Research Article

Mind and Matter Correlated in a Matrix: New Replication Using an Online Game

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The study investigates the interaction between mind and matter by exploring correlations between psychological behaviour and 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 a 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 4,096 cells (64x64). The Welch's T-test yielded a value of 3.811, with a corresponding p-value of 0.0001. The achieved power was high at 94%, while the effect size reached 0.084, above the required minimum meaningful effect size of 0.071. 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 0.069. The achieved power stood at 67%, while the effect size attained was 0.040, falling short of the minimum meaningful effect size required, which was 0.071.

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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[1], 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 within the Generalized Quantum Theory[2][3][4] and the Theoretical Model of Pragmatic Information (MPI)[5], 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[1], 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[1][6][7][8][9][10][11]. 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[12].

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[13].

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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 the University Polytechnic of Bragança and the 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 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) were 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 is in Appendix 1.

Game Screen

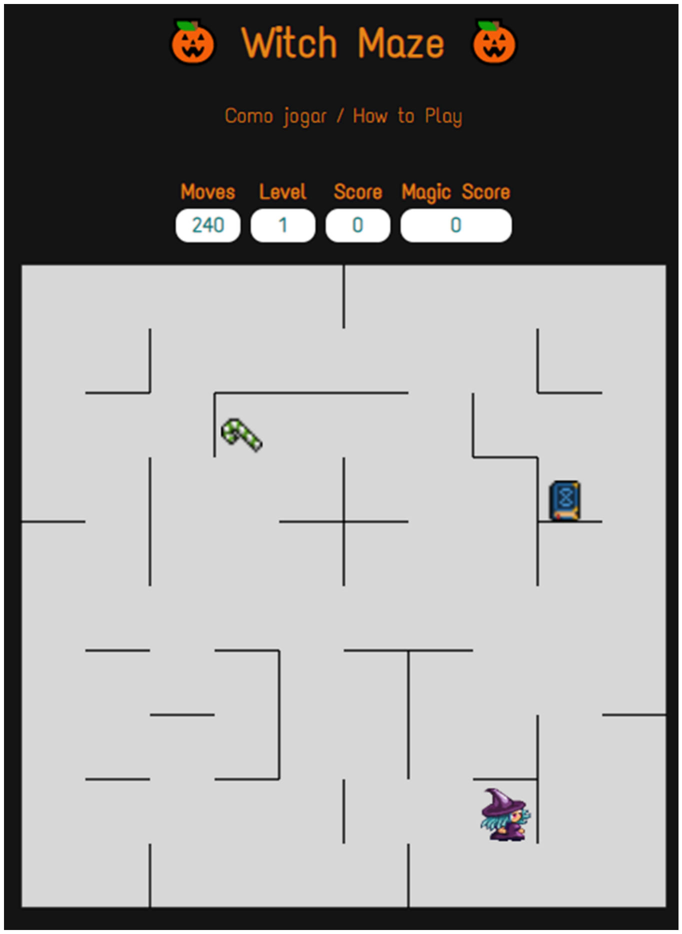

Figure 1. Witch Maze screenshot showing the first screen with the “How to play” click button, where instructions to play can be reached throughout the game; number of available moves, 240; Level 1; Score 0; Magic Score 0. In each level, the number of items adds 2 (2xn, n=level). The participant must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

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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 mentally 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 feature interspersed RNGs if participants play multiple times.

Control Session

For each experimental session, a corresponding control session is generated. In the experimental session, random numbers are generated with each participant's finger swipe. Subsequently, in the control session, all random numbers are produced at once, independent of participant intervention. Upon completion of each experimental session, 960 values are generated using the same random number generator that was employed for that session. These values are subsequently correlated with the psychological variables recorded during the experimental session, ensuring an exact replication.

