

## Article

# A Study on Potentially Beneficial Activities as Observed in Increased Values of Psychophysiological Coherence Measures

*Towards an understanding of psychophysiological coherence and inner peace in human social dynamics*

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## Abstract

This paper explores the potentially beneficial effects of three (3) activities on psychophysiological coherence, assessed by the coherence ratio measure and how that may contribute to individual inner peace and a holistic attunement beyond symbolism to ‘the vibe of the other’ in inter-subjective, social relationships. These activities are compared to a baseline coherence ratio in order to determine whether they are beneficial and can contribute to an increase in psychophysiological coherence that could contribute to the attainment of individual inner peace and increased social harmony. The coherence ratio is derived from heart rate variability (HRV) measurements of R-R intervals that are transformed via the Fast Fourier Transform into a frequency spectrum. This paper is the third in a sequence of papers that analyzes data collected during the ‘International Heart Rate Variability Synchronization Study’ in 2015.

**Keywords:** Psychophysiological coherence, synchronization, brain-heart dynamics, heart rate variability (HRV), cognition, intentionality, knowledge and meaning, inner peace, vibe of the thing.

## I. Introduction

In our many ways of conversing and interacting with each other, human beings use different symbols and abstractions that carry a great deal of valuable and meaningful information, sometimes explicitly conveyed and some other times veiled until revealed in eureka moments or sudden realizations. Inner peace, gentleness and freedom in social interactions, may physiologically and psychologically register as non-stressful, and may lead to the kind of openness that would allow us to experience ‘the vibe of nature and other humans’. Sometimes a deep spiritual experience or love for another person may arise without the mediation of any symbolism in spontaneous laughter, funny sounds or adorable sounds, like the laughter of a baby.

Here we explore the possibility that some potentially beneficial activities, as observed in increased values of psychophysiological coherence measures, may contribute to a holistic

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attunement beyond symbolism to ‘the vibe of the other’<sup>1</sup>, leading us into states of individual inner peace and in the direction of social harmony.

Over recent years the study of heart rate variability (HRV) has received increasing attention in the scientific community [1-8]. In particular, the study and understanding of psychophysiological coherence [9-13] has become of increasing importance in order to better understand the role the heart plays in regards to human health, inner peace, social harmony and general wellbeing [14-18].

Since it is now well known that HRV plays a key role in stress mitigation and overall human wellbeing [19, 20], it is of vital interest to understand better what activities are conducive to high levels of psychophysiological coherence and which activities are less effective or potentially even harmful.

In previous work, the authors have presented the potential beneficial effects of meditation and how it may impact HRV, inner peace and general wellbeing where statistically significant effects were observed [21]. Also in previous work, it was illustrated how potentially beneficial activities, such as meditation, can be compromised as a result of the environmental settings and produce even opposite results than expected [22].

In the work presented here, three (3) distinct activities have been studied, analyzed and compared regarding their effectiveness and likeliness to improve psychophysiological coherence. However, since this study is based on the results of a pilot study with a group of twenty (20) participants [21], it will require further experiments with a larger sample size to draw robust conclusions.

In the following section we will describe the three (3) different activities analyzed in this paper and provide a brief description of the experimental settings, as well as the measurement practice. After this section the methodology applied to this work will be presented, followed by the results obtained and their analysis. Here a set of hypothesis tests were performed where we tested  $H_0: \mu_{BL} \neq \mu_A$ , where  $\mu_{BL}$  refers to the mean coherence ratio (CR) of Baseline measurement periods and  $\mu_A$  refers to CR for any of the three (3) activities, as follows: (a) Gibberish Talk, (b) Mandala Drawing, and (c) Listening to a Reading. We aim at understanding if these activities are beneficial to the psychophysiological makeup of the participants and would accordingly result in higher CR mean values than Baseline. Finally, we will discuss these results and present our conclusions and future perspectives.

## II. Description of the Experiments

In 2015 over one hundred (100) people participated in a global HRV study, known as the ‘International Heart Rate Variability Synchronization Study’ [21], which was conducted in five (5) countries: one (1) group in the United States, one (1) in the United Kingdom, one (1) in Saudi Arabia, one (1) in Lithuania and two (2) groups in New Zealand, one (1) in the South Island and the other in the North Island. The work presented here is based on the data obtained from twenty (20) of the twenty-two (22) participants of the New Zealand North Island group. The two (2) omitted participants were in a different location and while measured like every other participant,

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<sup>1</sup> See “The Rhythms of the Via Negativa” in this same issue of *Scientific GOD Journal*.

they only partook in some activities, which allowed their data to be included in such activities in previous studies. However, for this study we lack the data of the two (2) above mentioned participants in the activities of *Gibberish Talk (Gibberish)*, *Mandala Drawing (Mandala)*, and *Listening to a Reading (Reading)*, and therefore they were excluded from the present analysis.

