Summary of Social Coherence & HRV Synchronisation Research Day Results

London, Data Recorded: 26th January 2020
Report Dated: 27 April, 2020
Report Author: Peter Granger

Dedication

This project is dedicated to the memory of my father, Cyril Granger who taught me so much about science and inspired me to carry out this research.

Social Coherence & HRV Synchronisation Research Day

26 January, 2020 - Summary of Results

Research Team

Lead Researcher - Peter Granger (Director Heartbond Ltd)
Research Day Organiser - Gavin Andrews (Managing Director, HeartMath UK & IRL)
Research Assistants - Dr. Carla Stanton (Medical Director, Heartmath UK & IRL), Claire Berry

Hypotheses Tested

1. Heart rate variability (HRV) coherence, associated with feelings of appreciation/gratitude/love, is a factor in the synchronisation of HRV measures between pairs of people who are in a relationship.

2. One person can influence another person's HRV measures through the intention of appreciation/gratitude/love.

Experimental Method

11 pairs of volunteers from the HeartMath UK community came together in a room in central London for the research day. Each volunteer was briefed about the aims and methods to be used during the research and all signed an informed consent form. The volunteers carried out a series of experiments to simultaneously measure their heart rate variability with a variety of experimental protocols. Data was analysed for heart rate variability synchronisation and these were used to test the two hypotheses listed above.

Room Layout: The room was laid out as shown in figure 1. Experimenters were divided into two groups with 5 pairs in per group (red - A to J and blue - K to T). Pairs stayed together for duration of the research day. Each pair sat at different ends of a table on seats approximately 2 metres apart and faced away from each other so there were no visual cues during the experiments. An extra pair sat on two chairs at the back and recorded their data during both sessions when they were in the room (X and Y). This same pair also recorded two nonlocal HRV synchronisation experiments - one during the research day and one on the following day.

Heart Rate Recording: Heart rate data was recorded using a purpose-developed mobile phone (Android) app that linked to a HeartMath Inner Balance ear-lobe plethsmographic sensor via Bluetooth. One pair (KL) used a Polar H10 ECG chestband sensor as input to the app. This same pair and the additional pair (XY) also measured HRV using a Firstbeat Bodyguard 24-hour ECG device that was fixed to their chests for the during of the research day and for one pair, into the next day. HR data and UST timestamp was recorded into each mobile phone memory for later download as a simple CSV file. All three types of monitor recorded useable data during the project although the Inner Balance device exhibited more noise due to movement artifacts and had a lower HR temporal resolution. Under comparison, the Polar and Firstbeat devices showed very similar data with near 1-second resolution and are recommended for any future research.

Experiment details: Each experiment had a 10 minute duration. The details of the 7 different experiments conducted are shown below. Each HRV recording was started and stopped by the experimenters by tapping the start and stop buttons on the app following a verbal countdown from the research lead organiser who stood at the front of the room. This meant that each group of paired experimenters conducted their experiments simultaneously.

7 different local experiments were carried out as follows:

- **Expt. 1** No focus on each other nor attempt to gain HRV coherence – both experimenters read book or magazine.
- **Expt. 2** Both experimenters feel appreciation/gratitude/love for each other. Both experimenters asked to attempt to gain HRV coherence as best they can.
- **Expt. 3** Intention. One experimenter (sender) feels appreciation/gratitude/love for the other experimenter (receiver) but the receiver reads as book/magazine and makes no effort to focus on sender. Sender and receiver sit facing away from each other.
- **Expt. 4** Intention. Swap around sender and receiver from Expt. 4. One experimenter (sender) feels appreciation/gratitude/love for the other experimenter (receiver) but the receiver reads as book/magazine and makes no effort to focus on sender. Sender and receiver sit facing away from each other.

Expt. 5 and 6 were not conducted.

Expt. 7 Each experimenter focuses love/appreciation/gratitude as a group - 6 pairs, 12 people in total.

Expt. 8 Directed Intention. Lead researcher defines focus and non-focus times by raising and dropping a white sheet of paper from front of room. Only senders can see this sheet. Receivers sit facing back wall, reading. Timings were not recorded.