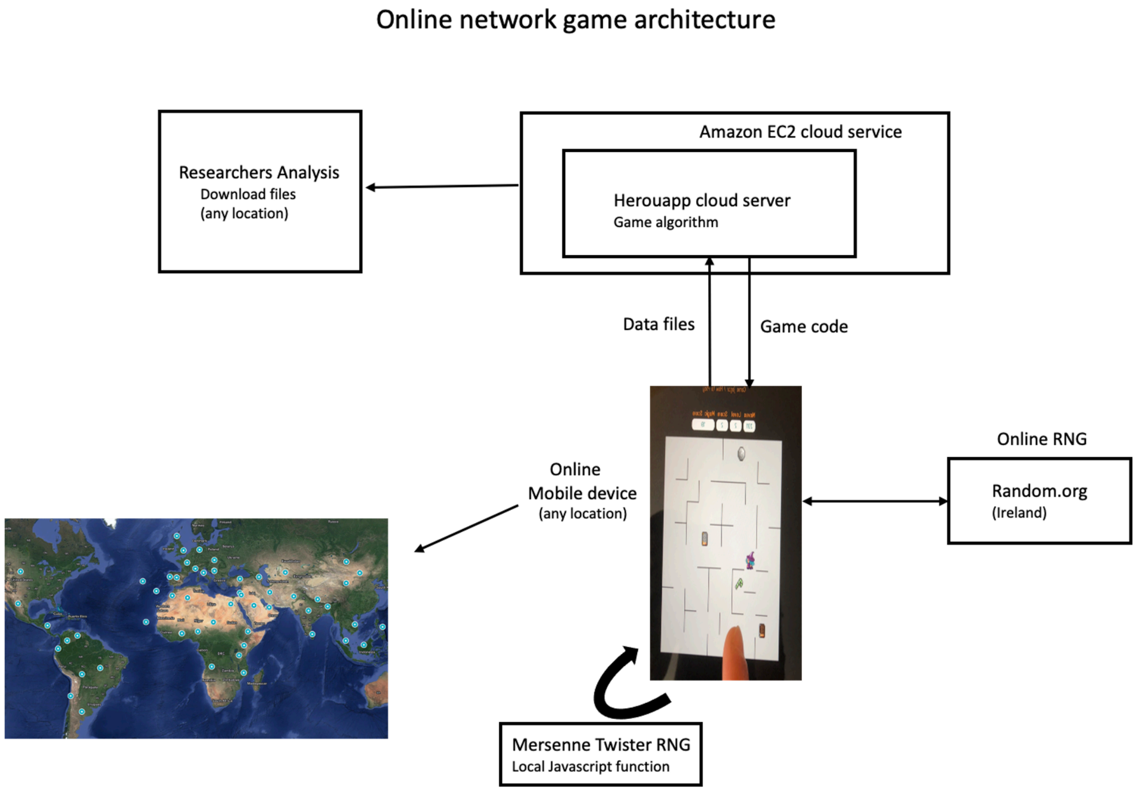

Figure 2. Game network architecture, displaying participant-contributed session locations, a screenshot of the game in progress, and the positions of both the RNG and server hosting the software.

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; 0,125; 0,212) were:

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- “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 (version 1.1.456) environments were installed and cloned in the 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 was performed with G*Power version 3.1.[14][15].

Quality control of games after data collection

Prior to analysis, a data quality check removed incomplete files and files associated with sessions played on 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[16]. Data were analyzed separately to compare the effects of different types of randomness in the study.

Random.org

An online true random number generator developed by Mads Haahr[17][18], Random.org uses atmospheric noise picked up by a radio tuned to a frequency with no broadcasting. It has passed the NIST suite of randomness statistical tests, making it a reliable choice.

Mersenne Twister

Developed by Matsumoto and Nishimura[19], Mersenne Twister was selected for its consistency in meeting requirements for Monte Carlo simulations; uncorrelated sequences, long period, and uniformity [20][21]. 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[7][9][12] used a matrix size of 45X45 variables corresponding to a 2045-cell matrix. For this study, a larger correlation matrix was built with a 64X64 size corresponding to a 4096-cell matrix. To construct the matrix, a 'fragmentation' step was developed to achieve the necessary matrix resolution of 64x64, which corresponds to 4x16 psychological variables by 4x16 physical variables. In this process, the 240 elements generated during each experimental session for each variable are divided into 16 sets, each containing 15 numbers (16x15=240). These 16 sets effectively act as replicates for each variable. Without fragmentation, the matrix resolution would be limited to 4x4 (4 psychological variables with 4 physical variables), which is inadequate for this type of study.

