# Mind and matter correlated in a matrix. New replication using an online game

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## Abstract

The study investigates the interaction between mind and matter by exploring correlations between psychological behaviour with a physical system. Psychological data, acquired during task performance, and physical variables from a random number generator are combined into matrices for joint analysis. The research aims to examine the statistical distribution of matrices generated in experimental sessions compared to control sessions.

A total of 726 participants from over 50 countries engaged in an online game via touchscreen device (mobile or tablet), yielding data from 10.964 studies. Random number generators Random.org (5.330 studies) and Mersenne twister (5.634 studies) were utilized, resulting in the analysis of 10.525.440 psychological variables and 21.050.880 random values as physical variables.

Random number generator data were analysed separately. The analysis using Random.org indicated statistically significant differences between experimental and control sessions when employing a matrix with 4096 cells (64x64). The Welch's T-test yielded a value of 3,811, with a corresponding p-value of 0,00013. The achieved power was high at 94%, while the effect size reached 0,0842, above the required minimum meaningful effect size of 0,0716. The analysis using Mersenne Twister did not exhibit statistically significant differences concerning the same matrix (64x64). The Welch's T-test resulted in a value of 1,813, with a corresponding p-value of 0,06987. The achieved power stood at 67%, while the effect size attained was 0,0400, falling short of the minimum meaningful effect size required which was 0,0716.

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**Keywords:** Mind and matter, Correlation matrix, Random number generator, online game.

## Introduction

Theories of mind-matter interaction have long captivated the scientific community, leading to the development of experimental models to test these theories. One such model aims to replicate mind-matter interaction by correlating psychological variables produced by a participant with physical variables of a system. The Correlation Matrix Method (CMM), developed by von Lucadou (1986), investigates mind-matter interaction by examining correlations between psychological systems, such as participant mental influence, and physical systems, such as a random number generator (RNG). The CMM lies in the Generalized Quantum Theory (Atmanspacher et al., 2002; Filk & Romer, 2011; Walach et al., 2014) and the Theoretical Model of Pragmatic Information (MPI) (von Lucadou, 1995), which hypothesizes that correlations between psychological and physical systems represent non-local manifestations of anomalous effects. Unlike standard experiments, the Correlation Matrix Method does not focus on success rates or chance expectations. Instead, it generates a correlation matrix of physical and psychological variables across experimental conditions, creating a cell matrix with all data where significant correlations are highlighted and their distribution throughout the experimental session is examined. The experimental matrix is then compared to a control matrix generated without participant intervention. According to Lucadou (1986), the hypothesis is that more significant correlations will be observed during experimental sessions compared to control sessions. Previous studies using this paradigm have reported successful results (Lucadou, 1986, 1991, 2006; Walach, 2015, 2020; Flores, 2017, 2018). However, a new statistical analysis based on Monte Carlo simulations was proposed to address a weakness in these studies. It was found that psychological variables exhibited high intercorrelations, and simulations provided a means to overcome the statistical dependence that may have influenced the initial significant results. When simulations of data were incorporated, the results from these studies diminished. Nonetheless, Flores still reports significant results in three out of five studies conducted during her doctoral research (Flores, 2021).

The present study aims to explore the statistical distribution disparity between matrices derived from experimental sessions and those from control sessions. It seeks to overcome previous limitations by implementing a novel approach that involves: A) Implementing a new setup using an online game running on mobile touchscreen devices to capture fresh psychological variables that reflect participant behavior during task performance. B) integrating two additional random number generators (RNGs) while replicating the conceptual Correlation Matrix Method. C) Implementing a new statistical analysis method. Prior to data collection the new software was validated (Flores, 2018).

## Methods

### Participants

A total of 726 participants from over 50 countries, contributed to 10.964 online experimental sessions conducted between March and May 2022. Participants were recruited from different pools, including colleagues and friends, Portuguese academic institutions such as University Polytechnic of Bragança and University of Minho, and social platforms like

Facebook groups, and micro job platforms (Rapid workers, Zeerk, Fiverr). While some participants volunteered, those using micro job platforms received a payment of 10 cents per experimental session. The study received ethical approval from the University of Braga Ethics Committee.

## The Experiment

The experimental setup was purposefully designed for this study, employing an online mobile game exclusively designed for touchscreen devices like smartphones or tablets. Finger swipes on the touchscreen constituted psychological variables, as data generated from keyboard devices did not meet the study's criteria. The game environment was designed to be engaging and user-friendly, featuring colourful items and a character named Morgana for closeness. Participants used a finger to manoeuvre the Morgana through a maze, collecting items in a roughly 3-minute session. The maze comprised 100 cells in a 10x10 configuration, with items placed randomly. Each session consisted of 240 touchscreen moves and progressed through nine levels. Upon reaching 240 moves, the experimental session concluded, initiating the subsequent control session.

The placement of items and the selection of the random number generator (RNG) was determined using the Math.random function in JavaScript.

