlations created by permutation, with exception to the threshold $p=0.001$ where the permutations counted 23 correlations against 2 expected by chance. This difference is extremely significant. No plausible explanation can be offered at the moment. The difference reflected on $p= 0.003$ for a threshold of $p= 0.001$.

Table 6 - 5 Diagonal superior with Original control

Diagonal superior	Pvalue 0.1	Pvalue 0.05	Pvalue 0.01	Pvalue 0.001	Pvalue 0.0001
Experimental cor	166	118	59	23	3
Control ORIGINAL	98	51	10	1	0
Number cells	900	900	900	900	900
Z (original)	5.145	6.830	10.957	15.565	∞

in all studies, the Z score got more significant results with the permuted data than with the original control. This is an unusual result as explained in the discussion.

Values for the top superior right keep highly significant even with permuted data. There are no decline effect in the third replication, which shows predictions of CMM to hold true.

Table 6 - 6 Diagonal superior with 10.000 permutations

Diagonal superior	Pvalue 0.1	Pvalue 0.05	Pvalue 0.01	Pvalue 0.001	Pvalue 0.0001
Experimental cor	166	118	59	23	3
10.000 permutations	74	38	5	3	0
Number cells	900	900	900	900	900
Z=	7.894	9.377	17.076	8.179	∞
P values	0.009	0.008	0.005	0.002	0.0003

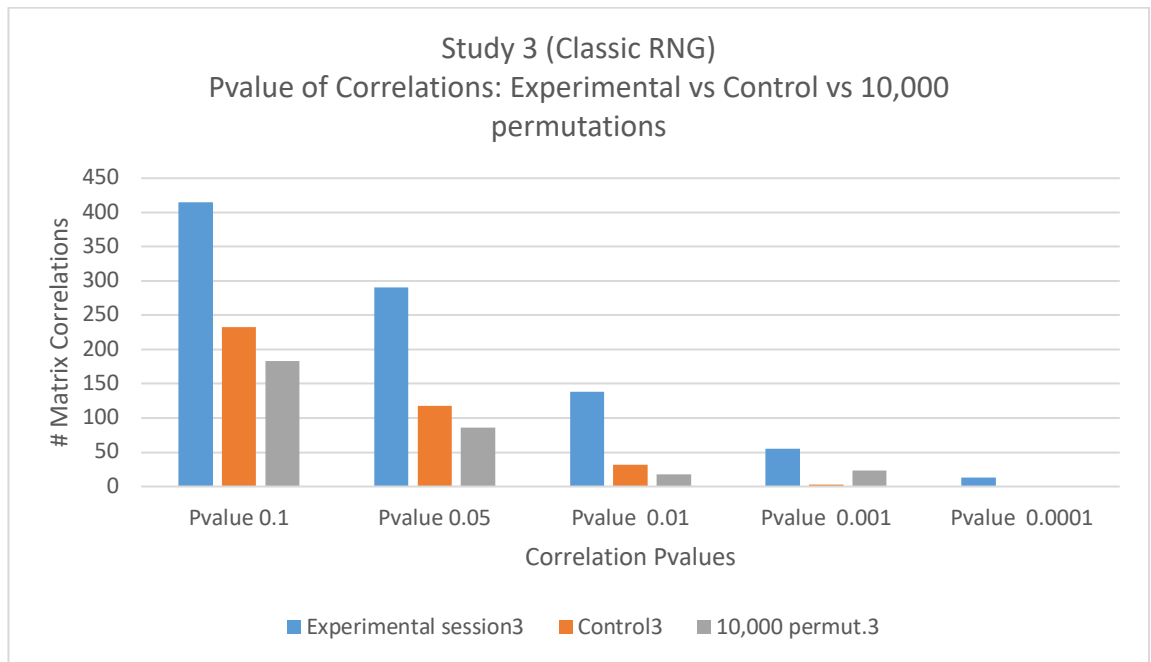


Figure 6 - 2 Experimental session, original control & permutation

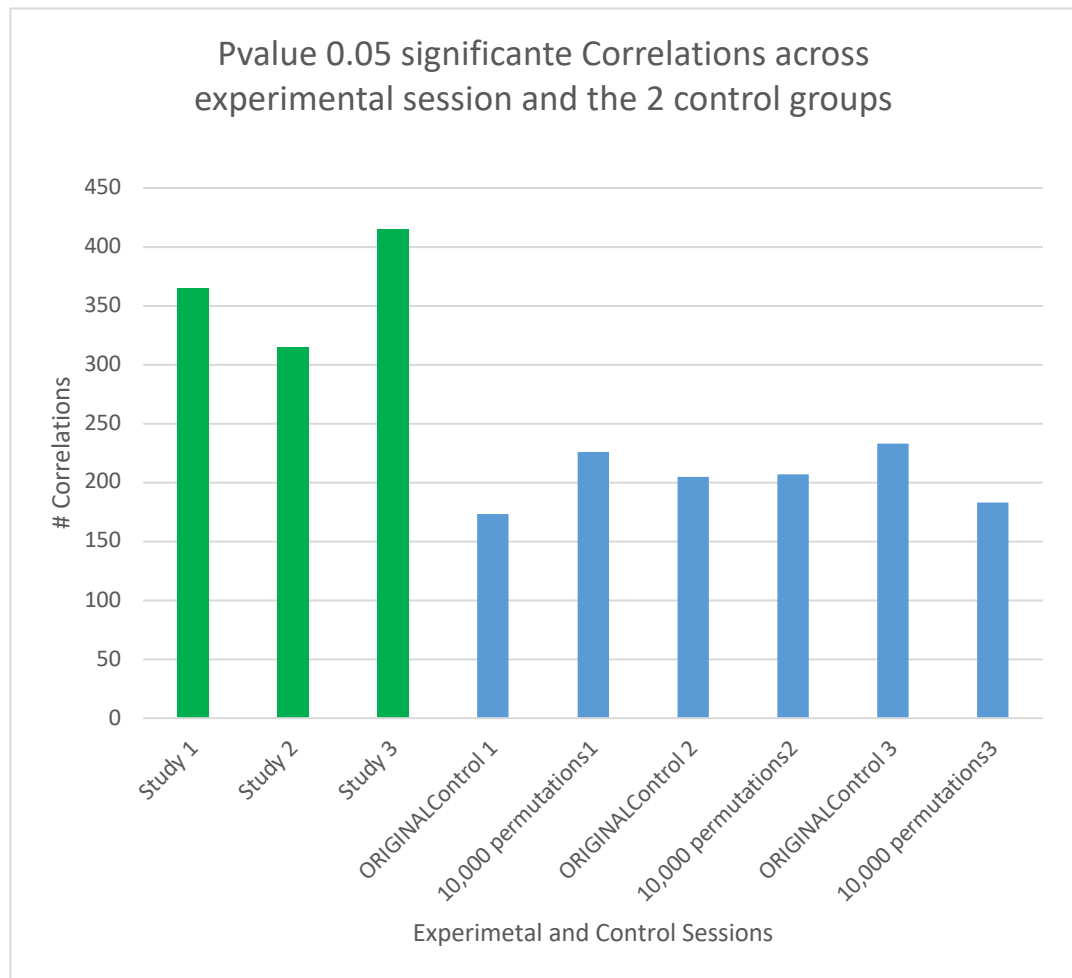


Figure 6 - 3 Pvalue 0.05 study 1, 2 & 3 Original control & permutation

Figure 6 - 3 presents a summary of the three studies realised with the classic RNG showing the original control alongside the permutation method, which works as a control as well. The two methods of control produce very similar results.

6.7. DISCUSSION

Arguments discussed in chapter 5 in the Discussion section that apply to the main study, due to study 3 to be a replication of study 1, are not going to be repeated again.

Since this study had only one participant it can be argued that the participant could have learnt the random options when performing the task, as it was performed 200 times. However, that seems difficult due to the randomness of the program. Nevertheless, it might be possible for an exceptional bright mind learn by heart all random possibilities, so the possibility could not be excluded. Certainly, it was not the case in this study.

Critics could also argue that being the experimenter and the participant on its own study allows to cheat and being biased when performing the experimental sessions.

To this critique, the reply or the researcher is too naïve or the critique have not understood the experiment.

First, and looking at the researcher side, cheating during a PhD work and giving the entire raw data for independent analysis is a contra census, because all data is recorded

and during the analysis one can see the patterns and behaviour of the participant.

Second, the experiment relies 'ALL' in a random process, which means that the participant had to be a very good clairvoyant in order to perform successfully.

Third, according to good scientific practice, the study was pre-registered, and all steps were previously defined.

Is true that the researcher participant knows a bit more of the analysis than a normal participant. Some behaviours, e.g., pressing always the same key produces more correlations or when the presses are always in the opposite direction of the last movement of the band. This behaviour is analysed, and these correlations are called causal, do not interfere with CMM results.

Moreover, one has to look at the results at the diagonal superior of the matrix, (see appendix 9). The significant correlations that manifest in this area of the matrix correspond to values non-contaminated by causal artefacts and as such are considered significant.

However, this study was the one that demonstrated more significant results. Some causal correlations were found in

different parts of the matrix. This can be explained due to the number of times the experiment was repeated; thus, the non-causal exceeds the causal correlations.

At the moment, only speculations can be made since there are no other studies to date, an exact replication, performed just by one participant 200 times.

Although, the significance obtained with the permutation analysis in the three studies, shows that the number of times the participant contributes to the study does not diminish the statistical significance

Whether one participant can create more organisational closure and obtain as a consequence, more significant correlations is also a possible explanation for the results found. The concept of organisational closure OC is according to CMM and MPI, the crucial element to create the bond between the psychological with the physical systems. The way how to create OC during the experimental session is still to be understood. Deeper focus on the OC concept can help to a better understanding of the entire CMM model. A possible explanation for the results with one single participant, is that OC becomes part of the experiment. It is easier to create with repetition of sessions and to keep it during the entire study.

The number of participants vs the number of sessions performed created more significant correlations (Walach et al., 2019), got support with study 1 and 2 and 3. The number of contributions per participant holds true, and keeps the significance with no or little decline effect.

Again, the explanation more plausible at the moment with data available, is the role of Organisational Closure (OC), which becomes stronger when participants become familiar with the experiment.

On the other hand, a negative point in having only one participant performing so many times the same experiment is that with no doubts the participant starts creating techniques to perform better or to understand how the process of interaction can happen with the random system. However, the process is random as explained before.

All sessions were carried out in the participant's place. I was alone when performing the sessions, to reproduce previous studies. Although, some participants concentrate better when alone, others feel more relaxed when not alone in the room. Some freedom should be given to participants to

choose the moment and place to perform the experimental session.

Two points are still to be explored. One is the issue related to the original RNG, a home-made RNG, that has been questioned on its validity (Matrix International Consortium, 2017). To answer that doubt a new RNG is going to be introduced in the next two replication studies.

The second issue is related with the measurement of OC. CMM considers the concept fundamental to create non-local or 'entanglement', bonds between psychic and physical. A measure to OC resulted from the international meeting was published in the protocol at the Open Science Framework. Also, a research note with a similar question was developed by Tierney et. al., (2018). This one was adopted to apply to studies 4 and 5. The question intends to be a measure of organisational closure.

Thus, study 4 and 5 were planned together to address both questions. Whether a new commercial RNG behaves in a similar way than the original one, also, to apply a question to measure OC.

CHAPTER 7 Introducing a new RNG and Organisational Closure measure

7.1. Introduction to Study 4

This chapter includes two studies that were designed and pre-registered at the same time. A measure of Organisational Closure was being tested for the first time, as well as a True RNG was introduced.

This study explores the behaviour of a true commercial RNG to compare with the original handmade RNG used in the previous studies.

Both RNGs are going to be compared with the same participant in the same experimental session.

This study also aims to measure organisational closure, an important concept for CMM, by asking participants about their perception of time compared with the real time they took performing the task.

For this study, the original control session, computer running alone without participant, was replaced by a permutation analysis method, as it was considered more

robust and reliable that the original control¹². The permutation will be the only control analysis used from now on.¹³

The new RNG aims to be exploratory and is supported by the Protocol (Walach, 2018) uploaded at Open Science Framework.

Finally, a measure of organisational closure in the format of a question was introduced in the study, which participants were asked at the end of the first experimental session.

7.2. METHODS

7.2.1 Design

This study is a replication from previous CMM studies that explores the use of a commercial True RNG in a PK experiment. The protocol consists in correlating psychological variables produced by a participant with physical variables produced by the True RNG with a participant performing a task against a permutation analysis. It is expected that the number of

¹² Conclusion reached by the International Consortium, Capri 2017

¹³ Its analysis was performed for the first three studies as more robust, keeping the 'old' Z-score as the original to compare exact replications.

correlations produced during the experimental session is higher than the number produced by the permutation analysis. Moreover, an attempt to measure organisational closure, OC, with a question will be implemented.

7.2.2. Participants

Participants were recruited through various means: by word of mouth from amongst acquaintances of the author and student recruited, through university mailing lists. Participants received no financial reward for participating in the study. A total of one hundred participants were recruited, the same number stipulated on the pre-registration protocol for this study, N of 100 had been reached.

For studies four and five, due to unforeseen health issues, a university undergraduate student was hired to collect data for the entire two studies. The student from the Erasmus program was visiting the University of Edinburgh. As happened with the previous student assistants, this person also received the appropriate training, which was followed by several one-to-one meetings and weekly reports.

All participants filled in the questionnaire before starting the experimental study. Age is taken in intervals of ten. The two

youngest age groups totalised 83 participants, 49 males and 34 females.

More males, 59%, than females 41% participated in the study. The age group between 10-20 years performed 40% and the following age group 21-30 years contributed 43% of the data. In total 83% of the participants were young participants.

Table 7 - 1: Shows total number of participants, their age taken in intervals of 10 years and gender for study 4

Age group	Female	Male	Total participants	Participants per age group %
10-20 ¹⁴	15	25	40	40.0%
21-30	19	24	43	43.0%
31-40	2	2	4	4.0%
41-50	2	3	5	5.0%
51-60	1	4	5	5.0%
61-70	2	0	2	2.0%
71-80	0	1	1	1.0%
Total	41	59	100	100.0%
% Total	41.0%	59.0%	100.0%	

¹⁴ The interval of ages 10–20-year-old is due to keep the original questionnaire here replicated. However, participants were 19 and 20 years old.

7.2.3. Materials

This study introduced a commercial true RNG. It was programmed and prepared in the same way as the original RNG, but without Markov chain process.

The same program was installed by the same IT technician in the True RNG to run the study, which was validated by Thilo Hinterberger. The experiment ran in the same laptop as the previous studies.

7.2.3.1. Measure of Organisational Closure

An addition to this study was the implementation of the measure of Organisational closure. Each participant should report on their subjective time estimation in the end of the first session. The researcher would wait for the participant to finish the first experimental session and would ask the question: *"Without looking at your watch, please estimate the time in minutes between when I said, "start when you are ready" and the present?"*

This hypothesis is exploratory to measuring Organisational Closure. The aim is to measure the perception of passage of

time for the participant while he performs the task, to compare with the real time taken to realise the task.

After the question each participant contribute with one answer which gives 100 estimation times, or OC measures.

7.2.3.2. New RNG

The new RNG was introduced in study four and used also in study five, as an answer to critics that the Markov chain process was producing more significant correlations than a commercial RNG would produce.

The new RNG, is a commercial device bought online.

The new RNG, had the same program installed in the original, which allowed them to run the same experimental session. This new RNG was much easier to install in all process, due to be a modern usb RNG, an automatic download performed the installation processes.

The version works with a semiconductor to create the random process. The semiconductor is biased to 12 volts using 5v to regulate voltage. It mixes an algorithm in 20 bits of entropy and 8 bits of output. The algorithm depends on one galois field to mix the fields and spread the entropy.

This small description of how the new commercial RNG is kept short as it is not part of the researcher background the

functioning of RNG. However, it seemed relevant to show that there are differences between the two RNGs in the way they create randomness.

7.2.3.3. Permutation as the only control

The permutation method, as explained in chapter 5, was also used to analyse data from the previous three studies. The method is part of chapter 5, sub-section 5.2.6.1.

7.2.4. Procedures

Participants had to contribute with two experimental sessions each in a row. One experimental session used the new RNG and the other the original RNG. The RNGs were used in alternative turns. For example, participant one did the first experimental session with the New RNG and the second session with the original or also called original RNG, while participant two did the first experimental session with the Classic and the second session with the New RNG, and so on.

Similar procedure as in study 1 were implemented. Participants arrived at an allocated room, and the process was the same as in study 1.

Both types of RNGs were used in alternated ways between participants. For example, if participant 1 does the first session with the original RNG, performs the second session with the new RNG. Participant 2 does the first experimental session with the new RNG and, the second session with the original RNG. And so on until the end of the study.

Each participant contributes with two experimental sessions in a row with both RNGs. This compulsory double contribution in a row was a novelty introduced in the study, as well as the question. The 100 participants from this study contribute 200 experimental sessions, 100 within each type of RNG.

7.2.5. Experimental Hypothesis

Hypothesis 1: replicates the CMM and predicts that no decline or small decline effect will occur compared with the previous studies. It is predicted that this fourth replication of the correlation matrix method will yield a greater proportion of significant correlations compared to 10.000 permutations as a control. The analysis will be performed for

the full matrix, 2025 cells, and for the superior right part of the matrix, 900 cells, as in the previous studies.

A) If the analyses performed for matrix, 2025 cells, obtain significant results, then the CMM hypothesis is confirmed for the entire matrix.

B) If the analyses performed for the superior right part of the matrix, 900 cells that cannot be contaminated by feedback about previous trials, and significant results are obtained, then the CMM hypothesis is confirmed for this set of data.

Hypothesis 2: The new RNG behaves in a similar way to the original RNG. Therefore, it is predicted that no significant difference will be found in the number of significant correlations obtained when the sessions are conducted with the new RNG, compared to the sessions conducted with the original RNG.

Hypothesis 3: Exploratory hypothesis: Participants estimating less time to perform the session than it objectively took are demonstrating greater Organisational Closure (OC).

At the end of the first session participants are asked:

“Without looking at your watch, please estimate the time in minutes between when I said, “start when you are ready” and the present?”

It is hypothesized that participants who state that the session took less time will show more significant CMM correlations compared to other participants.

7.2.6. Ethics

The pre-registration protocol for the study was made available on the Open Science Framework (OSF) before starting data collection.

The studies were approved by the Psychology Research Ethics Committee at the University of Edinburgh: 273-1718/2 20 April 2018, and were pre-registered and published at the OSF <https://osf.io/gfzbp/>.

7.3. Results

The permutation method produced more significant correlations in the experimental sessions than the original RNG. Results are negative values, calculated from

experimental sessions against the number of significant correlations obtained from permuted data.

Though, even CMM predicts the bigger number of significant correlations should occur within the experimental session, the effect found yields a $Z = -4.36$ for $p = 0.05$, which should be taken in consideration due to its significance. The negative significance was shown as well for $p = 0.01$ with $Z = -2.701$

The thresholds $p = 0.1$, $p = 0.05$, $p = 0.01$ got negative results but significant. In physics does not matter whether the number is positive or negative. Above the value considered significant, for these studies a $Z > 2$ is considered positive. For the diagonal superior, the original RNG also produced more significant correlations with the permutation method also having negative results could be considered significant as shown in table below.

Hypothesis one has to be rejected for the full matrix as well as for the diagonal superior of the matrix because the 10.000 permutations created more significant correlations than the experimental session.

Hypothesis two also is rejected. The New RNG produced much more significant correlations than the original RNG during the experimental sessions.

Hypothesis three, is an exploratory hypothesis that could not be tested, even though the question was asked to participants as predicted.

Table 7 - 2 All matrix with **original RNG**

P-value threshold	Pvalue 0.1	Pvalue 0.05	Pvalue 0.01	Pvalue 0.001	Pvalue 0.0001
(a) Experimental significant correlations	133	42	3	0	0
Significant correlations expected by chance	203	101	20	2	0
(b) Significant correlations from 10.000 permutations	196	103	20	3	0
(a) -(b) Correlations Difference	-63	-61	- 17	-3	0
Number cells	2025	2025	2025	2025	2025
Z	-3.348	-4.362	-2.701	-1.226	-

This table (7-2) reflects the correlations from 100 experimental sessions performed by 100 participants. Considering the number of participants contribution, this study four is similar in contribution to study 2 in which participants contributed with one or two sessions. The

difference between both studies is that in study 2 participants, often repeated the session in a different day. In the present study participants are performing the experiment same day in a row.

Since the permutation was producing values very similar to the original control, and due to lack of information about whether the original RNG would behave in a similar way than a commercial true RNG.

The original controls were dropped and replaced by the permutations as a method of control. That is the reason why in study 4 and 5 only permutations appear in the tables.

The Z score is calculated from the permuted data but when the results are negative the Pvalue are not calculated.

Table 7 - 3 **Original RNG** for top superior of the matrix

p-value thresholds	Pvalue 0.1	Pvalue 0.05	Pvalue 0.01	Pvalue 0.001	Pvalue 0.0001
Experimental cor	62	16	0	0	0
10.000 permutations	91	46	8	1	0
Number cells	900	900	900	900	900
Z=	-2.267	-3.211	-2.000	-0.707	-

Again, the number of correlations produced by the permutation method was higher than the ones produced in the experimental session. This result goes against the prediction of CMM. Experimental sessions produced by a participant should create a higher number of significant correlations than the control system. Since there are only negative values, P values cannot be calculated. However, Z scores calculated from permuted data yields significant results $p=0.05$ or a $Z= -3211$ and for a threshold $p=0.01$ corresponds a $Z= -2$.

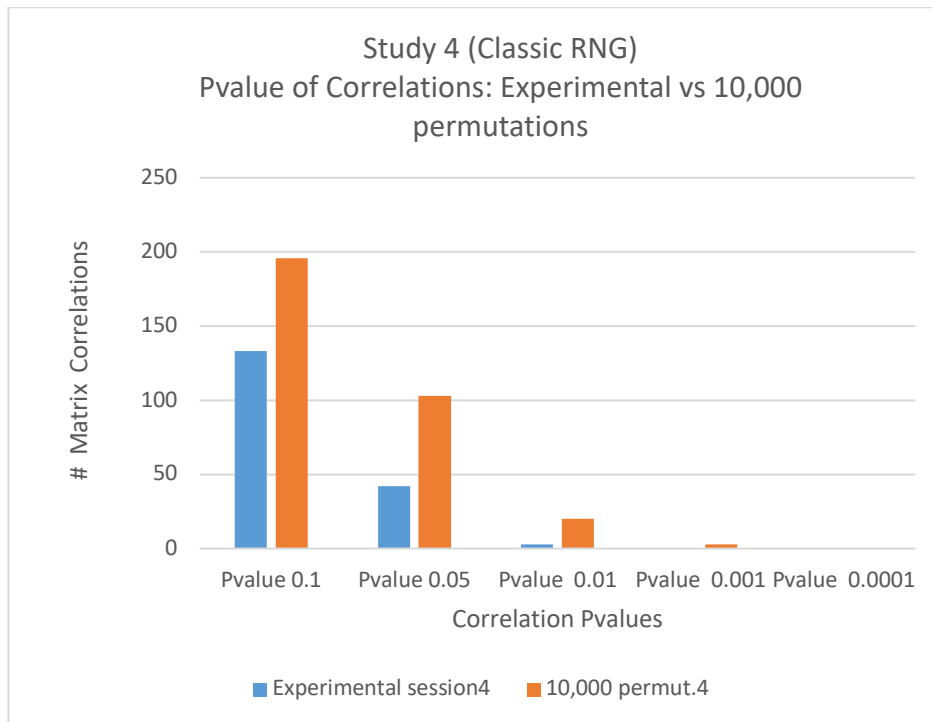


Figure 7 - 1 Original RNG & permutations for all matrix

Interesting to note how the permutations are in significant higher number than the ones produced during the experimental session.

The 100 sessions performed by the 100 participants presented different results with the new RNG than with the original RNG.

For the total matrix, after calculating the 10.000 permutations to each variable, for a sensitivity threshold of $p = 0.05$ corresponds a $p = 0.003$. The small Pvalue

thresholds presented negative values because more significant correlations were produced by the permutations than by the experimental sessions. The Z score was also significant $Z = 3.053$ for threshold $p=0.05$.

Table 7 - 4 Results from the entire matrix, 2025 cells, using New RNG. 10000 permutations as control

P-value threshold	Pvalue 0.1	Pvalue 0.05	Pvalue 0.01	Pvalue 0.001	Pvalue 0.0001
(a) Experimental significant correlations	215	103	9	0	0
Significant corr expected by chance	203	101	20	2	0
(b) Significant corr 10.000 permutations	129	68	17	2	0
(a) -(b) Correlations Difference	86	35	-8	-2	0
Number cells	2025	2025	2025	2025	2025
Z	5.533	3.053	-1.378	-1.000	-
((a) - (b))/10,000 Pvalue	0.009	0.003	-	-	-

Table 7 - 5 Number of significant correlations from experimental session compared with 10000 permutations using New RNG, for the 900 cells corresponding to top superior right

Diagonal superior	Pvalue 0.1	Pvalue 0.05	Pvalue 0.01	Pvalue 0.001	Pvalue 0.0001
Experimental cor	91	34	2	0	0
10.000 permutations	101	52	11	1	0
Number cells	900	900	900	900	900
Z=	-0.747	-1.818	-1.919	-0.707	-

The analysis from the new RNG data for the top superior of the matrix, shows that the number of significant correlations produced by the permutations is higher than the number of significant correlations produced by the experimental session. For this reason, the difference between them are negative results. As such, p values cannot be obtained from the top superior of the matrixes.

In the same line, the z scores calculated from the permutations are in all thresholds not significant.

With the results obtained, the hypothesis has to be rejected.

I would like to reiterate again that after calculating permutations from all matrix the top right of the matrix does not have relevant information.

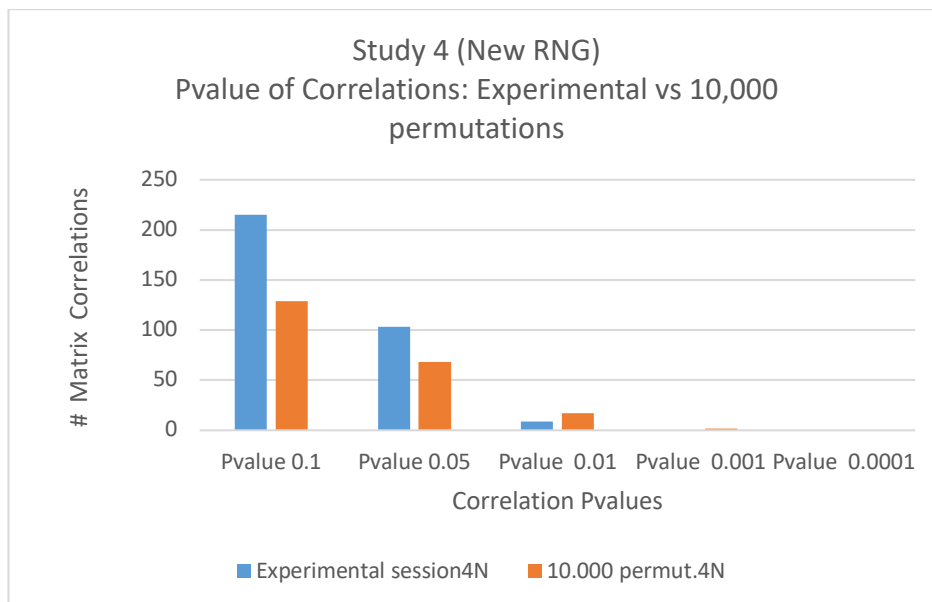


Figure 7 - 2 New RNG with permutations for all matrix

7.4. Discussion

A new protocol resulting from the international meeting and published at the Open Science Framework (Walach, 2017) suggested a different statistical analysis, a permutation, instead of the Z test.