Statistical analysis

The study entailed a comparison between the distribution of correlations derived from experimental and control sessions using Welch's T-test and the respective p-value, 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[15]. 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 analyses 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 is 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 size 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. 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.

The decision to shuffle the variables generated during the experimental session maintained the original distribution properties, an essential requirement for Monte Carlo simulations[22]. Given that the primary goal of this analysis was to generate estimates of the mean output, a small number of replications, less than 100 simulations, is sufficient[23]. Therefore, the current study employed 100 simulations, which were adequate to provide a clear estimate of the mean output.

Results

The statistical analyses performed were A) Welch T-tests and effect sizes, and 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

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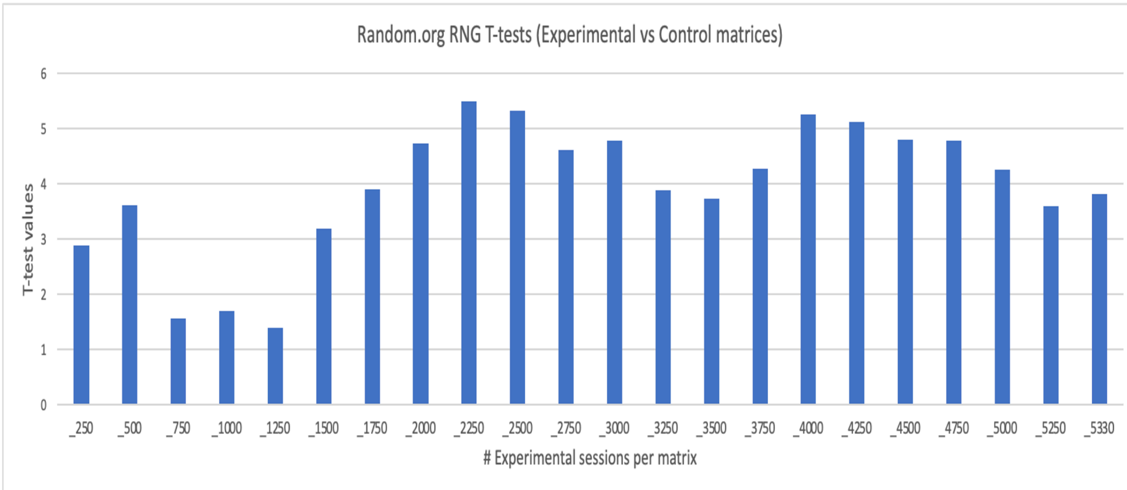

Figure 3. The x-axis displays the number of sessions in sets of 250 experimental sessions (22 datapoints), while the y-axis shows Welch T-test values between the distribution of experimental and control sessions. Bars show Welch T-test statistical significance with an increasing number of sessions in 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 sessior	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 sessior	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 3,941, accompanied by a p-value of 8,13E-5.