Over a period of fifteen (15) days the participants from the North Island New Zealand group followed a daily schedule of group meditations and activities, as follows:

- 1) 10 am – 10:30 am Meditation 1
- 2) 11 am – 11:30 am Gibberish, Mandala, or Reading
- 3) 2 pm – 2:30 pm Meditation 2
- 4) 3 pm – 3:30 pm Gibberish, Mandala, or Reading
- 5) 6 pm – 6:30 pm Meditation 3
- 6) 7 pm – 7:30 pm Gibberish, Mandala, or Reading

While each type of meditation technique (Meditation 1, 2 or 3) was performed by each participant at a set time of the day, the order of each activity during the day was randomly selected yet they could only happen at one (1) of the three (3) designated times of the day (listed above), where each activity happened once a day for all participants.

For the Gibberish activity, the participants were grouped into ten (10) pairs, which remained together for all fifteen (15) days of this study. Each pair had a designated area or room where they would remain together for the length of the activity and “talk” Gibberish with one another. It is also important to mention that this activity (Gibberish) was followed by a thirty (30) minute meditation, which has been studied in a previous work [22].

The Mandala activity was performed as a group activity, where all twenty (20) participants remained in the same room and used colored pencils to color in geometrical patterns, mandalas. The participants were given a free choice of color and provided with a paper that had some geometries printed on it, which allowed for many different possibilities of coloring a mandala.

The activity of Reading was also performed as a group activity with all participants together in the same room, listening to a presumably inspiring spiritual text, that was read by either of only two (2) participants selected for that task, while the remaining participants were listening. Participant 3 was reading for the first seven (7) days and Participant 12 for the following eight (8) days. The text was a chapter from ‘The Book of Knowledge: The Keys of Enoch’ [23] and throughout the fifteen (15) day study, two (2) different chapters were read, chapter 304 for the first seven (7) days and chapter 104 for the remaining eight (8) days.

The Baseline measurement time was a randomly chosen period of the day, different than the group activities, during daytime, randomly selected and unknown to the participants. This allowed for a reasonably good spectrum of activities performed by the participants in their day-to-day life outside the experimental setting times.

The data was collected via a Firstbeat Bodyguard 2 HRV recorder [24], which the participants wore for 23 hours per day, allowing for a one (1) hour break to shower and recharge the device. These one (1) hour periods were distributed amongst the twenty (20) participants in four (4) groups at different times of the day. The device was attached to the skin with two (2) electrodes on the chest area that started recording once connected, with a sample size of 1000Hz. For a

more detailed experimental protocol description and a listing of shower and recharge times, the reader is referred to [21].

### III. Methodology

For this work we analyzed the raw data obtained from the Firstbeat recorders. These devices recorded the R-R intervals, also known as the inter-beat intervals (IBI), for each of the participants for the duration of the fifteen (15) day study, 23 hours per day. Every time the device got disconnected, intentionally for the one (1) hour daily washing time, or unintentionally during sleep for example, the device started a new file once the connection was re-established. All these files were saved as text files, with the file extension *.txt*.

For the analysis of the data, the text files were imported into Kubios HRV Standard 3.2.0 [25] with the following settings:

- Artifact Correction: medium
- Artifact Acceptance Threshold: 10%
- Interpolation Rate: 4Hz
- R-R Interval Detrending:
  - Detrending method: smoothing priors
  - Smoothing parameter: 500

The program provides several forms of output results, however, for this analysis the *Frequency Domain* output was chosen to calculate the Coherence Ratio (CR) mean values of each participant for each day, as shown in equation (1). The frequency bands were set as follows:

- Very Low Frequency (VLF): 0 – 0.04Hz
- Low Frequency (LF): 0.04 – 0.15Hz
- High Frequency (HF): 0.15 – 0.4Hz

These results were then inserted into an excel spreadsheet and equation (1) was used in order to calculate the CR values for each activity, resulting in fifteen (15) CR values per participant per activity. From these fifteen (15) values one (1) CR mean value per participant per activity was then calculated. The following analysis is based on these CR mean values.