Since the problem with the original data analysis was related to dependency between some variables, mainly the psychological ones, right, left or both key presses; the permutation method is more reliable to deal with the dependencies. For this reason, a permutation method, consisting in permuting 10.000 times the experimental data, was adopted as a control for the CMM analysis.

As I had already analysed all data with the former Z formula, now identified as not suitable to deal with dependent variables, I decided to keep it in the thesis, showed in the tables. Moreover, the problem with dependent data was now solved. The permutation calculates independent data which opens the possibility to analyse the Z score with the new permuted data. The analysis was performed as an exercise to compare the results. This was an exploratory exercise.

The main idea is also due to the importance of knowing if we are dealing with two different realities, between control data

and experimental data. This Z test score can help, even with its limitations, to draw conclusions or find patterns regarding the behaviour of the data. Important to mention that I have consulted with a statistician¹⁵ who saw no wrong in this method, since the Z-test was used with permuted data.

Though my decision can be questioned, I particularly enjoyed the challenge because is an advantage when working on a piece of writing such as a PhD thesis, that allows students trying different approaches, not only following fellow senior researchers. In order to learn as much as possible.

The permutation and respective pvalue is also calculated and should be considered as the main analysis.

The Z test continues to be used with the permutation method of analysis, considering that after all data being permuted the dependencies that were the reason to remove it as the appropriate method of analysis do not, does not verify anymore. Moreover, this information was checked with Prof Jessica Utts for certainty. However, critics will always have an opposite perspective.

¹⁵ Professor Jessica Utts in a personal meeting we had together in August 2018 at the KPU office

The permutation method is going to be explained and exemplified for better understanding. That follows in the next section.

The results from study four can be considered significant whether having in account the Z score calculated from permutations. Negative results are found with the original RNG as well with the new RNG. Nevertheless, the permutation method produced more significant correlations than the experimental session for the original RNG, first hypothesis has to be rejected.

The number of significant correlations produced by the permutation method showed relevant results, it should be explored and be in consideration. Maybe, could even be a reason for future replication.

It was the first time that such kind of result happened in CMM studies. More replications are needed in order to check whether permutations continue to produce more significant correlations challenging this way the model. There is the need to understand the meaning of this significant data, - It can be argued that the effect is manifesting in the control data, due to the significance. This is a prediction that falls within the CMM arguments about the need of freedom for the effect to manifest (von Lucadou, 2016).

Moreover, one of the critiques very often heard from the original experiments from von Lucadou, was related to the RNG using Markov-chain system. It was argued that the Markov-process was producing the significant correlations counted. Also, that the original method of control, used in the first three studies, was not reliable. This study shows the opposite, that the commercial new RNG, produced significant results for all matrix, $p=0.003$ while the original RNG produced none. Moreover, decline effect verifies in this study.

However, the results are not conclusive due to the multiple variables introduced in the study.

The novelties were introduced in this study and with them some mistakes, which I acknowledge. Nonetheless, mistakes are part of the learning process. They are explained during the chapter in the respective sections. I would like to mention, that I learned with study four that only one variable should be introduced per study. Many variables were introduced at the same time in this study, which made difficult if not impossible to interpret the results.

A new program needs to be designed and prepared to analyse the organisational closure data. Attention to detail

is required to not change the original input and arrangement predicted by von Lucadou to correlate all variables between each other.

In this study each participant contributed with two compulsory sessions in a row. In previous studies participants have had contributed with multiple sessions but by their own choice because they were motivated to repeat. It can be argued that the compulsory sessions did not work in a successful way. One explanation can be that organisational closure was not established during the sessions due to the interruption to change RNG.

It recognised that this error could have been avoided if a pilot study had been performed prior to the study. Participants that did not enjoy the first session, performed the second session with no enthusiasm – OC theoretically was not part of the session because participant was not involved, consequently instructions had not been followed.

Another point that needs to be raised is the session set up. When participant finished a session with one RNG, the researcher had to be in the room to ask the OC question and to restart the new experimental session with the other RNG.

Participants from study 4, did not have the same privacy as participants in the first 3 studies.

Privacy given to participants in study 1, 2 and 3 was not reproduced in this study. A speculative approach is that it could have influenced somehow, the results of the study.

One issue against doing only permutations as control is that data cannot be influenced by the OC when is being permuted. It is argued by the CMM and von Lucadou that the experimental session used in the first 3 studies, running the control session following the experimental session would keep the OC. If the model CMM holds true, these results can reflect the lack of the original control that keeps OC while the control is being performed.

Moreover, the young age of the participants, and the shorter time they took to perform each session could be an explanation for the differences in results when compared with previous studies. To the argument whether speed of performance can influence the results, no evidence consolidated it.

Permutation method is calculated in these studies as a control against the experimental data and to replace the former analysis.

Important to refer that the permutation described for all five studies, only used data from the experimental sessions. No new random data was created or used, because the spirit of the model that is being tested considers organisational closure essential for all kind of analysis. OC is 'captured' during the experimental sessions with the participant, as such experimental data should be used. Thus, I consider this is the best way to testing the model as close as possible under all possible circumstances. Other options to perform the permutation is to create random data not related to the experiment.

Participants answered to the organisational closure question, however as explained already this analysis cannot be calculated individually. Thus, the OC answer is analysed for the entire group of participants and per time per sessions one and two.

For the present study the real time the 100 participants took to perform all study four was 621 minutes, nonetheless the sum of all answers for the time they estimated was in total 613 minutes.

The difference between real time and estimated time is strangely similar. From these values is difficult to draw conclusions because we are looking at all participants together.

The time presented and summed, only includes each experimental session excluding the time the researcher spent switching RNG and restarting a new session.

As already explained, studies 4 and 5 were planned together, with 100 participants performing 2 experimental sessions each, one with original RNG the other with new RNG to test them. Also, to ask the OC question alternated in the end of the first session in study 4 and in the end of second session in study 5. It was testing the OC in different moments of the session.

7.5. Study 5 - Replication study 5

7.5.1. Introduction to Study 5

This study is the fifth CMM replication in this thesis. The difference from study four is that in this study the organisational closure question was asked at the end of the second experimental session, and in this study is asked at the end of the first experimental session.

The aim of this variation related to time of asking the question to participant, was to explore perception of time, as related with OC. This new alternative could also give some information when compared with data from study four. Even though a problem to interpret OC measure was found, the experimental set-up cannot be addressed now because both studies were planned and pre-registered together before study 4 started.

7.6. METHODS

7.6.1. Design

The design is the same as in the previous study. In the present study the OC question is asked at the end of the first

experimental session instead of at the end of the second experimental session.

7.6.2. Participants

As in the previous study, the same student researcher collected all data from 100 participants, performing a total of 200 sessions.

The 100 participants were recruited according to the number stipulated on the pre-registered protocol published at OSF (Appendix 8).

The process of recruitment was the same used for study 4. In this study 83% of the participants were aged between 10 and 30 years old. 51% of the participants were aged between 21 and 30 years old and 65% were male. Detailed information on the participants' age and gender follows below in table 7-6

Table 7 - 6 Shows total number of participants, their age taken in intervals of 10 years and gender for study 5

Age group	Female	Male	Total participants	% Participants per age group
10-20	10	22	32	32.0%
21-30	18	33	51	51.0%
31-40	4	3	7	7.0%
41-50	2	3	5	5.0%
51-60	0	3	3	3.0%
61-70	1	0	1	1.0%
71-80	0	1	1	1.0%
Total	35	65	100	100.0%
% Total	35.0%	65.0%	100.0%	

7.6.3. Materials

Materials were exactly the same used in the previous experiment.

7.6.4. Procedure

The method used for this study five was exactly the same used in study four and study 1. The new element introduced was the order, the moment in which the question of organisational closure was asked. In this study the question was asked at the end of the second experimental session, after the participant had performed the experiment with the second RNG.

Important to reiterate that each participant contributed with two experimental sessions performed in a row. The method showed not being effective for some participants that often complained that they had not enjoyed the experiment or were already bored with it but the student collecting data, had politely ask them to repeat the session one more time. This can be confirmed by the time participants took performing the second session in study four compared with the time spent performing the first session. All details related with procedure of study five can be read at study four.

7.6.4. Experimental Hypothesis

Hypothesis 1: replicates the CMM and predicts that no decline or small decline effect will occur compared with the previous two studies. It is predicted that this fifth replication of the correlation matrix method will yield a greater proportion of significant correlations compared to 10.000 permutations as a control. The analysis will be performed for the full matrix, 2025 cells, and for the superior right part of the matrix, 900 cells, as in the previous studies.

A) If the analyses are performed for all of the matrix, and 2025 cells obtain significant results, then the CMM hypothesis is confirmed for the entire matrix.

B) If the analyses are done for the superior right part of the matrix, 900 cells that cannot be contaminated by feedback by previous trials, and the predicted significant results are obtained, then the CMM hypothesis is judged to be confirmed for this set of data.

Hypothesis 2: The New RNG behaves in a similar way to the classic RNG used in previous studies. Therefore, it is predicted that no significant difference will be found in the number of significant CMM correlations obtained when the

sessions are conducted with the New RNG, compared to the sessions conducted with the classic RNG.

Hypothesis 3: This is an exploratory hypothesis.

Participants estimating less time to perform the session than it objectively took are demonstrating greater Organisational Closure (OC).

At the end of the second session participants were asked:

"Without looking at your watch, please estimate the time in minutes between when I said "start when you are ready" in the beginning of the second experiment and the present?"

7.6.5. Ethics

The studies¹⁶ were approved by the Psychology Research Ethics Committee at the University of Edinburgh 311-1718/16 May 2018 and were pre-registered at the OSF <https://osf.io/gfzbp/>

¹⁶ Ethics for study 4 and 5 was asked at the same time as the studies were planned together and complemented each other

7.7. Results

For the entire matrix, the number of significant correlations produced with the original RNG were significant only for a $p = 0.1$. and $p = 0.01 = 0.0001$. The new RNG only showed significance at $p = 0.1$ which even though values are being calculated for this threshold, only the ones at a $p = 0.05$ are relevant for this thesis. For this reason, hypothesis 1 A has to be rejected.

The superior right of the matrix counted more significant correlations with the permutation method than created during the experimental session. These results reject hypothesis 1 B.

The part of the hypothesis related to the decline effect in this study compared with the previous ones has to be accepted.

Hypothesis 2 has to be accepted because there are no significant differences in the number of significant correlations produced by the original and the new RNG. Both only got small significance at $p = 0.1$ which is not part of the main analysis.

The organisational closure question, in this study was asked at the end of the first session. It looked at the time

participants thought it had taken them to perform the task, was a total of 552 minutes, while the real time they had taken to perform the task was 465 minutes (87minute difference). For 100 participants is reported a difference of 87 minutes which means less than a minute of perception per participant, which is not relevant. In total, participants took 217 minutes to perform the first experimental session, and 250 minutes to perform the second experimental session.

Participants estimate to spent 526 minutes [sum of all participants answers] performing the experimental session against 465 minutes real time.

This result goes against the OC measure prediction that argues that as less the perception of time, more involved the participant was in the task, not noticing the passage of time. However, participants had the notion that realizing the task took much more time than it took in reality.

It cannot be forgotten that time is being treated in total for all participants, which considering all participants has no significance. This measure unfortunately does not seem to add much in terms of OC information.

Study five uses two RNGs. The original RNG showed a Pvalue $p=0.0001$ for a sensitivity threshold of $p=0.01$ and for $p=0.001$ a real probability of $p=0.0002$. These values relate to the entire matrix or 2025 cells.

Table 7 - 7 – Study 5 – 100 participants – **Original RNG** oc question

All Matrix	Pvalue 0.1	Pvalue 0.05	Pvalue 0.01	Pvalue 0.001	Pvalue 0.0001
(a) Experimental significant correlations	262	117	24	2	0
Significant correlations expected by chance	203	101	20	2	0
(b) Significant correlations from 10.000 permutations	223	123	23	0	0
(a) -(b) Correlations Difference	39	6	1	2	0
Number cells	2025	2025	2025	2025	2025
Z=	1.958	-0.395	0.148	-	-
((a) - (b))/10,000 Permutations Pvalue	0.004	0.001	0.0001	0.0002	-

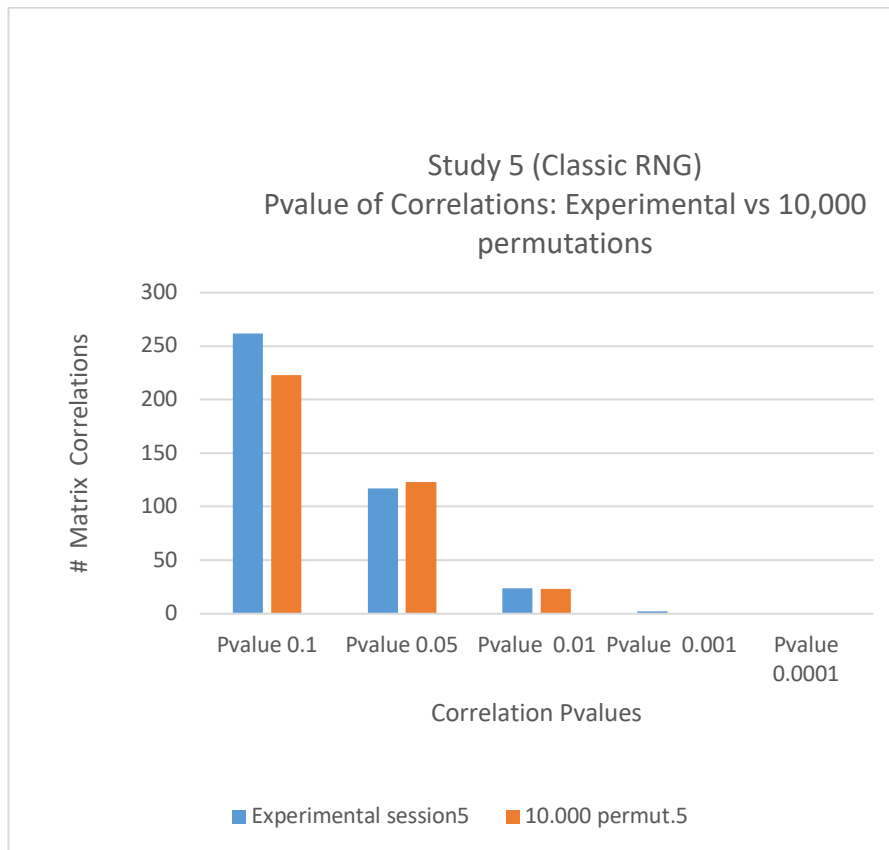


Figure 7 - 3 **original RNG** - experimental session & permuted data as a control.

Figure 7-3 shows in bars the difference in number of correlations produced during the experimental sessions and with the permutation method. For this results the original RNG was the one used.

For table 7-8 which describes results from the original RNG, the Pvalue were not calculated because the correlations

counted, produced by the permutation method are more than the correlations found with the experimental session. The difference between experimental sessions and permuted correlations is negative, so no P-values could be calculated. The exception is for threshold $p=0.1$ but as already explained this is not part of the main analysis.

Table 7 - 8 Diagonal superior right using **original RNG**

Diagonal superior	Pvalue 0.1	Pvalue 0.05	Pvalue 0.01	Pvalue 0.001	Pvalue 0.0001
Experimental cor	118	51	9	0	0
10.000 permutations	102	58	14	0	0
Number cells	900	900	900	900	900
Z=	1.190	-0.672	-0.945	-	-

Table 7 - 9 - NEW RNG all matrix

P-value threshold	Pvalue 0.1	Pvalue 0.05	P value 0.01	Pvalue 0.001	Pvalue 0.0001
(a) Experimental significant correlations	214	88	13	0	0
Significant correlations expected by chance	203	101	20	2	0
(b) Significant correlations 10.000 permutations	193	91	15	2	0
(a) -(b) Correlations Difference	21	-3	-2	-2	0
Number cells	2025	2025	2025	2025	2025
Z=	1.124	-0.228	-0.367	1.000	-
((a) -(b))/10,000) Permutation Pvalue	0.002	-	-	-	-

Table 7-9 shows results from study performed with new RNG. The same situation described for table 7-8, which used the

original RNG. No significant results with no p values calculated because the negative results. The analysis looks at the entire matrix.

Table 7-10 shows that permuted data produced the new RNG got more correlations than the experimental session

Table 7 – 10 new RNG for top superior right

Diagonal					
superior	Pvalue	Pvalue	Pvalue	Pvalue	Pvalue
Pvalue threshold	0.1	0.05	0.01	0.001	0.0001
Experimental cor	80	30	3	0	0
10.000 permutations	85	36	5	1	0
Number cells	900	900	900	900	900
Z=	-0.403	-0.722	-0.632	-0.707	-

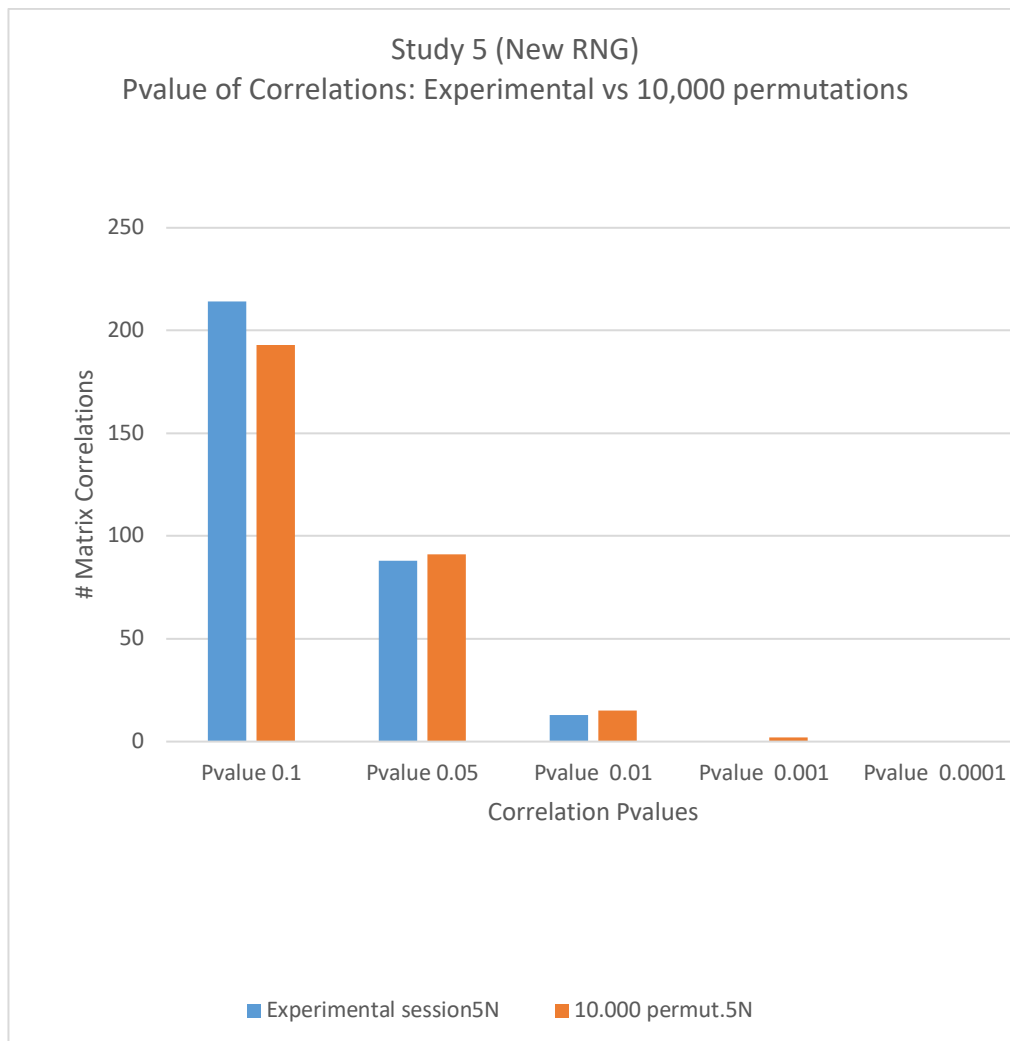


Figure 7 - 4 New RNG - right superior cells

Figure 7-4 shows the performance of the new RNG for study 5, focused on the top superior right. The experimental data was compared to the permuted data. Data from the all matrix is here represented.

7.8. Discussion

Since study four and five are very similar, the discussion in this section would be a close repetition of the one from study four, so the discussion is reported to the one presented in study four. Also, the arguments related to the original RNG, methods of analysis are discussed in study 1.

Both studies four and five had only 100 experimental sessions for each RNG. Von Lucadou estimated that 200 sessions are required in order to achieve a greater number of significant correlations when participant is performing the experimental sessions, than compared with the control sessions (von Lucadou 2006). Following his approach, neither of the analysis in both studies, four and five, acted accordingly. The data from the original and new RNG cannot be analysed together. The RNGs are too different and create randomness in completely different ways. Even a simple RNG synchronisation would not give reliable information.

On the other hand, the aim is to study the behaviour of the RNGs separately. To achieve this goal a new post-hoc analysis is going to be performed joining the 100 data set performed with the original RNG in study four and five, in a

total of 200 participations. The same happens for the new RNG which data produced in both studies totalise 200 sessions, are going to be analysed together.

CHAPTER 8 Post hoc Analysis

8.1. Studies Four and Five analysed together by RNG

This section intends to analyse 200 experimental sessions from the original RNG and 200 experimental sessions from the new RNG. The reason is due to von Lucadou's suggestion that an exact replication of the CMM should have 200 experimental sessions. Accordingly, to which the first three studies were constituted by 200 sessions.

Study 4 and 5 had 100 participants performing 100 experimental sessions with the original RNG and 100 with the new RNG, though, totalizing 200 sessions each study.

To perform a replication with 200 sessions with the same RNG, a post hoc analysis is being performed. The 100 participations obtained with the original RNG from study 4 and 5 are analysed together. And 100 sessions with data from new RNG from study 4 and 5 are going to be analysed together, performing a total of 200 experimental sessions.

These 200 sessions were performed by 200 participants. In this analysis no participant repeated the experimental

session with the same RNG but they repeated the experimental session twice one time with each RNG. The fact participants repeated the experimental session does not seem relevant because it also happened in studies 1, 2 and 3.

The same analysis was done for the original RNG, gathering together the 100 participants from study 4 and those from study 5. The tables with the results are shown below and explained.

8.1.1. Analysis & Results

Experimental sessions from study 4 and 5 using original RNG, created more significant correlations for the threshold .05 for the entire matrix (22025 cells), which gives a $p=.001$ of significance for the analysis. It shows a decline effect when compared with previous studies except for threshold

of .05. Though, CMM still holds as replicability was successful with 200 experimental sessions.

Table 8 – 1 – shows the results from 200 sessions, 100 study 4 plus 100 session from study 5 with original RNG for all matrix

All Matrix	Pvalue 0.1	Pvalue 0.05	Pvalue 0.01	Pvalue 0.001	Pvalue 0.0001
(a) Experimental cor	212	99	17	0	0
(b) 10.000 permutations	183	90	26	2	0
Number cells	2025	2025	2025	2025	2025
(a) -(b) Correlations					
Difference	29	9	-9	-2	0
P-value	0.002	0.001	-	-	-

The table shows the results for all matrix, analysing experimental sessions that used the original RNG. Again, only for a $p=0.5$ a significant $p=0.001$ manifests. These results were obtained from the original RNG.

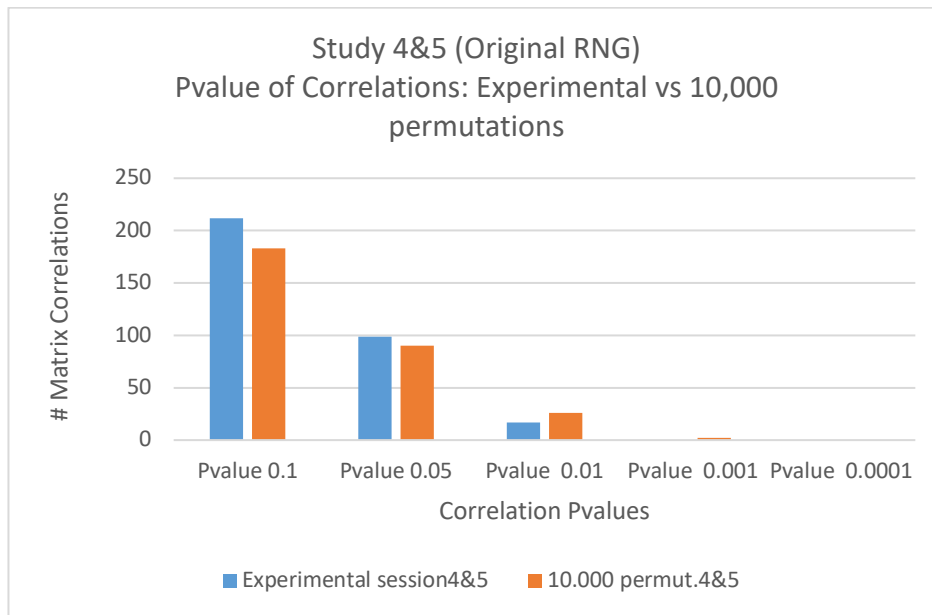


Figure 8 - 1 – Original RNG, 200 sessions, studies 4 & 5

Graphic showing results from 200 experimental sessions, performed with the Original RNG. 100 sessions from study four and 100 from study five.

Table 8 – 2 shows result 200 sessions from study 4 & 5 using **Original RNG** analysing the 900 cells belonging to top superior matrix

Diagonal superior- P threshold	Pvalue 0.1	Pvalue 0.05	Pvalue 0.01	Pvalue 0.001	Pvalue 0.0001
(a) Experimental cor	94	45	6	1	0
(b) 10.000 permutations	82	32	7	0	0
(a) - (b)	12	13	-1	1	0
Number cells	900	900	900	900	900
Z=	0.983	1.655	-0.267	-	-
P value	0.001	0.001	-	0.0001	-

Interesting to note that thresholds 0.1, 0.5 and 0.010 got significant results. The two last thresholds have a $p=0.001$ and 0.0001 respectively. These results manifested in the top superior of the matrix, though they did not appear when analysing all matrix.

It can be argued that even though there are not significance in all sensitivity thresholds used in previous studies for robustness of the results, the significance shown holds for

successful replication with 200 sessions (.05 $p=.001$; .001 $p=.0001$).

The new RNG introduced for studies 4 and 5 showed significant results for the entire matrix. The experimental sessions obtained more significant correlations than the permutation method, except for the threshold .0001.

There is no decline effect when analysed 200 sessions together as in studies 1,2 and 3. This shows robustness of the CMM method.

Table 8 - 3 results shown for all matrix data using the **new RNG and 200 experimental sessions 100** study 4 & 100 study 5

P value threshold	Pvalue 0.1	Pvalue 0.05	Pvalue 0.01	Pvalue 0.001	Pvalue0.0001
(a) Experimental correlations	277	148	24	3	0
(b) 10.000 permutations	214	97	19	1	0
(a) - (b)	53	51	5	2	0
Number cells	2,025	2,025	2,025	2,025	2,025
Z=	3.22	3.75	0.81	1.41	∞
P value	0.005	0.005	0.0005	0.0002 ¹⁷	-

Table 8-3 analysed all matrix, 200 experimental studies: 100 from study four and 100 from study five. Significant results were got. For the thresholds used as sensitivity analysis, results are p= 0.005, 0.0005 and 0.0002.

¹⁷ P value and Z score achieved from permuted data, is strangely not coherent.

Data from study 4 and study 5 resulting from the 200 participants that performed the experimental session with the new RNG was analysed. The cells of the matrix corresponding to the top superior right, 900 cells that correlate psychological variables with future physical variables got significance .05 $p=.001$.