Both sessions ran on the participant's device, and data files were stored on a dedicated online server until downloaded for analysis. Participants could contribute multiple sessions as the game was available online. For consecutive sessions, RNGs were interspersed. Game documentation on Appendix 1
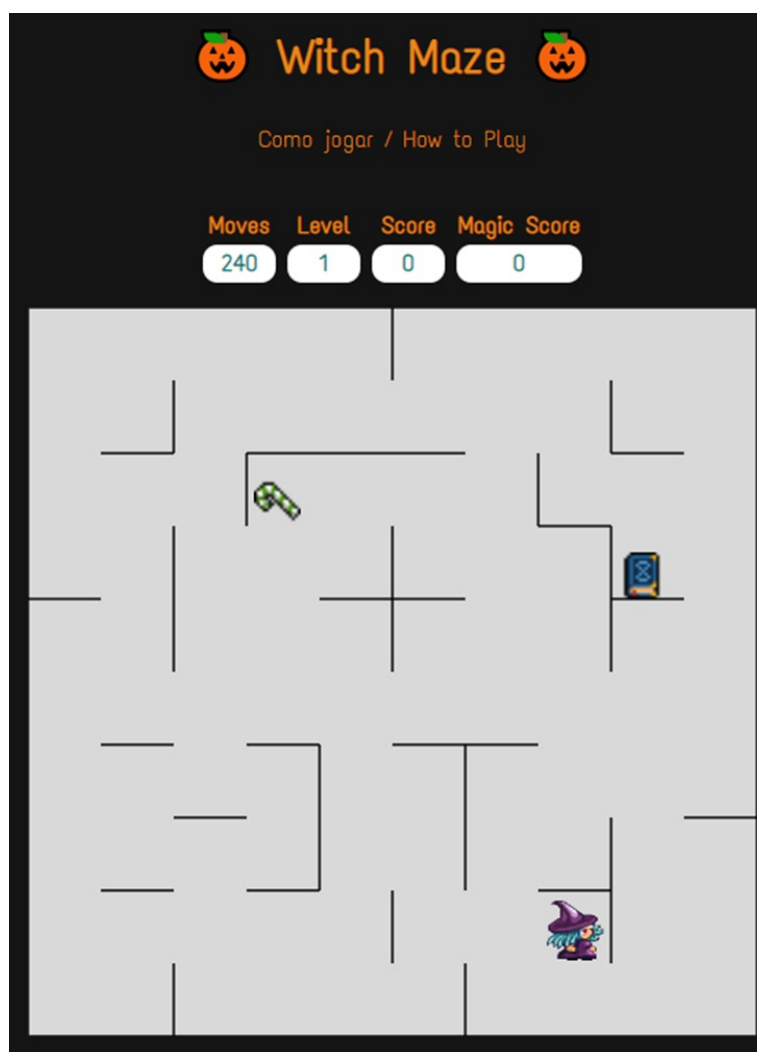
## Game Screen

**Figure 1.** Witch Maze screenshot showing the first screen with the "How to play" click button, where instructions to play can be reached throughout the game; number of available moves, 240; Level 1; Score 0; Magic Score 0. In each level number of items adds 2 (2xn, n=level). The participant must move the witch by finger swipes.

The game is freely available at https://witch-maze.herokuapp.com.

The Software source is freely available at https://github.com/adenild/witch-maze.

## Experimental session

An experimental session involved the online game, where participants swiped the screen to move the character (Morgana) to collect maze items. Upon accessing the online game, participants encounter the Data Privacy screen outlining the study's privacy policy. Agreeing to the privacy policy is mandatory to proceed with the session.

The subsequent screen provides instructions on how to play. These instructions remain accessible throughout the game by clicking the "How to Play" button located at the top of the screen. Participants are instructed to mental influence

Morgana and gather all the objects that appear within the maze. Upon completing the session, a screen appears stating: "Would you like to play again?" with answers "Yes" and "No" below. Selecting "yes" leads the participant to start a new game from the beginning.

The study software randomly selects one of two available random number generators for the first experimental session. Subsequent sessions featured interspersed RNGs if participants played multiple times.

## Control Session

For each experimental session, a corresponding control session is generated. This control session runs automatically on the participant's device after the completion of the experimental session without their knowledge. The participant remained unaware of the control session's execution, as it operated in the background.
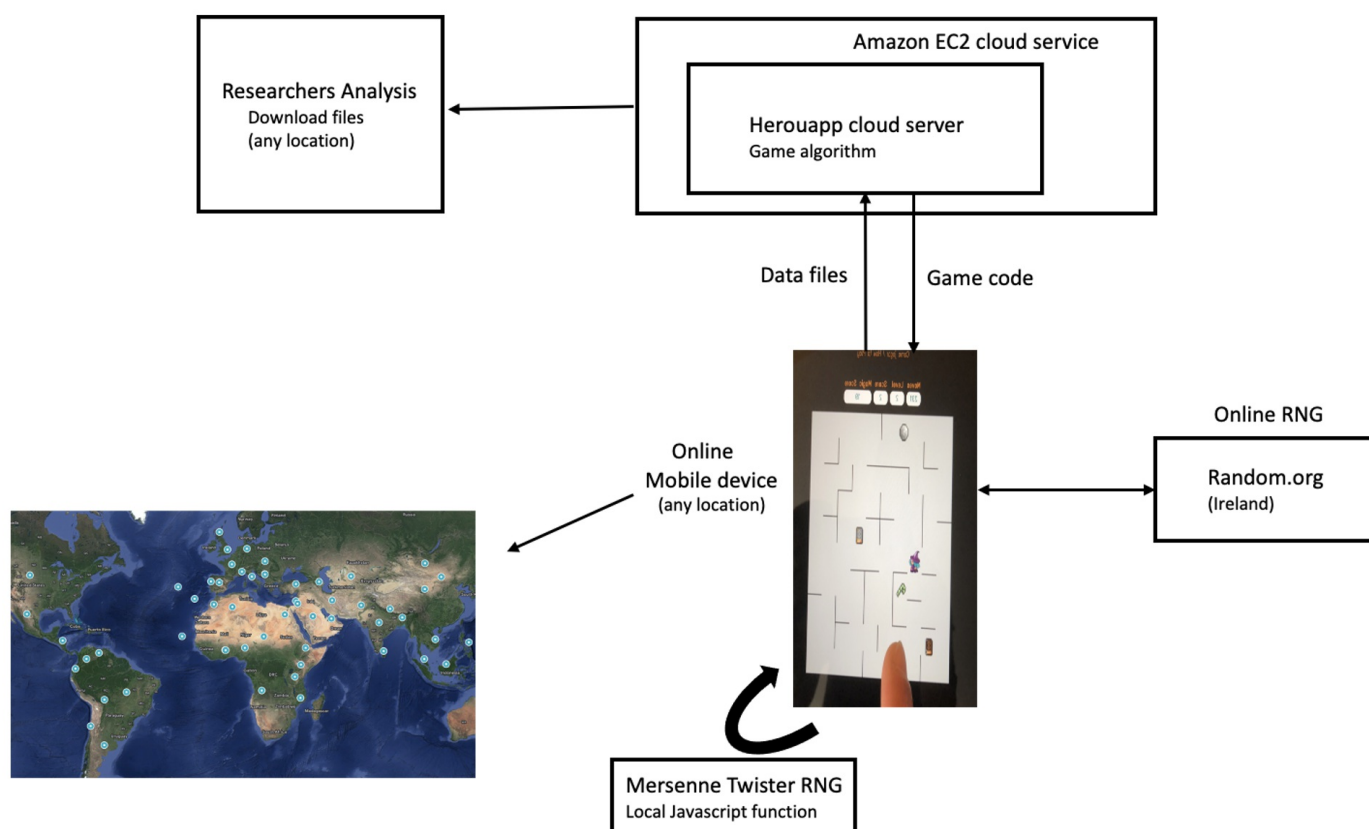