The equation for the Coherence Ratio (CR) is as follows:

$$CR_w = \frac{LFP_w}{TP_w - LFP_w} \quad (1)$$

with  $w =$  the period of the activity

where LFP is defined as the Low Frequency (LF) Power, VLFP is defined as the Very Low Frequency (VLF) Power and HFP is defined as the High Frequency (HF) Power, while TP is the Total Power and computed as follows:

$$TP_w = VLFP_w + LFP_w + HFP_w \quad (2)$$

For a discussion and deeper exploration of this and other formulas to calculate the coherence ratio, the reader is referred to the work of [13, 26].

## IV. Results & Analysis

In this section the reader is introduced to a set of results and analysis concerning the CR mean values of the three (3) activities analyzed in this study (Gibberish, Mandala & Reading) and how they compare to the Baseline CR mean values. The results for each of the three (3) activities has also been tested regarding our general working hypothesis that each of these activities is beneficial to the psychophysiological state of the participants and will result in an increase of CR mean values when compared to Baseline.

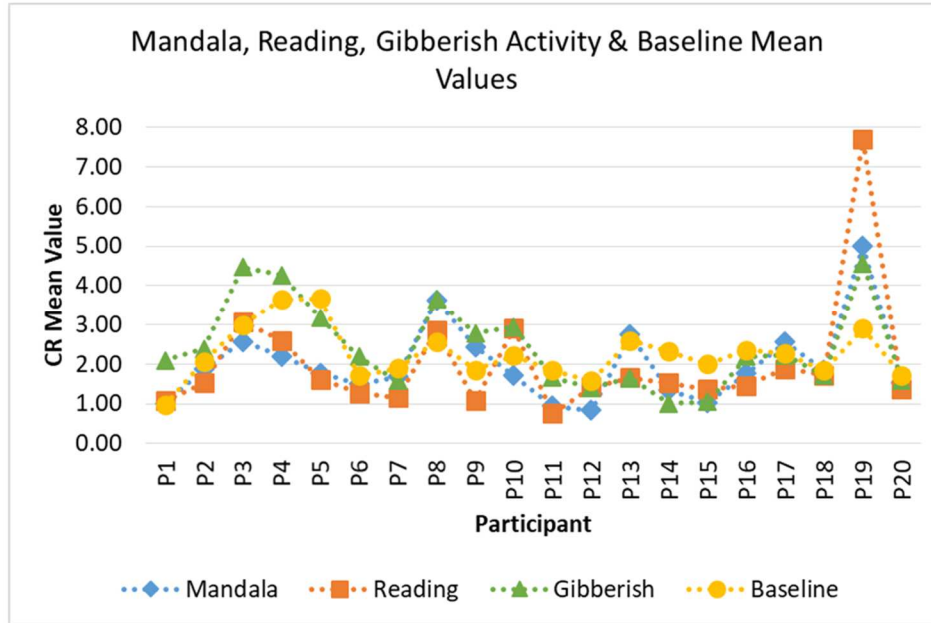
In order to validate our general working hypothesis, we tested three (3) distinct hypotheses:

- **Hypothesis 1:**  $H_0: \mu_{BL} \neq \mu_G$ , where  $\mu_G$  refers to the mean CR values for the activity Gibberish per participant and is expected to show statistically significantly higher values than the mean CR values of Baseline measurement periods,  $\mu_{BL}$ .
- **Hypothesis 2:**  $H_0: \mu_{BL} \neq \mu_M$ , where  $\mu_M$  refers to the mean CR values for the activity Mandala per participant and is expected to show statistically significantly higher values than the mean CR values of Baseline measurement periods,  $\mu_{BL}$ .
- **Hypothesis 3:**  $H_0: \mu_{BL} \neq \mu_R$ , where  $\mu_R$  refers to the mean CR values for the activity Reading per participant and is expected to show statistically significantly higher values than the mean CR values of Baseline measurement periods,  $\mu_{BL}$ .

We performed a statistical analysis to determine whether the CR mean values of Gibberish, Mandala and Reading are larger, equal or smaller than the Baseline CR mean values.

First of all, in Figure 1, a comparative graph is presented that displays the CR mean value of each of the twenty (20) participants for the fifteen (15) days measured for all three (3) activities and Baseline. We can observe that the CR mean values for the activity reading are below baseline for a significant number of participants. The situation is different for the activities Gibberish and Mandala showing a more diverse behavior.