Expt. 9 Directed Intention. Lead researcher defines focus and non-focus times by raising and dropping a white sheet of paper from front of room. Only senders can see this sheet. Receivers sit facing back wall, reading.

Timings were as follows for Expt. 9 (secs from start of expt.):

Non-Focus (Sender distracts themself by reading)	**Focus** on receiver
0-60	61-150
151-240	241-360
361-480	481-600

Time Stamp: Inner Balance and Polar data was recorded via Bluetooth into the mobile phone and was timestamped using Universal System Time. The app was designed to record one heart rate value every second through an internal resampling algorithm. Mobile phones used in the experiments were checked for their time slippage against UST using the web app www.time.is . Differences between the phone app time and UST were recorded at intervals during the day. Timings were then corrected from each experiment to ensure that each experimenter had the same time-zero start time. Timing from the Firstbeat monitors was obtained from an internal timestamp which was downloaded with the HR data by the HeartMath Institute and then input to the analysis algorithms developed for this research project.

Data Analysis: Some mobile phones used in the experiments did not record regular time intervals, dropping some HR values. This irregular time sampling was corrected by developing an interpolation algorithm that resampled the data using a spline-interpolation function. The data output from this reprocessing was HR sampled at a regular 1 second time interval.

Frequency Domain Processing

The HR timeseries were run through a discrete fast fourier transform algorithm to extract frequency power bins. The time window for the fourier transform was 32 seconds . This relatively short window was used to gain a greater time resolution in the frequency and synchronisation analysis.

Actual Frequency Bins Used in Recording APP algorithm:

Low Frequency Max (LF) - Maximum in frequency bin range 0.06-0.16 Hz

Sum High Frequency (SumHF) - Sum of frequency bin range 0.19 - 0.47 Hz

These differ from the standard frequency bands due to the limitations of frequency bin width definition with a 32 bin fourier transform (16 usable bins) and desire to allow higher frequencies in HF band to increase freqeuncy resolution.

Time Domain Processing

Time domain processing was carried out using a purpose-designed algorithm based on previous research. This algorithm essentially estimates the HRV amplitude by analysing beat-to-beat changes in heart rate. These were input as a one second time sample series. The absolute change in heart rate each second was then put through an algorithm that calculated the maximum of this series over a 3 second window. This was then smoothed with a running average over 6 seconds to obtain the MaxDiffHR value for each HR time series - a measure of how HRV amplitude changed with time in each experiment.

Correlation Coefficients of HRV Measures: The correlation coefficients of various HRV measures were calculated for the experimenter pairs using a Spearman correlation algorithm with a 30 second window. This ran down the data one sample (1 sec) at a time calculating correlation coefficients. This yielded a correlation coefficient time series for the key HRV measures.

Correlation values were recorded in a spreadsheet for each experiment along with the averaged HRV measures.

Data Display: Data was displayed visually as charts using an Excel spreadsheet. Heart rates and other HRV measures were overlain and vertically scaled by adjusting the vertical scales of the charts to aid the identification of visual correlation. Cross-plots of key HRV measures and correlation coefficients were produced.