Table 8 - 4 shows result from 200 sessions from 900 cells from right superior of the matrix. Data was collected with **new RNG** study 4 & study 5

Pv threshold	Pvalue 0.1	Pvalue 0.05	Pvalue 0.01	Pvalue 0.001	Pvalue 0.0001
(a) Experimental correlations	116	54	6	1	0
(b) 10.000 permutations	106	40	9	1	0
(a) - (b)	10	14	-3	0	0
Number cells	900	900	900	900	900
Z=	0.73	1.60	- 0.71	-	∞
P value	0.0001	0.001	-	-	-

Table 8-4, uses data produced by the new RNG. When analysed data for the top superior right results were obtained $p = 0.001$.

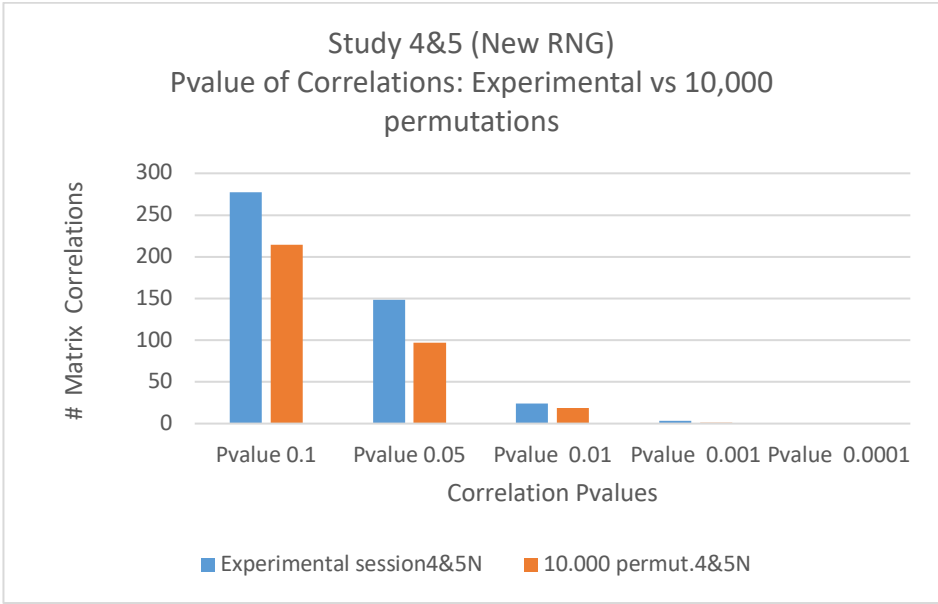


Figure 8 – 2 New RNG for studies 4 & 5 altogether

Graphic of bars demonstrating analysis results from the new RNG.

With 200 experimental sessions, for all matrix, the new RNG, produced more significant correlations during the experimental condition than with the permutation method, for the entire matrix. The significance of the results holds for a $p < 0.05$ with a $p = 0.001$ for the diagonal superior matrix cells.

The original RNG, for the entire matrix, only got significant results $p=0.001$, while for the top superior right of the matrix the $p=0.001$ and 0.0001 .

Overall, the new RNG performed more significant results when compared with the original RNG.

8.1.2. Discussion

The new RNG, a True RNG, got more significant results than the original one, a home-made RNG. Critics have claimed that the significant correlations found in previous studies were produced by the home-made RNG, this proves them wrong. It can be an explanation that the number of sessions to collect enough data is the fundamental requirement.

More significant results were found in the analysis with 200 sessions per RNG than in study four and five just with 100 sessions per analyse.

In all studies Pvalues are achieved from permutation data and not equivalent to Z score.

Since this was a post hoc analysis the discussion will be part of the next chapter, where all points related to the analysis are brought together.

CHAPTER 9 Conclusion and future perspectives

The aim of this dissertation was to explore the topic of mind-matter interaction and to provide some insight whether mind could relate with matter without the aid of any causal interference. The topic has been developed by the correlation matrix method for more than 30 years, by von Lucadou. CMM can be considered a new paradigm, and as a consequence it still needs to be tested. The model overlaps in some points with MPI principles and is theoretically supported by the GQT. The study chosen to this dissertation was a psychokinesis experiment, developed originally by von Lucadou and replicated by Walach et.al., (2019), Despite PK positive results there is no consensus on the genesis of the concept due to its difficulty in reproducibility. CMM argues to have the solution to the problem. The issue in PK and other parapsychological themes is explained by assuming the phenomena as constituted by non-local entanglement correlations instead of casual (cause-effect) situations.

This thesis aimed to contribute to test the method. Doing so by replicating the original study five times, according to the requirements imposed by CMM and MPI. The CMM hold its significant results on the studies carried out. According to

the thesis it can be argued that CMM is a robust model to follow.

Before delving into the PK studies, some time was spent with chapter two. Which presented how the fields of Physics and Psychology grew alongside sharing some fundamental concepts like synchronicity, complementarity and entanglement. Those concepts became the base for CMM and GQT. Carl Jung and Niels Bohr discussed unexplained situations as belonging to the field of Parapsychology. Jung using the concept of 'synchronicity' raised the interest of Wolfgang Pauli, when himself needed psychotherapy. Physicist Bohr and Pauli agreed that synchronicity and complementarity, should be studied by Psychology and Parapsychology, contributing for its development.

The notion of synchronicity is later assimilated by the MPI as a root to apply to psychotherapy. The unexplained phenomena were interpreted as meaning coincidences caused by information that mediates between sense and meaning. The concept of complementary was absorbed by the GQT and re-written to apply to Psychology.

Jung and Pauli dialogue marked the beginning of a new era with the introduction of the concept of complementarity and presenting the notion of holism in psychology.

After demonstrating the links between physics, psychology and parapsychology as explanations for paranormal situations, a brief discussion of mind-matter and mind-body from Aristoteles, Pythagoras and Descartes complemented the origin of the concepts of the thesis. These authors also discussed the possibility of correlations between mind-matter as plausible to explain reality (Atmanspacher, 2012).

Chapter three delved into the theories of GQT, MPI and CMM. They hypothesize that in study 1, the effects of mind-matter interaction are produced by non-local entanglement correlations instead of causal direct effects. This explanation solves the problem of replicability and uses the Quantum theory from physics, proved for long.

It argues that more significant correlations have to be produced during the experimental session than in the control session, because participants, are asked to interact mentally with an RNG interface. The participant presence and mental influence are requirements of the MPI, as information is sent from the sender (participant) to the receiver (RNG), called system, (RNG is in place creating random values). The concept of system verifies in the studies because both RNGs were integrated into the computer and run independently of

the laptop for all study. Participant sends information to the system, that is measured by the significance of the correlations established between physical and psychological variables. The structure of GQT is this way implemented in the study.

To be accurate with the complementarity concept, after collecting data, the data-set file kept unseen until open for analysis. Complementarity says that the observer defines the position, or measurement (value) of the variables when looked at them. As explained in the studies, data for each study was opened all at the same time after completion of each study (data from 200 sessions collected).

The concept of entanglement correlation, also called synchronistic manifestations, was measured during the PK task. The model creates and allows the manifestation of non-local, entanglement or synchronistic events. Doing so, whether in the presence of organisational closure. An OC measure was defined in chapter three and later described again for studies 4 and 5.

The thesis did not restrict to replicate CMM studies. An article on the validation of methods and analysis programs was written. Chapter four is composed by the article about

the process of software validation, providing tools, information and guidance on the process. As said, there are many ways to validate a personal software. The process of writing the article about the validation carried on the software used in the study, and respective publication was a very fruitful work.

Chapter five defines Methods, material and analysis used in the replication performed in study 1. The original study from von Lucadou, suffered from issues that were elucidated with the present work.

As a critical reflection on the experimental study, the key presses collected as psychological variables could be considered problematic, because they could have connections with each other due to internal electronic behaviour, like voltage of the laptop for example. In case this happened, correlations counted and considered non-local could be confused (Walach 2014). To solve the issue a new RNG was built by Walach and used in my studies. The new RNG was re-engineered to generate its own voltage to not influence the production of psychological variables. Also, to protect any interference with the physical variables. Care was taken and the RNG was involved in a shielded structure of aluminium. To check for the robustness of the

correlations created and external influences, data from the top superior right of the matrix, psychological variables, were correlated with future physical variables, counted and analysed independently.

Moreover, a methodological weakness found in the original study, was an elevated number of intercorrelations verified between some psychological and physical variables. These specific correlations could lead to an overestimated number of non-local correlations, specifically an overestimation of the Z-score result (Walach, 2017). This problem was solved by replacing the initial method of analysis Z difference by the permutation method. The permutation of the psychological and physical values allowed to get robust results, bias free.

Another critical point from CMM, was the need to create organisational closure during the experimental session, without having a method to measure it. This verified in study 1, 2 and 3. The concept was applied by the researchers in the studies mainly by the way they interacted with participants, to get them involved with the system. There was also a small demographic questionnaire to be filled in by participants with the exclusive intention to help to create

the OC. A tentative to create a question as a measure of OC, study 4 and 5, demonstrated to alter the main requirements of CMM, as mentioned above, not getting helpful information.

With these limitations in consideration, the studies were performed as planned and explained along the dissertation, the new implementations were introduced when requested, such as the method of analysis and the OC measure.

Hence, studies 1, 2 and 3 were exact replications using the same materials, method and control technique, with the psychological data from the participant running in an 'empty' program. The introduction of the permutation method to analyse the data and to be used as control, improved the reliability of the results because addressed the dependency between psychological variables. Moreover, the analysis on the cells from the top superior right of the matrix, which are considered not containing causal effects as the physical data was not yet produced, contributed for the enhancement of the CMM.

In study 1, participants were allowed to contribute with the number of experimental sessions as they wished, following Walach's original study (2015). 44 participants contributed

213 experimental sessions. The RNG used Markov-chain model and the analysis performed was a Z score. Afterwards, the permutation analysis obtained a significant results $p=0.0002$, for the top superior of the matrix.

In study 2, participants were asked to contribute with one session. Only if they wished they could perform a second session. it had been questioned if the number of contributions per participant would create an impact on the results. Thus, the number of contributions per participation was limited. 105 participants realised 200 experimental sessions. Analysis was performed first with Z Difference and later on with permutation method.

The permutation analysis showed a $p=0.0002$ for the top superior right of the matrix. No difference was found in the number of times each participant contributed for a total of 200 sessions per study.

In study 3 only one participant (me) contributed with 200 sessions. The sessions were performed in different days, at different hours, to simulate the previous two studies. Before performing each session, the participant read the instructions, spent some time connecting with them, meditating on their content and then started running the sessions. All efforts were done to avoid biased behaviour or

other way of creating any kind of artefact. However causal correlations were shown in parts of the raw data.

The permutation method showed a $p=0.0003$ for the top superior of the matrix.

The predictions of CMM, that the experimental sessions run with participants would produce more significant correlations than the control, where the computer run the same program with psychological data from participant but with no one touching or looking at the computer, hold true for these first three studies, using the permutation method.

As for the statistics, the number of permutations per study were 10.000. The analysis for the first three studies permuted 10.000 times the experimental data allowing to do new correlations. The number of significative correlations lowered the results when compared with the original method of control. This can be interpreted as if the permutation method is correct, the previous Z was inflated. However, the results from the three studies demonstrated still significant results. For the entire matrix, as well as for the 900 cells corresponding to the top superior of the matrix.

According to some authors (e.g., T Filk), statisticians and physics, they agree that after running a permutation 10.000

times with the experimental data, to look at the 900 cells have no relevance because, during the permutation process all values change place several times that the 900 cells contain new correlations. These new correlations are produced with permuted data that are not future data anymore. I sympathise with this position as it is coherent.

Study 4 explores two new questions. The study still uses the same original RNG, but a new RNG was introduced, and a measure of organisational closure administered. 100 participants were recruited and asked to perform two experimental sessions each. One session with the original RNG and another session with the new RNG. This way the behaviour of both RNG could be compared, as the same participant performed the experiment with both in a row.

The RNG was swapped from each experimental session. Whether in one experimental session the first participant performed first with the original RNG followed by the new RNG, the second participant would perform the first session with the new RNG and the second session with the original, and so on.

For study 4 only the 10.000 permutations of the experimental correlations were used as control.as the method has been considered the most reliable statistical tool.

The organisational closure measure, question, was asked to participants at the end of the first experimental session

From the analysis with the original RNG, fewer correlations were produced during experimental sessions than with the permutation method. The new RNG got more correlations for a threshold of p value 0,05, $p=0.003$, but for all other p values thresholds, used for sensitivity analysis, more correlations were produced by the permutation method than during the experimental session.

Possible explanations,

1. New researcher.
 2. The student-researcher, because he had to ask participants the OC question, was always in the room with the participants, which did not happen in the first two experiments.
 3. The instructions were not transmitted the same way as in studies 1 and 2, which could have affected the results.
 4. Organisational closure with participants was not created.
 5. The decline effect is a fact that is not solved yet.
- However, it is important to call the attention to the fact that even though the CMM prediction was not verified, a strong negative Z was found, which requires more studies to reach its understanding.

6. Only data for 100 participants were analysed per RNG, instead of 200 sessions as in the previous studies
7. Boredom or lack of interest from participants.

It is interesting to see that the new RNG produced a higher number of significant correlations when compared with the original RNG. However, the reason to change RNG was proposed during a meeting group, based on the conviction that the significant correlations achieved were produced by the original RNG and its Markov-chain process.

Study 5 was an exact replication of study 4 and was intended to validate study 4. Also 100 participants were recruited to contribute with two experimental sessions each, one with each RNG type. This time the OC question was asked in the end of the second session.

The OC measure ended up not being able to be analysed in studies 4 and 5 as planned as the way the matrix correlation was created by von Lucadou does not allow to get individual results because is based on correlations.

This study has no significant results with the peculiarity of both RNG producing with the permutation as a control, a very

slight difference of more significant correlations than the experimental sessions.

Therefore, the results for studies 4 and 5 showed a different pattern compared to studies 1, 2 and 3.

The age of participants in study 1, 2 and 3 was more even than in study 4 and 5 where participants were mainly young individuals. Also, young people are very used to computers and playing games. They are more comfortable doing the experiment considering it as a game. In study 1 and 2, participants were more mature, none was recruited from university but on clubs and churches. Some participants were not familiar with laptops, so they put an extra effort to contribute and help the researcher. Participant motivation can be an argument to explain the differences in results, in CMM terminology, OC is a real factor to produce results.

The student-researcher admitted that he was becoming bored itself to run so many sessions in such short time. Relevant to mention that the data collection for study 4 and 5 was completed in around three months as the student had to return to his country. Moreover, some participants did not feel like to do the second session but may have felt obliged to do it.

As a post hoc analysis, and because the number of recommended experimental sessions by von Lucadou is around 200 experimental sessions per study, and since both RNGs were being compared, data produced by original RNG in study 4 and 5 were analysed together as well as for the new RNG.

With 200 sessions the CMM predictions are reiterated as true for study 4. More significant correlations are produced during experimental sessions than with permutation method. However, significance is greater at $p=0.5$ with new RNG. It was obtained a $p=0.0001$, from 900 data cells permuted from original RNG. For the same 900 cells the new RNG obtained $p=0.001$

The analysis of the 5 independent studies were checked and validated from an external physicist confirming the results shown in the thesis. Dr, Thomas Filk is knowledgeable on CMM. (see appendix 11)

Five studies replicated around 800 experimental sessions all together which is a significant contribution for the method tested in this thesis.

Nonetheless, there are still questions to answer concerning the results obtained in study 5.

Moreover, it is suggested for future research, to have special consideration in the role of the researcher which, should be carefully controlled, as well as the instructions given to participants, should be precise and always equal.

To introduce one variable per study instead of several in the same study, is highly recommended contributing to eliminate or identify any relevant alterations.

To choose only independent variables, that can be analysed to give clear and undoubtedly results.

To get deeper knowledge in RNGs is recommended, as they have an important role in the study.

The problem with using commercial RNG is that companies that built them don't give important information on how their randomness is created, namely the algorithms, which makes difficult to identify correlations as a manifestation of anomalous events or created by the proper system as noise.

Theoretical ideas from GQT, MPI and CMM, are coming together with notions of Physics and Psychology, being integrated in a natural way. I consider the studies realised were very productive and worthwhile for the consolidation of CMM.

In conclusion, from a methodological perspective, this dissertation contributed to implement new tools, to improve empirical developments and to contribute with data that helps to validate the Correlation Matrix Model as a robust model.

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APPENDIX

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WELCOME TO OUR PSI EXPERIMENT!!

Here you can test your normal/paranormal or creative talents.

Experiment Instructions:

The following PSI Experiment involves moving the red colour in the graphic on the screen as far as possible in the direction of the arrow using your intuition.

The arrow can be pointed left (←) or right (→). Through skilful pressing of the right or left SHIFT key, please try to control the red colour in the spiral as far as possible in the direction of the arrow. When there is a Rhombus (<>) rather than an arrow, the colour should be kept as close to the middle as possible.

The left SHIFT button should be pushed with the left hand, the right SHIFT button with the right hand.

DON'T THINK TOO MUCH! WORK QUICKLY AND INTUITIVELY.

There are 9 test runs, 1 test consists of 80 key presses to the left, 80 key presses to right, 80 key presses to centre, this test repeats 3 times.

At the end of the 9 tests you will receive an evaluation of how you did. If you wish, you can then do another run of the experiment. The test takes around 15 minutes.

Many thanks for your participation!

All Data in this study will be handled confidentially and will be anonymized before being saved and used. This will be done by researcher Ana Flores the only person with access to the raw data. You can stop the experiment at any time if you wish so and all your data will be deleted. Please contact by email Ana Flores on Ana.Flores@ed.ac.uk

If you have understood the instructions and are ready to begin, please sign here:

.....

.....

Name

Place,

Date

Appendix 2 – Information to participant



INFORMATION ON OUR EXPERIMENT

Thank you for volunteering to take part in our parapsychological study. Here you can test your normal/paranormal or creative talents. In this experiment, you will be asked to follow the instructions given below.

Experiment Instructions:

The following parapsychological Experiment involves viewing an image of a spiral fractal pattern displayed on a laptop screen. You are asked to influence the movement of the pattern using your mind or intuition in the direction of an arrow positioned on top of the screen.

The arrow appears heading to the right, left or centre. The three positions of the arrow, indicate the direction in which you should try to mentally influence the movement of the fractal.

You should press the right or left shift key on the laptop keyboard according to your wish. The press of the keyboard keys is what makes the experiment progress. However, the movement of the display is driven by a random number generator.

The study is composed of 9 runs; 1 run consists of 80 key presses with the arrow pointing to the left, 80 key presses with the arrow pointed to the right, and 80 key presses trying to keep the bands close to the centre. The three runs ($80+80+80=240$ key presses) repeat 3 times, to make 9 runs in total. At the end of the 9 runs you will receive feedback on how you performed. The test takes around 15-20 minutes.

Through skilful pressing of the right or left SHIFT key, please try to control the red band in the spiral as far as possible in the direction ($\rightarrow$) or ($\leftarrow$) of the arrow. When there is a Rhombus ($\langle \rangle$) rather than an arrow, the red band should be kept as close to the centre as possible.

***DON'T THINK TOO MUCH! WORK QUICKLY
AND INTUITIVELY.
ENJOY & HAVE A GREAT TIME.***

Many thanks for your participation!

All Data in this study will be handled confidentially and will be anonymized before being saved and used. This will be done by researcher Ana Flores, the only person with access to the raw data.

You can stop the experiment at any time if you wish so and all your data will be deleted. Please contact by email Ana Flores on Ana.Flores@ed.ac.uk or Prof Caroline Watt Caroline.Watt@ed.ac.uk at Koestler Parapsychology Unit, School of Philosophy, Psychology and Language Sciences, University of Edinburgh, Edinburgh EH8 9JZ.

Appendix 3 – Participant questionnaire



Participant

Code _____

Dear Participant,

I do sincerely appreciate your interest in my study that explores a new method of data analyse on *whether mind impacts the material world*.

If you agree to continue, could you please fill in the following items:

Sex: Male ____ Female _____

Education: High school _____
University _____

Age:

10 – 20 _____	21 - 30 _____	31 – 40 _____
41 – 50 _____	51 – 60 _____	61 – 70 _____
71 – 80 _____	81 or over _____	

I am left-handed yes _____ No _____

I believe that human Psyche can have a direct influence on matter
Yes _____ Don't know ____ No _____

I believe I can influence chance
Yes _____ Don't know ____ No _____

Appendix 4 – Pre-registration study 1

KPU Registry ID Number: 1022

Date submitted: 21st March 2016

Study Registration for the KPU Study Registry

The title or name of the experiment (for listing the experiment in the registry).

Correlational Matrix Replication study

The name, affiliation, and email address for the lead experimenter(s) for the study.

Ana Flores, University of Edinburgh: s1374045@ed.ac.uk

A short description or abstract of the purpose and design of the experiment. The purpose of the present experiment is to replicate the correlation matrix experiment theorised by Walter von Lucadou (1987) and followed by von Lucadou, Walach and Romer (2007).

The experiment examines whether human intention operates on a random number generator (RNG). The aim of the original experiment was to compare the number of significant correlations between physical variables (RNG behaviour) and psychological variables (participant key-pressing behaviour) in a matrix with the number of correlations appearing in a control matrix. The experiment set-up is intended to capture generalised non-local correlations and has been reported to be replicable in previous studies.

The same psychological and physical variables used in previous studies will be employed in the present study.

Participants will try to mentally influence a fractal appearing on the computer screen to “shrink”, “grow” or “leave” it stable according to the instructions. The instructions to influence the fractal to right, left or centre are called trials, 80 trials make one sub-run and three set of 80 trials complete one run. Three repeated runs are one session. Each session should take between 10 and 20 minutes. After each session the computer will run a new session without participants to simulate the behaviour of the system during the experiment. The psychological variables from the participant are used together in the empty run

to construct the control session.

In previous studies, the psychological and physical variables are all entered into the matrix and a $Z_{\text{Difference}}$ binomial analysis is used to compare the number of significant correlations in the experimental matrix with the number in the control matrix. However, because the participant receives feedback on RNG performance, this method of analysis may incorporate causal correlations (i.e. psychological artifacts that should be excluded when testing for ψ) for those parts of the matrix where the psychological data is correlated with previously collected physical data. This is because the feedback on RNG behaviour may influence the participant's subsequent behaviour. It is also preferable to employ a simulation or permutation method rather than $Z_{\text{Difference}}$ to generate a distribution of scores against which the experimental distribution may be compared to obtain a p-value. $Z_{\text{Difference}}$ was developed for cases when the theoretical P for the binomial distribution is known and not for cases when P is being estimated from a sample of data (which is normally handled with a 2×2 analysis). Also $Z_{\text{Difference}}$ and 2×2 analyses are based on the assumption that each event (correlation) is independent, which is not true for these studies. The effects of dependencies are difficult to predict, but one of the most common effects is increased variance relative to the assumption of independence - which makes an outcome appear more significant than is actually the case. Simulations or permutation analyses are the safest and most convincing approach for situations like this.

Data will be collected by the researcher and by (2-3) undergraduate students who will receive the required training.

A statement or list of the specific hypothesis or hypotheses being tested, and whether each hypothesis is confirmatory or exploratory. (**confirm/explore guidance**)

Hypothesis 1 replicates the method of analysis employed by Walach and von Lucadou. Hypothesis 2 explores an alternative method of analysis that is applied to the section of the data that is not susceptible to causal correlation from RNG feedback influencing the psychological data.

H1- Exploratory hypothesis: the original $Z_{\text{Difference}}$ analysis method as used by Walach and von Lucadou will be applied to the full matrix, and it is predicted that this method of analysis will yield greater proportion of significant correlations compared to the control sessions.

H2 - Exploratory hypothesis: it is hypothesised that the number of significant correlations in the above-diagonal part of the matrix (the part where the psychological data have been collected *prior to* the physical data) will be significantly greater than the number expected by chance. This analysis will be conducted using a permutation or simulation analysis.

The planned number of participants and the number of trials per participant.

The planned number of sessions (as defined in section 3 above) is 220 or the number reached when data collection ends on 30th April 2016, whichever comes first. As in the original study, participants may contribute more than one session.

A statement that the registration is submitted prior to testing the first participant, or indicating the number of participants tested when the registration (or revision to the registration) was submitted.

I confirm that this registration is submitted prior to testing participant.

The following additional information is needed for studies that include confirmatory analyses:

Specification of all analysis decisions that could affect the confirmatory results, including: the specific statistical test for each confirmatory hypothesis, whether the test is one-sided or two-sided, the criterion for acceptable evidence, any transformations or adjustments to the data, any criteria for excluding or deleting data, and any corrections for multiple analyses. Checklists and examples for registering classical analyses, permutation and bootstrap analyses, Bayesian analyses, and classification analyses are provided in the [statistics registration document](#). (This information can be included in section 4 above for simple experiments.)

The study has 5 physical measures:

TR: the number of times the output of the Markov-chain RNG yields “1” during one run.

DT: the number of steps the fractal display deviated from the optimum in either direction or from the central position.

KR: deviation of the actual physical output of the Markov chain from the ideal Markov- chain.

ZT: mean voltage output at the fourth channel out of eight 5- ZV: standard deviation of this voltage output at channel 4

Each of the 5 physical measures will be found for each of the 9 sub-runs in a session which gives 45 physical data points for a session.

Similarly, there are 5 psychological measures describing the behaviour of the participant:

1- T1: number of right shift-key presses 2- T2: number

of left shift-key presses 3-

T3: number of double
presses

DR: mean time between key presses

DV: variance of time between key presses

Each of the 5 psychological measures will be found for each of the 9 sub-runs in a session, which gives 45 psychological data points for a session. The correlation matrix will be generated by correlating each of the 45 physical variables with each of the 45 psychological variables (2025 total correlations) using the session as the unit of analysis. The pure psi correlations that cannot be contaminated by feedback about

previous trials are the 990 correlations above the diagonal of the matrix.

These are correlation between psychological variables and future physical (RNG) variables and exclude correlations with past physical variables for which the participant received feedback. The control correlations are generated by correlating the observed psychological data with the control physical data.

I will calculate non-parametric correlations using Spearman coefficient with alpha set at a two-tailed p-value of 0.1 for the main analysis and a $p \leq .05$ for sensitivity analysis.

The formula for $Z_{\text{Difference}}$ used in the previous studies is:

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

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

The specific methods for conducting the permutation or simulation analysis are not pre-specified for this initial exploratory study. All raw data will be deposited with a third party (Dr. Caroline Watt) and the analyses only start after all data has been collected.

The power analysis or other justification for the number of participants and trials.

This line of research is investigating a theory that makes traditional analyses of effect size and statistical power not applicable for typical psi experiments. The planned sample size is based on previous experiments in this line of research and the recommendations of those developing the theory (von Lucadou recommends 220 sessions minimum).

The methods for randomization in the experiment.

The RNG is the same as used in Walach's experiments and was built by the workshop of the University Hospital in Freiburg according to von Lucadou's

specifications. As in all previous experiments the RNG output is smoothed by a Markov-chain window with lag 1 that makes the appearance of the output look more like a natural process and slows the change process. The noise-current of a Zener-diode is used as the random source. The equivalent voltage of the noise-current is amplified and is measured by an analogue- digital converter, which is read out by the USB-Interface of the computer. To produce the Markov-chain the momentary 12-bit number (voltage) R_{i+1} is compared with the previous one R_i . A decrease of the momentary voltage is indicated as a "1" and an increase as a "0". If no change of the decay rate occurred the event is omitted.

A detailed description of the experimental procedure. Participants are seated in front of a computer that displays a fractal curve that is either growing or shrinking. The participants receive a written standardized instruction, similar

combining physical and psychological conditions of the PK process. to experimental conditions used previously giving instructions to intentionally attempt the curve to shrink, to grow or to be kept stable, in accordance with instructions that will appear on the computer screen. On the top of the screen an arrow points to the left, right or centre indicating the direction toward which the participant should try to influence the fractal.