In Table I all the CR mean values for each participant are listed and the highest and lowest results are marked in blue and orange respectively for each of the twenty (20) participants. From this table it can be derived that most participants have scored their highest CR mean values in either Gibberish or in Baseline. Only two (2) participants scored their top CR mean value in the Mandala activity, while for only one (1) participant the highest CR mean value was recorded during the Reading activity.



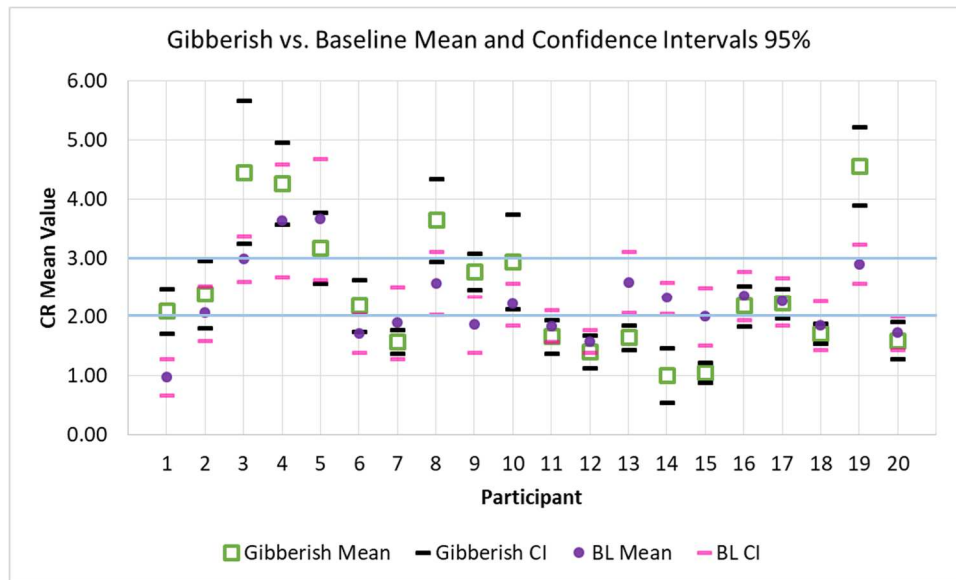
**Figure 1.** It displays the CR Mean Value of the fifteen (15) days for all three (3) activities and the Baseline for all twenty (20) Participants. Gibberish is displayed with green triangles, Mandala with blue diamonds, Reading with orange squares and Baseline with yellow circles.

**Table I.** CR Mean Values of Gibberish, Mandala, Reading, and Baseline for all Participants

	Gibberish	Mandala	Reading	Baseline
P1	2.10	1.02	1.08	0.97
P2	2.39	1.88	1.53	2.06
P3	4.46	2.57	3.08	2.99
P4	4.27	2.20	2.60	3.64
P5	3.18	1.78	1.62	3.67
P6	2.19	1.50	1.27	1.71
P7	1.57	1.69	1.15	1.89
P8	3.65	3.63	2.84	2.57
P9	2.78	2.43	1.08	1.86
P10	2.94	1.71	2.90	2.21
P11	1.66	0.94	0.76	1.84
P12	1.40	0.84	1.42	1.58
P13	1.65	2.75	1.66	2.60
P14	1.00	1.34	1.53	2.33
P15	1.05	1.04	1.37	2.00
P16	2.19	1.77	1.46	2.36
P17	2.23	2.56	1.88	2.26
P18	1.72	1.84	1.73	1.85
P19	4.56	5.00	7.70	2.90
P20	1.60	1.54	1.38	1.72

In order to get a clear understanding of how each of the three (3) activities compares to Baseline, comparative graphs were created that display the mean values together with their corresponding confidence intervals (CI) for  $\alpha = 0.05$ .