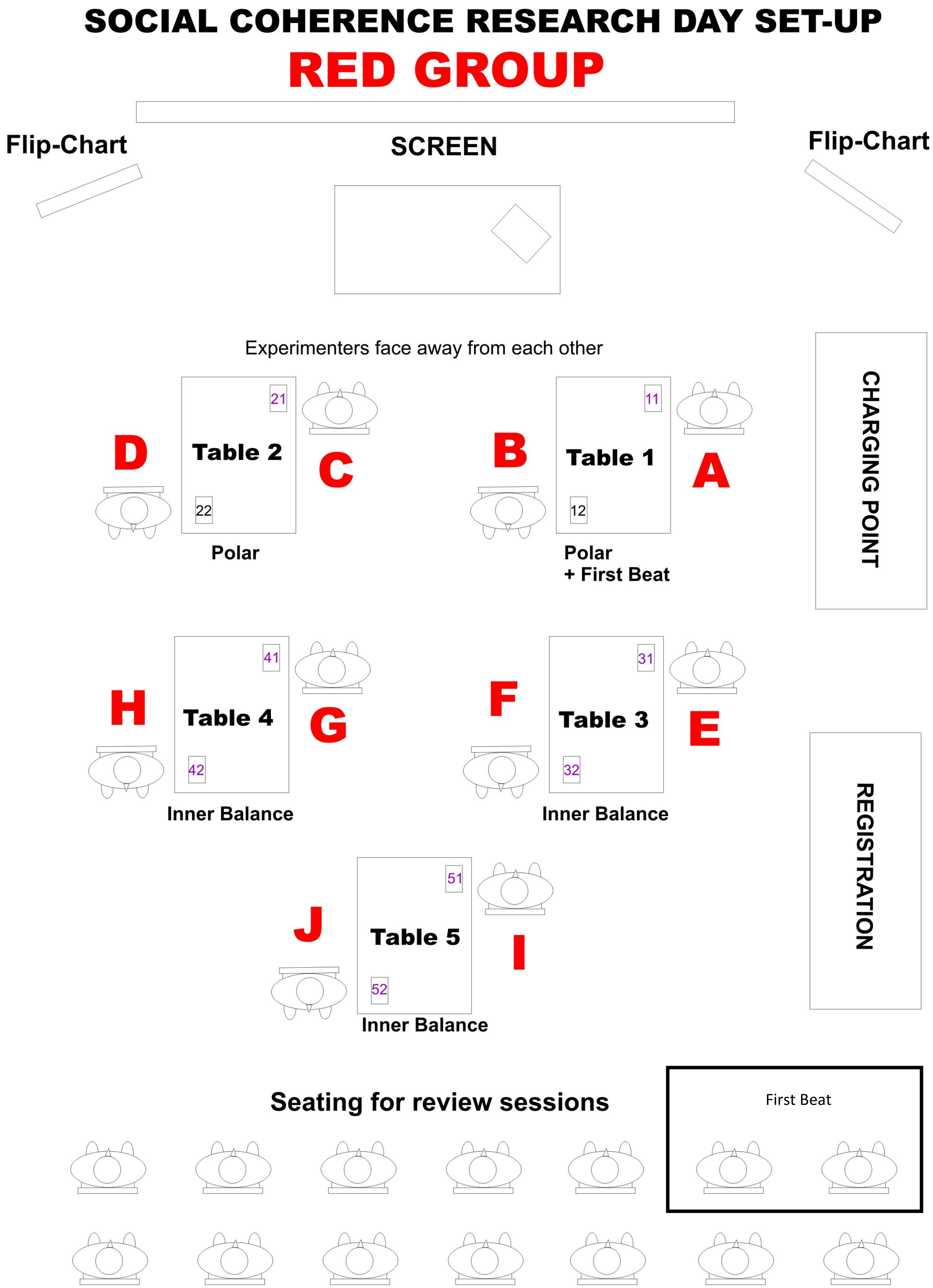


Figure 1. Room Layout. Blue team had similar layout

Data Recorded:

Data from 59 paired HRV synchronisation experiments (57 local, 2 nonlocal) were analysed and considered to be of sufficient reliability for conclusions to be drawn. Some recordings were subject to noise and movement artifacts and these may limit some of the frequency domain power spectra and the numerical estimations of correlation. A small number of the paired experiments did not yield synchronisation data because one of the heart rate series did not record successfully onto the app.

Key research findings and examples

*1. **General Observations** Heart Rate Variability (HRV) synchronisation across a range of HRV measures was evident between all pairs and was observed to a greater or lesser extent in most of the successfully recorded experiments conducted during the research project.*

Correlation of HRV measures was observed in most of the 59 experiments conducted. 42 of these show significant correlation of HRV measures (greater than 0.15 Spearman correlation coefficient, where = 1 is 100% in phase correlation and -1 is 100% out of phase.