**Figure 2.** Game network architecture, displaying participant-contributed session locations, a screenshot of the game in progress, and the positions of both the RNG and server hosting the software.

## Outcome Variables

## Psychological Variables

Psychological variables were recorded through participant finger swipes on the touch screen device during the experimental session. Seven psychological variables were recorded: "swipeCoordXFinish", end position of the X coordinate on the swipe; "swipeCoordXStart", start position of the X coordinate on the swipe; "swipeCoordYFinish" (SF), end position of the Y coordinate on the swipe; "swipeCoordYStart", start position of the Y coordinate on the swipe; "swipeDistance" (SD), swipe distance in pixels; "swipeTime" (ST), duration time of the swipe in milliseconds; Timestep (TS), time between the player's last two moves in milliseconds.

A Pearson correlation test was conducted to select four variables with the lowest correlations for inclusion in the study. The Psychological variables identified with low correlation (0,002; 0,004; 0,021; 0,12; 0,21) were:

- "swipeCoordXFinish" (sF), end position of the Y coordinate on the swipe (units: pixels).
- "swipeDistance" (sD), length between start and end coordinates. (units: pixels).
- "swipeTime" (sT), duration time of the swipe. (units: milliseconds).
- "timestep" (Ts), time between the player's last two moves. (units: milliseconds).

| | swipeCoord XStart | swipeCoord YStart | swipeCoord XFinish | swipeCoor dYFinish | Swipe distance | Swipe time | Time step |
|---|---|---|---|---|---|---|---|
| swipeCoordXStart | 1 | | | | | | |
| swipeCoordYStart | | 1 | | | | | |
| swipeCoordXFinish | 0,9854 | 0,4905 | 1 | | | | |
| swipeCoordYFinish | 0,4876 | 0,987 | | 1 | | | |
| Swipe distance | 0,2034 | 0,1043 | 0,2123 | 0,11 | 1 | | |
| Swipe time | -0,0043 | -0,0296 | -0,0044 | -0,0302 | -0,022 | 1 | |
| Time step | 0,0024 | -0,0152 | 0,002 | -0,0158 | -0,212 | 0,1259 | 1 |

**Table 1.** Pearson correlation between psychological variables

## Physical Variables

Physical variables were generated during both the experimental and control sessions. In the experimental session, each participant's finger swipe communicated with the RNG, generating four random numbers per swipe - a total of 960 random values per experimental session. The same RNG used in the experimental session produced 960 random values when the control session was activated. Physical variables, labelled V1, V2, V3, and V4 ranged between 1 and 3 and were created by either Random.org or Mersenne Twister RNG.

## Data recording

All data related to experimental and control sessions, generated by the random number generators, and relevant

information were recorded and saved in files outlined in Appendix 2.

## Computing and software description

Analyses were conducted on a MacBook Pro (2,6 GHz 6-Core Intel Core i7 and 16 GB 2667 MHz DDR4). Twelve RStudio (1.1.456 version) environments were installed and cloned in Anaconda Navigator 2.1.4 desktop graphical interface. Quality control and some complementary tests were performed using bash command-line tools and Python algorithms within the SPYDER IDE 5.3.0 environment. Matrix construction and statistical analysis were performed using the R programming language. Python algorithms were developed to download game files from web servers. Sensitivity power analysis performed with G*Power version 3.1. (Faul, F., et al., 2009; Bartlett, J.E., 2021).

## Quality control of games after data collection

Prior to analysis, a data quality check removed incomplete files, and files associated to sessions played in desktop computers instead of touchscreen devices. A total of 772 files were removed, corresponding to 389 experimental sessions. Following quality control, 10,964 experimental files remained: 5.330 using Random.org and 5.634 using Mersenne Twister.

## Random Number Generator

The experiment utilized two random number generators, Random.org and Mersenne Twister to explore the possibility of obtaining different effects with the generated randomness. The option for this study was to use well studied and accepted RNGs, both producing random values between 1 and 3 (Kenny, C., 2012). Data were analyzed separately to compare effects of different types of randomness in the study.

## Random.org

An online true random number generator developed by Mads Haahr (1998, 1999), Random.org uses atmospheric noise picked up by a radio tuned to a frequency with no broadcasting. It has passed the NIST suit of randomness statistical tests, making it a reliable choice.

## Mersenne Twister

Developed by Matsumoto and Nishimura (1998) Mersenne Twister was selected for its consistency in meeting requirements for Monte Carlo simulations; uncorrelated sequences, long period and uniformity (Ghersi et al., 2017; Hongo, K., et al., 2010). It is deterministic, but we utilized participant finger swipes to provide a timestamp seed, ensuring true non-deterministic random values.