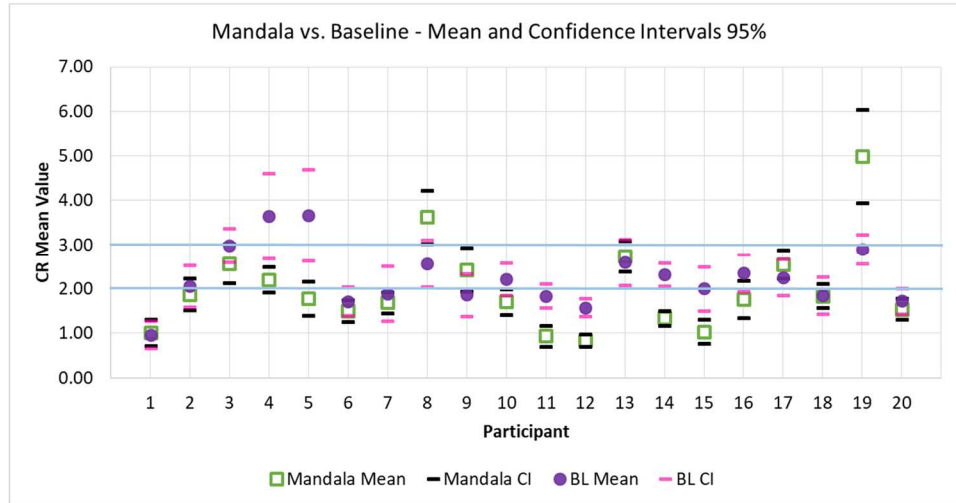
In Figure 2 the reader can appreciate the CR mean values for Gibberish, symbolized by the green squares, together with the CI (black lines) in relationship to the Baseline CR mean values (purple circles) and their corresponding CI (pink lines).



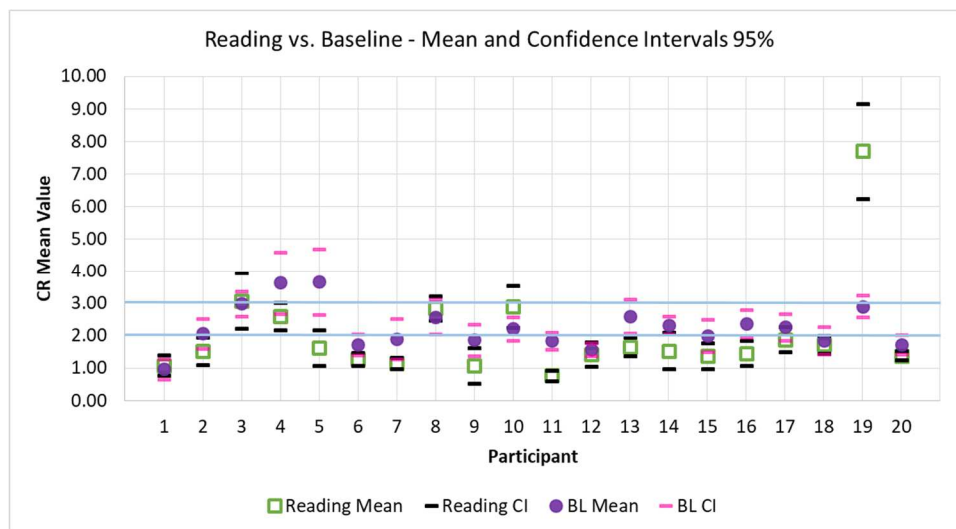
**Figure 2.** It displays the CR mean values (green rimmed squares) for Gibberish with their associated confidence intervals (CI) of 95% (black dashes), together with the CR mean values (purple circles) for Baseline and their associated CI (pink dashes) for each participant. The blue lines mark low coherence (below 2), medium coherence (between 2 and 3) and high coherence (above 3).

For the Mandala activity, a quite different picture emerges as can be derived from Figure 3. Only two (2) participants display high coherence (Participant 8 & 19), while thirteen (13) participants display low coherence. Even participants that were recorded with high coherence for their Baseline (Participant 4 & 5) recorded medium or low coherence in this activity.

Finally, in Figure 4 the CR mean values for each of the twenty (20) participants during Reading is displayed in comparison to their Baseline CR mean values. A similar image emerges as already described for Mandala. The Reading activity also left a large majority of the participants, fifteen (15) of them, in low coherence and four (4) in medium coherence, while only one (1) participant achieved very high CR mean values, with a mean CR value of above seven (7). Once again, as already mentioned for the Mandala activity, participants with high CR mean values for Baseline only achieved medium or low coherence during this activity and most participants recorded CR mean values below their Baseline CR mean values.



**Figure 3.** It displays the CR mean values (green rimmed squares) for Mandala with their associated confidence intervals (CI) of 95% (black dashes), together with the CR mean values (purple circles) for Baseline and their associated CI (pink dashes) for each participant. The blue lines mark low coherence (below 2), medium coherence (between 2 and 3) and high coherence (above 3).