Participants are also told they may press the shift keys on the computer keyboard in any order they want and that the use of the keys will progress the experiment.

The computer used for the experiment will be disconnected from the internet while the experiment is conducted.

References:

Lucadou, Wv. (1987) A multivariate PK experiment. Part I. An approach *European Journal of Parapsychology*; 6 (4):305-45.

Lucadou Wv, Romer H, Walach H, (2007) Synchronistic Phenomena as Entanglement Correlations in Generalised quantum Theory. *Journal of Consciousness Studies*. 14 (4): 50-7

Appendix 5 – pre-registration study 2

KPU Registry ID Number: 1031 Date Submitted: 15th March 2017

Study Registration for the KPU Study Registry

1. The title or name of the experiment (for listing the experiment in the registry).

Exact Replication of the Correlation Matrix Method experiment (KPU Registry study ID 1022).

2. The name, affiliation, and email address for the lead experimenter(s) for the study. s1374045@ed.ac.uk

Ana Flores, University of Edinburgh:

3. A short description or abstract of the purpose and design of the experiment.

The present study is an exploratory exact replication of the study pre-registered at KPU study registry with number 1022 on 21st March 2016. Study 1022 was a replication of the correlation matrix method (CMM) developed by Walter von Lucadou (1987) and von Lucadou, Walach and Romer (2007). Although this is an exact replication study, it is not registered as confirmatory because the CMM method is under development by a research consortium and the preferred method of analysis has not yet been determined by the consortium.

Von Lucadou et al.'s method claims to have solved the problem of decline effect and replication issues in parapsychological experiments. The method was successfully replicated with the pre-registered study 1022.

The present study intends to be another exact replication of the original von Lucadou et al.'s method, to test the new paradigm's claim to eliminate the decline effect problem.

The study explored whether human intention operates on a random number generator (RNG). By comparing the number of significant correlations between physical variables, produced by the RNG with psychological variables, produced by participants' behavior, namely key-presses. Physical and psychological variables are all correlated in all runs with each other and correlations displayed in a matrix table.

The physical and psychological variables are the same used in the replication study 1022 done by the researcher and in previous studies, Walach (2014).

Participants will try to mentally influence a fractal appearing on the computer screen to "shrink", "grow" or "leave" it stable according to the instructions. The instructions to influence the fractal to right, left or centre are called trials, 80 trials make one sub-run and three set of 80 trials complete one run. Three repeated runs are one session. Each session should take between 10 and 20 minutes.

After each session the computer will run a new session without participants to simulate the behaviour of the system during the experiment. The psychological variables from the participant are used together in the empty run to construct the control session.

Data will be analyzed using the ZDiff as in original and previous studies just as a comparison information value. A permutation or simulation method of statistical analysis will also be applied.

Data will be collected by the researcher and an undergraduate intern who will receive the required training.

4. A statement or list of the specific hypothesis or hypotheses being tested, and whether each hypothesis is confirmatory or exploratory. (confirm/explore guidance)

Hypothesis 1 replicates the method of analysis employed by Walach and von Lucadou. Hypothesis 2 explores an alternative method of

analysis that is applied to the section of the data that is not susceptible to causal correlation from RNG feedback influencing the psychological data.

H1- Exploratory hypothesis: the original ZDifference analysis method as used by Walach and von Lucadou will be applied to the full matrix, and it is predicted that this

method of analysis will yield greater proportion of significant correlations compared to the control sessions.

H2 - Exploratory hypothesis: it is hypothesised that the number of significant correlations in the above-diagonal part of the matrix (the part where the psychological data have been collected *prior to* the physical data) will be significantly greater than the number expected by chance. This analysis will be conducted using ZDifference and a permutation or simulation analysis.

5. The planned number of participants and the number of trials per participant.

The planned number of participants is 220 or the number reached by the 30th April 2017 whichever comes first. As in the previous and original studies, participants may contribute with more than one session, on the same day or another, if they express their wish to do so.

6. A statement that the registration is submitted prior to testing the first participant, or indicating the number of participants tested when the registration (or revision to the registration) was submitted.

I confirm that this registration is submitted prior to testing participants.

The following additional information is needed for studies that include confirmatory analyses:

7. Specification of all analysis decisions that could affect the confirmatory results, including: the specific statistical test for

each confirmatory hypothesis, whether the test is one-sided or two-sided, the criterion for acceptable evidence, any transformations or adjustments to the data, any criteria for excluding or deleting data, and any corrections for multiple analyses. Checklists and examples for registering classical analyses, permutation and bootstrap analyses, Bayesian analyses, and classification analyses are provided in the statistics registration document. (This information can be included in section 4 above for simple experiments.)

The study has 5 physical measures:

- 1- TR: the number of times the output of the Markov-chain RNG yields "1" during one run.
- 2- DT: the number of steps the fractal display deviated from the optimum in either direction or from the central position.
- 3- KR: deviation of the actual physical output of the Markov chain from the ideal Markov- chain.
- 4- ZT: mean voltage output at the fourth channel out of eight. 5- ZV: standard deviation of this voltage output at channel 4.

Each of the 5 physical measures will be found for each of the 9 sub-runs in a session which gives 45 physical data points for a session.

Similarly, there are 5 psychological measures describing the behaviour of the participant:

- 1- T1: number of right shift-key presses.
- 2- T2: number of left shift-key presses.
- 3- T3: number of double presses.
- 4- DR: mean time between key presses.
- 5- DV: variance of time between key presses.

Each of the 5 psychological measures will be found for each of the 9 sub-runs in a session, which gives 45 psychological data points for a session. The correlation matrix will be generated by correlating each of the 45 physical variables with each of the 45 psychological variables (2025 total correlations) using the session as the unit of analysis. The pure psi correlations that cannot be

contaminated by feedback about previous trials are the 900 correlations above the diagonal of the matrix. It is considered diagonal matrix the present trials performed by the participant during the session, to which correspond 225 correlations. The correlations above the diagonal of the matrix are correlations between psychological variables and future physical (RNG) variables and exclude correlations with physical variables for which the participant has received feedback. The relevant excluded diagonal cells for the matrix are the correlations for the 5 physical variables by 5 psychological variables in the same sub-run (25 correlations for each of the 9 sub-runs, which is 225 of the 2025 total correlations and leaves half of the remaining 1800 correlations above this diagonal). The control correlations are generated by correlating the observed psychological data with the control physical data.

I will calculate non-parametric correlations using Spearman coefficient with alpha set at a two-tailed p-value of 0.1 for the main analysis and a $p \leq .05$ for sensitivity analysis. The formula for ZDifference used in the previous studies:

The specific methods for conducting the permutation or simulation analysis are still being explored by the researcher and a group of researchers' part of an international consortium dedicated to study the present new methodology, which will be applied to the exploratory study. Other post-hoc methods of analysis will be used if decision is reached by the members of the consortium

The data files are only open after finishing collect of data and the analyses only start after all data has been collected.

8. The power analysis or other justification for the number of participants and trials.

Traditional analysis of effect size and statistical power is not applicable to this line of research. The 220 experimental sessions specified for this study are based on previous studies using this line of research.

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

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

9. The methods for randomization in the experiment. If a pseudorandom generator is used, specify how and when the seed(s) will be obtained.

The RNG is the same as used in Walach's experiments and was built by the workshop of the University Hospital in Freiburg according to von Lucadou's specifications. As in all previous experiments the RNG output is smoothed by a Markov-chain window with lag 1 that makes the appearance of the output look more like a natural process and slows the change process. The noise-current of a Zener-diode is used as the random source. The equivalent voltage of the noise-current is amplified and is measured by an analogue-digital converter, which is read out by the USB-Interface of the computer. To produce the Markov-chain the momentary 12-bit number (voltage) R_{i+1} is compared with the previous one R_i . A decrease of the momentary voltage is indicated as a "1" and an increase as a "0". If no change of the decay rate occurred the event is omitted.

10. A detailed description of the experimental procedure.

Participants receive a written standardized instruction giving instruction to intentionally attempt the curve to shrink, to grow or to be kept stable, in accordance with instruction appearing on the screen. On the top of the screen an arrow points to the left, right or centre indicating the direction toward which the participant should try to influence the fractal.

Participants are seated in front of the laptop and are told to press the right or left shift key on the keyboard in any order they want and that the use of the keys will progress the experiment.

The computer should have battery full charged, be plugged during experiment and RNG should be plugged and be working for half an hour prior to the commencement of the session.

The control sessions are run by the main researcher as soon as possible. Preferably on the same day the data is collected. The researcher will take the laptop and RNG to different places to collect data such as social gatherings, clubs, yoga and meditation sessions, conferences, etc. An independent room will be allocated to accommodate the equipment for the purpose of collecting data.

References:

Lucadou, Wv. (1987) A multivariate PK experiment. Part I. An approach combining physical and psychological conditions of the PK process. *European Journal of Parapsychology*; 6 (4):305-45.

Lucadou Wv, Romer H, Walach H, (2007) Synchronistic Phenomena as Entanglement Correlations in Generalised Quantum Theory. *Journal of Consciousness Studies*. 14 (4): 50-74

Walach H (2014) Mind-matter interactions - On the rollercoaster from data to theory and back again. *Behind and Beyond the brain*. 10 Symposium Bial Foundation, p 85- 11

Appendix 6 – Pre-registration study 3

Replication of a Psychokinesis study using the Correlation Matrix Method

Description of the purpose and design of the experiment.

The purpose of the present experiment is to replicate the correlation matrix experiment theorised by Walter von Lucadou (1987) and followed by von Lucadou, Walach and Romer (2007).

The experiment examines whether human intention operates on a random number generator (RNG). The aim of the original experiment was to compare the number of significant correlations produced between physical variables (RNG behaviour) and psychological variables (participant key-pressing behaviour) in a matrix with the number of correlations appearing in a control matrix.

The experiment set-up is intended to capture generalised non-local correlations and has been reported to be replicable in previous studies.

The same psychological and physical variables used in previous studies will be employed in the present study.

Participant will try to mentally influence a fractal appearing on the computer screen to “shrink”, “grow” or “leave” it stable according to the instructions. The instructions to influence the fractal to right, left or centre are called trials, 80 trials make one sub-run and three set of 80 trials complete one run. Three repeated runs are called one session. Each session should take between 10 and 20 minutes.

After each session the computer will run a new session without participants to simulate the behaviour of the system during the experiment. The psychological variables from the participant are used together in the empty run to construct the control session.

In previous studies, the psychological and physical variables are all entered into the matrix and a ZDifference binomial analysis is used to compare the number of significant correlations in the experimental matrix with the number in the control matrix.

A list of hypotheses being tested,

Hypothesis 1 replicates the method of analysis employed by Walach and von Lucadou. Hypothesis 2 explores whether one single participant get similar result as 200 participants as in previous studies.

The study will have one participant, who runs 200 experimental sessions per study. Data will be open and analysed only after finishing the 200 sessions. The control sessions will be performed as soon as possible after the experimental session. The sessions should be performed in different days and different times of the day. The participant reads the experimental instructions before the beginning of each experimental session.

It is confirmed that registration is submitted prior to the start of the study.

Description of the experimental procedure.

Participant is in front of a computer that displays a fractal curve that is either growing or shrinking.

The goal is to intentionally attempt the curve to shrink, to grow or to be kept stable, in accordance with instructions that will appear on the computer screen. On the top of the screen an arrow points to the left, right or centre indicating the direction toward which the participant should try to influence the fractal.

The study has 5 physical measures:

- 1- TR: the number of times the output of the Markov-chain RNG yields "1" during one run.
- 2- DT: the number of steps the fractal display deviated from the optimum in either direction or from the central position.
- 3- KR: deviation of the actual physical output of the Markov chain

from the ideal Markov- chain.

4- ZT: mean voltage output at the fourth channel out of eight

5- ZV: standard deviation of this voltage output at channel 4

Each of the 5 physical measures will be found for each of the 9 sub-runs in a session which gives 45 physical data points for a session.

Similarly, there are 5 psychological measures describing the behaviour of the participant:

1- T1: number of right shift-key presses 2- T2: number of left shift-key presses 3- T3: number of double presses 4- DR: mean time between key presses 5- DV: variance of time between key presses

Each of the 5 psychological measures will be found for each of the 9 sub-runs in a session, which gives 45 psychological data points for a session. The correlation matrix will be generated by correlating each of the 45 physical variables with each of the 45 psychological variables (2025 total correlations) using the session as the unit of analysis. The pure psi correlations that cannot be contaminated by feedback about

Previous trials are the 900 correlations above the diagonal of the matrix. These are correlation between psychological variables and future physical (RNG) variables and exclude correlations with past physical variables for which the participant received feedback.

I will calculate non-parametric correlations using Spearman coefficient with alpha set at a two-tailed p-value of 0.1 for the main analysis and a $p \leq .05$ for sensitivity analysis. The formula for ZDifference used in the previous studies is:

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

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

References:

Lucadou, Wv. (1987) A multivariate PK experiment. Part I. An approach combining physical and psychological conditions of the PK process. *European Journal of Parapsychology*; 6 (4):305-45.

Lucadou Wv, Romer H, Walach H, (2007) Synchronistic Phenomena as Entanglement Correlations in Generalised quantum Theory. *Journal of Consciousness Studies*. 14 (4): 50-74

Appendix 7 – pre-registration study 4

Replication of Correlation Matrix Method

Pre-registration Protocol

2.April.2018

Ana Flores

PhD candidate

School of Psychology PPLS, University of Edinburgh

Ana.Flores@ed.ac.uk

Introduction

The purpose of the study is to replicate a theoretical model that explores the meaning of significant correlations produced between psychological and physical variables as a quantum theoretical strand.

This is the fourth replication produced by the author of the same project. Previous studies replicated with success the correlation matrix method (CMM) (Lucadou, 1987).

Despite the significant results more replications are needed to clear doubts and understand deeper the meaning of the data.

To continue improving on the CMM theory is important at this point, to clarify whether the RNG (classic) used in previous studies is somehow interfering with the process and as a consequence with the significant results achieved. To elucidate this point a new type of random number generator, a commercial TRUE RNG3 will be used to compare its performance against the original RNG. This way the validity of the data will be carefully checked and improvements in methodology introduced.

The Experiment

The study explores whether human intention operates on a random number generator (RNG). By comparing the number of significant correlations between physical variables, produced by the RNG with psychological variables, produced by participants' behaviour,

namely key-presses. Physical and psychological variables are all correlated in all runs with each other and correlations displayed in a matrix table (Lucadou, Romer & Walach, 2007).

The physical and psychological variables are the same used in the replication study 1022 and 1031 carried out by the researcher and in previous studies by Walach (2014).

Participants will try to mentally influence a fractal appearing on the computer screen to “shrink”, “grow” or “leave” it stable according to the instructions. The instructions to influence the fractal to right, left or centre are called trials, 80 trials make one sub-run and three set of 80 trials complete one run. Three repeated runs are one session. Each session should take between 10 and 20 minutes.

Hypothesis

Hypothesis 1: replicates the CMM predicting no decline or small decline effect will occur comparing with previous two studies. It is predicted that this third replication of the correlation matrix method will yield greater proportion of significant correlations compared to 10.000 permutations as control. The analysis will be performed to the full matrix, 2025 cells, and to the superior right part of the matrix, 900 cells, as in the previous studies.

A) If analyses to all matrix, 2025 cells obtain significant results, CMM hypothesis is confirmed for the entire matrix.

B) If analyses to superior right part of the matrix, 900 cells that cannot be contaminated by feedback about previous trials, obtain the predicted significant results the CMM hypothesis is judged confirmed for this set of data.

Hypothesis 2: TRUE RNG3 behaves in similar way to the classic RNG used in previous studies. Therefore, it is predicted that no significant difference will be found in the number of significant CMM correlations obtained when sessions conducted with the TRUE RNG3 are compared to sessions conducted with the classic RNG.

Hypothesis 3: Participants estimating less time to perform the session than it objectively took are demonstrating greater Organisational Closure (OC).

In the end of first session participants are asked:

“Without looking at your watch, please estimate the time in minutes between when I said “start when you are ready” and the present?”

It is hypothesized that participants who answer that the session took less time experienced a subjective time contraction which is the essence of OC measure, and it is predicted that these participants will show more significant CMM correlations compared to other participants.

Experimental Procedure

1-100 participants of any age will be recruited to contribute with two experimental sessions each.

2-The type of RNG used will alternate between participants viz:- participant 1 will do first session with original (classic) random number generator followed by a second session with True RNG, participant 2 will do first experimental session with True RNG and second session with classic RNG. And so on till the end.

3-So for the comparison of RNGs, there will be 100 sessions in each RNG condition. Each participant will also report on their subjective time estimation in the first session only.

4-The experiment is conducted in a face-to-face setting, preferably having a dedicated room or when the case the researcher taking the laptop to friends and family homes make sure appropriate conditions are kept. The most important is the well-being and relaxed environment provided.

5-The organizational closure would be careful treated by, welcoming in a friendly way the participants, informing participants of all details relative to the study in a light/graceful way, by filling in a small questionnaire.

6-Participant signs a consent form approved by the University of Edinburgh Ethics committee.

Experimental set-up

The random number generator drives a display on the laptop screen.

Participant is instructed to intentionally attempt the curve from

the display to shrink, grow or to keep it stable, in accordance with instruction appearing on the screen. On the top of the screen an arrow points to the left, right or centre indicating the direction toward which the participant should try to influence the fractal.

Participant is told to press the right or left shift key on the keyboard in any order they want and that the use of the keys will progress the experiment.

Participants are expected to contribute with two sessions each performed one after the other, each session will be with each type of RNG. It is planned to run 100 sessions with each type of RNG in a total of 200 experimental sessions.

The computer should have battery full charged, be plugged during experiment and both RNG are plugged before starting first session.

Variables

The study uses the same five psychological and five physical variables than in previous studies plus one new variable called organizational closure as explained below:

5 physical variables:

- 1- TR: the number of times the output RNG yields "1" during one run.
 - 2- DT: the number of steps the fractal display deviated from the optimum in either direction or from the central position.
 - 3- KR: deviation of the actual RNG output from the ideal.
 - 4- ZT: mean voltage output at the fourth channel out of eight.
 - 5- ZV: standard deviation of this voltage output at channel 4.
- Each of the 5 physical measures will be found for each of the 9 sub-runs in a session which gives 45 physical data points for a session.

Similarly, there are 5 psychological measures describing the behaviour of the participant:

- 1- T1: number of right shift-key presses.
- 2- T2: number of left shift-key presses.
- 3- T3: number of double presses.
- 4- DR: mean time between key presses.
- 5- DV: variance of time between key presses.

Each of the 5 psychological measures will be found for each of the 9 sub-runs in a session, which gives 45 psychological data points for a session. The correlation matrix will be generated by correlating each of the 45 physical variables with each of the 45 psychological variables (2025 total correlations) using the session as the unit of analysis. The pure psi correlations that cannot be contaminated by feedback about previous trials are the 900 correlations above the diagonal of the matrix. It is considered diagonal matrix the present trials performed by the participant during the session, to which correspond 225 correlations. The correlations above the diagonal of the matrix are correlations between psychological variables and future physical (RNG) variables and exclude correlations with physical variables for which the participant has received feedback. The relevant excluded diagonal cells for the matrix are the correlations for the 5 physical variables by 5 psychological variables in the same sub-run (25 correlations for each of the 9 sub-runs, which is 225 of the 2025 total correlations and leaves half of the remaining 1800 correlations above this diagonal). The control correlations are generated by a permutation method.

A non-parametric correlation coefficient Spearman will be calculated with alpha set at a two-tailed $p = 0.05$.

Data will be analysed by comparing the experimental data set (CE) to a control data set created from CE, using a permutation method that consists of producing 10.000 matrices as control.

From the newly created control data set, the number of matrices with similar or higher number of statistically significant correlations divided by 10.000 yields the true probability that the result observed could have occurred by chance. This analysis can yield a p-value of $1/10.000 = 0.0001$.

The target of the analysis is the right part above the diagonal of the matrix, with a true $p \leq 0.05$. This analysis is described as 'primary' because it is the section of the matrix that is not susceptible to possible orthodox causal correlations due to feedback on previous trials influencing participant behaviour. It therefore gives a purer indication of the hypothesised entanglement correlations than the full matrix. The second target is the analysis of the full matrix considering a true $p \leq 0.05$.

Analysis

100 participants contribute each with 2 sessions, one session using classic RNG and the other session with a TRUE RNG3 in a total of 200 sessions as in previous studies.

This study compares the performance of the previous RNG (classic) with a commercial one TRUE RNG3. The classic RNG was programmed according to von Lucadou's specifications. As in all previous experiments the RNG output is smoothed by a Markov-chain window with lag 1 that makes the appearance of the output look more like a natural process and slows the change process. The noise-current of a Zener-diode is used as the random source. The equivalent voltage of the noise-current is amplified and is measured by an analogue- digital converter, which is read out by the USB-Interface of the computer. To produce the Markov-chain the momentary 12-bit number (voltage) R_{i+1} is compared with the previous one R_i . A decrease of the momentary voltage is indicated as a "1" and an increase as a "0". If no change of the decay rate occurred the event is omitted.

TrueRNG 3 is a commercial RNG considered the next generation Hardware Random Number Generator. Its speed goes over 400 kbits/second and has a whitener with an entropy mixing algorithm. The TrueRng3 uses an entropy random source to mix the algorithm that takes in 20 bits and outputs 8 bit to ensure that maximum entropy is maintained. The algorithm uses multiplication in a galois field similar to a cyclic redundancy check to mix the ADC inputs thoroughly while spreading the entropy evenly across all bits.

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Appendix 8 – pre-registration study 5

Replication of Correlation Matrix Method

Pre-registration Protocol

2.June.2018

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Introduction

The purpose of the study is to replicate a theoretical model that explores the meaning of significant correlations produced between psychological and physical variables as a quantum theoretical strand.

This is the fourth replication produced by the author of the same project. Previous studies replicated with success the correlation matrix method (CMM) (Lucadou, 1987).

Despite the significant results more replications are needed to clear doubts and understand deeper the meaning of the data.

To continue improving on the CMM theory is important at this point, to clarify whether the RNG (classic) used in previous studies is somehow interfering with the process and as a consequence with the significant results achieved. To elucidate this point a new type of random number generator, a commercial TRUE RNG3 will be used to compare its performance against the original RNG. This way the validity of the data will be carefully checked and improvements in methodology introduced.

The Experiment

The study explores whether human intention operates on a random number generator (RNG). By comparing the number of significant

correlations between physical variables, produced by the RNG with psychological variables, produced by participants' behaviour, namely key-presses. Physical and psychological variables are all correlated in all runs with each other and correlations displayed in a matrix table (Lucadou, Romer & Walach, 2007).

The physical and psychological variables are the same used in the replication study 1022 and 1031 carried out by the researcher and in previous studies by Walach (2014).

Participants will try to mentally influence a fractal appearing on the computer screen to "shrink", "grow" or "leave" it stable according to the instructions. The instructions to influence the fractal to right, left or centre are called trials, 80 trials make one sub-run and three set of 80 trials complete one run. Three repeated runs are one session. Each session should take between 10 and 20 minutes.

Hypothesis

Hypothesis 1: replicates the CMM predicting no decline or small decline effect will occur comparing with previous two studies. It is predicted that this third replication of the correlation matrix method will yield greater proportion of significant correlations compared to 10.000 permutations as control. The analysis will be performed to the full matrix, 2025 cells, and to the superior right part of the matrix, 900 cells, as in the previous studies.

A) If analyses to all matrix, 2025 cells obtain significant results, CMM hypothesis is confirmed for the entire matrix.

B) If analyses to superior right part of the matrix, 900 cells that cannot be contaminated by feedback about previous trials, obtain the predicted significant results the CMM hypothesis is judged confirmed for this set of data.

Hypothesis 2: TRUE RNG3 behaves in similar way to the classic RNG used in previous studies. Therefore, it is predicted that no significant difference will be found in the number of significant CMM correlations obtained when sessions conducted with the TRUE RNG3 are compared to sessions conducted with the classic RNG.

Hypothesis 3: Participants estimating less time to perform the session than it objectively took are demonstrating greater Organisational Closure (OC).

In the end of second session participants are asked:

“Without looking at your watch, please estimate the time in minutes between when I said “start when you are ready” and the present?”

It is hypothesized that participants who answer that the session took less time experienced a subjective time contraction which is the essence of OC measure, and it is predicted that these participants will show more significant CMM correlations compared to other participants.

Experimental Procedure

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2-The type of RNG used will alternate between participants viz:- participant 1 will do first session with original (classic) random number generator followed by a second session with True RNG, participant 2 will do first experimental session with True RNG and second session with classic RNG. And so on till the end.

3-So for the comparison of RNGs, there will be 100 sessions in each RNG condition. Each participant will also report on their subjective time estimation in the first session only.