## Building correlation matrix

Following the von Lucadou correlation matrix method, two correlation matrices were constructed: one with experimental data and another with control data. The matrices correlated psychological variables with physical variables using Spearman correlation. The experimental matrix incorporated data from the experimental session, while the control matrix included psychological variables from the experimental session correlated with physical data generated exclusively during the control session. Previous studies, (Lucadou, 2006, Walach, 2020 & Flores, 2021) used a matrix size of 45X45 variables corresponding to 2045 cell matrix. For this study a bigger correlation matrix was built with 64X64 size corresponding to 4096-cell matrix. To construct the matrix, 240 elements of each variable were fragmented in 16 groups of columns with 15 elements per column, for each of the 4 variables.

## Statistical analysis

The study entailed a comparison between the distribution of correlations derived from experimental and control sessions using Welch's T-test, assuming the normal distribution of the data. Moreover, Cohen's effect sizes (d) related to the Welch test were computed within the CMM context.

Given the absence of a reference effect size in the CMM, we executed sensitivity analysis utilizing G*Power software. This process involved computing the critical effect size based on alpha, Beta (where power equals 1-Beta), and the quantity of matrix cells. This analysis allowed us to determine the minimum meaningful effect size required for detecting disparities (Bartlett, J.E., 2021). Subsequently, Monte Carlo simulations and power analyses were performed to validate the findings. Notably, we gave particular emphasis to results associated with the last datapoint and average datapoints, thus warranting their inclusion in our discussion.

Matrix analyzes were performed separately for the Mersenne Twister and Random.org random number generators (RNGs). To understand the impact of the number of experimental sessions per matrix, an increment method was employed, adding sets of 250 sessions to create a matrix. The initial matrix comprised the first 250 sessions, followed by the second with 500 sessions, the third with 750 sessions, and so forth, until reaching the total number of sessions: 5.330 for Random.org (22 datapoints or matrices) and 5,634 for Mersenne Twister (23 datapoints or matrices). The last data point in both analyses includes data from all experimental studies, representing the result of the analysis. The null hypothesis, suggesting no difference in the distribution of both matrices, is rejected if: a) p-value < 0,05 (≈ t-test = 2), and b) Beta =<0,1 (power >= 0,9), and c) the effect size achieved should be above the minimum meaningful effect size obtained in sensitivity power analysis.

Moreover, the study employed a double-blind condition, ensuring participants remained unaware of the random choices in the study. Researchers also lacked control over the randomness, eliminating experimental biases arising from participant expectations.

Following Welch T-tests and effect sizes studies, Monte Carlo simulations were performed for additional validation. These simulations provide an empirical method for evaluating estimators under various conditions, investigating properties of the distributions of random variables through simulated random numbers (Paxton et al, 2014; Gentle, 1985). Consequently,

the Monte Carlo simulation consists of one stage involving only physical variables: 1) Physical variables generated during both the experimental session and control run are shuffled before constructing the correlation matrix, followed by a Welch t-test comparison between both shuffled matrices. This condition is essential to reproduce probable distributions of experimental sessions.

The shuffling was implemented using the R *sample* command (Ripley, B.D., 1987).

The decision to shuffle the variables generated during the experimental session maintained the original distribution properties, an essential requirement for Monte Carlo simulations (Chang, C., 1994). Given that the primary goal of this analysis as to generate estimates of the mean output, a small number of replications, less than 100 simulations, is sufficient (Bonate, P., 2001). Therefore, the current study employed 100 simulations, which were adequate to provide a clear estimate of the mean output.

## Results

The statistical analysis performed were A) Welch T-tests and effect sizes, B) Monte Carlo simulations and respective Monte Carlo Power. The results are presented in the following figures.

**A.1) Results from analysis with Welch T-test for the RNG Random.org**
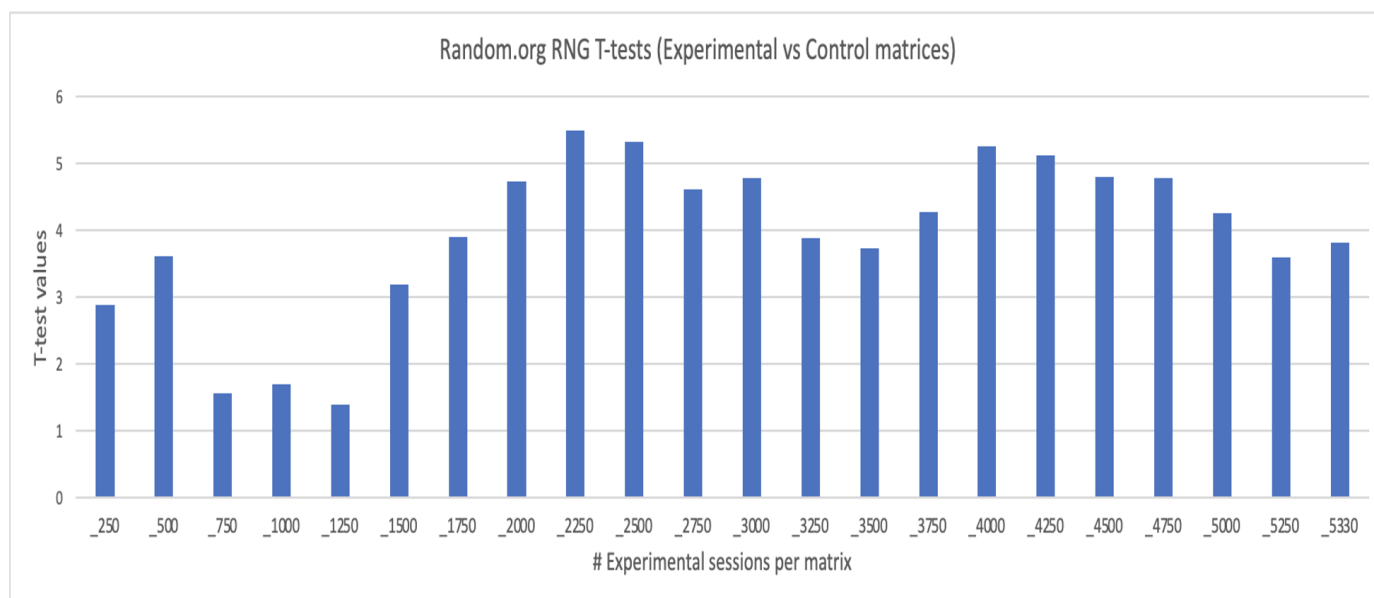


**Figure 3.** The x-axis displays the number of sessions in sets of 250 experimental sessions (22 datapoints), while the y-axis shows Welch T-test values between the distribution of experimental and control sessions. Bars show Welch T-test statistical significance with an increasing number of sessions in each set until reaching a total of 5,330 sessions.