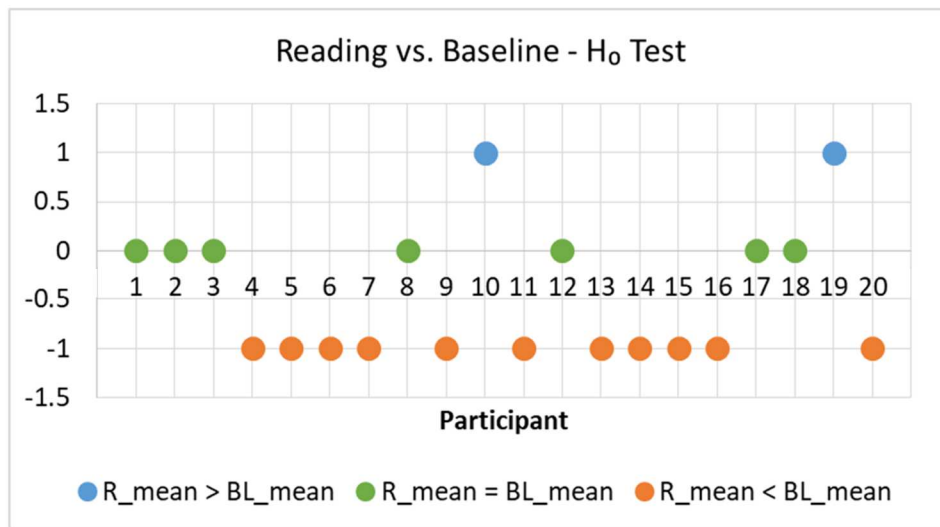
**Figure 4.** It displays the CR mean values (green rimmed squares) for Reading with their associated confidence intervals (CI) of 95% (black dashes), together with the CR mean values (purple circles) for Baseline and their associated CI (pink dashes) for each participant. The blue lines mark low coherence (below 2), medium coherence (between 2 and 3) and high coherence (above 3).

In order to verify (or correct) the impressions derived from the visual inspection of Figure 2, 3 and 4, a hypothesis test was performed to determine whether CR mean values are statistically significantly equal or different. The results are presented in Figure 5, 6 and 7, where the green circles identify those activity CR mean values that are statistically accepted to be equal to the Baseline CR mean values, while the blue circles identify those activity CR mean values that are



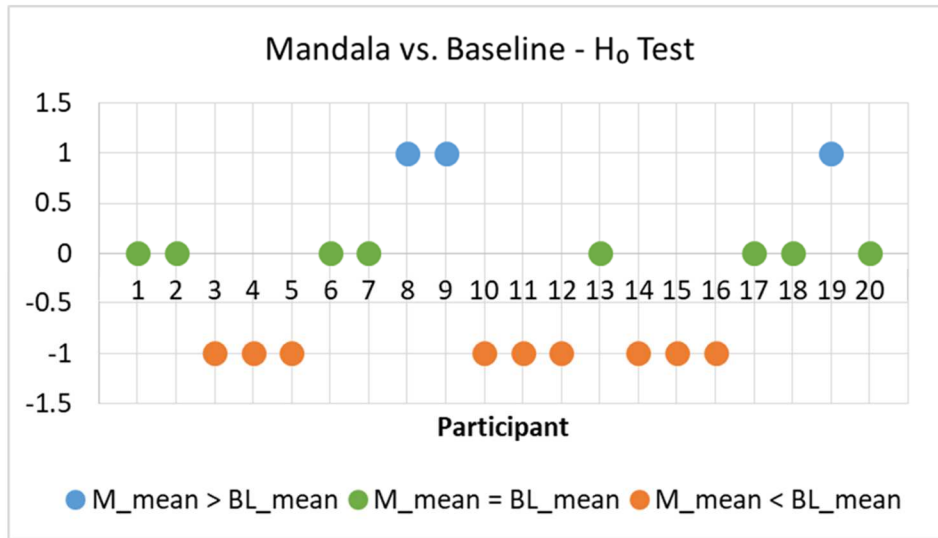
accepted to be larger, and the orange circles those ones that are accepted to be smaller than Baseline CR mean values.

In Figure 5 the reader can appreciate the results of the hypothesis test for the Reading activity vs. Baseline. We observe that only two (2) participants reached higher CR mean values during this activity compared to Baseline periods, while seven (7) participants displayed equal CR mean values for Reading and Baseline. The remaining eleven (11) participants, the majority, scored lower CR mean values.