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List of references

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Appendix 9 – Matrices for study 1 to 5

Study 1 Correlations matrix

Study1	PHYSICAL VARIABLES										Correlations																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
	TR1	TR1	KR1	ZT1	ZV1	TR2	TR2	TR2	KR2	ZT2	ZV2	TR3	TR3	TR3	KR3	ZT3	ZV3	TR4	TR4	TR4	TR4	TR5	TR5	TR5	TR5	TR6	TR6	TR6	TR6	TR6	TR6	TR7	TR7	TR7	TR7	TR7	TR7	TR8	TR8	TR8	TR8	TR8	TR8	TR9	TR9	TR9	TR9	TR9																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
T11	-0.080		-0.096			-0.068	-0.039	-0.005	0.010	-0.056	-0.012	0.076	0.011	-0.073	0.009	0.009	0.032	0.025	0.036	0.115	0.049	0.045	0.032	-0.102	0.056	-0.020	-0.074	-0.067	-0.010	0.021																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											

Study 2 Correlations matrix

Exp Correlations		PHYSICAL VARIABLES																																										
		TR1	DT1	KR1	ZT1	TR2	DT2	KR2	ZT2	TR3	DT3	KR3	ZT3	TR4	DT4	KR4	ZT4	TR5	DT5	KR5	ZT5	TR6	DT6	KR6	ZT6	TR7	DT7	KR7	ZT7	TR8	DT8	KR8	ZT8	TR9	DT9	KR9	ZT9							
P	T11	1.00	0.029	-0.08	0.041	0.025	-0.05	-0.08	-0.1	-0.03	0.036	-0.07	-0.09	-0.04	-0.05	-0.07	-0.03	0.035	0.084	0.058	-0.09	-0.11	-0.003	0.047	0.075	-0.12	0.108	0.075	0.023	0.046	-0.12	-0.07	0.062	0.105	0.048	-0.11	-0.04	0.032	0.05	0.069	-0.01	0.06		
S	T21	0.054	1.00	0.031	0.045	0.03	0.022	-0.04	-0.03	0.02	0.032	0.071	-0.01	0.025	0.052	-0.02	-0.05	0.041	0.123	-0.05	0.077	-0.13	0.05	0.03	-0.04	0.029	0.008	-0.01	0.117	0.097	-0.04	0.042	0.058	0.053	0.022	-0.01	0.042	-0.01	0.042					
Y	T31	-0.01	0.051	-0.05	-0.02	0.047	0.047	0.097	0.007	-0.07	0.013	0.097	0.09	0.084	0.007	-0.01	0.02	-0.09	0.06	0.053	0.047	-0.1	-0.1	-0.05	0.091	-0.1	-0.06	-0.04	-0.1	0.064	-0.1	-0.06	0.065	0.042	-0.05	-0.08	-0.09	0.086	-0.01	0.091				
C	DR1	0.036	-0.06	-0.01	-0.03	-0.07	0.126	0.077	0.097	0.042	0.008	0.059	0.106	0.002	0.06	0.125	0.002	0.074	-0.04	0.044	-0.1	0.058	-0.03	0.052	0.044	-0.02	0.007	-0.08	-0.02	0.107	-0.09	0.006	0.018	-0.02	0.101	0.024	0.047	-0.1	0.008					
H	DV1	-0.06	0.075	0.014	-0.1	-0.11	-0.02	0.018	-0.07	0.016	0.106	0.068	-0.04	0.066	0.055	0.073	0.015	-0.04	0.017	-0.07	0.111	0.001	0.134	0.031	0.066	-0.03	0.023	-0.04	-0.03	0.027	0.041	0.032	-0.04	0.092	0.003	0.033	0.003	-0.013	0.013					
O	T12	0.117	-0.13	-0.05	0.057	-0.01	-0.04	0.059	0.075	-0.01	-0.02	0.102	0.029	0.081	0.078	-0.01	-0.06	0.111	0.117	-0.03	0.078	-0.01	-0.04	-0.11	-0.13	0.079	0.005	0.039	-0.04	0.062	0.03	0.02	-0.02	-0.01	0.031	0.01	-0.02	-0.03	-0.05	0.018	0.03			
L	T22	-0.04	0.063	0.047	0.091	0.06	0.052	0.047	0.01	0.109	-0.12	-0.12	-0.05	-0.09	-0.04	-0.1	0.103	0.058	0.044	-0.1	-0.07	0.02	0.079	0.122	0.008	-0.03	0.013	0.095	0.08	-0.02	-0.1	0.074	-0.1	0.081	0.1	0.118	0.079	-0.01	0.08	0.034	0.031	0.052	-0.01	0.001
O	T32	-0.04	0.063	0.047	0.091	0.06	0.052	0.047	0.01	0.109	-0.12	-0.12	-0.05	-0.09	-0.04	-0.1	0.103	0.058	0.044	-0.1	-0.07	0.02	0.079	0.122	0.008	-0.03	0.013	0.095	0.08	-0.02	-0.1	0.074	-0.1	0.081	0.1	0.118	0.079	-0.01	0.08	0.034	0.031	0.052	-0.01	0.001
G	DR2	0.019	-0.05	-0.12	0.079	-0.02	-0.1	-0.067	-0.02	0.078	0.099	0.084	0.082	0.02	-0.05	-0.12	-0.01	0.104	0.061	0.016	0.016	-0.11	0.007	-0.06	0.06	0.002	0.01	0.004	0.039	0.114	-0.08	-0.09	0.064	-0.01	0.032	0.075	0.044	0.031	-0.05	-0.043	0.008	0.004	0.049	
I	DV2	0.003	-0.03	-0.07	0.056	0.042	-0.11	-0.01	-0.01	0.066	-0.01	0.01	0.055	-0.09	0.015	0.026	0.015	0.045	-0.01	0.012	0.014	-0.06	0.057	0.048	-0.027	0.057	0.053	0.01	-0.04	0.064	0.005	0.055	-0.06	0.095	0.085	-0.01	0.083	0.04	76-04	96-04	0.006	0.004	0.078	
C	T13	-0.01	0.005	-0.03	-0.1	0.006	-0.01	-0.07	-0.1	-0.1	0.04	-0.07	0.02	-0.03	-0.03	0.06	-0.01	0.017	0.035	-0.02	0.018	-0.04	0.055	0.026	-0.05	0.031	0.025	0.007	-0.05	-0.13	0.075	-0.02	-0.1	-0.12	-0.02	-0.11	-0.12	-0.05	-0.12	-0.05				
A	T23	-0.04	0.017	0.006	0.029	0.054	0.078	-0.01	-0.03	-0.12	-0.02	0.051	0.018	-0.1	-0.11	0.007	0.122	-0.07	-0.07	0.03	0.034	0.092	0.018	0.03	0.096	0.055	-0.02	-0.04	0.114	0.121	0.038	0.011	0.003	0.013	0.019	0.075	0.001	0.039	0.003	0.008	0.003	0.003		
L	T33	0.028	-0.03	0.032	0.111	-0.01	0.018	0.042	0.041	0.041	-0.03	0.067	0.112	-0.05	-0.01	0.089	-0.05	0.118	0.082	0.024	0.04	-0.04	-0.06	0.017	-0.05	0.03	0.102	0.008	0.027	-0.01	0.071	-0.1	-0.01	0.03	0.073	0.032	0.092	0.093	-0.008	-0.08	0.008			
D	DR3	0.047	-0.06	-0.1	0.022	-0.08	-0.11	-0.04	-0.02	-0.01	0.092	0.031	0.023	-0.03	-0.11	-0.09	0.109	-0.09	0.067	-0.1	-0.007	-0.11	-0.06	0.04	0.026	0.083	0.003	-0.07	0.03	0.028	0.02	0.009	0.017	0.057	0.06	0.021	86-04	0.029	-0.01	0.018	0.033	-0.02	0.068	
V	DV3	-0.04	-0.09	0.048	-0.01	-0.06	0.036	-0.07	-0.02	-0.03	0.049	0.095	-0.01	-0.11	0.084	-0.06	-0.1	-0.07	-0.09	0.015	0.012	-0.11	-0.012	0.103	0.075	0.003	0.016	-0.05	-0.1	0.004	-0.07	0.007	-0.05	0.046	0.024	-0.08	0.035	0.055	0.004	-0.08	0.03	0.072		
A	T14	-0.11	0.13	-0.03	-0.02	0.035	0.028	-0.11	-0.12	-0.03	0.036	-0.012	0.011	-0.07	0.022	-0.06	-0.13	0.085	0.053	0.07	-0.04	-0.11	0.071	-0.11	0.032	0.047	-0.12	0.098	-0.02	0.009	0.015	0.026	0.037	0.003	0.069	-0.07	-0.07	0.03	0.006	-0.03	-0.12	0.034		
R	T24	0.007	0.036	0.126	-0.09	0.005	-0.1	-0.06	0.127	-0.11	0.011	0.01	0.036	-0.1	0.117	-0.13	0.065	-0.12	-0.04	0.02	0.053	0.028	-0.01	-0.06	0.061	0.084	0.013	-0.11	0.043	-0.03	0.089	0.067	0.066	-0.01	-0.05	0.076	0.049	0.111	0.034	0.004	0.007			
I	T34	0.007	0.13	0.015	0.041	-0.01	-0.01	0.109	0.114	0.049	-0.06	-0.01	0.056	0.088	0.019	0.03	0.012	-0.04	0.08	0.009	0.086	-0.05	0.07	0.008	-0.04	0.111	0.007	-0.06	-0.01	0.01	-0.1	-0.04	0.003	-0.08	0.022	0.067	0.034	-0.01	0.003	0.134	0.034			
A	DR4	-0.04	-0.05	-0.08	-0.028	0.027	-0.07	-0.01	0.072	-0.01	0.061	0.03	0.022	-0.02	-0.01	0.041	0.02	0.075	-0.01	-0.01	0.004	-0.05	-0.06	-0.089	0.103	0.022	-0.02	-0.04	0.063	-0.09	-0.08	0.043	0.04	0.012	0.048	-0.05	0.002	0.047	0.037	0.019	0.012	0.095	0.106	
B	DV4	-0.02	-0.06	0.056	0.049	-0.03	-0.05	0.033	0.096	-0.01	-0.07	-0.04	0.021	-0.01	0.116	-0.07	-0.02	0.038	-0.02	0.011	0.01	0.044	0.05	-0.07	0.025	0.038	-0.07	-0.02	-0.03	-0.04	0.085	-0.04	0.067	-0.01	0.062	0.014	0.002	-0.11	-0.05	0.017	-0.01	0.017		
L	T15	-0.13	-0.13	-0.11	0.038	0.034	0.053	0.014	0.076	-0.09	-0.04	-0.02	0.015	0.106	-0.01	0.02	-0.1	0.118	0.12	-0.11	0.018	0.12	-0.11	0.032	-0.05	0.009	-0.06	0.054	-0.11	0.009	0.054	-0.07	-0.09	-0.06	-0.1	0.095	0.072	-0.04	0.021	-0.03	-0.018	-0.01	0.018	
E	T25	-0.09	0.089	0.057	-0.05	0.042	0.011	0.026	-0.01	-0.07	0.005	0.04	0.058	-0.1	0.05	-0.11	0.045	0.013	-0.01	-0.023	0.061	0.125	0.02	0.11	0.012	0.042	0.043	-0.13	0.097	0.033	0.126	-0.11	0.118	0.081	-0.116	0.029	0.059	0.016	0.072	0.102	0.043			
S	T35	-0.03	0.103	-0.05	0.03	-0.03	-0.02	-0.11	-0.11	0.089	0.029	-0.02	-0.11	-0.02	0.018	0.03	-0.09	0.114	-0.03	-0.08	0.056	-0.02	0.079	-0.02	0.075	-0.01	-0.08	0.047	0.091	0.06	0.01	0.08	0.01	-0.09	0.045	-0.04	0.005	-0.03	0.079	0.009	0.009	0.009		
DR5	-0.01	-0.05	-0.04	0.009	-0.11	-0.02	0.031	-0.11	0.092	0.084	0.028	0.015	-0.11	-0.06	0.02	0.059	-0.12	-0.06	0.062	0.064	-0.08	-0.07	0.01	66-04	0.086	0.033	-0.12	0.008	0.104	-0.1	-0.08	-0.02	-0.01	0.077	0.027	-0.04	-0.01	-0.03	-0.01	-0.07	0.001	0.004	0.001	0.084
T26	-0.02	-0.04	0.017	0.03	-0.13	-0.05	0.081	-0.04	0.117	-0.08	-0.02	-0.02	-0.05	-0.08	0.004	0.029	-0.05	0.022	-0.085	0.092	-0.07	-0.03	0.073	0.059	-0.04	-0.08	-0.06	0.018	0.015	-0.03	-0.01	0.04	0.022	0.004	0.02	-0.07	0.049	-0.03	-0.04	0.031	0.011	0.014		
T36	-0.01	-0.06	-0.11	0.027	0.028	-0.02	0.018	-0.02	0.026	0.087	0.04	0.115	-0.09	-0.01	16-03	-0.02	-0.01	-0.08	0.048	0.031	0.026	-0.01	-0.04	-0.01	-0.02	-0.08	-0.03	-0.1	0.129	0.012	0.056	-0.03	-0.01	-0.08	-0.05	-0.1	0.042	-0.02	-0.01	-0.09	-0.05	-0.05	0.119	
DR6	-0.04	0.031	0.015	-0.01	0.038	0.013	0.096	-0.11	-0.11	-0.05	-0.01	-0.07	0.023	-0.06	0.038	-0.01	-0.07	-0.11	-0.028	0.081	0.013	-0.05	0.036	0.041	-0.12	0.022	0.034	0.068	0.064	-0.05	-0.05	0.046	0.057	-0.04	0.079	-0.07	-0.05	-0.07	-0.05	-0.07	-0.05			
D	-0.01	0.004	-0.11	-0.02	-0.02	0.03	0.03	-0.12	-0.02	0.073	0.004	-0.1	-0.06	0.046	-0.02	0.075	-0.03	66-04	-0.01	0.08	0.046	-0.05	-0.07	-0.04	-0.04	0.036	-0.07	-0.1	0.092	-0.11	-0.07	0.031	-0.09	-0.05	-0.04	-0.06	0.032	0.095	0.04	-0.01	-0.12	0.031		
DR6	0.01	-0.03	-0.01	-0.02	-0.05	-0.06	0.003																																					

Study 3 – Correlations matrix

		Correlations Study 3																																							
		Z01	Z02	Z03	Z04	Z05	Z06	Z07	Z08	Z09	Z10	Z11	Z12	Z13	Z14	Z15	Z16	Z17	Z18	Z19	Z20	Z21	Z22	Z23	Z24	Z25	Z26	Z27	Z28	Z29	Z30	Z31	Z32	Z33	Z34	Z35	Z36	Z37	Z38	Z39	Z40
P	Z01	0.02	0.007	-0.027	0.033	-0.047	0.041	0.073	0.096	-0.095	-0.125	-0.135	-0.042	-0.113	-0.209	-0.033	-0.118	-0.044	0.134	-0.040	-0.085	-0.040	-0.094	-0.137	0.044	-0.112	-0.034	0.025	-0.028	0.027	0.124	-0.008	-0.025	-0.041	0.004	-0.011	0.071	0.018	0.018	0.018	0.018
	Z02	-0.168	0.010	0.010	-0.025	0.036	-0.023	-0.033	-0.163	-0.018	-0.075	-0.075	-0.044	-0.048	-0.116	0.036	-0.116	0.036	-0.080	-0.085	-0.137	-0.051	-0.035	0.041	-0.065	0.026	-0.031	-0.041	-0.108	-0.041	0.068	0.073	0.110	0.046	-0.045	-0.047	-0.024	-0.035	-0.045	-0.035	
Y	Z03	-0.048	-0.020	-0.149	-0.116	-0.075	-0.127	-0.232	-0.047	0.005	0.075	-0.005	-0.126	-0.244	-0.027	0.078	-0.152	0.128	-0.087	-0.102	-0.084	-0.104	-0.134	-0.005	-0.071	-0.079	-0.040	0.222	-0.008	-0.011	0.022	-0.120	-0.017	-0.005	-0.218	-0.074	-0.242	-0.025	-0.185	-0.057	
C	Z04	-0.011	-0.020	0.018	-0.008	-0.027	-0.022	-0.005	-0.008	-0.018	-0.038	-0.018	-0.038	-0.018	-0.038	-0.040	-0.007	-0.078	-0.051	-0.178	-0.058	-0.030	-0.076	-0.022	-0.014	-0.074	-0.022	0.014	0.019	-0.113	-0.017	-0.008	-0.120	-0.075	-0.057	-0.048	-0.034	-0.124	-0.040		
H	Z05	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005		
H	Z06	0.005	-0.011	-0.007	-0.004	-0.013	-0.028	-0.059	-0.113	-0.001	-0.000	-0.001	-0.000	-0.001	-0.000	-0.001	-0.000	-0.001	-0.000	-0.001	-0.000	-0.001	-0.000	-0.001	-0.000	-0.001	-0.000	-0.001	-0.000	-0.001	-0.000	-0.001	-0.000	-0.001	-0.000	-0.001	-0.000	-0.001	-0.000		
L	Z07	-0.016	-0.069	0.000	-0.011	-0.009	0.047	0.011	-0.113	-0.009	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000		
O	Z08	-0.044	-0.017	0.068	0.010	-0.007	-0.041	0.128	0.017	-0.014	-0.116	-0.008	-0.005	-0.013	0.028	0.100	-0.003	-0.003	-0.000	-0.003	-0.000	-0.003	-0.000	-0.003	-0.000	-0.003	-0.000	-0.003	-0.000	-0.003	-0.000	-0.003	-0.000	-0.003	-0.000	-0.003	-0.000	-0.003	-0.000	-0.003	-0.000
O	Z09	-0.005	-0.020	-0.041	-0.004	-0.004	-0.004	-0.005	-0.006	-0.009	-0.020	-0.008	-0.008	-0.005	-0.013	0.028	0.100	-0.003	-0.003	-0.000	-0.003	-0.000	-0.003	-0.000	-0.003	-0.000	-0.003	-0.000	-0.003	-0.000	-0.003	-0.000	-0.003	-0.000	-0.003	-0.000	-0.003	-0.000	-0.003	-0.000	
I	Z10	-0.053	-0.049	-0.010	-0.007	-0.007	-0.003	-0.007	-0.004	-0.005	-0.007	-0.004	-0.005	-0.007	-0.004	-0.005	-0.007	-0.004	-0.005	-0.007	-0.004	-0.005	-0.007	-0.004	-0.005	-0.007	-0.004	-0.005	-0.007	-0.004	-0.005	-0.007	-0.004	-0.005	-0.007	-0.004	-0.005	-0.007	-0.004	-0.005	
C	Z11	-0.066	-0.055	-0.116	-0.236	-0.102	-0.058	-0.071	-0.220	-0.069	-0.025	-0.069	-0.025	-0.118	-0.117	0.087	-0.005	-0.115	-0.044	-0.038	-0.102	-0.156	-0.011	-0.007	-0.040	-0.040	-0.013	-0.010	-0.113	-0.008	-0.042	-0.040	-0.042	-0.009	-0.102	-0.009	-0.102	-0.009	-0.102	-0.009	
A	Z12	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005		
L	Z13	-0.076	-0.007	-0.097	-0.043	-0.027	0.051	-0.029	-0.064	0.051	-0.047	-0.053	-0.053	-0.044	-0.043	-0.005	-0.047	-0.060	-0.060	-0.060	-0.060	-0.060	-0.060	-0.060	-0.060	-0.060	-0.060	-0.060	-0.060	-0.060	-0.060	-0.060	-0.060	-0.060	-0.060	-0.060	-0.060	-0.060	-0.060		
L	Z14	-0.077	-0.080	-0.141	-0.435	-0.022	-0.041	-0.200	-0.081	-0.006	-0.020	-0.060	-0.060	-0.060	-0.060	-0.060	-0.060	-0.060	-0.060	-0.060	-0.060	-0.060	-0.060	-0.060	-0.060	-0.060	-0.060	-0.060	-0.060	-0.060	-0.060	-0.060	-0.060	-0.060	-0.060	-0.060	-0.060	-0.060	-0.060		
V	Z15	-0.055	-0.032	-0.158	-0.055	-0.083	-0.048	-0.158	-0.047	0.020	0.006	0.109	-0.004	-0.010	-0.024	-0.076	-0.024	-0.104	-0.134	-0.140	-0.047	-0.058	-0.059	-0.008	-0.012	-0.011	-0.011	-0.011	-0.011	-0.011	-0.011	-0.011	-0.011	-0.011	-0.011	-0.011	-0.011	-0.011	-0.011		
A	Z16	-0.076	-0.093	-0.139	-0.256	-0.067	-0.029	-0.073	-0.067	-0.007	-0.027	-0.086	-0.124	-0.020	-0.078	-0.055	-0.019	-0.081	-0.069	-0.105	-0.038	-0.065	-0.020	-0.043	-0.038	-0.065	-0.020	-0.043	-0.038	-0.065	-0.020	-0.043	-0.038	-0.065	-0.020	-0.043	-0.038	-0.065	-0.020		
R	Z17	-0.059	-0.029	-0.059	-0.048	-0.036	0.053	0.119	-0.024	-0.210	-0.011	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047			
R	Z18	-0.059	-0.029	-0.059	-0.048	-0.036	0.053	0.119	-0.024	-0.210	-0.011	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047			
A	Z19	-0.059	-0.029	-0.059	-0.048	-0.036	0.053	0.119	-0.024	-0.210	-0.011	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047			
A	Z20	-0.059	-0.029	-0.059	-0.048	-0.036	0.053	0.119	-0.024	-0.210	-0.011	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047	-0.047		
B	Z21	-0.044	-0.054	-0.080	-0.062	-0.052	0.048	0.047	-0.003	-0.094	-0.041	-0.080	-0.110	-0.059	-0.118	-0.077	-0.025	-0.087	-0.120	-0.042	-0.004	-0.024	-0.044	-0.037	-0.049	-0.034	-0.044	-0.037	-0.049	-0.034	-0.044	-0.037	-0.049	-0.034	-0.044	-0.037	-0.049	-0.034	-0.044		
L	Z22	-0.005	-0.005	-0.006	-0.010	-0.020	-0.007	-0.010	-0.049	-0.018	-0.027	-0.060	-0.122	-0.068	-0.102	-0.068	-0.076	-0.076	-0.076	-0.076	-0.076	-0.076	-0.076	-0.076	-0.076	-0.076	-0.076	-0.076	-0.076	-0.076	-0.076	-0.076	-0.076	-0.076	-0.076	-0.076	-0.076	-0.076			
L	Z23	-0.024	-0.002	-0.015	-0.002	-0.002	0.008	-0.007	-0.016	-0.070	0.005	0.005	-0.040	-0.089	-0.122	-0.020	-0.136	-0.127	-0.060	-0.122	-0.060	-0.122	-0.060	-0.122	-0.060	-0.122	-0.060	-0.122	-0.060	-0.122	-0.060	-0.122	-0.060	-0.122	-0.060	-0.122	-0.060	-0.122			
S	Z24	-0.013	-0.013	-0.013	-0.024	-0.021	-0.004	-0.005	-0.081	-0.051	-0.081	-0.051	-0.081	-0.051	-0.081	-0.051	-0.081	-0.051	-0.081	-0.051	-0.081	-0.051	-0.081	-0.051	-0.081	-0.051	-0.081	-0.051	-0.081	-0.051	-0.081	-0.051	-0.081	-0.051	-0.081	-0.051	-0.081	-0.051			
	Z25	-0.111	-0.115	-0.115	-0.115	-0.115	-0.115	-0.115	-0.115	-0.115	-0.115	-0.115	-0.115	-0.115	-0.115	-0.115	-0.115	-0.115	-0.115	-0.115	-0.115	-0.115	-0.115	-0.115	-0.115	-0.115	-0.115	-0.115	-0.115	-0.115	-0.115	-0.115	-0.115	-0.115	-0.115	-0.115	-0.115	-0.115			
	Z26	-0.080	-0.080	-0.080	-0.080	-0.080	-0.080	-0.080	-0.080	-0.080	-0.080	-0.080	-0.080	-0.080	-0.080	-0.080	-0.080	-0.080	-0.080	-0.080	-0.080	-0.080	-0.080	-0.080	-0.080	-0.080	-0.080	-0.080	-0.080	-0.080	-0.080	-0.080	-0.080	-0.080	-0.080	-0.080	-0.080	-0.080			
	Z27	-0.058	-0.059	-0.059	-0.205	-0.060	-0.036	0.064	-0.200	-0.028	-0.172	-0.011	-0.139	-0.220	-0.006	-0.110	-0.113	-0.258	-0.021	-0.002	-0.028	-0.225	-0.011	-0.132	-0.208	-0.049	-0.108	-0.074	-0.057	-0.215	-0.004	-0.054	-0.038	-0.244	-0.041	-0.039	-0.075	-0.241			
	Z28	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006				
	Z29	-0.122	-0.044	-0.071	-0.011	-0.010	-0.044	-0.041	-0.044	-0.051	-0.041	-0.044	-0.051	-0.041	-0.044	-0.051	-0.041	-0.044	-0.051	-0.041	-0.044	-0.051	-0.041	-0.044	-0.051	-0.041	-0.044	-0.051	-0.041	-0.044	-0.051	-0.041	-0.044	-0.051	-0.041	-0.044	-0.051				
	Z30	-0.110	-0.027	-0.116	-0.111	-0.023	-0.013	-0.044	-0.111	-0.039	-0.075	-0.025	-0.038	-0.116	-0.030	-0.115	-0.020	-0.051	-0.114	-0.011	-0.114	-0.011	-0.114	-0.011	-0.114	-0.011	-0.114	-0.011	-0.114	-0.011	-0.114	-0.011	-0.114	-0.011	-0.114	-0.011	-0.114				
	Z31	-0.110	-0.027	-0.116	-0.111	-0.023	-0.013	-0.044	-0.111	-0.039	-0.075	-0.025	-0.038	-0.116	-0.030	-0.115	-0.020	-0.051	-0.114	-0.011	-0.114	-0.011	-0.114	-0.011	-0.114</																

permutation matrix

[illegible]

Study 4 Original RNG Correlations

[illegible]

Permutations Original RNG

[illegible]

New RNG Correlations

[illegible]

[illegible]

Study 5 Correlations Original RNG

Corr Study (range)		Bonds		T1		T2		T3		T4		T5		T6		T7		T8		T9		T10		T11		T12		T13		T14		T15		T16		T17		T18		T19		T20		T21		T22		T23		T24		T25		T26		T27		T28		T29		T30		T31		T32		T33		T34		T35		T36		T37		T38		T39		T40		T41		T42		T43		T44		T45		T46		T47		T48		T49		T50		T51		T52		T53		T54		T55		T56		T57		T58		T59		T60		T61		T62		T63		T64		T65		T66		T67		T68		T69		T70		T71		T72		T73		T74		T75		T76		T77		T78		T79		T80		T81		T82		T83		T84		T85		T86		T87		T88		T89		T90		T91		T92		T93		T94		T95		T96		T97		T98		T99		T100		T101		T102		T103		T104		T105		T106		T107		T108		T109		T110		T111		T112		T113		T114		T115		T116		T117		T118		T119		T120		T121		T122		T123		T124		T125		T126		T127		T128		T129		T130		T131		T132		T133		T134		T135		T136		T137		T138		T139		T140		T141		T142		T143		T144		T145		T146		T147		T148		T149		T150		T151		T152		T153		T154		T155		T156		T157		T158		T159		T160		T161		T162		T163		T164		T165		T166		T167		T168		T169		T170		T171		T172		T173		T174		T175		T176		T177		T178		T179		T180		T181		T182		T183		T184		T185		T186		T187		T188		T189		T190		T191		T192		T193		T194		T195		T196		T197		T198		T199		T200		T201		T202		T203		T204		T205		T206		T207		T208		T209		T210		T211		T212		T213		T214		T215		T216		T217		T218		T219		T220		T221		T222		T223		T224		T225		T226		T227		T228		T229		T230		T231		T232		T233		T234		T235		T236		T237		T238		T239		T240		T241		T242		T243		T244		T245		T246		T247		T248		T249		T250		T251		T252		T253		T254		T255		T256		T257		T258		T259		T260		T261		T262		T263		T264		T265		T266		T267		T268		T269		T270		T271		T272		T273		T274		T275		T276		T277		T278		T279		T280		T281		T282		T283		T284		T285		T286		T287		T288		T289		T290		T291		T292		T293		T294		T295		T296		T297		T298		T299		T300		T301		T302		T303		T304		T305		T306		T307		T308		T309		T310		T311		T312		T313		T314		T315		T316		T317		T318		T319		T320		T321		T322		T323		T324		T325		T326		T327		T328		T329		T330		T331		T332		T333		T334		T335		T336		T337		T338		T339		T340		T341		T342		T343		T344		T345		T346		T347		T348		T349		T350		T351		T352		T353		T354		T355		T356		T357		T358		T359		T360		T361		T362		T363		T364		T365		T366		T367		T368		T369		T370		T371		T372		T373		T374		T375		T376		T377		T378		T379		T380		T381		T382		T383		T384		T385		T386		T387		T388		T389		T390		T391		T392		T393		T394		T395		T396		T397		T398		T399		T400		T401		T402		T403		T404		T405		T406		T407		T408		T409		T410		T411		T412		T413		T414		T415		T416		T417		T418		T419		T420		T421		T422		T423		T424		T425		T426		T427		T428		T429		T430		T431		T432		T433		T434		T435		T436		T437		T438		T439		T440		T441		T442		T443		T444		T445		T446		T447		T448		T449		T450		T451		T452		T453		T454		T455		T456		T457		T458		T459		T460		T461		T462		T463		T464		T465		T466		T467		T468		T469		T470		T471		T472		T473		T474		T475		T476		T477		T478		T479		T480		T481		T482		T483		T484		T485		T486		T487		T488		T489		T490		T491		T492		T493		T494		T495		T496		T497		T498		T499		T500		T501		T502		T503		T504		T505		T506		T507		T508		T509		T510		T511		T512		T513		T514		T515		T516		T517		T518		T519		T520		T521		T522		T523		T524		T525		T526		T527		T528		T529		T530		T531		T532		T533		T534		T535		T536		T537		T538		T539		T540		T541		T542		T543		T544		T545		T546		T547		T548		T549		T550		T551		T552		T553		T554		T555		T556		T557		T558		T559		T560		T561		T562		T563		T564		T565		T566		T567		T568		T569		T570		T571		T572		T573		T574		T575		T576		T577		T578		T579		T580		T581		T582		T583		T584		T585		T586		T587		T588		T589		T590		T591		T592		T593		T594		T595		T596		T597		T598		T599		T600		T601		T602		T603		T604		T605		T606		T607		T608		T609		T610		T611		T612		T613		T614		T615		T616		T617		T618		T619		T620		T621		T622		T623		T624		T625		T626		T627		T628		T629		T630		T631		T632		T633		T634		T635		T636		T637		T638		T639		T640		T641		T642		T643		T644		T645		T646		T647		T648		T649		T650		T651		T652		T653		T654		T655		T656		T657		T658		T659		T660		T661		T662		T663		T664		T665		T666		T667		T668		T669		T670		T671		T672		T673		T674		T675		T676		T677		T678		T679		T680		T681		T682		T683		T684		T685		T686		T687		T688		T689		T690		T691		T692		T693		T694		T695		T696		T697		T698		T699		T700		T701		T702		T703		T704		T705		T706		T707		T708		T709		T710		T711		T712		T713		T714		T715		T716		T717		T718		T719		T720		T721		T722		T723		T724		T725		T726		T727		T728		T729		T730		T731		T732		T733		T734		T735		T736		T737		T738		T739		T740		T741		T742		T743		T744		T745		T746		T747		T748		T749		T750		T751		T752		T753		T754		T755		T756		T757		T758		T759		T760		T761		T762		T763		T764		T765		T766		T767		T768		T769		T770		T771		T772		T773		T774		T775		T776		T777		T778		T779		T780		T781		T782		T783		T784		T785		T786		T787		T788		T789		T790		T791		T792		T793		T794		T795		T796		T797		T798		T799		T800		T801		T802		T803		T804		T805		T806		T807		T808		T809		T810		T811		T812		T813		T814		T815		T816		T817		T818		T819		T820		T821		T822		T823		T824		T825		T826		T827		T828		T829		T830		T831		T832		T833		T834		T835		T836		T837		T838		T839		T840		T841		T842		T843		T844		T845		T846		T847		T848		T849		T850		T851		T852		T853		T854		T855		T856		T857		T858		T859		T860		T861		T862		T863		T864		T865		T866		T867		T868		T869		T870		T871		T872		T873		T874		T875		T876		T877		T878		T879		T880		T881		T882		T883		T884		T885		T886		T887		T888		T889		T890		T891		T892		T893		T894		T895		T896		T897		T898		T899		T900		T901		T902		T903		T904		T905		T906		T907		T908		T909		T910		T911		T912		T913		T914		T915		T916		T917		T918		T919		T920		T921		T922		T923		T924		T925		T926		T927		T928		T929		T930		T931		T932		T933		T934		T935		T936		T937		T938		T939		T940		T941		T942		T943		T944		T945		T946		T947		T948		T949		T950		T951		T952		T953		T954		T955		T956		T957		T958		T959		T960		T961		T962		T963		T964		T965		T966		T967		T968		T969		T970		T971		T972		T973		T974		T975		T976		T977		T978		T979		T980		T981		T982		T983		T984		T985		T986		T987		T988		T989		T990		T991		T992		T993		T994		T995		T996		T997		T998		T999		T1000	