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

doi.org/10.32388/0PAHC2.2

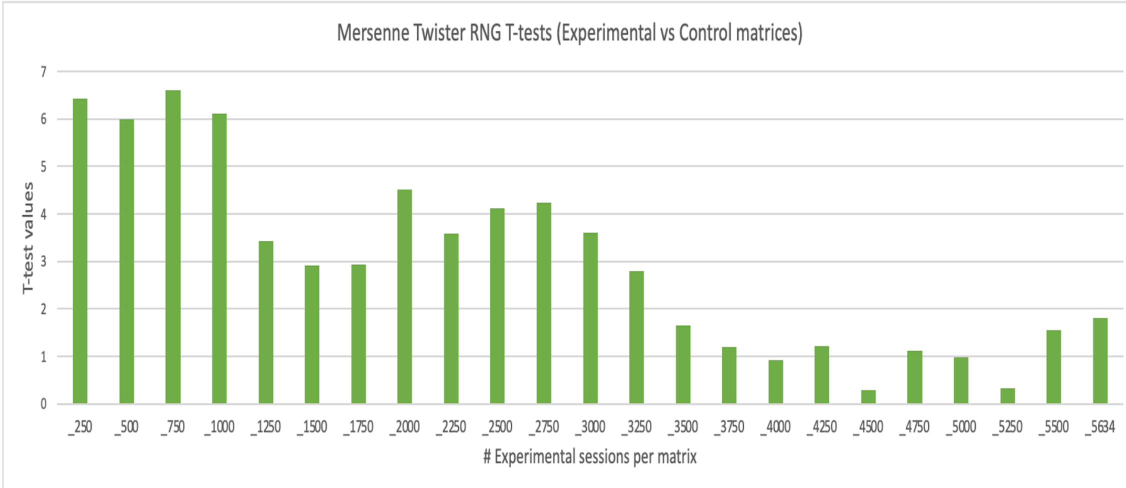

Figure 4. The x-axis shows the number of sessions in sets of 250 experimental sessions (23 datapoints), and the y-axis displays Welch T-test values between the distribution of experimental and control sessions. Bars represent Welch's T-test statistical significance with an increasing number of sessions 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 sessior	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 sessior	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 0,002 for the average analysis across the 23 datapoints.

A.3) Analysis of Effect sizes

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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 0,084. The average effect size across all 22 datapoints stood at 0,087.

In the context of the Mersenne Twister, the effect size achieved for the last (23rd) datapoint was 0,040. The average effect size across all 23 datapoints amounted to 0,065.

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

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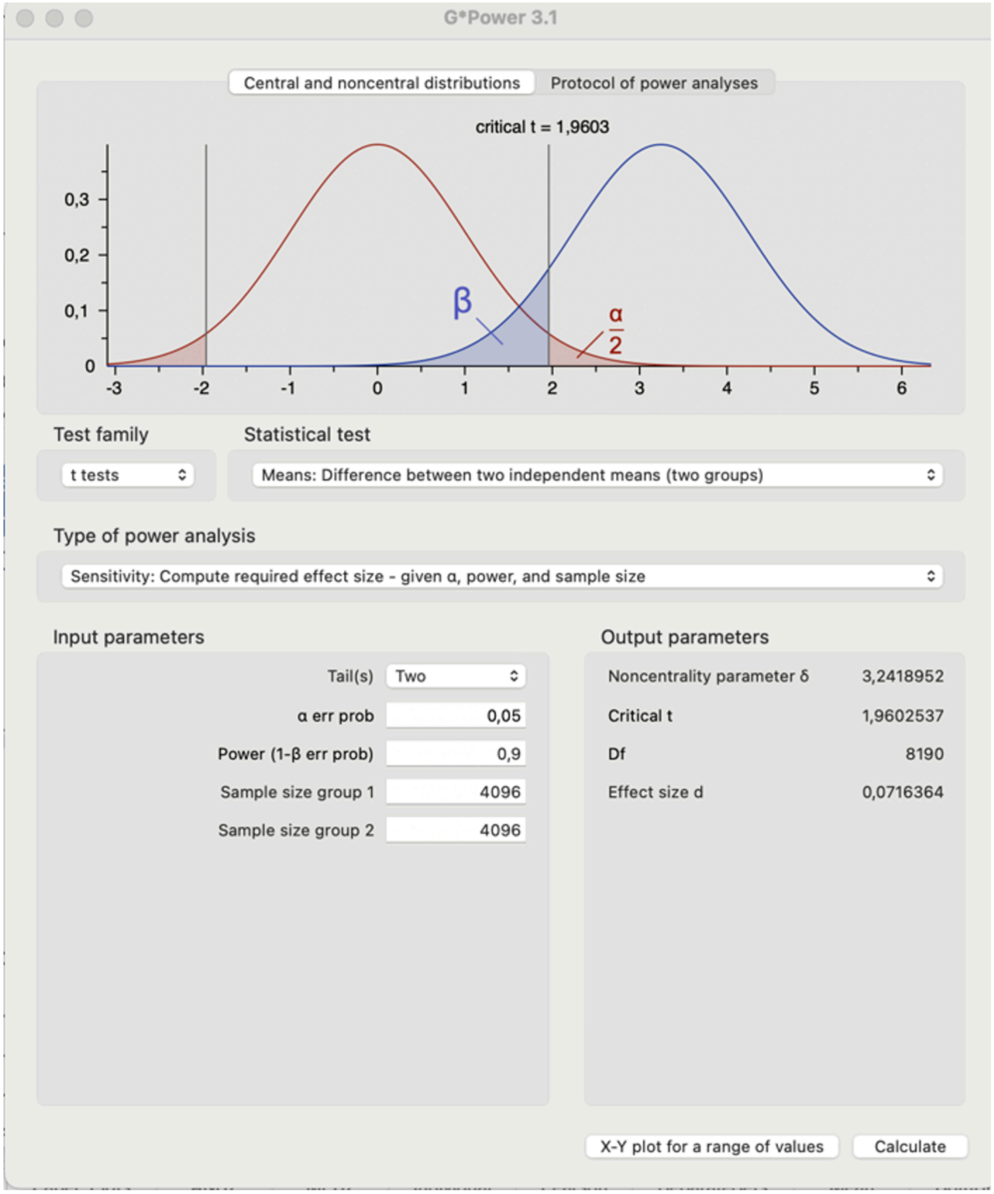