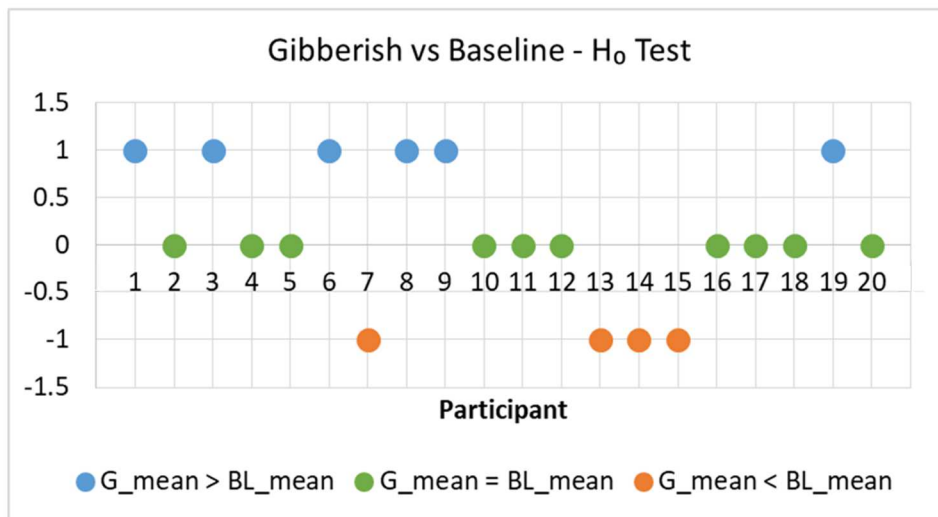
**Figure 5.** It displays the results of the H<sub>0</sub> Hypothesis testing for Reading vs. Baseline, where blue circles represent H<sub>0</sub>=0, while green circles represent H<sub>0</sub>=1 for the CR mean values being statistically equal and the orange circles H<sub>0</sub>=1 for the CR mean values for Reading are statistically less than the CR mean values of Baseline.

In Figure 6, similar results can be observed. While for three (3) participants the Mandala activity can be regarded as a beneficial activity for their coherence and for eight (8) participants it appears that Mandala produces at least equal coherence levels compared to Baseline, for nine (9) participants it must be noted that drawing mandalas, at least for the group of participants in this study is by no means a conducive activity in order to raise coherence and did in fact cause the participants to drop in their CR mean values when compared to Baseline.



**Figure 6.** It displays the results of the H<sub>0</sub> Hypothesis testing for Mandala vs. Baseline, where blue circles represent H<sub>0</sub>=0, while green circles represent H<sub>0</sub>=1 for the CR mean values being statistically equal and the orange circles H<sub>0</sub>=1 for the CR mean values for Mandala are statistically less than the CR mean values of Baseline.

Finally, when comparing the Gibberish activity with Baseline some important differences can be recognized, see Figure 7.



**Figure 7.** It displays the results of the H<sub>0</sub> Hypothesis testing for Gibberish vs. Baseline, where blue circles represent H<sub>0</sub>=0, green circles H<sub>0</sub>=1 for the CR mean values being statistically equal and the orange circles H<sub>0</sub>=1 for the CR mean values for Gibberish which are statistically less than the CR mean values of Baseline.

For most participants this activity leads to higher or equal CR mean values, as in the Baseline period. For six (6) participants this activity produced higher CR mean values than they displayed for Baseline and only four (4) participants displayed lower CR mean values than during Baseline. Out of the three (3) activities compared with Baseline, Gibberish is by far the most likely activity to cause a statistically significant increase of the CR mean values, while activities

Mandala and Reading are more likely to cause a significant decrease in CR mean values. In the following section we will briefly discuss the results presented here.

## V. Discussion

In the present work it has been postulated, as the working hypothesis, that the activities analyzed in this study have beneficial effects on the CR mean values. The previous analysis showed that:

- 1) The activity Gibberish shows some promising indications for this to be the case. While six (6) participants displayed higher CR mean values than they did for Baseline, only four (4) showed lower CR mean values.
- 2) In contrast, the activity Mandala shows little evidence for this to be the case. While nine (9) participants showed lower CR mean values compared to Baseline, only three (3) participants displayed larger CR mean values.
- 3) The results obtained from the Reading activity are similar to the results from the Mandala activity where only two (2) participants showed larger CR mean values. The majority of the participants, eleven (11) of them, displayed smaller CR mean values compared to their Baseline CR mean values.