	Permutat	Study5	Original RNG																										
			T81	T72	T81	T72	T81	T72	T81	T72	T81	T72	T81	T72	T81	T72	T81	T72	T81	T72	T81	T72	T81	T72	T81	T72	T81	T72	
P	T1	T11	0.004	0.033	0.088	0.099	0.082	0.001	0.060	0.046	-0.130	-0.227	-0.050	0.053	0.203	-0.103	-0.039	0.043	-0.015	0.038	-0.046	0.036	0.050	0.040	0.020	0.096	0.040	0.038	
		T12	-0.034	-0.024	-0.001	-0.114	-0.033	-0.040	-0.063	-0.066	-0.074	-0.074	-0.041	0.136	0.056	0.041	0.071	0.099	0.024	0.000	-0.040	-0.023	-0.055	0.021	0.110	0.032	0.056	-0.081	0.059
Y	C	T31	0.096	0.095	0.065	0.000	0.010	0.008	-0.037	0.104	0.077	0.214	-0.041	0.071	-0.045	0.040	0.005	-0.034	-0.062	0.005	-0.021	-0.046	-0.106	0.052	-0.091	-0.212	0.048	0.069	0.077
		T32	-0.081	-0.097	-0.127	-0.088	-0.001	0.004	-0.049	-0.022	-0.029	0.003	0.008	-0.112	0.086	0.115	0.103	0.045	-0.022	0.033	0.139	-0.082	-0.140	-0.032	0.006	0.135	-0.167	-0.046	0.005
H	O	DW1	-0.060	-0.058	-0.022	-0.087	-0.153	-0.103	0.038	0.077	0.051	0.077	0.211	-0.161	0.059	-0.015	-0.044	-0.099	-0.066	0.039	0.077	-0.055	-0.035	-0.151	-0.064	-0.111	-0.109	-0.088	-0.061
		DW2	0.042	0.021	-0.036	0.047	0.020	0.248	-0.062	-0.043	-0.012	-0.104	-0.022	0.134	-0.021	-0.220	-0.139	0.102	-0.051	-0.139	-0.164	0.050	-0.354	-0.080	-0.117	-0.053	0.013	0.107	0.189
L	O	T22	-0.083	-0.046	-0.016	0.015	0.041	-0.015	-0.079	0.095	0.039	-0.065	-0.242	0.041	-0.006	-0.022	0.040	-0.034	0.107	0.065	-0.198	-0.047	0.043	0.022	0.042	-0.022	0.013	0.018	0.059
		T32	0.112	0.046	0.004	0.029	0.154	0.084	0.021	0.047	0.107	0.120	0.015	0.022	0.052	0.025	0.101	0.058	0.090	0.020	0.046	-0.015	0.033	0.022	0.066	0.076	0.096	0.274	0.034
G	D	O82	-0.100	-0.134	0.088	0.015	-0.013	-0.085	0.052	-0.144	0.027	0.028	-0.260	0.125	0.134	0.024	-0.018	-0.075	-0.042	-0.016	-0.077	-0.083	-0.022	-0.176	-0.057	-0.022	-0.059	-0.044	-0.082
		DW3	-0.092	-0.130	-0.027	-0.061	-0.138	0.064	0.010	-0.025	0.042	0.021	0.021	0.044	-0.037	-0.067	0.088	-0.033	-0.183	0.063	0.019	0.014	-0.118	-0.062	-0.005	-0.107	-0.207	-0.111	-0.029
C	T	T13	0.006	-0.011	-0.010	-0.034	-0.106	-0.091	0.118	0.139	0.104	-0.144	-0.131	0.041	0.001	0.123	-0.110	-0.077	-0.018	-0.061	-0.094	-0.098	-0.127	-0.203	0.033	0.021	-0.024	-0.038	0.033
		T23	0.033	0.199	-0.089	-0.069	0.052	0.089	0.110	-0.050	0.050	0.152	0.075	0.043	0.057	0.045	-0.059	-0.099	-0.099	0.046	-0.040	-0.137	0.021	-0.018	-0.066	-0.			

[illegible]

Permutations New RNG

[illegible]

Appendix 10 – Analysis program in R

```
## Matrix algorithm
#####
## Open all files (non-controls);
##
setwd("C:/Users/PF41880/Desktop/R/Ana_Experiment/X_All_Experi
mental_Files")

##### Log* / Bew*
NumberOfExperiments <- 200 ## 200 experiences
lf_Log <- list.files(path
="C:/Users/PF41880/Desktop/R/Ana_Experiment/X_All_Experimenta
l_Files", pattern=glob2rx("Log*.csv"))
lf_Bew <- list.files(path
="C:/Users/PF41880/Desktop/R/Ana_Experiment/X_All_Experimenta
l_Files", pattern=glob2rx("Bew*.csv"))

T11_final <-0 ## variable 1
T21_final <-0 ## variable 2
T31_final <-0 ## variable 3
T41_final <-0 ## variable 4
T51_final <-0 ## variable 5
TR1_final <- 0 ## variable 6
ZT1_final <- 0 ## variable 7
ZV1_final <- 0 ## variable 8
KR1_final <- 0 ## variable 9
DT1_final <- 0 ## variable 10

for (m in 1:length(lf_Log)) { ##for m
  #print(lf_Log[m])
  print("-----")
  print(m)

T11_table <- read.csv(lf_Log[m], sep=";", header=TRUE)      ##
variable 1

T21_table <- read.csv(lf_Log[m], sep=";", header=TRUE)      ##
variable 2

T31_table <- read.csv(lf_Log[m], sep=";", header=TRUE)      ##
variable 3
```

```

T41_table <- read.csv(lf_Log[m], sep=";", header=TRUE)      ##
variable 4 (and 5)

TR1_table <- read.csv(lf_Bew[m], sep=";", header=TRUE)      ##
variable 6

ZT1_table <- read.csv(lf_Log[m], sep=";", header=TRUE)      ##
variable 7

ZV1_table <- read.csv(lf_Log[m], sep=";", header=TRUE)      ##
variable 8

KR1_table <- read.csv(lf_Log[m], sep=";", header=TRUE)      ##
variable 9

DT1_table <- read.csv(lf_Log[m], sep=";", header=TRUE)      ##
variable 10
DT1_Bewer_table <- read.csv(lf_Bew[m], header=TRUE, sep = ";")
## variable 10

#####A1
==1 Variable 1 = Start
## Matrix algorithm
#####
##

## T11 Calculation
## Input file: log (Log_Ana_..._001.csv)

#T11_table <- read.csv("Log_Ana_..._001.csv",sep=";" ,
header=TRUE)

## Calculate the right key press per run (set of 80 lines)
## Positions:
# Column P - last column;
# Count the "RShift" from positions 1-80,81-160,161-240...
# 1- T11_table[1:80,16]
# 2- T11_table[81:160,16]

## Run a loop with 9x80 runs:

LinePosition <- 1
T11_Array <- matrix(1:9)

for (j in 1:9) { ##for j

  RShift_counter <- 0
  for (i in 1:80) { T11 <- T11_table[LinePosition,16] ## start for i
    #print(i)
    #          print (LinePosition)

```

```

#           print(T11)
## if RShift present then increment
if (!is.na(T11) && T11=="RShift"){RShift_counter <-
(RShift_counter+1)}

#           print(RShift_counter)

LinePosition <- (LinePosition+1)

} # end for i
T11_Array[j] <- RShift_counter

} ## end for j
print(If_Log[m])
print(T11_Array)

## Add all values
T11_final <- c(T11_final,T11_Array)

T11_Array <- 0
T11_table <-0

#####A1
==1 -Variable 1 =End

#####A1
==2
## Matrix algorithm
#####
## First approach to calculation of the 10 variables,
## based on the files of the participant: ..._Ana_..._001....csv

## T21 Calculation
## Input file: log (Log_Ana_..._001.csv)

## Calculate the right key press per run (set of 80 lines)
## Positions:
# Column P - last column;
# Count the "BShift" from positions 1-80,81-160,161-240...
# 1- T21_table[1:80,16]
# 2- T21_table[81:160,16]

## Run a loop with 9x80 runs:

LinePosition <- 1
T21_Array <- matrix(1:9)

for (j in 1:9) { ##for j

```

```

BShift_counter <- 0
for (i in 1:80) { T21 <- T21_table[LinePosition,16] ## start for i
#print(i)
# print (LinePosition)
# print(T21)
## if BShift present then increment
if (!is.na(T21) && T21=="Shift both"){BShift_counter <-
(BShift_counter+1)}

# print(BShift_counter)

LinePosition <- (LinePosition+1)

} # end for i
T21_Array[j] <- BShift_counter

} ## end for j
print(If_Log[m])
print(T21_Array)

## Add all values
T21_final <- c(T21_final,T21_Array)

T21_Array <-0
T21_table <-0

#####A1
==2

#####A1
==3
## Matrix algorithm
#####
## First approach to calculation of the 10 variables,
## based on the files of the participant: ..._Ana_..._001....csv

## T31 Calculation
## Input file: log (Log_Ana_..._001.csv)

#T31_table <- read.csv("Log_Ana_..._001.csv",sep=";",
header=TRUE)

## Calculate the right key press per run (set of 80 lines)
## Positions:
# Column P - last column;
# Count the "LShift" from positions 1-80,81-160,161-240...
# 1- T31_table[1:80,16]
# 2- T31_table[81:160,16]

## Run a loop with 9x80 runs:

```

```

LinePosition <- 1
T31_Array <- matrix(1:9)

for (j in 1:9) { ##for j

  LShift_counter <- 0
  for (i in 1:80) { T31 <- T31_table[LinePosition,16] ## start for i
    #print(i)
    # print (LinePosition)
    # print(T31)
    ## if LShift present then increment
    if (!is.na(T31) && T31=="LShift"){LShift_counter <-
(LShift_counter+1)}

    # print(LShift_counter)

    LinePosition <- (LinePosition+1)

  } # end for i
  T31_Array[j] <- LShift_counter

} ## end for j
print(lf_Log[m])
print(T31_Array)

## Add all values
T31_final <- c(T31_final,T31_Array)

T31_Array <- 0
T31_table <-0

#####A1
==3

#####A1
==4 and 5
## Matrix algorithm
#####
## First approach to calculation of the 10 variables,
## based on the files of the participant: ..._Ana_..._001....csv

## T41 Calculation - Time mean; T51 Calculation - Time var
## Input file: log (Log_Ana_..._001.csv)

#T41_table <- read.csv("Log_Ana_..._001.csv",sep=";",
header=TRUE)

T41_time <- as.vector(T41_table[,3])
#split the factor vector into a list

```



```

T41_time2 <-strsplit(T41_time,":")
#merge the list into factor matrix
T41_time3<-do.call(rbind,T41_time2)
#change the factor matrix to numeric matrix by applying as.numeric
function to each column
T41_time3<-data.frame(apply(T41_time3,2,as.numeric)) ###matrix

#check if the values are numeric
str(T41_time3)
#calculate row sums and it to the last column of the data matrix
#T41_time3$all<-rowSums(T41_time3)

# Format time (Excel)
TimeWith720Values <-
(T41_time3[1]*0.041666666666666700000)+(T41_time3[2]*0.00069
4444444444444000)+(T41_time3[3]*0.000011574074074074100)+(T
41_time3[4]* 0.000000011574074074074)

## Run a loop with 9x80 runs to calculate the differences each 80:

#####Matrices

T41_Array <- matrix(1:9)
T51_Array <- matrix(1:9)
T41_1_Array <- matrix(1:79)
T41_2_Array <- matrix(1:79) #
T41_3_Array <- matrix(1:79) #
T41_4_Array <- matrix(1:79) #
T41_5_Array <- matrix(1:79) #
T41_6_Array <- matrix(1:79) #
T41_7_Array <- matrix(1:79) #
T41_8_Array <- matrix(1:79) #
T41_9_Array <- matrix(1:79) #

##### 1

i <- 0

for (j in 2:80) { ##for j

  i <- j-1

  T41_1_Array[i] <- TimeWith720Values[j,1]-TimeWith720Values[i,1]
#80      79      80      79
  #print(j)
  #print(T41_1_Array[i])

} ## end for j

T41_Array[1] <- mean(T41_1_Array)

```

```

T51_Array[1] <- var(T41_1_Array)

##### 2
i <- 0
x <- 1
for (j in 82:160) { ##for j

  i<-j-1

  T41_2_Array[x] <- TimeWith720Values[j,1]-
TimeWith720Values[i,1]
  # 81      1      81      80

  #print(j)
  #print(T41_2_Array[x])
  x <- x+1
} ## end for j

T41_Array[2] <- mean(T41_2_Array)
T51_Array[2] <- var(T41_2_Array)

##### 3
i<-0
x <- 1

for (j in 162:240) { ##for j

  i<-j-1

  T41_3_Array[x] <- TimeWith720Values[j,1]-
TimeWith720Values[i,1]

  #print(j)
  #print(T41_3_Array[x])
  x <- x+1
} ## end for j

T41_Array[3] <- mean(T41_3_Array)
T51_Array[3] <- var(T41_3_Array)

##### 4
i<-0
x <- 1

for (j in 242:320) { ##for j

  i<-j-1

  T41_4_Array[x] <- TimeWith720Values[j,1]-
TimeWith720Values[i,1]

```

```

    #print(j)
    #print(T41_4_Array[x])
    x <- x+1

} ## end for j

T41_Array[4] <- mean(T41_4_Array)
T51_Array[4] <- var(T41_4_Array)

##### 5

i<-0
x <- 1

for (j in 322:400) { ##for j

    i<-j-1

    T41_5_Array[x] <- TimeWith720Values[j,1]-
TimeWith720Values[i,1]

    #print(j)
    #print(T41_5_Array[x])
    x <- x+1

} ## end for j

T41_Array[5] <- mean(T41_5_Array)
T51_Array[5] <- var(T41_5_Array)
##### 6

i<-0
x <- 1

for (j in 402:480) { ##for j

    i<-j-1

    T41_6_Array[x] <- TimeWith720Values[j,1]-
TimeWith720Values[i,1]

    #print(j)
    #print(T41_6_Array[x])
    x <- x+1

} ## end for j

T41_Array[6] <- mean(T41_6_Array)
T51_Array[6] <- var(T41_6_Array)

```

```
##### 7
```

```
i<-0
x <- 1

for (j in 482:560) { ##for j

  i<-j-1

  T41_7_Array[x] <- TimeWith720Values[j,1]-
TimeWith720Values[i,1]

  #print(j)
  #print(T41_7_Array[x])
  x <- x+1

} ## end for j

T41_Array[7] <- mean(T41_7_Array)
T51_Array[7] <- var(T41_7_Array)
```

```
##### 8
```

```
i<-0
x <- 1

for (j in 562:640) { ##for j

  i<-j-1

  T41_8_Array[x] <- TimeWith720Values[j,1]-
TimeWith720Values[i,1]

  #print(j)
  #print(T41_8_Array[x])
  x <- x+1

} ## end for j

T41_Array[8] <- mean(T41_8_Array)
T51_Array[8] <- var(T41_8_Array)
```

```
##### 9
```

```
i<-0
x <- 1

for (j in 642:720) { ##for j

  i<-j-1
```

```

    T41_9_Array[x] <- TimeWith720Values[j,1]-
    TimeWith720Values[i,1]

    #print(j)
    #print(T41_9_Array[x])
    x <- x+1

} ## end for j

T41_Array[9] <- mean(T41_9_Array)
T51_Array[9] <- var(T41_9_Array)

print(lf_Log[m])
print(T41_Array)
print(T51_Array)

## Add all values
T41_final <- c(T41_final,T41_Array)
T51_final <- c(T51_final,T51_Array)

T41_Array <- 0
T41_table <-0
T51_Array <- 0
T51_table <-0
#####A1
==4 and 5

#####A1
==6
## Matrix algorithm
#####
## First approach to calculation of the 10 variables,
## based on the files of the participant: ..._Ana_..._001....csv

## TR1 Calculation - Cumulative "1"
## Input file: log (Bewertung_Ana_..._001.csv)
#C <- Bewertung_Ana_..._001[,7]

#TR1_table <- read.csv("Bewertung_Ana_..._001.csv",
header=TRUE, sep =";")

TR1_Array <- matrix(1:9)

TR1_matrix <- as.matrix(TR1_table[,7])

TR1_Array[1] <- TR1_matrix[1]
TR1_Array[2] <- TR1_matrix[2]
TR1_Array[3] <- TR1_matrix[3]

```

```

TR1_Array[4] <- TR1_matrix[4]
TR1_Array[5] <- TR1_matrix[5]
TR1_Array[6] <- TR1_matrix[6]
TR1_Array[7] <- TR1_matrix[7]
TR1_Array[8] <- TR1_matrix[8]
TR1_Array[9] <- TR1_matrix[9]

print(TR1_Array)

## Add all values
TR1_final <- c(TR1_final,TR1_Array)

TR1_Array <- 0
TR1_table <- 0
TR1_matrix <- 0
#####A1
==6

#####A1
==7
## Matrix algorithm
#####
## First approach to calculation of the 10 variables,
## based on the files of the participant: ..._Ana_..._001....csv

## ZT Calculation - Mean channel 4
## Input file: log (Log_Ana_20160403_001.csv)

#ZT1_table <- read.csv("Log_Ana_..._001.csv",sep = ";",
header=TRUE)

ZT1_Array <- matrix(1:9)

ZT1_matrix <- as.matrix(ZT1_table[,7])

##### 9 Loops

for (j in 1:9) { ##for j    j=1, j=2, j=3

  y <- j-1          #   y=0, y=1, y=2
  a <- y*80+1       #   a=1, a=81, a=161
  b <- a+79         #   b=80,b=160 , a=240

  ZT1_Provisory_matrix <- ZT1_matrix[a:b] # [1:80], [81,160],
[161,240]
  # print(ZT1_Provisory_matrix)
  # print(j)

  ZT1_Array[j] <- mean(ZT1_Provisory_matrix)

```

```

} ## end for j

print(lf_Log[m])
print(ZT1_Array)

## Add all values
ZT1_final <- c(ZT1_final,ZT1_Array)

ZT1_Array <- 0
ZT1_table <- 0
ZT1_matrix <-0
#####A1 ==7

#####A1
==8
## Matrix algorithm
#####
## First approach to calculation of the 10 variables,
## based on the files of the participant: ..._Ana_..._001....csv

## ZV Calculation - standard deviation channel 4
## Input file: log (Log_Ana_..._001.csv)

#ZV1_table <- read.csv("Log_Ana_..._001.csv", header=TRUE)

ZV1_Array <- matrix(1:9)

ZV1_matrix <- as.matrix(ZV1_table[,7])

##### 9 Loops

for (j in 1:9) { ##for j    j=1, j=2, j=3

  y <- j-1          #  y=0, y=1, y=2
  a <- y*80+1        #  a=1, a=81, a=161
  b <- a+79          #  b=80,b=160 , a=240

  ZV1_Provisory_matrix <- ZV1_matrix[a:b] # [1:80], [81,160],
[161,240]
  #print(ZV1_Provisory_matrix)
  #print(j)

  ZV1_Array[j] <- sd(ZV1_Provisory_matrix)

} ## end for j
print(lf_Log[m])
print(ZV1_Array)

## Add all values
ZV1_final <- c(ZV1_final, ZV1_Array)

```

```

ZV1_Array <- 0
ZV1_table <- 0
ZV1_matrix <- 0
#####A1 ==8

#####A1
==9
## Matrix algorithm
#####
## First approach to calculation of the 10 variables,
## based on the files of the participant: ..._Ana_..._001....csv

## KR Calculation
## Input file: log (Log_Ana_..._001.csv)

KR1_table <- read.csv("Log_Ana_..._001.csv", sep = ";",
header=TRUE)

KR1_Array <- matrix(1:9)

KR1_matrix <- as.matrix(KR1_table[,12])
#####
Loops

for (h in 1:9) { ##for h #####
Main Loop ##

  y <- h-1      #
  a <- y*80+1   #
  b <- a+79     #

  KR1_Provisory_matrix <- KR1_matrix[a:b] # [1:80], [81,160],
[161,240]
  # print(KR1_Provisory_matrix)
  # print(h)

  #####
  K0 <- matrix(1:10)
  RL <- 80

  #####

  ##### Theoretical Autocorrelation

  K00 <- 0.5*RL
  for (i in 1:10) { # for i

    j <- (-1/3)^i

```



```

K0[i] <- ((1-j)/4+j/2)*RL

} # for i end
##### Measured
Autocorrelation, case K1[0] (K10)
RL <- 80
K10 <- 0
sk <- 0

for (k in 0:0) { # for k

  for (i in 1:RL)    { # for i

    if (!is.na(KR1_Provisory_matrix[i]) &&
KR1_Provisory_matrix[i]==0) {} else { # else

      j=i+k
      if (j>RL) {j <- i+k-RL}
      if (!is.na(KR1_Provisory_matrix[j]) &&
KR1_Provisory_matrix[j]==0) {} else {sk <- sk+1}

    } # else end

  } # for i end

  K10 <- sk
  sk <- 0

} # for k end

##### Measured Autocorrelation, Cases 1 to
10

RL <- 80

K1 <- matrix(1:10)

sk <- 0

for (k in 1:10) { # for k

  for (i in 1:RL)    { # for i

    if (!is.na(KR1_Provisory_matrix[i]) &&
KR1_Provisory_matrix[i]==0) {} else { # else

      j=i+k
      if (j>RL) {j <- i+k-RL}

```

```

        if (!is.na(KR1_Provisory_matrix[j]) &&
KR1_Provisory_matrix[j]==0) {} else {sk <- sk+1}

    } # else end

} # for i end

K1[k] <- sk
sk <- 0

} # for k end

#####
Deviation from the Theoretical Autocorrelation

KR <- 0

### First case (K00-K10):
KR1 <- KR +((K10-K00)^2)/K00
KR <- KR1

#### Other 10 cases:

for (i in 1:10) { # for i

    KR <-KR +((K1[i]-K0[i])^2)/K0[i]

} # for i end
KR1_Array[h] <- KR

} ## end for h ##### Main Loop

print(If_Log[m])
print(KR1_Array)

## Add all values
KR1_final <- c(KR1_final,KR1_Array)

KR1_Array <- 0
KR1_table <- 0
KR1_matrix <-0
#####A1
==9

#####
#####A1 ==10
## Matrix algorithm
#####
## First approach to calculation of the 10 variables,

```

```

## based on the files of the participant: ..._Ana_..._001....csv

#####
## DT Calculation ##### DT
Calculation####
#####

## Input file: log (Bew_Ana_..._001.csv)

#DT1_table <- read.csv("Log_Ana_..._001.csv",sep = ";",
header=TRUE)

DT1_Array <- matrix(1:9)

DT1_matrix <- as.matrix(DT1_table[,16]) ### Column:
Left/Right/Both ---"LShift" , "RShift", "Shift both"

DT1_col12_matrix <- as.matrix(DT1_table[,12]) ### Column:
Left/Right/Both --- "1" , "0"

##### "l", "m", "r" values
from Bewertung file

#DT1_Bewer_table <- read.csv("Bewertung_Ana_..._001.csv",
header=TRUE, sep =";")

DT1_Bewer_Array <- matrix(1:9)

DT1_Bewer_matrix <- as.matrix(DT1_Bewer_table[,6])

##### 9 Loops

for (h in 1:9) { ##for h #####
Main Loop

  y <- h-1          #
  a <- y*80+1        #
  b <- a+79          #

  DT1_Provisory_matrix <- DT1_matrix[a:b] # [1:80], [81,160],
[161,240] # Col 16
  DT1_col12_Provisory_matrix <- DT1_col12_matrix[a:b] # [1:80],
[81,160], [161,240] # Col 12
  #print(DT1_Provisory_matrix)
  #print(DT1_col12_Provisory_matrix)
  # print(h)