The overall average correlation coefficient of all the HRV measures estimated was positive at 0.0075 over 57 experiments, recording a total of 9.5 hours of data. The fact that the correlation coefficient remains positive over this averaged dataset shows that it is a robust phenomenon. It appears that HRV synchronisation is a naturally occurring effect and it is expected that it can occur in any two people who are engaged in some form of relationship. Figure 2 shows heart rate synchronisation of a pair during Experiment 2 where both experimenters were focusing on each other without looking at each other.

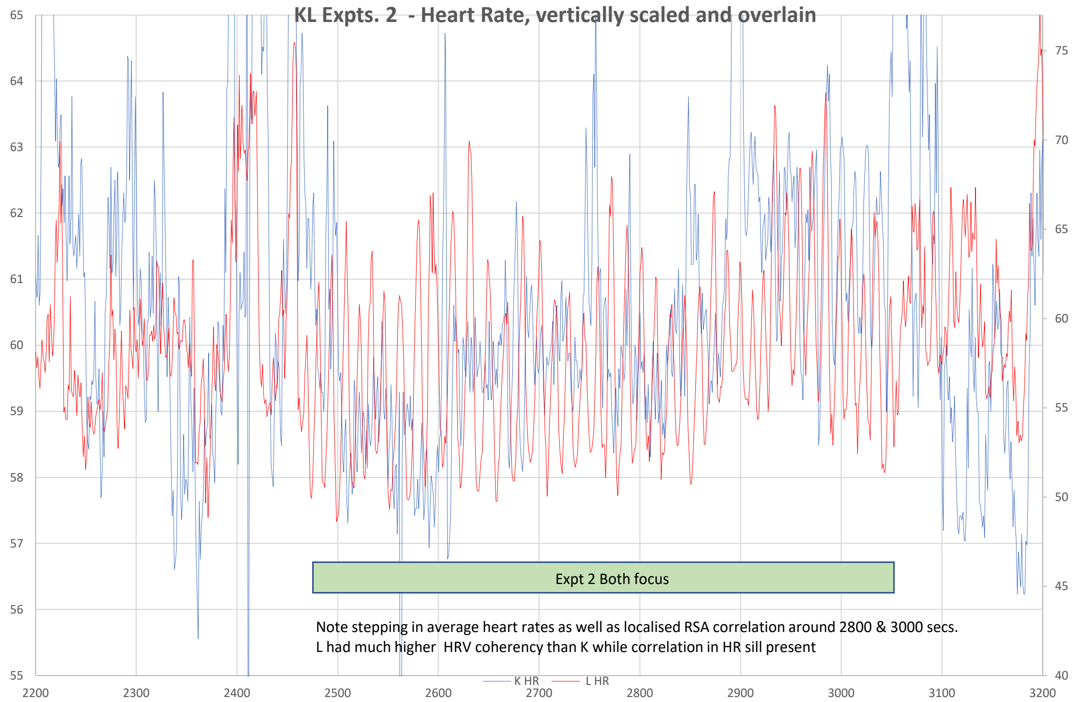


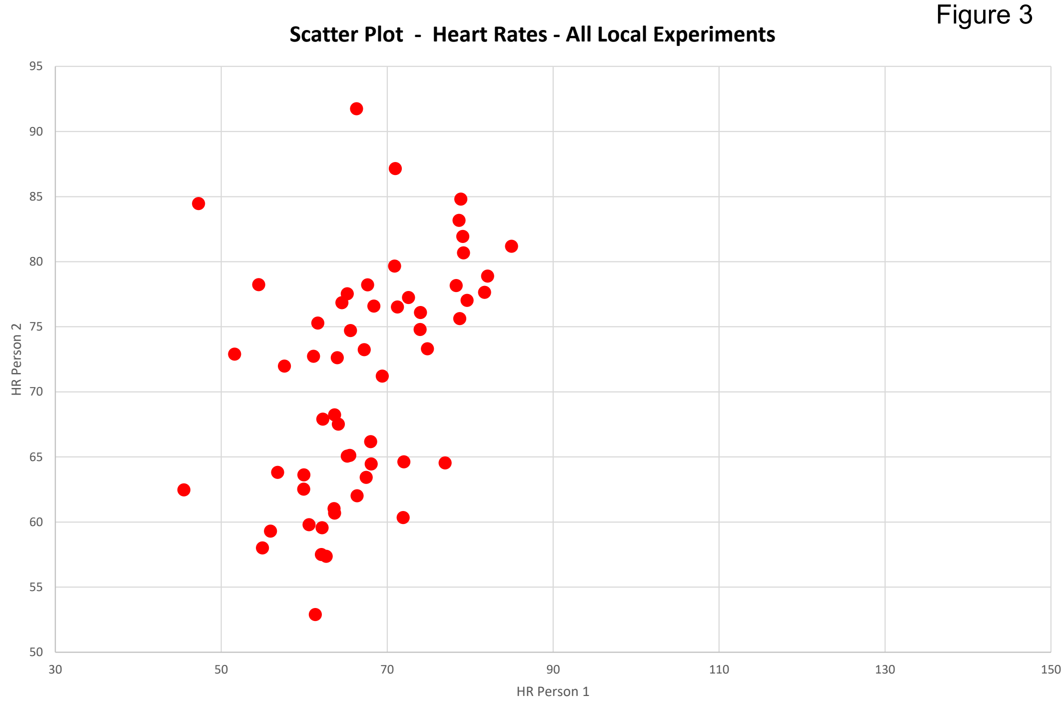
Figure 2

2 . **Evidence of ULF or VLF Bulk Shift in HRV Synchronisation** *The data revealed that heart rate synchronisation includes an important ultra low or very low frequency element which appears as a bulk shift in average heart rates between two people who are conducting an experiment. This has the effect of making the difference in average heart rates smaller in an experiment.*

Synchronisation of heart rate variability (HR) is most strikingly demonstrated by the cross-plot of the paired experimenter average heart rates, shown below in Figures 3, 4 and 4a.
The synchronisation is evident from the approximately linear trend in the relationship between heart rates (Fig. 3). The heart rates of paired experimenters lie on a broad scatter line of increasing heart rate. This is also evident on the cross-plot (Fig. 4) for all the heart rate data for the most significant correlations on the research day. This shows that the heart rates of two people who are focused on each other have at least two elements involved in the synchronisation.

The first is a base level shift where the two average heart rates become more similar (DC shift, in VLF or ULF) and secondly, a shorter-period synchronisation usually related to the RSA breathing pattern/ baroreflex (LF and HF) . W**e believe this is a new discovery that has come out of the research day.**