The results from Random.org show high significance across most matrices, except for the datapoints of 750, 1.000, and 1.250 which did not exhibit statistically significant results. The average correlations from experimental sessions

consistently yield positive results, whereas most control session averages are negative.

| Random.org | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Experimental session | 250 | 500 | 750 | 1000 | 1250 | 1500 | 1750 | 2000 | 2250 | 2500 | 2750 | 3000 |
| Welch's t-test | 2,89 | 3,62 | 1,56 | 1,70 | 1,39 | 3,19 | 3,89 | 4,73 | 5,50 | 5,32 | 4,61 | 4,79 |
| P-Value | 0,0039 | 0,0003 | 0,1188 | 0,0897 | 0,1646 | 0,0014 | 0,0001 | 2,332E-06 | 4,011E-08 | 1,055E-07 | 4,072E-06 | 1,696E-06 |
| | | | | | | | | | | | | |
| Experimental session | 3250 | 3500 | 3750 | 4000 | 4250 | 4500 | 4750 | 5000 | 5250 | 5330 | Average | |
| Welch's t-test | 3,89 | 3,74 | 4,28 | 5,26 | 5,12 | 4,80 | 4,79 | 4,26 | 3,59 | 3,81 | 3,94 | |
| P-Value | 0,0001 | 0,0002 | 1,897E-05 | 1,487E-07 | 3,152E-07 | 1,640E-06 | 1,706E-06 | 2,029E-05 | 0,0003 | 0,0001 | 0,0001 | |

**Table 3.** Displays the number of experimental sessions in sets of 250 (totaling 5.330 sessions) with respective Welch's T-test values and P-values.

The analysis of the average of the 22 datapoints revealed a T-test value of 3,9418, accompanied by a p-value of 8,13E-5

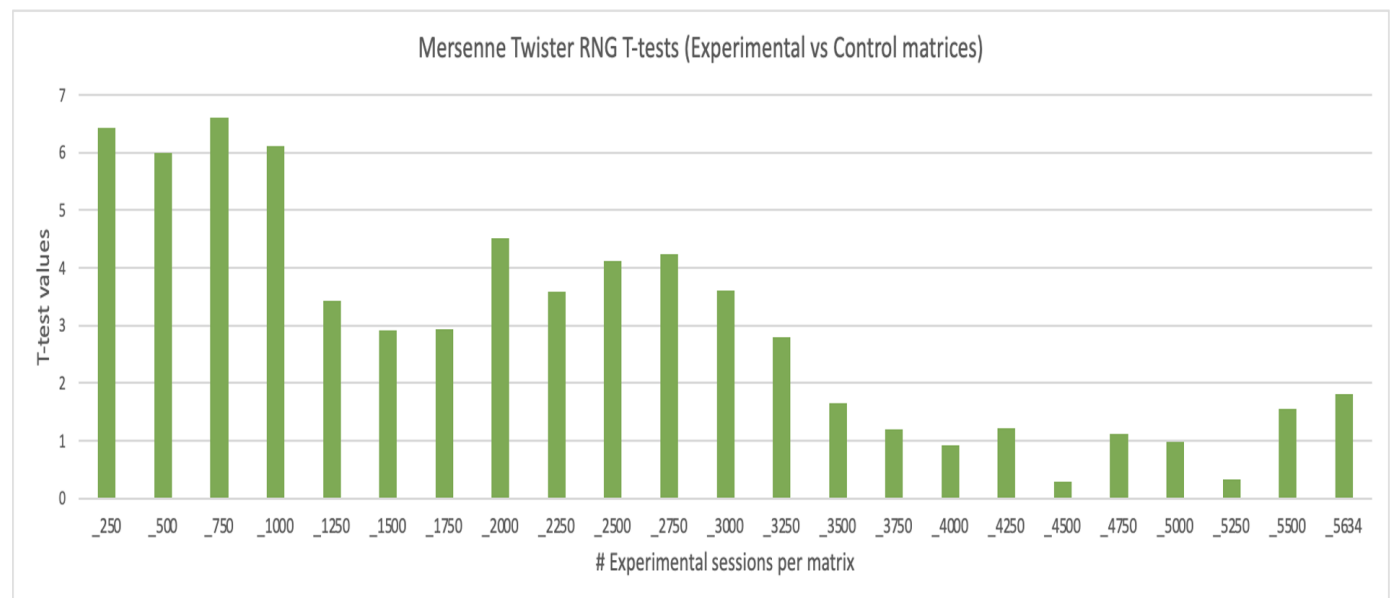**A.2) Results from analysis with Welch T-test for the RNG Mersenne Twister**



**Figure 4.** The x-axis shows the number of sessions in sets of 250 experimental sessions (23 datapoints), and the y-axis displays Welch T-test values between the distribution of experimental and control sessions. Bars represent Welch's T-test statistical significance with an increasing number of sessions in each set until reaching a total of 5.634 sessions.