```

```
#####
##### Test DT

tt <- 0
dt <- 0
tr <- 0
T1 <- 0
T2 <- 0
T3 <- 0
TU <- 0

for (z in 1:80) { ## for z loop

  if (!is.na(DT1_Provisory_matrix[z]) &&
DT1_Provisory_matrix[z]=="LShift"){T1 <- T1+1}
  if (!is.na(DT1_Provisory_matrix[z]) &&
DT1_Provisory_matrix[z]=="RShift"){T3 <- T3+1}
  if (!is.na(DT1_Provisory_matrix[z]) &&
DT1_Provisory_matrix[z]=="Shift both"){T2 <- T2+1}

  tr <- tr + DT1_col12_Provisory_matrix[z]

  TU <- 2*DT1_col12_Provisory_matrix[z]-1
  tt <- tt+TU
  if (tt< -10) {tt<- -10}
  if (tt> 17) {tt<- 17}

  if (!is.na(DT1_Bewer_matrix[h]) && DT1_Bewer_matrix[h]=="m")
{dt <- dt +abs(tt)}
  if (!is.na(DT1_Bewer_matrix[h]) && DT1_Bewer_matrix[h]=="l")
{dt <- dt +(17-(tt))}
  if (!is.na(DT1_Bewer_matrix[h]) && DT1_Bewer_matrix[h]=="r")
{dt <- dt +(10+(tt))}

} ## for z loop end

DT1_Array[h] <- dt

} ## end for h ##### Main Loop
print(If_Log[m])
print(If_Bew[m])
print(DT1_Array)

## Add all values
DT1_final <- c(DT1_final,DT1_Array)
```

```

DT1_Array <- 0
DT1_table <- 0
DT1_matrix <-0
#####A1 ==10

    } ## end for m

##### Record data from all variables  ## In fact the following
11 lines of code are not needed...

Final_AllVariables_Array <- list()

Final_AllVariables_Array[[1]] <- T11_final  ## variable 1
Final_AllVariables_Array[[2]] <- T21_final  ## variable 2
Final_AllVariables_Array[[3]] <- T31_final  ## variable 3
Final_AllVariables_Array[[4]] <- T41_final  ## variable 4
Final_AllVariables_Array[[5]] <- T51_final  ## variable 5
Final_AllVariables_Array[[6]] <- TR1_final  ## variable 6
Final_AllVariables_Array[[7]] <- ZT1_final  ## variable 7    #9
Final_AllVariables_Array[[8]] <- ZV1_final  ## variable 8    #10
Final_AllVariables_Array[[9]] <- KR1_final  ## variable 9    #8
Final_AllVariables_Array[[10]] <- DT1_final  ## variable 10  #7
#####
##### "MonteCarlo"/Permutations
#####
###
MonteCarlo <- 0  ## "0" means there is no MonteCarlo, change to
"1" to run "MonteCarlo"
if (MonteCarlo > 0) {  ## If Initial Montecarlo ## Start ##

    #####
    ### shuffling Variable T11 ### 1
    #####

    MaxiLoop <-10000  ## Number of permutations
    #MaxiCol=1801  ## 200 exp*9 +1 (1= initial zero)
    MaxiCol=(NumberOfExperiments*9+1)

    for (rn1 in 1:MaxiLoop) {  ## Variable T11
        posA <- floor(runif(1, min=2, max=MaxiCol))
        posB <- floor(runif(1, min=2, max=MaxiCol))

        Intermediat1 <- T11_final[posA]
        T11_final[posA] <- T11_final[posB]
        T11_final[posB] <- Intermediat1

        # print(posA)
        # print(posB)

```

```

} ## End variable T11

#####
### shuffling Variable T21 ### 2
#####

for (rn1 in 1:MaxiLoop) { ## Variable T21
  posA <- floor(runif(1, min=2, max=MaxiCol))
  posB <- floor(runif(1, min=2, max=MaxiCol))

  Intermediat2 <- T21_final[posA]
  T21_final[posA] <- T21_final[posB]
  T21_final[posB] <- Intermediat2

  # print(posA)
  # print(posB)
} ## End variable T21

#####
### shuffling Variable T31 ### 3
#####

for (rn1 in 1:MaxiLoop) { ## Variable T31
  posA <- floor(runif(1, min=2, max=MaxiCol))
  posB <- floor(runif(1, min=2, max=MaxiCol))

  Intermediat3 <- T31_final[posA]
  T31_final[posA] <- T31_final[posB]
  T31_final[posB] <- Intermediat3

  # print(posA)
  # print(posB)
} ## End variable T31

#####
### shuffling Variable T41 ### 4
#####

for (rn1 in 1:MaxiLoop) { ## Variable T41
  posA <- floor(runif(1, min=2, max=MaxiCol))
  posB <- floor(runif(1, min=2, max=MaxiCol))

  Intermediat4 <- T41_final[posA]
  T41_final[posA] <- T41_final[posB]
  T41_final[posB] <- Intermediat4

  # print(posA)
  # print(posB)
} ## End variable T41

```

```

} ## End variable T41

#####
### shuffling Variable T51 ### 5
#####

for (rn1 in 1:MaxiLoop) { ## Variable T51
  posA <- floor(runif(1, min=2, max=MaxiCol))
  posB <- floor(runif(1, min=2, max=MaxiCol))

  Intermediat5 <- T51_final[posA]
  T51_final[posA] <- T51_final[posB]
  T51_final[posB] <- Intermediat5

  # print(posA)
  # print(posB)

} ## End variable T51

#####
### shuffling Variable TR1 ### 6
#####

for (rn1 in 1:MaxiLoop) { ## Variable T11
  posA <- floor(runif(1, min=2, max=MaxiCol))
  posB <- floor(runif(1, min=2, max=MaxiCol))

  Intermediat6 <- TR1_final[posA]
  TR1_final[posA] <- TR1_final[posB]
  TR1_final[posB] <- Intermediat6

  # print(posA)
  # print(posB)

} ## End variable TR1

#####
### shuffling Variable ZT1 ### 7
#####

for (rn1 in 1:MaxiLoop) { ## Variable ZT1
  posA <- floor(runif(1, min=2, max=MaxiCol))
  posB <- floor(runif(1, min=2, max=MaxiCol))

  Intermediat7 <- ZT1_final[posA]
  ZT1_final[posA] <- ZT1_final[posB]
  ZT1_final[posB] <- Intermediat7

  # print(posA)
  # print(posB)

```

```

} ## End variable ZT1

#####
### shuffling Variable ZV1 ### 8
#####

for (rn1 in 1:MaxiLoop) { ## Variable ZV1
  posA <- floor(runif(1, min=2, max=MaxiCol))
  posB <- floor(runif(1, min=2, max=MaxiCol))

  Intermediat8 <- ZV1_final[posA]
  ZV1_final[posA] <- ZV1_final[posB]
  ZV1_final[posB] <- Intermediat8

  # print(posA)
  # print(posB)
} ## End variable ZV1

#####
### shuffling Variable KR1 ### 9
#####

for (rn1 in 1:MaxiLoop) { ## Variable KR1
  posA <- floor(runif(1, min=2, max=MaxiCol))
  posB <- floor(runif(1, min=2, max=MaxiCol))

  Intermediat9 <- KR1_final[posA]
  KR1_final[posA] <- KR1_final[posB]
  KR1_final[posB] <- Intermediat9

  # print(posA)
  # print(posB)
} ## End variable KR1

#####
### shuffling Variable DT1 ### 10
#####

for (rn1 in 1:MaxiLoop) { ## Variable DT1
  posA <- floor(runif(1, min=2, max=MaxiCol))
  posB <- floor(runif(1, min=2, max=MaxiCol))

  Intermediat10 <- DT1_final[posA]
  DT1_final[posA] <- DT1_final[posB]
  DT1_final[posB] <- Intermediat10

  # print(posA)
  # print(posB)
} ## End variable DT1

```



```

} ## End variable DT1

#####
#####
} ## If Initial Montecarlo ## End ##

##### End MonteCarlo
#####
#####
#

#####
##### Matrix Correlations:

### Variables:

# Variable with number of experience (200 in this test)
#NumberOfExperiments <- 200 ## 200 experiences ## Now in
line 13

# Matrix_Correlation_Array (final size - 45*45)
Matrix_Correlation_Array <- list() # It will have 45 entries, each
with 45 values ## to correlations
Matrix_Correlation_Array_Pvalue <- list() # It will have 45
entries, each with 45 values ## to P-value

# Matrix_T11_Line_Array (provisory array) - to store the
correlation results, 45 values
Matrix_T11_Line_Array <- 0
Matrix_T11_Line_Array_Pvalue <- 0 ## to store p-values
# and the others:
Matrix_T21_Line_Array <- 0
Matrix_T21_Line_Array_Pvalue <- 0 ## to store p-values
Matrix_T31_Line_Array <- 0
Matrix_T31_Line_Array_Pvalue <- 0 ## to store p-values
Matrix_T41_Line_Array <- 0
Matrix_T41_Line_Array_Pvalue <- 0 ## to store p-values
Matrix_T51_Line_Array <- 0
Matrix_T51_Line_Array_Pvalue <- 0 ## to store p-values

# Matrix (sequence of values) with the values to perform the
correlation, "provisory" matrices,
## values coming from variables stored at
Final_AllVariables_Array matrix,
## Size of the sequence of values equal to the number of
participants (13 participants, sequence of 13 values in the array);

```

```

# Psychological variables:
SequenceoFValues_T11_Array <-
matrix(1:NumberOfExperiments) #1
SequenceoFValues_T21_Array <-
matrix(1:NumberOfExperiments) #2
SequenceoFValues_T31_Array <-
matrix(1:NumberOfExperiments) #3
SequenceoFValues_T41_Array <-
matrix(1:NumberOfExperiments) #4
SequenceoFValues_T51_Array <-
matrix(1:NumberOfExperiments) #5
# Physical variables:
SequenceoFValues_TR1_Array <-
matrix(1:NumberOfExperiments) #6
SequenceoFValues_ZT1_Array <-
matrix(1:NumberOfExperiments) #7 #9
SequenceoFValues_ZV1_Array <-
matrix(1:NumberOfExperiments) #8 #10
SequenceoFValues_KR1_Array <-
matrix(1:NumberOfExperiments) #9 #8
SequenceoFValues_DT1_Array <-
matrix(1:NumberOfExperiments) #10 #7

## Extracting the values from
Final_AllVariables_Array/Variable_Final, according with each run
(1..9) for all participantes:
#### Psychological
## Variable T11:
## Variable T21:
## Variable T31:
## Variable T41:
## Variable T51:

for (runs in 1:9) { ## for runs

#   print(runs)
#   print("-----")
  for (ev in 0:NumberOfExperiments-1) { ## for ev
    ## Simulation with run 1
    RunNumber <-(9*ev+runs+1) ## +1 , to avoid the initial
value "0"
    SequenceoFValues_T11_Array[ev+1] <-
(T11_final[RunNumber])
    SequenceoFValues_T21_Array[ev+1] <-
(T21_final[RunNumber])
    SequenceoFValues_T31_Array[ev+1] <-
(T31_final[RunNumber])

```

```

        SequenceoFValues_T41_Array[ev+1] <-
(T41_final[RunNumber])
        SequenceoFValues_T51_Array[ev+1] <-
(T51_final[RunNumber])

    } ## end for ev

    # Re-start RunNumber
    RunNumber<-0

    ## Start Extending (Extracting the run sequences from the
*_Final_Array)

    for (ext in 1:9) { ## for ext

        for (ev1 in 0:NumberOfExperiments-1) { ## for ev1
            RunNumber1 <-(9*ev1+ext+1) ## +1 , to avoid the initial
value "0"
            ##### Physical variables
            ## Variable TR1:
            ## Variable DT1:
            ## Variable KR1:
            ## Variable ZT1:
            ## Variable ZV1:

            SequenceoFValues_TR1_Array[ev1+1] <-
(TR1_final[RunNumber1])
            SequenceoFValues_DT1_Array[ev1+1] <-
(DT1_final[RunNumber1])
            SequenceoFValues_KR1_Array[ev1+1] <-
(KR1_final[RunNumber1])
            SequenceoFValues_ZT1_Array[ev1+1] <-
(ZT1_final[RunNumber1])
            SequenceoFValues_ZV1_Array[ev1+1] <-
(ZV1_final[RunNumber1])

        } # for ev1

        RunNumber1<-0

        ##### Correlations Starts here

        ## Test:

        ###c=cor.test(rank(a[,1]),rank(a[,2]),method = 'pearson')
        ## c$estimate ## correlation
        ## c$p.value ## p-value

        #####

        #1 =corr and p-values
        #print("#1-----T11")

```

```

        xyzw <-
(cor.test(rank(SequenceoFValues_T11_Array),rank(SequenceoFVal
ues_TR1_Array),method="pearson"))
        Matrix_T11_Line_Array <-
c(Matrix_T11_Line_Array,xyzw$estimate)
        Matrix_T11_Line_Array_Pvalue <-
c(Matrix_T11_Line_Array_Pvalue,xyzw$p.value) ## p-value

        xyzw <-
(cor.test(rank(SequenceoFValues_T11_Array),rank(SequenceoFVal
ues_DT1_Array),method="pearson"))
        Matrix_T11_Line_Array <-
c(Matrix_T11_Line_Array,xyzw$estimate)
        Matrix_T11_Line_Array_Pvalue <-
c(Matrix_T11_Line_Array_Pvalue,xyzw$p.value) ## p-value

        xyzw <-
(cor.test(rank(SequenceoFValues_T11_Array),rank(SequenceoFVal
ues_KR1_Array),method="pearson"))
        Matrix_T11_Line_Array <-
c(Matrix_T11_Line_Array,xyzw$estimate)
        Matrix_T11_Line_Array_Pvalue <-
c(Matrix_T11_Line_Array_Pvalue,xyzw$p.value) ## p-value

        xyzw <-
(cor.test(rank(SequenceoFValues_T11_Array),rank(SequenceoFVal
ues_ZT1_Array),method="pearson"))
        Matrix_T11_Line_Array <-
c(Matrix_T11_Line_Array,xyzw$estimate)
        Matrix_T11_Line_Array_Pvalue <-
c(Matrix_T11_Line_Array_Pvalue,xyzw$p.value) ## p-value

        xyzw <-
(cor.test(rank(SequenceoFValues_T11_Array),rank(SequenceoFVal
ues_ZV1_Array),method="pearson"))
        Matrix_T11_Line_Array <-
c(Matrix_T11_Line_Array,xyzw$estimate)
        Matrix_T11_Line_Array_Pvalue <-
c(Matrix_T11_Line_Array_Pvalue,xyzw$p.value) ## p-value

#2
# print("#2-----T21")
xyzw <-
(cor.test(rank(SequenceoFValues_T21_Array),rank(SequenceoFVal
ues_TR1_Array),method="pearson"))
        Matrix_T21_Line_Array <-
c(Matrix_T21_Line_Array,xyzw$estimate)
        Matrix_T21_Line_Array_Pvalue <-
c(Matrix_T21_Line_Array_Pvalue,xyzw$p.value) ## p-value

```

```

        xyzw <-
        (cor.test(rank(SequenceoFValues_T21_Array),rank(SequenceoFValues_DT1_Array),method="pearson"))
        Matrix_T21_Line_Array <-
        c(Matrix_T21_Line_Array,xyzw$estimate)
        Matrix_T21_Line_Array_Pvalue <-
        c(Matrix_T21_Line_Array_Pvalue,xyzw$p.value) ## p-value

        xyzw <-
        (cor.test(rank(SequenceoFValues_T21_Array),rank(SequenceoFValues_KR1_Array),method="pearson"))
        Matrix_T21_Line_Array <-
        c(Matrix_T21_Line_Array,xyzw$estimate)
        Matrix_T21_Line_Array_Pvalue <-
        c(Matrix_T21_Line_Array_Pvalue,xyzw$p.value) ## p-value

        xyzw <-
        (cor.test(rank(SequenceoFValues_T21_Array),rank(SequenceoFValues_ZT1_Array),method="pearson"))
        Matrix_T21_Line_Array <-
        c(Matrix_T21_Line_Array,xyzw$estimate)
        Matrix_T21_Line_Array_Pvalue <-
        c(Matrix_T21_Line_Array_Pvalue,xyzw$p.value) ## p-value

        xyzw <-
        (cor.test(rank(SequenceoFValues_T21_Array),rank(SequenceoFValues_ZV1_Array),method="pearson"))
        Matrix_T21_Line_Array <-
        c(Matrix_T21_Line_Array,xyzw$estimate)
        Matrix_T21_Line_Array_Pvalue <-
        c(Matrix_T21_Line_Array_Pvalue,xyzw$p.value) ## p-value

        #3
        #print("#3-----T31")
        xyzw <-
        (cor.test(rank(SequenceoFValues_T31_Array),rank(SequenceoFValues_TR1_Array),method="pearson"))
        Matrix_T31_Line_Array <-
        c(Matrix_T31_Line_Array,xyzw$estimate)
        Matrix_T31_Line_Array_Pvalue <-
        c(Matrix_T31_Line_Array_Pvalue,xyzw$p.value) ## p-value

        xyzw <-
        (cor.test(rank(SequenceoFValues_T31_Array),rank(SequenceoFValues_DT1_Array),method="pearson"))
        Matrix_T31_Line_Array <-
        c(Matrix_T31_Line_Array,xyzw$estimate)
        Matrix_T31_Line_Array_Pvalue <-
        c(Matrix_T31_Line_Array_Pvalue,xyzw$p.value) ## p-value

```

```

        xyzw <-
        (cor.test(rank(SequenceoFValues_T31_Array),rank(SequenceoFVal
ues_KR1_Array),method="pearson"))
        Matrix_T31_Line_Array <-
        c(Matrix_T31_Line_Array,xyzw$estimate)
        Matrix_T31_Line_Array_Pvalue <-
        c(Matrix_T31_Line_Array_Pvalue,xyzw$p.value) ## p-value

        xyzw <-
        (cor.test(rank(SequenceoFValues_T31_Array),rank(SequenceoFVal
ues_ZT1_Array),method="pearson"))
        Matrix_T31_Line_Array <-
        c(Matrix_T31_Line_Array,xyzw$estimate)
        Matrix_T31_Line_Array_Pvalue <-
        c(Matrix_T31_Line_Array_Pvalue,xyzw$p.value) ## p-value

        xyzw <-
        (cor.test(rank(SequenceoFValues_T31_Array),rank(SequenceoFVal
ues_ZV1_Array),method="pearson"))
        Matrix_T31_Line_Array <-
        c(Matrix_T31_Line_Array,xyzw$estimate)
        Matrix_T31_Line_Array_Pvalue <-
        c(Matrix_T31_Line_Array_Pvalue,xyzw$p.value) ## p-value

        #4
        #print("#4-----T41")
        xyzw <-
        (cor.test(rank(SequenceoFValues_T41_Array),rank(SequenceoFVal
ues_TR1_Array),method="pearson"))
        Matrix_T41_Line_Array <-
        c(Matrix_T41_Line_Array,xyzw$estimate)
        Matrix_T41_Line_Array_Pvalue <-
        c(Matrix_T41_Line_Array_Pvalue,xyzw$p.value) ## p-value

        xyzw <-
        (cor.test(rank(SequenceoFValues_T41_Array),rank(SequenceoFVal
ues_DT1_Array),method="pearson"))
        Matrix_T41_Line_Array <-
        c(Matrix_T41_Line_Array,xyzw$estimate)
        Matrix_T41_Line_Array_Pvalue <-
        c(Matrix_T41_Line_Array_Pvalue,xyzw$p.value) ## p-value

        xyzw <-
        (cor.test(rank(SequenceoFValues_T41_Array),rank(SequenceoFVal
ues_KR1_Array),method="pearson"))
        Matrix_T41_Line_Array <-
        c(Matrix_T41_Line_Array,xyzw$estimate)
        Matrix_T41_Line_Array_Pvalue <-
        c(Matrix_T41_Line_Array_Pvalue,xyzw$p.value) ## p-value

```

```

        xyzw <-
        (cor.test(rank(SequenceoFValues_T41_Array),rank(SequenceoFVal
ues_ZT1_Array),method="pearson"))
        Matrix_T41_Line_Array <-
        c(Matrix_T41_Line_Array,xyzw$estimate)
        Matrix_T41_Line_Array_Pvalue <-
        c(Matrix_T41_Line_Array_Pvalue,xyzw$p.value) ## p-value

        xyzw <-
        (cor.test(rank(SequenceoFValues_T41_Array),rank(SequenceoFVal
ues_ZV1_Array),method="pearson"))
        Matrix_T41_Line_Array <-
        c(Matrix_T41_Line_Array,xyzw$estimate)
        Matrix_T41_Line_Array_Pvalue <-
        c(Matrix_T41_Line_Array_Pvalue,xyzw$p.value) ## p-value

        #5
        #print("#5-----T51")
        xyzw <-
        (cor.test(rank(SequenceoFValues_T51_Array),rank(SequenceoFVal
ues_TR1_Array),method="pearson"))
        Matrix_T51_Line_Array <-
        c(Matrix_T51_Line_Array,xyzw$estimate)
        Matrix_T51_Line_Array_Pvalue <-
        c(Matrix_T51_Line_Array_Pvalue,xyzw$p.value) ## p-value

        xyzw <-
        (cor.test(rank(SequenceoFValues_T51_Array),rank(SequenceoFVal
ues_DT1_Array),method="pearson"))
        Matrix_T51_Line_Array <-
        c(Matrix_T51_Line_Array,xyzw$estimate)
        Matrix_T51_Line_Array_Pvalue <-
        c(Matrix_T51_Line_Array_Pvalue,xyzw$p.value) ## p-value

        xyzw <-
        (cor.test(rank(SequenceoFValues_T51_Array),rank(SequenceoFVal
ues_KR1_Array),method="pearson"))
        Matrix_T51_Line_Array <-
        c(Matrix_T51_Line_Array,xyzw$estimate)
        Matrix_T51_Line_Array_Pvalue <-
        c(Matrix_T51_Line_Array_Pvalue,xyzw$p.value) ## p-value

        xyzw <-
        (cor.test(rank(SequenceoFValues_T51_Array),rank(SequenceoFVal
ues_ZT1_Array),method="pearson"))
        Matrix_T51_Line_Array <-
        c(Matrix_T51_Line_Array,xyzw$estimate)
        Matrix_T51_Line_Array_Pvalue <-
        c(Matrix_T51_Line_Array_Pvalue,xyzw$p.value) ## p-value

```

```

        xyzw <-
(cor.test(rank(SequenceoFValues_T51_Array),rank(SequenceoFVal
ues_ZV1_Array),method="pearson"))
        Matrix_T51_Line_Array <-
c(Matrix_T51_Line_Array,xyzw$estimate)
        Matrix_T51_Line_Array_Pvalue <-
c(Matrix_T51_Line_Array_Pvalue,xyzw$p.value) ## p-value

##### Correlations Ends here

    } ## end for ext

## Defining the line to insert the values
Lines45 <- (runs-1)*5+1

## Feed the final matrix correlation
#1
Matrix_Correlation_Array[[Lines45]] <- Matrix_T11_Line_Array
#   print(Matrix_T11_Line_Array)
Matrix_Correlation_Array_Pvalue[[Lines45]] <-
Matrix_T11_Line_Array_Pvalue ## p-value
#   print(Matrix_T11_Line_Array_Pvalue) ## p-value

#2
Matrix_Correlation_Array[[Lines45+1]] <-
Matrix_T21_Line_Array
#   print(Matrix_T21_Line_Array)
Matrix_Correlation_Array_Pvalue[[Lines45+1]] <-
Matrix_T21_Line_Array_Pvalue ## p-value
#   print(Matrix_T21_Line_Array_Pvalue) ## p-value

#3
Matrix_Correlation_Array[[Lines45+2]] <-
Matrix_T31_Line_Array
#   print(Matrix_T31_Line_Array)
Matrix_Correlation_Array_Pvalue[[Lines45+2]] <-
Matrix_T31_Line_Array_Pvalue ## p-value
#   print(Matrix_T31_Line_Array_Pvalue) ## p-value

#4
Matrix_Correlation_Array[[Lines45+3]] <-
Matrix_T41_Line_Array
#   print(Matrix_T41_Line_Array)
Matrix_Correlation_Array_Pvalue[[Lines45+3]] <-
Matrix_T41_Line_Array_Pvalue ## p-value
#   print(Matrix_T41_Line_Array_Pvalue) ## p-value

#5

```



```

        Matrix_Correlation_Array[[Lines45+4]] <-
Matrix_T51_Line_Array
#   print(Matrix_T51_Line_Array)
        Matrix_Correlation_Array_Pvalue[[Lines45+4]] <-
Matrix_T51_Line_Array_Pvalue ## p-value
#   print(Matrix_T51_Line_Array_Pvalue) ## p-value

# Re-initialize the Variable Lines
Matrix_T11_Line_Array <- 0
Matrix_T21_Line_Array <- 0
Matrix_T31_Line_Array <- 0
Matrix_T41_Line_Array <- 0
Matrix_T51_Line_Array <- 0
Matrix_T11_Line_Array_Pvalue <- 0
Matrix_T21_Line_Array_Pvalue <- 0
Matrix_T31_Line_Array_Pvalue <- 0
Matrix_T41_Line_Array_Pvalue <- 0
Matrix_T51_Line_Array_Pvalue <- 0

} ## end for runs

```

```

##### Extracting PValues from the correlation Matrix

#####
##### Alternative to this block of code at lines 1385-1450 !!!!

### Extracting Pvalues < 0.1
results<-lapply(Matrix_Correlation_Array_Pvalue,function(x)
table(x<0.1))
print("Pvalue < 0.1")
do.call(rbind,results)

### Extracting Pvalues < 0.05
results<-lapply(Matrix_Correlation_Array_Pvalue,function(x)
table(x<0.05))
print("Pvalue < 0.05")
do.call(rbind,results)

### Extracting Pvalues < 0.01
results<-lapply(Matrix_Correlation_Array_Pvalue,function(x)
table(x<0.01))
print("Pvalue < 0.01")
do.call(rbind,results)

### Extracting Pvalues < 0.001
results<-lapply(Matrix_Correlation_Array_Pvalue,function(x)
table(x<0.001))

```

```

print("Pvalue < 0.001")
do.call(rbind,results)

### Extracting Pvalues < 0.0001
results<-lapply(Matrix_Correlation_Array_Pvalue,function(x)
table(x<0.0001))
print("Pvalue < 0.0001")
do.call(rbind,results)

#####
##### Extracting Correlations All Matrix (2025 cells)
#####

InitialColumn <- 2
Corr_Value <-0

for (yyy in 1:40) { ## Start yyy loop ## Correlation Values

  CorrCounterX <-0

  for (zzz in 1:45) { ## Start zzz loop

    RLine <- Matrix_Correlation_Array[zzz]

    RLineNumeric <- as.numeric(unlist(RLine))

    # print(RLineNumericInterval)

    ##### Loop to count the Correlation less than...
    for (jjj in InitialColumn:46) { ## Start jjj loop
      # print(RLineNumericInterval[jjj])

      ## < 1
      if (abs(RLineNumeric[jjj]) < Corr_Value) {CorrCounterX <-
CorrCounterX+1}

    } ## End jjj loop

    # print("----+++++")

  } ## End zzz loop

  ##### Print Correlations:
  #print ("CorrelationValue")

```

```

cat("Correlation Value < ", Corr_Value, "=", CorrCounterX,'\n')

Corr_Value <- Corr_Value +0.01

} ## End yyy loop

#####
##### Extracting PValues All Matrix (2025 cells)
#####
#### Initial column with zeros removed from the results!!!
(InitialColumn <- 2)

InitialColumn <- 2
PValuesCounter01 <-0
PValuesCounter005 <-0
PValuesCounter001 <-0
PValuesCounter0001 <-0

for (iii in 1:45) { ## Start iii loop

  RLine <- Matrix_Correlation_Array_Pvalue[iii]

  RLineNumeric <- as.numeric(unlist(RLine))

  RLineNumericInterval <- RLineNumeric[InitialColumn:46]

  #   print(RLineNumericInterval)

  ##### Loop to count the Pvalues less than...
  for (jjj in 1:length(RLineNumericInterval)) { ## Start jjj loop
    print(RLineNumericInterval[jjj])

    ## <0.1
    if((RLineNumericInterval[jjj]) < 0.1) {PValuesCounter01 <-
PValuesCounter01+1}

    ## <0.05
    if((RLineNumericInterval[jjj]) < 0.05) {PValuesCounter005 <-
PValuesCounter005+1}

    ## <0.01
    if((RLineNumericInterval[jjj]) < 0.01) {PValuesCounter001 <-
PValuesCounter001+1}

    ## <0.001
    if((RLineNumericInterval[jjj]) < 0.001) {PValuesCounter0001 <-
PValuesCounter0001+1}
  }
}