Figure 5. G*Power Computation of Required Effect Size. G*Power software was utilized to compute the necessary effect size, also known as the minimum meaningful effect size. It was derived based on an alpha of 0,05, a beta level of 0,10, and a sample size represented by the matrix cells amounting to 4,096. The calculated effect size (d) was determined to be 0,071.

As noted in the previous section (A.3), Random.org demonstrated an actual effect size of 0,084 for the last (22nd) datapoint, surpassing the minimum effect size threshold computed, which stood at 0,071. However, in the case of the Mersenne Twister, the achieved effect size value of 0,040 for the last (23rd) datapoint falls below the required minimum meaningful effect size.

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B) Results from Monte Carlo simulations and Power analysis

Random.org

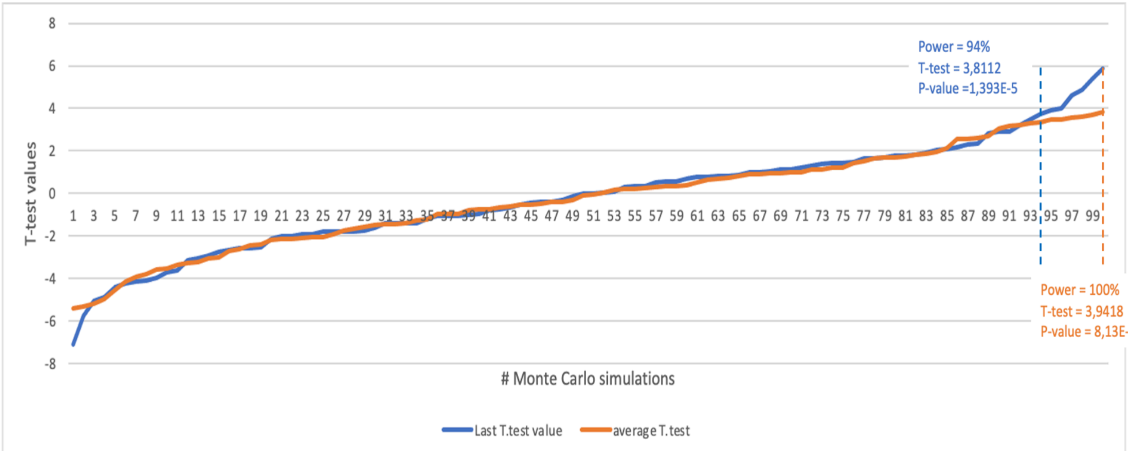

Figure 7. Random.org

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 = 3,811 with a 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 = 3,941 with a respective statistical power of 100%.