The RNG Mersenne Twister shows non-significant results in the last groups of matrices, between 3.500-5.634 datapoints. The average correlations from experimental sessions are always positive, while most control session averages are negative.

| Mersenne Twister | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Experimental session | 250 | 500 | 750 | 1000 | 1250 | 1500 | 1750 | 2000 | 2250 | 2500 | 2750 | 3000 |
| Welch's t-test | 6,43 | 6,00 | 6,60 | 6,11 | 3,43 | 2,92 | 2,93 | 4,52 | 3,59 | 4,11 | 4,24 | 3,61 |
| P-Value | 1,4E-10 | 2,1E-09 | 4,226E-11 | 1,031E-09 | 0,0006 | 0,0035 | 0,0034 | 6,233E-06 | 0,0003 | 3,919E-05 | 2,288E-05 | 0,0003 |

| Experimental session | 3250 | 3500 | 3750 | 4000 | 4250 | 4500 | 4750 | 5000 | 5250 | 5500 | 5630 | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Welch's t-test | 2,80 | 1,64 | 1,20 | 0,92 | 1,22 | 0,29 | 1,11 | 0,98 | 0,32 | 1,55 | 1,81 | 2,97 |
| P-Value | 0,0051 | 0,1003 | 0,2287 | 0,3597 | 0,2220 | 0,7732 | 0,2658 | 0,3255 | 0,7460 | 0,1202 | 0,0699 | 0,0030 |

**Table 4.** Displays the number of experimental sessions in sets of 250 (totaling 5.634 sessions) with respective Welch's T-test values and P-values.

The analysis using the Mersenne Twister demonstrated notable differences between the distributions of experimental and control session correlations. Specifically, the T-test resulted in a value of 2,972, yielding a p-value of 0,0029 for the average analysis across the 23 datapoints.

### A.3) Analysis of Effect sizes

Cohen's (d) Effect sizes were computed based on the mean and variance outcomes derived from Welch T-tests. The comprehensive results for these effect sizes are presented in Annex 2, encompassing computations for all datapoints.

For Random.org, the effect size obtained for the last (22nd) datapoint was 0,0842. The average effect size across all 22 datapoints stood at 0,0871.

In the context of the Mersenne Twister, the effect size achieved for the last (23rd) datapoint was 0,0400. The average effect size across all 23 datapoints amounted to 0,0656.

### A.4) Sensitivity analysis for determining Minimum Meaningful Effect size

**Figure 5.** G*Power Computation of Required Effect Size.
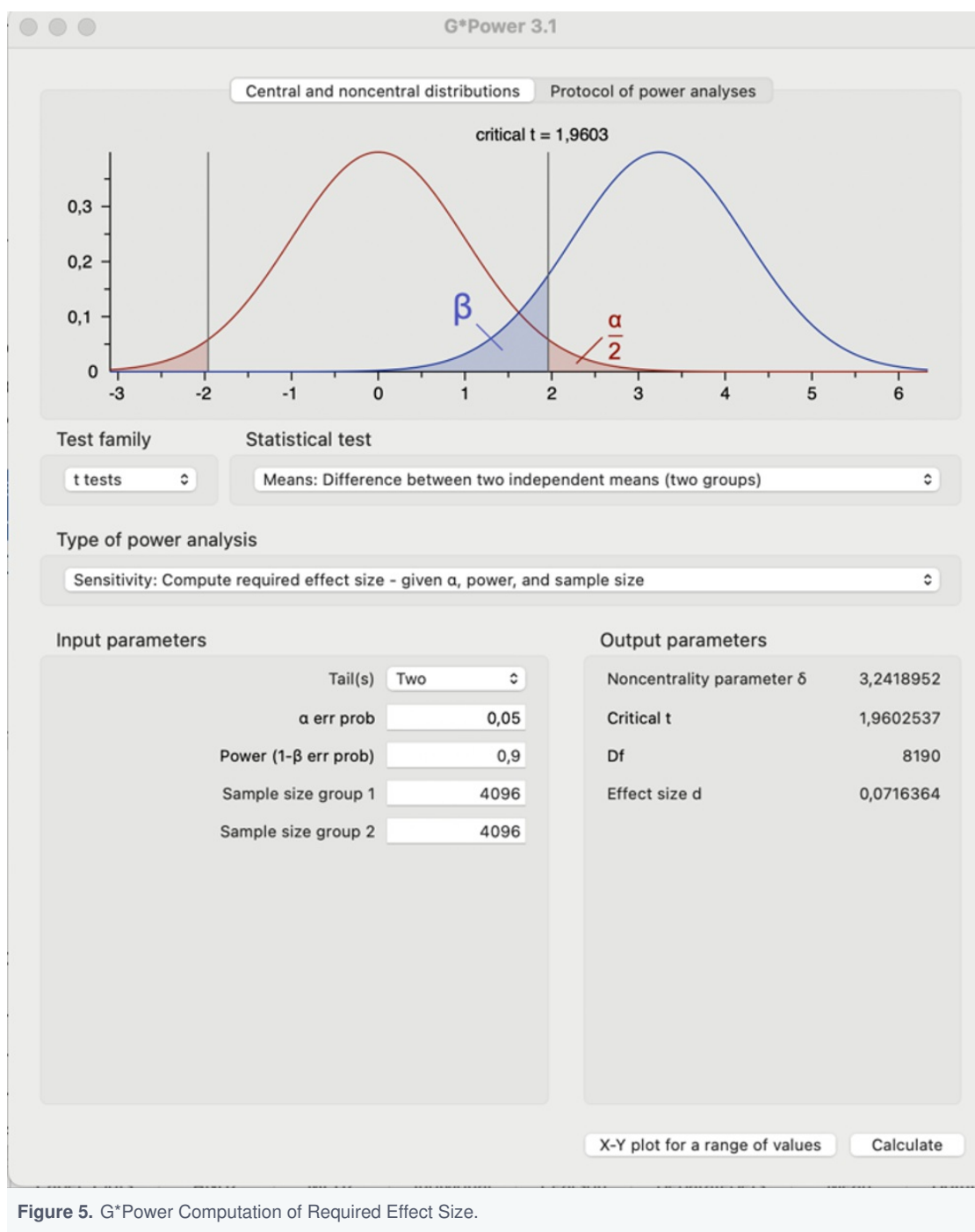
GPower software was utilized to compute the necessary effect size, also known as the minimum meaningful effect size. It was derived based on an alpha 0,05, a beta level of 0,10, and sample size represented by the matrix cells amounting to 4.096. The calculated effect size (d) was determined to be 0,0716364

As noted in the previous section (A.3), Random.org demonstrated an actual effect size of 0,0842 for the last (22nd) datapoint, surpassing the minimum effect size threshold computed, which stood at 0,0716364. However, in the case of Mersenne Twister, the achieved effect size value of 0,0400 for the last (23rd) datapoint falls below the required minimum meaningful effect size.