Figure 3



Cross-plot of heart rates for highest correlation coeffs. > 0.1

Figure 4

Cross-plot of heart rates for OP experiment pair

Figure 4a

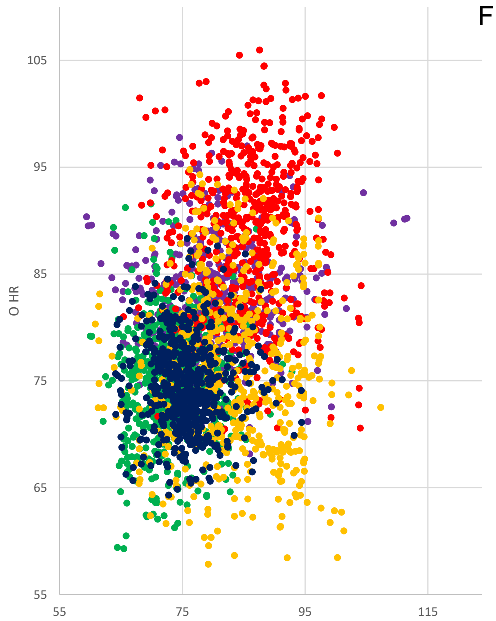
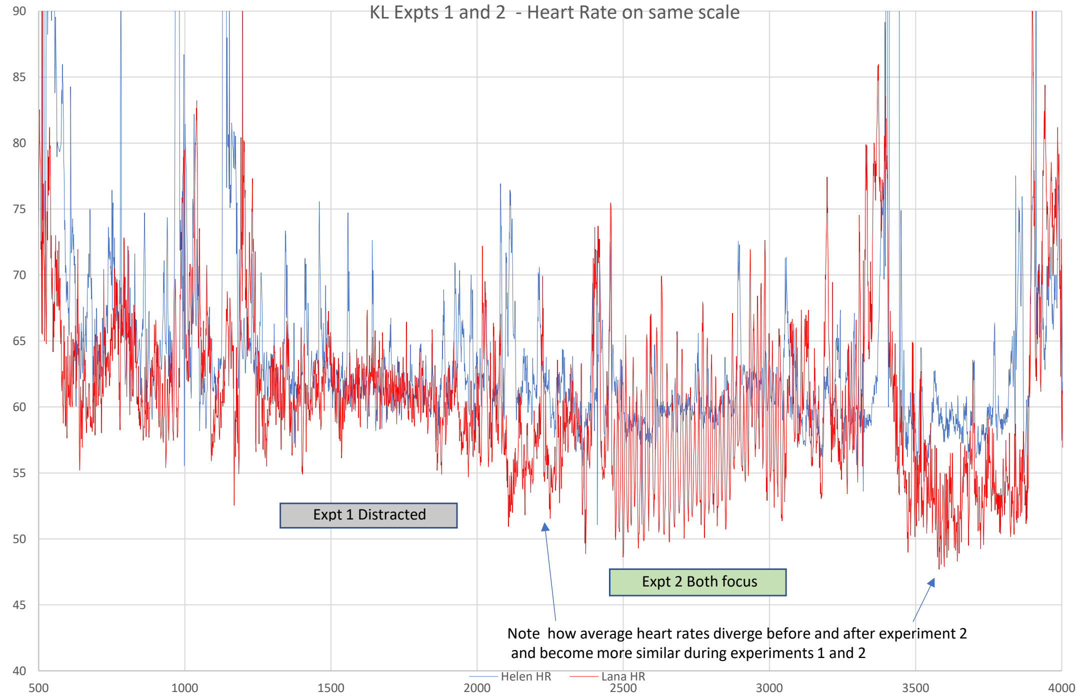


Figure 4a shows that the DC element in HR synchronisation is also evident in the set of cross-plots from one experimenter pair for all the experiments they were involved in during the research day. Note the general linear trend of the cloud of points with increasing HR. The size of the cloud of data points for each experiment is related to the amount of coherence displayed by each experimenter.

Figure 5 shows the example from figure 1 in the context of the longer Firstbeat Bodyguard recording of this pair. The heart rates are displayed on the same vertical scale showing how the average heart rates diverge before and after experiment 2 but tend to coincide during the experiment where both are focusing on each other. Surprisingly, this same effect is also present during experiment 1 where both experimenters were asked to distract themselves by reading a book or magazine.

