

## 1) Hypothesis

The goal of this study is to test whether a directed psychophysical influence on the outcome of quantum experiments by a conscious observer is possible. It therefore constitutes a test of the randomness postulate in quantum mechanics.

One of the toughest mysteries of quantum mechanics is regarding the so called measurement problem. According to quantum physics quantum states such as the position of an electron or photon consist of different superposed eigenstates as shown in the famous double-slit experiment. Surprisingly every actual measurement of the position still always reveals one defined result. Early on von Neumann reached the conclusion that a measurement must constitute of something more than the formation of a correlation between object and measurement device. He proposed a different process, which only comes into effect during a measurement: the state reduction or wavefunction collapse (Neumann, 1932). However this process follows a fundamentally different dynamic, since it is discontinuous and introduces a probabilistic element to the theory. Physical laws seem to depend on whether the process is a measurement or not.

It is not clear yet how to interpret a superposition of states or a measurement process and different interpretations give varying answers. For many physicists and other scientists though quantum mechanics seem to possess some kind of intrinsic relation with the human mind, since it can be argued that the wave function collapses not until it interacts with consciousness (e.g. von Neumann, 1932; Wigner, 1967; Stapp, 2007). This close connection between consciousness and the transition from the quantum state to the classical state could allow a directed influence on the selection of the realized eigenstate: a mind-matter-interaction.

This study aims to understand this mechanism in close connection to far-eastern teachings like Daoism and Mahayana-Buddhism. A central aspect in these teachings is meditation as an entry point to transcendental states of experience and even supernatural-like abilities. Shared characteristics between meditative states of consciousness and properties of quantum mechanics consist for instance of an altered time perception, a simultaneous experience of different states as one or abilities that seem inexplicable from a classical physical point of view but could find a basis in certain quantum properties (e.g. so-called precognition, telepathy, psychokinesis). Meditation could therefore serve as a catalyst for mind-matter-interactions based on quantum mechanical principles.

In this study we will use a loving-kindness meditation, which focuses on a specific emotional state. People in this meditative state could show a significant different influence on preferring quantum states that are associated with the emotion. We hypothesize that this effect is stronger with skilled meditators.

H1: People who are currently practicing a loving-kindness meditation will influence the outcome of a quantum based random number generator (QRNG) in a way that generates more meditation-related sounds than chance would suggest.

H2: People who have experience with meditation will influence the outcome of a QRNG more than unskilled meditators.

H0: Practicing a loving-kindness meditation will not influence the outcome of a QRNG and it will generate sounds at random (50/50 probability).

## 2) Dependent variable

Our dependant variable will constitute of the number of meditation-related sounds. These consist of 6 different singing bowl sounds in f-key and a chanted "Yam"-sound. In spiritual acoustics the f-key corresponds with the frequency of the heart chakra, which according to yogic teaching is responsible for the experience and processing of love and kindness and related emotions. The chanted "Yam"-sound is one of the seven Bija-mantras and is attributed to the heart-chakra as well (Bodian, 2007). We chose to offer a range of similar but slightly varied sounds to keep the experimental part pleasant and lively.

Depending on the outcome of the QRNG participants will either hear one of these meditation-related stimuli or a meaningless sound consisting of white noise.

## 3) Method

The experiment will examine the influence of the meditative state on experienced meditators and participants without prior meditation experience. A classical control group is not required since the independent functioning of the randomness process is already well established (Turiel, 2007).

The following method will be used:

**Software and Computer:** The study will be conducted on different sets of laptops in combination with quantum random number generators (QRNG). A software accesses the output of the QRNG and plays either a random sound out of the meditative sounds set or white noise, depending on the result of the quantum experiment inside the QRNG. The sounds will be played to the participants via headphones.

**Quantum state generation:** It is crucial for this experiment to create a truly random event. Since software RNGs are deterministic and therefore cannot be seen as "true" RNGs we rely on an external hardware RNG that passes elaborate tests of randomness like the DIEHARD oder NIST tests (Turiel, 2007). The QRNG from id Quantique that we will use in this experiment passes these tests of randomness. This means the generator's results cannot be predicted (or influenced) in any other way than through a psychophysical mechanism that connects mind and matter during the transition from the quantum state to the classical state.