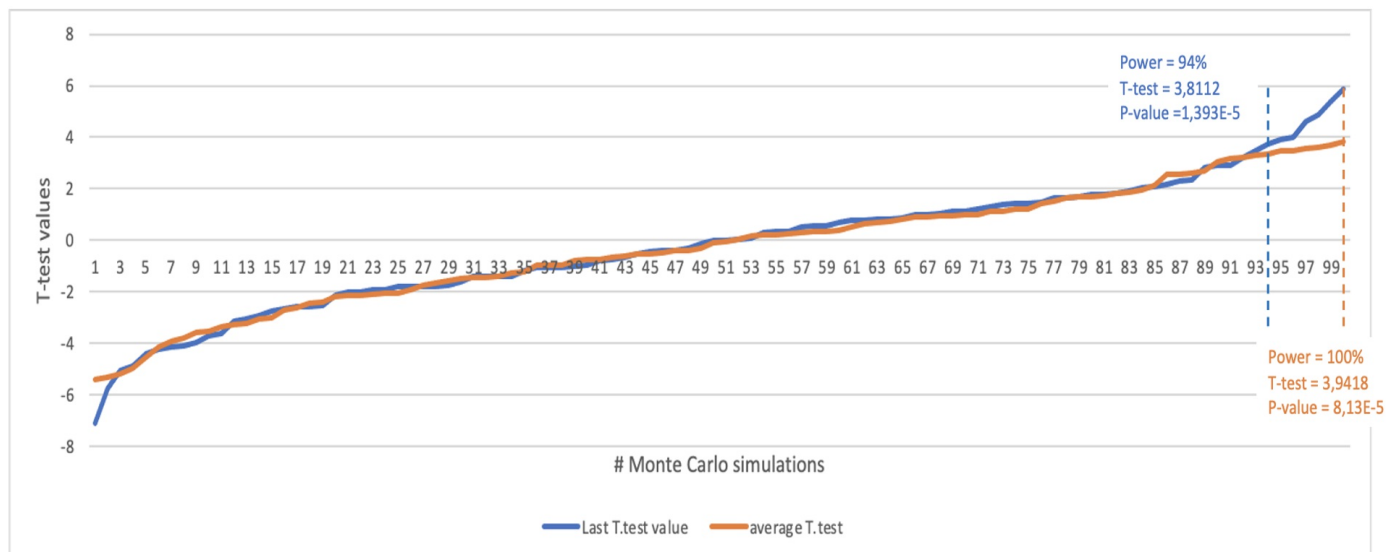## B) Results from Monte Carlo simulations and Power analysis

Random.org



**Figure 7.** Random Org

a. The horizontal blue line represents the value of the last t-test, the $22^{nd}$ datapoint (5.330 sessions), of each Monte Carlo simulation. Values are presented in ascending order. The dashed vertical blue line shows the t-test = 3,8112 with respective statistical Power of 94%.

b. The horizontal orange line represents the average t-test of the 22 values of each Monte Carlo simulation. Values are presented in ascending order. The dashed vertical orange line shows the t-test = 3,9418 with respective statistical Power of 100%.
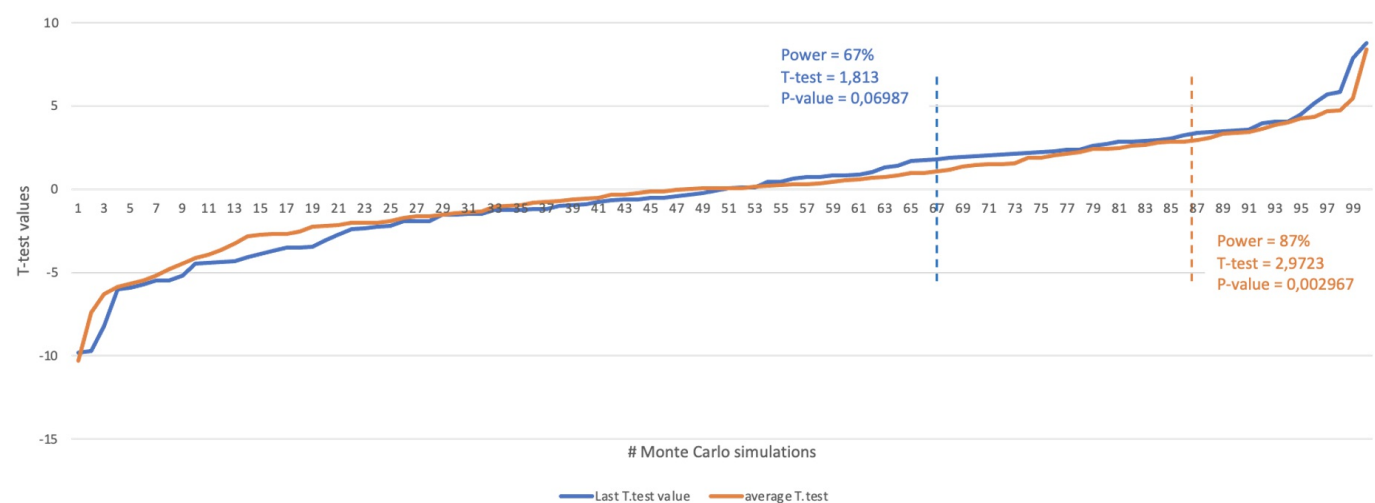
Mersenne Twister



**Figure 8.** Mersenne Twister

a. The horizontal blue line represents the value of the last t-test, the 23$^{rd}$ datapoint (5.634 sessions), of each Monte Carlo simulation. Values are presented in ascending order. The dashed vertical blue line shows the t-test =1,813 with respective statistical Power of 67%.

b. The horizontal orange line represents the average t-test of the 23 values of each Monte Carlo simulation. Values are presented in ascending order. The dashed vertical orange line shows the t-test = 2,9723 with respective statistical Power 87%.