```

```

    } ## End jjj loop

    #    print("----+++++")

} ## End iii loop

##### Print PValues:
print ("Extracting PValues All Matrix")
print ("PValue 0.1:")
print(PValuesCounter01)

print ("PValue 0.05:")
print(PValuesCounter005)

##### Print PValues:
print ("PValue 0.001:")
print(PValuesCounter001)

##### Print PValues:
print ("PValue 0.0001:")
print(PValuesCounter0001)

#####Extracting PValues from diagonal Superior (50%
cells)###
#### Initial column with zeros removed from the results!!!
(InitialColumn <- 2)

InitialColumn <- 2
PValuesCounter01 <-0
PValuesCounter005 <-0
PValuesCounter001 <-0
PValuesCounter0001 <-0

for (iii in 1:45) { ## Start iii loop

    RLine <- Matrix_Correlation_Array_Pvalue[iii]

    RLineNumeric <- as.numeric(unlist(RLine))

    RLineNumericInterval <- RLineNumeric[InitialColumn:46]

#    print(RLineNumericInterval)

    ##### Loop to count the Pvalues less than...
    for (jjj in 1:length(RLineNumericInterval)) { ## Start jjj
loop
        print(RLineNumericInterval[jjj])

        ## <0.1

```

```

        if((RLineNumericInterval[jjj]) < 0.1) {PValuesCounter01
<- PValuesCounter01+1}

        ## <0.05
        if((RLineNumericInterval[jjj]) < 0.05)
{PValuesCounter005 <- PValuesCounter005+1}

        ## <0.01
        if((RLineNumericInterval[jjj]) < 0.01)
{PValuesCounter001 <- PValuesCounter001+1}

        ## <0.001
        if((RLineNumericInterval[jjj]) < 0.001)
{PValuesCounter0001 <- PValuesCounter0001+1}

                                } ## End jjj loop

#   print("----+++++")

    InitialColumn <- InitialColumn +1

        } ## End iii loop

##### Print PValues:
print ("Extracting PValues from diagonal Superior")
print ("PValue 0.1:")
print(PValuesCounter01)

print ("PValue 0.05:")
print(PValuesCounter005)

##### Print PValues:
print ("PValue 0.001:")
print(PValuesCounter001)

##### Print PValues:
print ("PValue 0.0001:")
print(PValuesCounter0001)

#####
##### Extracting PValues from Diagonal Superior excluding
central regions (900 cells) ##
#### Initial column with zeros removed from the results!!!
(InitialColumn <- 2)
InitialColumn <- 7 ## 6 +1 (the zero)
InitialLine <- 1

PValuesCounter01 <-0
PValuesCounter005 <-0
PValuesCounter001 <-0

```

```

PValuesCounter0001 <-0

for (iii in 1:8) { ## Start iii loop ## 8 cycles of 5 lines

  for (bbb in 1:5) { ## Start bbb loop # Sets of 5 lines
    RLine <- Matrix_Correlation_Array_Pvalue[InitialLine]

    InitialLine <- InitialLine+1

    RLineNumeric <- as.numeric(unlist(RLine))

    RLineNumericInterval <- RLineNumeric[InitialColumn:46]

#    print(RLineNumericInterval)
#    print("----+++++++")

    ##### Loop to count the Pvalues less than...
    for (jjj in 1:length(RLineNumericInterval)) { ## Start jjj loop
      #print(RLineNumericInterval[jjj])

      ## <0.1
      if((RLineNumericInterval[jjj]) < 0.1) {PValuesCounter01 <-
PValuesCounter01+1}

      ## <0.05
      if((RLineNumericInterval[jjj]) < 0.05) {PValuesCounter005 <-
PValuesCounter005+1}

      ## <0.01
      if((RLineNumericInterval[jjj]) < 0.01) {PValuesCounter001 <-
PValuesCounter001+1}

      ## <0.001
      if((RLineNumericInterval[jjj]) < 0.001) {PValuesCounter0001
<- PValuesCounter0001+1}

    } ## End jjj loop

  } ## End bbb loop
#  print("----+++++++")

  InitialColumn <- InitialColumn +5

} ## End iii loop

##### Print PValues:
print ("Extracting PValues from Digonal Superior excluding central
regions")
print ("PValue 0.1:")
print(PValuesCounter01)

```

```

print ("PValue 0.05:")
print(PValuesCounter005)

##### Print PValues:
print ("PValue 0.001:")
print(PValuesCounter001)

##### Print PValues:
print ("PValue 0.0001:")
print(PValuesCounter0001)

#####
##### Extracting PValues from Digonal central regions (225
cells) #####
#### Initial column with zeros removed from the results!!!
(InitialColumn <- 2)

# Central blocks : 5x5 squares

# 011111000000000000000000....
# 011111000000000000000000....
# 011111000000000000000000....
# 011111000000000000000000...
# 011111000000000000000000...
# 000000111110000000000000...
# 000000111110000000000000...
# 000000111110000000000000...
# 000000111110000000000000...
# 000000111110000000000000...
# 000000000000111110000000...
# 000000000000111110000000...
# 0.....

InitialColumn <- 2 ## 1 +1 (the zero)
InitialLine <- 1

PValuesCounter01 <-0
PValuesCounter005 <-0
PValuesCounter001 <-0
PValuesCounter0001 <-0

for (iii in 1:9) { ## Start iii loop ## 9 cycles of 5 lines

  for (bbb in 1:5) { ## Start bbb loop # Sets of 5 lines
    RLine <- Matrix_Correlation_Array_Pvalue[InitialLine]

    InitialLine <- InitialLine+1

    RLineNumeric <- as.numeric(unlist(RLine))
  }
}

```

```

RLineNumericInterval <-
RLineNumeric[InitialColumn:(InitialColumn+4)]

#   print(RLineNumericInterval)
#   print("----+++++++")

##### Loop to count the Pvalues less than...
for (jjj in 1:5) { ## Start jjj loop
  #print(RLineNumericInterval[jjj])

  ## <0.1
  if((RLineNumericInterval[jjj]) < 0.1) {PValuesCounter01 <-
PValuesCounter01+1}

  ## <0.05
  if((RLineNumericInterval[jjj]) < 0.05) {PValuesCounter005 <-
PValuesCounter005+1}

  ## <0.01
  if((RLineNumericInterval[jjj]) < 0.01) {PValuesCounter001 <-
PValuesCounter001+1}

  ## <0.001
  if((RLineNumericInterval[jjj]) < 0.001) {PValuesCounter0001
<- PValuesCounter0001+1}

} ## End jjj loop

} ## End bbb loop
#   print("----+++++++")

InitialColumn <- InitialColumn +5

} ## End iii loop

##### Print PValues:
print ("Extracting PValues from Digonal central regions")
print ("PValue 0.1:")
print(PValuesCounter01)

print ("PValue 0.05:")
print(PValuesCounter005)

##### Print PValues:
print ("PValue 0.001:")
print(PValuesCounter001)

##### Print PValues:
print ("PValue 0.0001:")

```



```

print(PValuesCounter0001)

#####
##### Extracting PValues ignoring 2 physical variables (ZT and
ZV) #####
##### Initial column with zeros removed from the results!!!
(InitialColumn <- 2)

# Avoid columns 4th/5th each 5 columns:

# 111001110011100111001110011100....
# 111001110011100111001110011100....
# 111001110011100111001110011100....
# 111001110011100111001110011100....
# 111001110011100111001110011100....
# 111001110011100111001110011100....
# 111001110011100111001110011100....
# 111001110011100111001110011100....
# 111001110011100111001110011100....
# 111001110011100111001110011100....
# 111001110011100111001110011100....
# 111001110011100111001110011100....
# .....

InitialColumn <- 2 ## 1 +1 (the zero)
#InitialLine <- 1

PValuesCounter01 <-0
PValuesCounter005 <-0
PValuesCounter001 <-0
PValuesCounter0001 <-0

for (iii in 1:45) { ## Start iii loop ## 45 lines
  InitialColumn <- 2
  Line <- iii
  RLine <- Matrix_Correlation_Array_Pvalue[Line]
  RLineNumeric <- as.numeric(unlist(RLine))
#   print(RLineNumeric)

  for (bbb in 1:9) { ## Start bbb loop # 9 cycles reading 3 columns

    RLineNumericInterval <-
RLineNumeric[InitialColumn:(InitialColumn+2)]
#     print(RLineNumericInterval)
#     print("----+++++")

    ##### Loop to count the Pvalues less than... Reading the 3
columns
    for (jjj in 1:3) { ## Start jjj loop

```

```

        #print(RLineNumericInterval[jjj])

        ## <0.1
        if((RLineNumericInterval[jjj]) < 0.1) {PValuesCounter01 <-
PValuesCounter01+1}

        ## <0.05
        if((RLineNumericInterval[jjj]) < 0.05) {PValuesCounter005 <-
PValuesCounter005+1}

        ## <0.01
        if((RLineNumericInterval[jjj]) < 0.01) {PValuesCounter001 <-
PValuesCounter001+1}

        ## <0.001
        if((RLineNumericInterval[jjj]) < 0.001) {PValuesCounter0001
<- PValuesCounter0001+1}

    } ## End jjj loop

    InitialColumn <- InitialColumn+5

} ## End bbb loop
# print("----+++++")

#InitialColumn <- InitialColumn +5

} ## End iii loop

##### Print PValues:
print ("Extracting PValues from 3 columns/skipping 2columns")
print ("PValue 0.1:")
print(PValuesCounter01)

print ("PValue 0.05:")
print(PValuesCounter005)

##### Print PValues:
print ("PValue 0.001:")
print(PValuesCounter001)

##### Print PValues:
print ("PValue 0.0001:")
print(PValuesCounter0001)

```

Appendix 11. - Analysis by Dr. Thomas Filk

Analysis of data taken by Ana Borges Flores in
replications of the matrix experiment of Walter von
Lucadou

by Thomas Filk

1 Preliminary remarks

I assume that the matrix experiment as well as the general determination of correlation matrices is known. I mainly describe the results which I obtained for the correlations matrices as well as the comparison with permuted data. It should be emphasized that I wrote all programs for this analysis myself (in C++) using only the standard libraries of C++. All functions related to the determination of the correlation matrix (calculating average values, variances, ranks, and correlations, etc.) have been written by me. I did not copy or transcribe previously existing programs.

As a general remark: The values in the correlation matrices which have been obtained by Ana Borges Flores and the values which I obtain in my analysis differ slightly in non-relevant digits. Very likely the reason is that she uses a program written in R and I use programs written in C++. The accuracies in both programs differ (essentially, my program uses 6 relevant digits when copying data into a file and later reading these data again, while the program of

Mrs. Borges Flores uses more digits) which in the ranking of values can lead to different assignments, in particular when values (by chance) coincide in the analysis which uses less precision. I might run my program again with higher precision in print-outs which will change the ranking correlations slightly

We compared our results for the rankings and for the correlations in study 1 explicitly and found only discrepancies in non-relevant digits which can be attributed to the above mentioned accuracies of the analysis. The overall results and, in particular, the huge differences between experiment and control or between experiment and permuted data were the same. Concerning the different permutation analysis see section 3.

For notation: A study consists of roughly 200 experiments. Each experiment consists of 9 runs. Each run consists of 80 single steps. In each step several psychological and physical data are recorded. However, for the correlation matrix only 5 psychological and 5 physical data are relevant. Further- more, for the correlation matrix only the average value (or total sum) of these data in one run are relevant. The psychological data are: (1) total number of right shift key pressures, (2) total number of left shift key pressures, (3) total number of double key pressures, (4) average time (duration) between two key pressures, (5) variance in duration between key pressures. The physical data are: (1) average deviation of random process from expected value, (2) maximum deviation of the random process relative to instructed target (here, Walter von Lucadou set 17 as a possible upper value of deviations - this value is exceeded only very rarely), (3) deviation of the physical sampling process from the ideal Markov chain behavior,

the so-called KR value (see next paragraph), (4) average voltage output of a particular diode to generate random numbers, (5) average variance of voltage fluctuations of this diode.

The E-correlations matrix is the 45×45 matrix obtained from the correlations of the psychological data (5 different data in 9 runs) with the physical data (5 different data in 9 runs) in the experiment. The C-correlations matrix refers to the 45×45 matrix obtained from the correlations of the psychological data of the experiment with the physical data of the control run.

Note on the KR value: A mathematical analysis of the procedure to obtain the random numbers 0 and 1 (depending on whether the voltage increased or decreased with respect to its previous value) revealed that this is, strictly speaking, not a Markov process. The deviations from a Markov process, however, are so small (less than $1/300$ for the KR values) that it turned out not to be important for this analysis. I used the KR-formula of Walter von Lucadou (but compared also with the correct formula and convinced myself that the results are not changed in any relevant way).

2 Analysis of correlations matrices in the experiments

I received from Ana Borges Flores the following raw data sets:

Study 1: 213 experiments and 213 controls. These data I already received in 2016 after a meeting in Italy. All other data I received recently.

Study 2: 200 experiments and 199 controls. For one experiment I didn't receive a corresponding control file. Therefore, I performed two analyses: one with 200 experiments and for the

missing control (which corresponded to a “Fortsetzungslauf”). I took the same control as for the previous run. In a second analysis I deleted the experiment for which there is no control, leaving me with 199 experiments. The differences were minor.

Study 3: 200 experiments and 200 controls.

Study 4: 100 experiments with the random number generator used by Walter von Lucadou (termed “classic” RNG) and 105 experiments with a new random number generator (termed “true” RNG).

Study 5: 103 experiments with the classic RNG and 101 experiments with the true RNG.

For the three studies (1, 2 and 3) for which control runs were performed, I calculated the correlation matrix of 45×45 (psychological times physical; 5 parameters for each of the 9 runs) normalized ranks of the variables (according to the procedure which will be described in the thesis of Mrs. Borges Flores) obtained from the experiments in this study as well as the 45×45 correlation matrix of the psychological variables obtained from the experiment with the physical variables obtained in the control run.

The most striking effect observed in previous studies of Walter von Lucadou and others was the excess of large correlations in the E-correlation matrix of psychological variables with physical variables (of the same experiment) in comparison with the number of large correlations in the C-correlations matrix, for which the physical variables of the control run were used.

3 Permutation of data sets and comparison

The $45 \times 45 = 2025$ entries in the correlation matrices are not independent. One simple reason is that there are only 2×45 (almost) independent variables for which one calculates correlations. But even these 90 variables are not completely independent because, e.g., more “left key pressures” imply less “right key pressures” etc.

Therefore, it has been suggested to compare the E-correlation matrix with correlation matrices which have been obtained from permutations of the data. This makes the control runs dispensable. In study 4 and 5 no control runs were made and the analysis of studies 1, 2 and 3 show that indeed there is no essential difference between a comparison of psychological data with permuted physical data from the control runs or from the experimental runs. 10.000 permutations were considered as sufficient.

I performed the permutations as follows: I enumerated the experiments in a study (e.g., from 1 to 213 in study 1). Then I associated the 45 psychological data of an experiment with the 45 physical data of an arbitrarily chosen different experiment. For this I made a random permutation of the numbers 1 to 213 and assigned the psychological data of each experiment (1 to 213) with the physical data of the permuted experiments. There was no permutation of data within an experiment, i.e., the order of psychological data and physical data within an experiment remained unchanged. For this permuted set I calculated the correlation matrices as before (for study 1, 2 and 3 I calculated both correlation matrices: the one with the physical data of the experiment and the one with the physical data of the control).

This gave me a total of 10.000 correlations matrices (for study 1, 2 and 3 of E- and C-type). The numbers in the table compare the experimental correlation matrix with these 10.000 correlations matrices obtained by permutation of the physical data as compared to the psychological data. Note however, that I do not shuffle data within an experiment, i.e. psychological data of run 1 are always correlated with the physical data of run 1 (of a permuted experiment), etc.

4 Results

The results for all studies are summarized in the table on the last page. For study 2 I had two data sets: One where I deleted the experimental data for which I do not have the control data (leaving 199 experiments) and one for which I copied the control data also to the “Fortsetzungslauf” for which no genuine control data seem to exist. The table contains the analysis for the 200 data, but for comparison I added the information of the correlations matrices also for the 199 data.

For each study this table gives the following information:

The first line contains threshold values for the correlations. A value of 0.18 means that the subsequent data refer to all correlations which are equal to or above 0.18.

“Exp. (E)” and “Ctrl. (C)” refer to the E-correlations matrix and the C-correlations matrix, respectively. A number of 316 for threshold 0.12 in the line “Exp. (E)” means that 316 entries in the E-correlations matrix are equal or above 0.12, and a number

28 in the row of threshold 0.16 and the line “Ctrl. (C)” means that 28 entries in the C-correlations matrix are equal or above 0.18

The next 4 lines refer to a comparison of the experimental (E) correlations matrix and the control (C) correlations matrix with the E- and C-correlation matrices obtained from 10.000 permutation. ALL means all 10.000 matrices.

(a) “Perm. Exp. $\geq$ E”: In this case the control matrices obtained from 10.000 permutations of the experimental physical data are compared with the E-correlations matrix. A number of 2 in the column of threshold 0.12 means that 2 of the 10.000 correlations matrices used for comparison have more than 316 correlations above threshold 0.12. A 0 below the thresholds 0.14, 0.16, 0.18 and 0.20 means that none of the 10.000 correlations matrices has more correlations above these threshold values as compared to the E-correlations matrix. For very large threshold values some matrices among the 10.000 actually do have more large correlations (equal or above) as the E-correlations matrix. In some combinations such large correlations indeed occur.

(b) “Perm. Ctrl. $\geq$ E”: Same as above but now the numbers refer to the 10.000 permutations of the physical data in the control runs and their matching to the psychological data in the experiments.

(c) “Perm. Exp. $\geq$ C”: This number refers to the number of matrices in the sample of 10.000 correlations matrices

for which the number of correlations is larger than the corresponding value in the C-correlation matrix. The number 7534 for a threshold of 0.12 means: 7534 matrices among 10.000 have more correlations above the threshold 0.12 as the C-correlations matrix, i.e. more or equal than 142.

3

(d) "Perm. Ctrl. $\geq$ C": Same as above but now the 10.000 sample matrices are obtained from correlating permuted physical data with experimental psychological data.

4. The last two lines for a study give the average number of entries in the 10.000 correlation matrices obtained by permuting the physical data of the experiment (Exp.) or the control (Ctrl.) which exceed the corresponding threshold. The two numbers are almost equal. This indicates that it doesn't matter whether we compare the psychological data with randomized physical data from the experiment or with randomized physical data from the control run. And this justifies that in study 4 and 5 no control runs were made but only experimental runs. A comparison with randomized experimental data seems to be sufficient.

The number 83.5 (or 83.9) below threshold 0.14 means that on average a correlation matrix among the sample of 10.000 correlation matrices with permuted data has more than 83.5 entries above the threshold value of 0.14. This explains also why more than half of the 10.000 have more correlations above a threshold of 0.14 as the C-correlation matrix (namely 69) but none has more than 204 entries above this threshold.

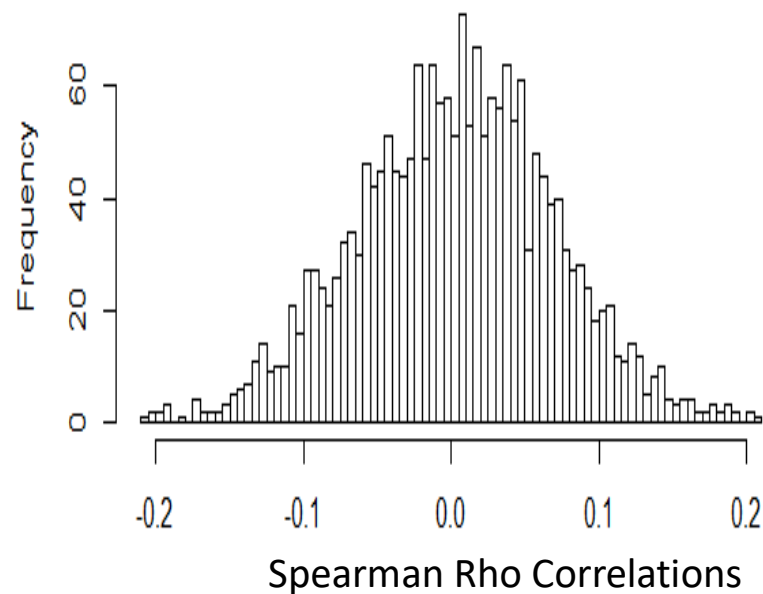
For studies 4 and 5 I distinguished between classical RNG (C) and true RNG (T). There is no comparison with control runs. The first line gives the number of entries in the experimental correlation matrix which exceed the threshold. The second line gives the number of matrices (among 10.000) which have more entries in the correlation matrices of permuted data which exceed this threshold as compared to the experimental correlation matrix. The third line gives the average number of entries in the 10.000 correlation matrices which exceed the corresponding threshold. For study 4C (classic RNG) the situation is reversed as compared to the other studies: the correlations in the experimental matrix are exceptionally small. Studies 4T and 5C and 5T do not show any particular signs of abnormality.

Study	(thresholds)	0.12	0.14	0.16	0.18	0.20	0.22	0.24	0.26	0.28	0.30
1 (213)	Exp. (E)	316	204	124	75	43	24	13	6	2	1
	Ctrl. (C)	142	69	28	12	0	0	0	0	0	0
	Perm. Exp. $\geq$ E	2	0	0	0	0	1	2	15	108	157
	Perm. Ctrl. $\geq$ E	0	0	0	0	0	0	1	17	101	141
	Perm. Exp. $\geq$ C	7534	7524	8178	7514	ALL	ALL	ALL	ALL	ALL	ALL
	Perm. Ctrl. $\geq$ C	7728	7727	8356	7648	ALL	ALL	ALL	ALL	ALL	ALL
	Perm. Exp. (av.)	163	83.5	39.6	17.3	6.96	2.57	0.86	0.26	0.073	0.019
	Perm. Ctrl. (av.)	163	83.9	39.7	17.4	6.96	2.55	0.85	0.26	0.067	0.016
2 (199)	Exp. (E)	286	185	122	69	44	18	11	5	2	2
	Ctrl. (C)	142	74	49	22	7	1	0	0	0	0
2 (200)	Exp. (E)	291	183	115	67	41	16	11	5	2	2
	Ctrl. (C)	138	73	47	21	7	1	0	0	0	0
	Perm. Exp. $\geq$ E	25	26	16	12	10	67	25	76	242	48
	Perm. Ctrl. $\geq$ E	71	56	34	32	24	95	50	92	258	48
	Perm. Exp. $\geq$ C	9328	8709	4870	5001	6465	8910	ALL	ALL	ALL	ALL
	Perm. Ctrl. $\geq$ C	9210	8518	4751	4837	6252	8775	ALL	ALL	ALL	ALL
	Perm. Exp. (av.)	183	97.4	48.0	21.9	9.27	3.61	1.30	0.42	0.126	0.033
	Perm. Ctrl. (av.)	183	97.2	48.0	21.9	9.23	3.58	1.28	0.42	0.130	0.036
3 (200)	Exp. (E)	394	282	206	140	101	69	43	19	8	1
	Ctrl. (C)	235	128	72	36	22	7	3	2	1	0
	Perm. Exp. $\geq$ E	0	0	0	0	0	0	0	0	1	287
	Perm. Ctrl. $\geq$ E	0	0	0	0	0	0	0	0	0	305
	Perm. Exp. $\geq$ C	436	735	531	648	227	1288	1654	877	1001	ALL
	Perm. Ctrl. $\geq$ C	493	790	547	655	218	1318	1598	891	1052	ALL
	Perm. Exp. (av.)	183	97.9	48.3	22.1	9.36	3.62	1.29	0.42	0.125	0.033
	Perm. Ctrl. (av.)	183	97.2	48.0	21.9	9.25	3.60	1.28	0.43	0.131	0.035
4C (100)	Exp. (E)	368	243	153	85	39	18	9	3	0	0
	Perm. Exp. $\geq$ E	9365	9340	9284	9529	9827	9878	9781	9849	ALL	ALL
	Perm. Exp. (av.)	473	333	226	148	93.6	56.8	33.2	18.6	10.0	5.16
4T (105)	Exp. (E)	481	344	222	135	79	39	15	7	2	0
	Perm. Exp. $\geq$ E	3073	2710	3605	4581	5092	6475	8197	8084	8925	ALL
	Perm. Exp. (av.)	449	311	208	133	82.4	48.8	27.8	15.1	7.9	2.73
5C (100)	Exp. (E)	561	410	277	169	101	61	38	21	13	4
	Perm. Exp. $\geq$ E	1491	1452	1846	2740	3361	3457	3011	3096	2478	4055
	Perm. Exp. (av.)	466	326	221	144	90.4	54.7	31.7	17.7	9.46	4.88
5T (105)	Exp. (E)	526	374	258	160	88	51	29	14	6	2
	Perm. Exp. $\geq$ E	1648	1813	1945	2785	4340	4518	4446	4961	5437	6404
	Perm. Exp. (av.)	457	318	214	138	86.1	51.5	29.4	16.2	8.49	4.30

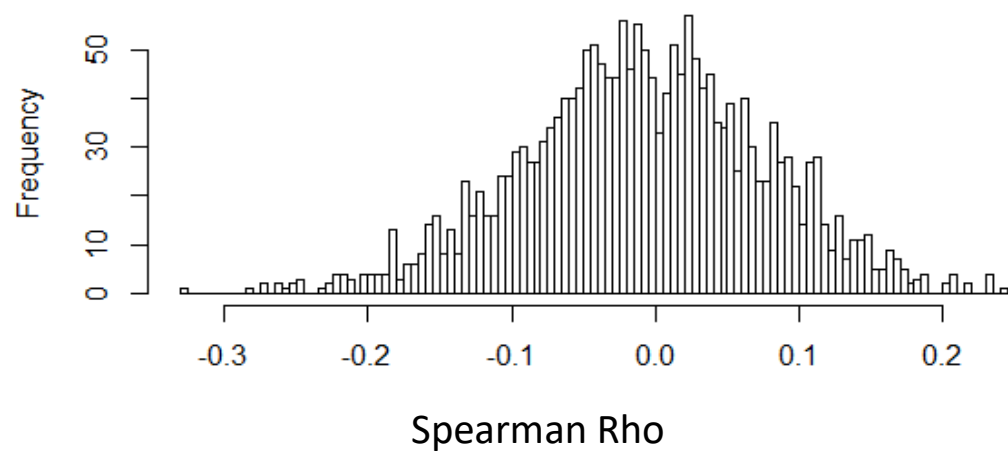
Appendix 12 – Data normal distribution

1

Histogram of Permutations

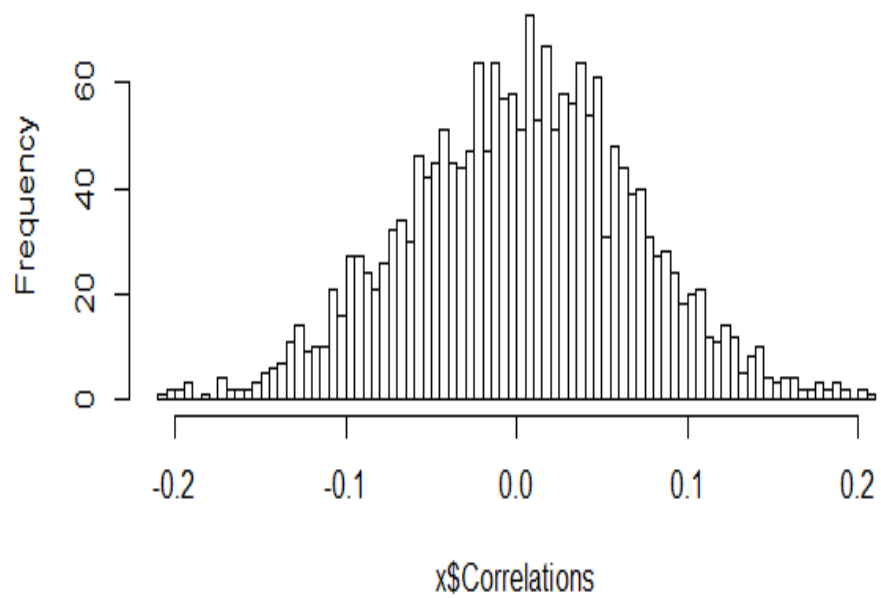


Histogram of CE experiment



Study 1

Histogram of x\$Correlations



Histogram of x\$Correlations