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Mersenne Twister

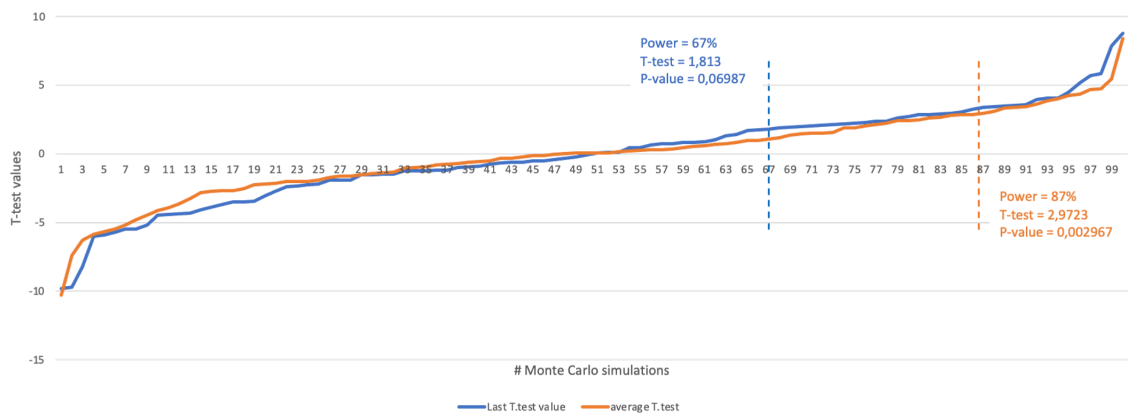

Figure 8. Mersenne Twister

a. The horizontal blue line represents the value of the last t-test, the 23rd 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 a 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 a respective statistical Power of 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.

For Random.org, concerning the last datapoint, an effect size of 0,084 (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 = 0,0001; Welch T-test = 3,811).

For Random.org, concerning the average datapoints, an effect size of 0,087 (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 0,040 (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 = 0,069; Welch T-test = 1,813). This leads 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 0,065 (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 =

0,002; Welch T-test = 2,972). 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[7][9][12], building on prior studies conducted as part of a doctoral degree[12].

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, which are 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. Furthermore, due to the relatively small participant pool in each of these studies, the data generated by those sources were collectively analyzed to compensate for the limited sample size in individual studies. However, the present study successfully conducted separate analyses 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.

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.

Statements and Declarations

Funding

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Ethics

The studies involving human participants were reviewed and approved by the Ethics Committee of the University of Braga. The participants provided their informed consent by agreeing to the online privacy policy.

Data Availability

The raw data supporting the conclusions of this article (anonymized psychological variables and random number generator outputs) are available from the corresponding author upon reasonable request, subject to privacy and ethical restrictions.

Author Contributions

Conceptualization: A.B.F.; Methodology: A.B.F.; Software: A.B.F. and P.R.F.; Validation: A.B.F. and P.R.F.; Formal Analysis: A.B.F. and P.R.F.; Investigation: A.B.F.; Resources: A.B.F.; Data Curation: A.B.F. and P.R.F.; Writing—Original Draft Preparation: A.B.F.; Writing—Review and Editing: A.B.F. and P.R.F.; Visualization: A.B.F. and P.R.F.; Supervision: A.B.F.; Project Administration: A.B.F.; Funding Acquisition: A.B.F.