Results from both RNGs show, on average, statistically significant outcomes (Welch T-test >=2, p-value < 0,05). Welch T-tests always yield positive results, indicating that the average correlations of the control matrices are consistently lower than those of the experimental matrices. Interestingly, the mean of correlations for the experimental matrix is always positive, while the mean for control matrices is mostly negative.

To Random.org, concerning the last datapoint, an effect size of 0,0842 (above the minimum requirement of 0,071) was detected with a power of 94% within the 4.096 matrix cells, maintaining an alpha level below 0,05 (alpha = 0,00013; Welch T-test = 3,8112).

For Random.org concerning the average datapoints, an effect size of 0,0871 (exceeding the minimum meaningful requirement of 0,071) was identified with a power surpassing 90% (100%) within the 4.096 matrix cells, maintaining an alpha level below 0,05 (alpha = 8,13E-5; Welch T-test = 3,941). Hence, our conclusion suggests a significant distinction (alpha < 0,05) between distributions. The combination of adequate power (> 90%) and a substantial number of samples (4.096) allowed us to sensitively detect this difference.

For Mersenne Twister regarding the last datapoint, an effect size of 0,0400 (below the minimum meaningful requirement of 0,071) was identified with a power of less than 90% (67%) within the 4.096 matrix cells, maintaining an alpha level above 0,05 (alpha = 0,06987; Welch T-test = 1,813). Leading to the conclusion of no significant difference (alpha > 0,05) between distributions. Despite the considerable sample size (4096), our power was insufficient (< 90%) to detect this difference.

Regarding the average datapoints, an effect size of 0,0656 (also below the minimum meaningful requirement of 0,071) was detected with a power of less than 90% (87%) within the 4096 matrix cells, while the alpha level remained below 0,05 (alpha =

0,002967; Welch T-test = 2,9723). Despite observing a significant difference between distributions, we lacked sufficient power despite the substantial sample size (4.096) to sensitively detect this difference.

## Discussion

The study revealed that the statistical distribution of matrices generated from experimental sessions differs from those resulting from control sessions.

The present study serves as a conceptual replication of the correlation matrix experiment (von Lucadou, 2006; Walach et al., 2020, Flores, 2021) building on prior studies conducted as part of a doctoral degree (Flores, 2021).

The study introduced several improvements: a new setup, new types of analysis, an enlarged matrix (64X64), testing two new random number generators (RNGs), and incorporating new psychological and physical variables. The introduction of novelty aligns with the MPI and CMM requirements, essential for replications.

The study exhibits strengths, notably a robust participant pool comprising 726 individuals from over 50 countries, contributing to a total of 10.564 experimental sessions. The data collection encompassed RNG usage from both Random.org and Mersenne Twister. The dataset itself comprised an extensive volume, including 10.525.440 psychological variables and 21.050.880 physical variables providing a solid foundation for comprehensive analysis. The study achieved notable statistical power, reaching between 94% and 100% with Random.org and between 67% and 87% with Mersenne Twister.

For Random.org, the effect size calculated for the 5.330 sessions was 0,0842, while the average effect size amounted to 0,0871. Hence, our conclusion suggests a significant distinction (alpha < 0,05) between distributions. The combination of adequate power (> 90%) and a substantial number of samples (4.096) allowed us to sensitively detect this difference. In contrast, for Mersenne Twister, the effect size obtained for the 5.634 sessions was 0,0400, and the average was 0,0656. We lacked sufficient power (less than 90%) despite the substantial sample size (4.096) to sensitively detect this difference.

The matrix's larger size (64X64) enabled a more in-depth analysis, shedding light on potential effects with and without participant intervention. In prior studies, both homemade and commercial random number generators were utilized (von Lucadou, Walach, etc.). However, due to the limited number of participants per study, the data generated by those sources underwent joint analysis. This study successfully conducted separate analysis for the random number generators used.

The use of two well-studied and validated RNGs facilitated a comprehensive comparison. Random.org displayed more significant results compared to Mersenne Twister, emphasizing the influence of RNG type on study outcomes.

The study identified weaknesses, such as the inability to record participants who did not complete the experimental session and potential challenges arising from global time zone differences. This limitation might primarily affect analysis when data is considered in a temporal sequence.

Given that the psychological variables remain consistent across both the experimental and control matrices, the observed distribution disparities might be attributed to the physical variables. These physical variables, being random in nature, potentially impact the distribution differences based on their order. Therefore, the primary inquiry addressed by Monte Carlo simulations is whether the sequence of random numbers affects the significance of the matrix's distribution.

The study opens questions for future research. The different results obtained with Random.org (online) and Mersenne Twister (device-based) warrant further exploration. Future studies could investigate the underlying mechanisms behind

these differences and their implications for the CMM. Future studies could employ larger sample sizes and more extensive data collection to determine the optimal parameters for future CMM studies.

The possibility of participant influence, despite their blindness to the RNG, needs to be addressed in future studies. Implementing stricter control measures and incorporating additional blinding mechanisms could help address this potential confound.

## Acknowledgments

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