Figure 5



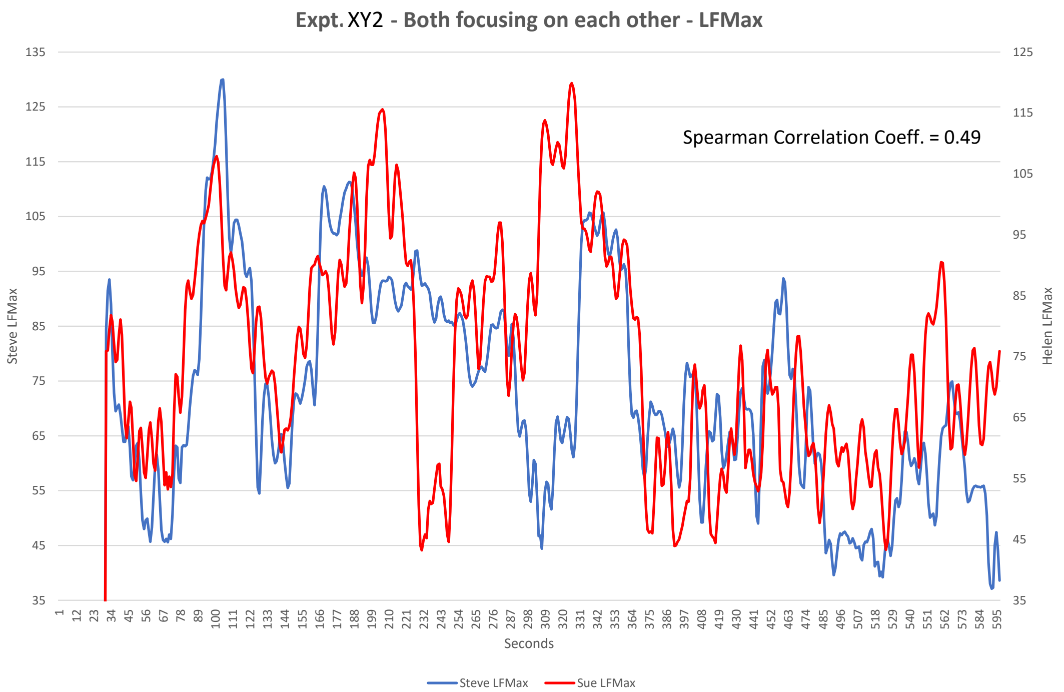
3. ***HRV Synchronisation and Frequency Bands*** *HRV synchronisation was observed for a range of HRV measures including heart rate, maximum low frequency component (a measure of coherence), sum of the high frequency components as well as time domain HRV parameters.*

Some of the HRV correlations were very high (up to 0.49) and these coincide, in some cases, with at least one experimenter having expertise in the HeartMath method. It is clear that some of the pairs had consistently high correlations across the range of experiments.

The highest average correlations across all experiments was observed for the following HRV measures:

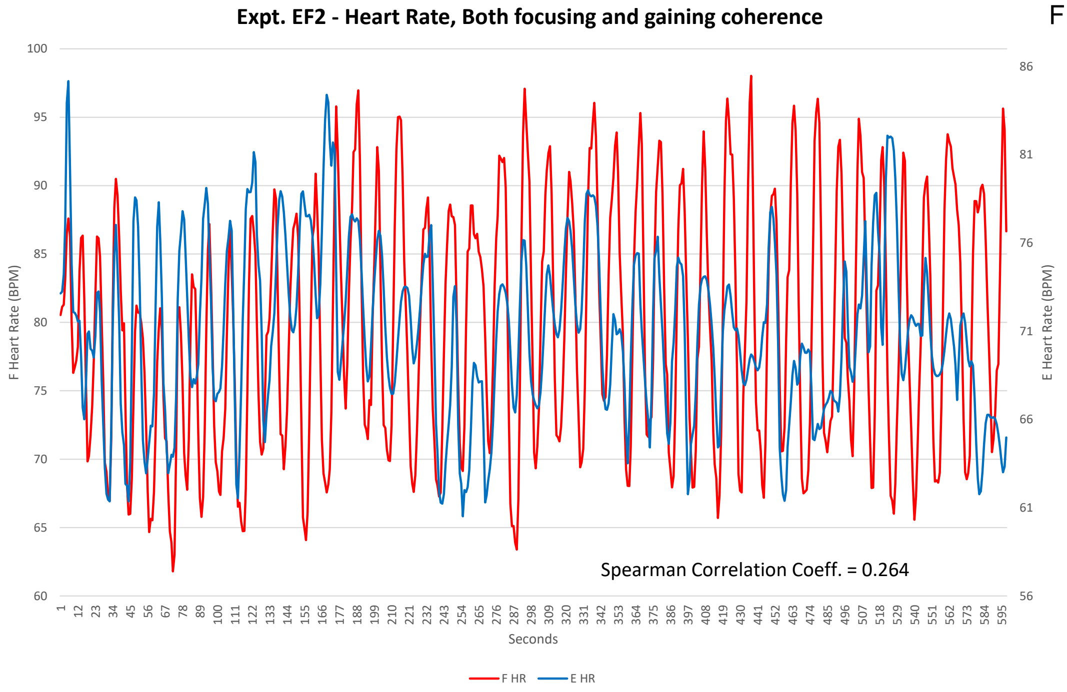
Maximum of Low Frequency Component of HRV (LFMax) – 0.05 (A measure of coherent breathing/ baroreflex patterns). The example in Figure 6 shows a high correlation coefficient for LFMax for the KL pair. LFMax here is a simplified measure of coherence. For this research it was found that the inclusion of the high frequency component in the HRV coherence estimation was disadvantageous due to the noisy nature of the HF component of the fourier transform, relating to both movement artifacts and HR sampling limitations on the Inner Balance heart monitor.