While these results may first come as a surprise, there are some possible explanations for them. Listening to a reading, even though presumably inspiring, comes with certain energy demands on the brain in order to create meaning and integrate the received information from the reading, the creation of knowledge. The Cycle of Creation of Knowledge and Meaning and its associated energy demands has been described by [27-30]. Further, in some cases the reading may also have caused an increase in stress due to the perceived lack of comprehension, struggle to find meaning and possibly dealing with the feeling of inadequacy due to the lack of being able to make sense of the content being received. Such an experience certainly would trigger emotions that in turn would cause the CR mean values to drop and therefore reduce the psychophysiological coherence ratio (CR) of the participant [11, 31, 32].

In the case of Mandala, a similar scenario may be playing out since the participants were presented with the task to color in a mandala-like pattern. Here the participant had to make a decision on the shape of his or her mandala, as well as the color scheme. Since every activity was limited to a 30-minute period, some participants expressed a certain pressure they felt to finish their mandala within this time, even though every participant was given the opportunity to continue their mandala during the next mandala activity slot. Once again the creation of meaning and the associated energy consumption may also play a role in this activity, for example, as a consequence of the search for patterns together with the perception of being slow or late leading to some level of stress.

In contrast to the two (2) previously discussed activities, the Gibberish activity may provide the opportunity to have less need to generate meaning and knowledge and therefore a lesser energy requirement. However, this may only be a partial explanation for the results obtained, since, as discussed in previous work [22], information in the form of gibberish sounds, body language and facial expression may play a part while being processed as new meanings, also relevant to the cycle of creation of knowledge and meaning. There is another element that is unique to this

activity over the other two (2) and can possibly describe better why we observe higher CR mean values for a significant number of participants. As the authors have mentioned in some of their work [33], there is a possible synergy between two (2) people happening in positive emotions dynamics, which may allow for an increase of psychophysiological coherence. For example, if one (1) person displays stronger tendencies towards higher coherent states, this may have an impact on the other person and result in an improvement of their own psychophysiological states. This phenomenon has been called entrainment [22], and from our perspective, in order to be conclusive about that, we will require further experiments and closer analysis.

Before closing this section, it is important to mention another aspect in relation to a previous hypothesis, from a previous study, stating that fun activities may result in a temporary increase of psychophysiological coherence, followed by a kind of taxing effect shortly after due to energy depletion [22], as for example, when children enjoy playing for a while until they get hungry or tired.

The results obtained from the analysis presented in this paper, however, raise some questions regarding this hypothesis, since particularly the drawing of mandalas has been reported as a fun activity by most participants, while resulting in higher than baseline CR mean values only in three (3) out of twenty (20) cases. In order to better appreciate the effects a particular activity has on the CR mean value, as it develops in time (very fun, fun, less interesting, tired) or activities, which are fun yet with detrimental effects post activity periods, further studies will be required. Such an undertaking is certainly worthwhile if we ought to better understand which kind of activities lead to an overall increase in general wellbeing.

## VI. Conclusions & Future Perspectives

In this work we have explored the potentially beneficial activities of talking gibberish, drawing mandalas and listening to a spiritual reading, in terms of their effectiveness in contributing to an increase in psychophysiological coherence assessed via HRV measurements and the derived coherence ratio. These activities were compared to a Baseline coherence ratio to determine if they are a viable tool to improve psychophysiological coherence.

We have shown in our statistical analysis that only the Gibberish activity can be regarded as potentially beneficial and that the other two (2) activities in many cases have an opposite effect, however, this requires further research with a larger database of participants. Here it is important to note that there seems to be a dimension associated to the individual, since certain activities are beneficial to some, while having an opposite effect on others. Further, there are other factors that may play a role and need to be considered when designing activities to improve psychophysiological coherence, such as energy consumption due to mentally engaged tasks, impinging on the creation of knowledge and meaning and its associated brain dynamics, for example.

For future work, we foresee great benefit in gaining better understanding of how people affect each other when socializing and the effect that particular ways of interacting may impact psychophysiological coherence.

A first theoretical attempt has been made by the authors already and can serve as a good beginning point for such future research [22, 33]. Further, we propose that more studies need to be done that explore the long-term effects in psychophysiological coherence and inner peace that certain activities may produce. This may include future meditation studies, for example, that may show conclusively activities or practices that are capable of causing prolonged high coherence levels and states of inner peace putting us in touch with the sacredness of nature and the ‘vibe of the other’.

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