To create a random event in the form of a quantum experiment, this device will create a quantum state consisting of two eigenstates that correspond with the two possible states of a bit (0/1) that is transferred to the computer. A 0 bit will lead to the playback of a white noise sound while a 1 bit will lead to the playback of a target stimuli. The QRNG is connected to the laptop via USB. Since it is not operating with a buffer, it is ensured that the bit that decides which stimulus will be played is generated directly prior to the playback of the sounds.

**Procedure:** The participants will be tested individually in a quiet and distraction-free environment. The experimenters will introduce themselves and read a standardized instruction, which reads as follows:

*Herzlichen Dank für die Teilnahme am Experiment!*

*Der Gesamte Versuch dauert etwa 30 min. Falls Sie sich zu irgendeinem Zeitpunkt unwohl fühlen, können Sie das Experiment, wenn Sie wollen, jederzeit abbrechen.*

*Der erste Teil besteht aus einer geführten Meditation der Liebenden Güte. Wählen Sie hierfür bitte Ort und Zeit so, dass Sie ruhig und ungestört sind und sich ganz auf die Meditation einlassen können.*

*Auf die geführte Meditation der liebenden Güte folgt nach einer kurzen Pause im zweiten Teil des Experiments eine Klangmeditation. In dieser werden Ihnen für etwa 14 Minuten verschiedene Klänge vorgespielt. Ihre Augen können während der Klangmeditation gerne geschlossen bleiben.*

*Lassen Sie sich ganz auf das Hören der Klänge ein und versuchen Sie währenddessen weiterhin die Empfindungen aus der Meditation wahrzunehmen und die Gefühle von Liebe, Wärme und Herzengüte in sich zu spüren.*

*Es kann sein, dass während der Meditation und der Klänge unterschiedliche Gefühle und Empfindungen wie zum Beispiel Unruhe in Ihnen aufkommen und Sie möglicherweise Liebe und Herzengüte anfangs nicht so bewusst in sich wahrnehmen.*

*Falls dies so ist, machen Sie sich keine Gedanken. Die Meditation der liebenden Güte entfaltet Ihre Wirkung, auch wenn Sie es vielleicht anfangs nicht gleich spüren – manchmal schieben sich eben ein paar Wolken vor die Sonne und es braucht etwas Zeit und Geduld, bis sie weiterziehen. Nehmen Sie einfach war, was da ist und heißen Sie es Willkommen, so wie jetzt in diesem Moment gerade ist.*

*Wenn die Musik am Ende verklungen ist, wenden Sie sich bitte an den Versuchsleiter um den kurzen Fragebogen auszufüllen. Dies wird nochmals etwa 5 Minuten in Anspruch nehmen.*

*Herzlichen Dank!*

To begin with, participants will listen to a guided loving-kindness meditation which will then transition to the experimental part and the playback of the sounds. Participants will listen to a total of 100 sounds before they will hear the ending of the guided meditation and will finally be asked to fill out a questionnaire. All sounds are 5 seconds long and are edited to fade out. The experiment and the questionnaire should take about 25-30 mins.

#### **4) Analyses and Sample Size**

Data will be analysed with a Bayesian one sample t-test to test whether the number of meditation-related sounds is significant greater than chance would suggest (50%). For various reasons Bayesian statistics is preferred by many authors to examine so-called psi phenomena (see Wagenmakers, 2011).

Therefore suggestions by Wagenmakers will be followed regarding sample size estimation, data collection, and data analyses:

1. A Bayesian one sample t-test, with a one-tailed approach and a  $r = .1$  from the Cauchy distribution will be performed
2. After a minimum of 50 subjects, the Bayes factor is monitored continuously after each subsequent participant (i.e. after  $n=51$ , again after  $n=52$ , etc.) until it supports  $H_0$  or  $H_1$ , passing the threshold for strong evidence (BF 10 and BF 1/10).

Thus, evidence can be monitored until the data either support  $H_0$  or  $H_1$ . We expect the skilled meditators to perceive significantly more meditation-related stimuli than a truly random distribution would suggest. We expect to find a slightly weaker effect with non-meditators in the same direction.

Prior research with similar hypothesis suggests an effect size of about  $\delta = 0.25 - 0.3$  which corresponds to a relative deviation of about 1.4-1.5% from the random value.

## References:

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