References

1. [a, b, c] *von Lucadou W (1986). Experimental investigations on the influenceability of stochastic quantum physical systems by the observer. H.-A. Herchen.*
2. [^] *Atmanspacher H, Römer H, Walach H (2002). "Weak quantum theory: Complementarity and entanglement in physics and beyond." Foundations of physics.* ***32****:379-406.*
3. [^] *Filk T, Römer H (2011). "Generalized quantum theory: Overview and latest developments." Axiomathes.* ***21****(2):211-220.*
4. [^] *Walach H, Lucadou WV, Römer H (2014). "Parapsychological phenomena as examples of generalized nonlocal correlations—A theoretical framework." Journal of Scientific Exploration.* ***28****(4):605-631.*

5. ^von Lucadou W (1995). "The model of pragmatic information (MPI)." *European Journal of Parapsychology*. **11**:58-75.
6. ^von Lucadou W (1991). "Some remarks on the problem of repeatability of experiments dealing with complex systems." In: Information Dynamics. Boston, MA: Springer US; p. 143-151.
7. a, b, c von Lucadou W (2006). "Self-Organization of temporal structures—a possible solution for the intervention problem." *AIP Conference Proceedings*. **863**(1):293-315.
8. ^Walach H, Loef M (2015). "Using a matrix-analytical approach to synthesizing evidence solved incompatibility problem in the hierarchy of evidence." *Journal of Clinical Epidemiology*. **68**(11):1251-1260.
9. a, b, c Walach H, Horan M, Hinterberger T, von Lucadou W (2020). "Evidence for anomalistic correlations between human behavior and a random event generator: Result of an independent replication of a micro-PK experiment." *Psychology of consciousness: Theory, research, and practice*. **7**(2):173.
10. ^Flores A, Watt C, Tierney I (2017). "Replication and extension of a new paradigm for psychokinesis: Mind-matter interaction through non-local entangled correlations?." *Society for Psychical Research*.
11. ^Flores A, Tierney I, Watt C (2018). "Where mind connects with matter: Replicating the correlation matrix method." *Parapsychological Association*. p. 15.
12. a, b, c, d Flores A (2021). "Mind and matter correlated in a matrix. Replicating a new method." *University of Edinburgh ERA*. doi:10.7488/era/1491.
13. ^Flores AB (2018). "Edinburgh Software Validation Test for Researchers in Psychology." *Open Science Journal of Psychology*. **5**(5):68-72.
14. ^Faul F, Erdfelder E, Buchner A, Lang AG (2009). "Statistical power analyses using G* Power 3.1: Tests for correlation and regression analyses." *Behavior research methods*. **41**(4):1149-1160.
15. a, b Bartlett JE (2021). *Introduction to power analysis: A guide to G* power, jamovi, and superpower.*
16. ^Kenny C (2012). "Random Number Generators: An Evaluation and Comparison of Random. org and Some Commonly Used Generators, Apríl 2005." *Trinity College Dublin*. http://www.random.org/analysis/Analysis2005.pdf.
17. ^Haahr M (1998). "Random.org." *random.org*. https://www.random.org.
18. ^Haahr M (1999). "random. org: Introduction to Randomness and Random Numbers." *Statistics*. (June):1-4.
19. ^Matsumoto M, Nishimura T (1998). "Mersenne twister: a 623-dimensionally equidistributed uniform pseudo-random number generator." *ACM Transactions on Modeling and Computer Simulation (TOMACS)*. **8**(1):3-30.

20. ^*Ghersi D, Parakh A, Mezei M (2017). "Comparison of a quantum random number generator with pseudorandom number generators for their use in molecular Monte Carlo simulations." Journal of computational chemistry.* ***38****(31):2713-2720.*

21. ^*Hongo K, Maezono R, Miura K (2010). "Random number generators tested on quantum Monte Carlo simulations." Journal of computational chemistry.* ***31****(11):2186-2194.*

22. ^*Chang CS (1994). "Stability, queue length, and delay of deterministic and stochastic queueing networks." IEEE Transactions on Automatic Control.* ***39****(5):913-931.*

23. ^*Bonate PL (2001). "A brief introduction to Monte Carlo simulation." Clinical pharmacokinetics.* ***40****:15-22.*

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