Figure 6



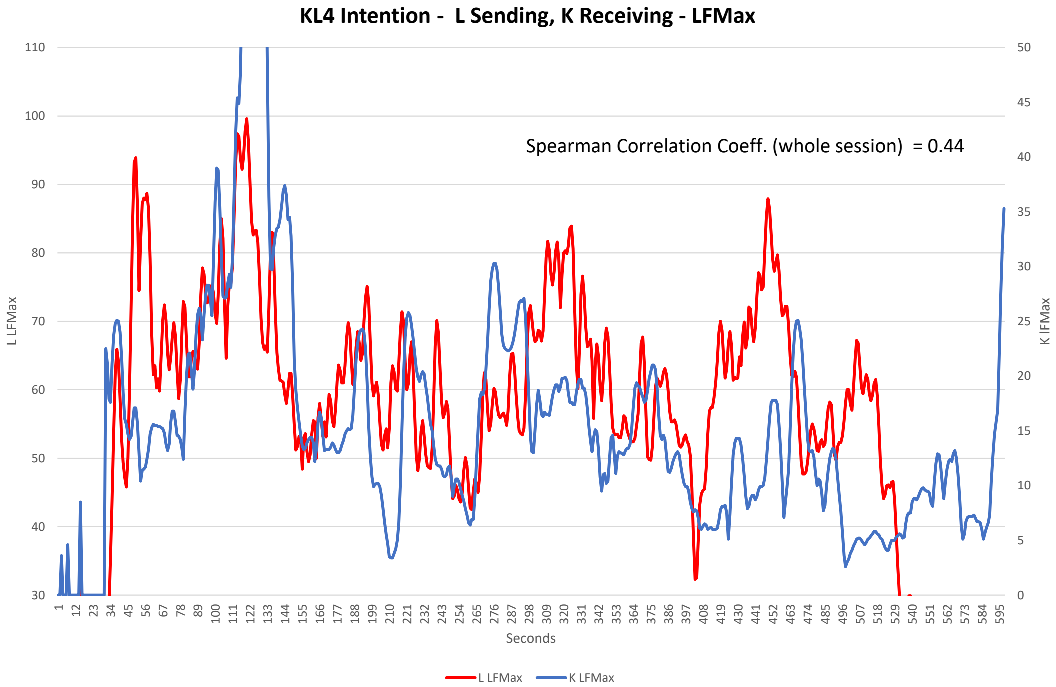
Heart Rate (HR) – 0.019 (heart rate correlation for whole experiment) . Figure 7 shows an example of a high value of HR correlation for the EF pair. In this case both have relatively high HRV coherence which shows correlation of the RSA/baroreflex trace for much of the experiment.

Figure 7



Intention Effect – 0.028 Experimenter 2 in the pairs had, on average, a greater intentional effect which is probably a result of there being more HRV expertise in the second person of each pair. Figure 8 shows an example of an intention experiment result for the KL pair, with a high value of correlation coefficient suggesting that L is influencing the frequency content of K's heart rate variability. This chart shows the maximum of the low frequency component of HRV for both experimenters.

Figure 8



4 . **HRV Amplitude as a Measure of Coherence** *Analysis of the research data showed that HRV amplitude is useful as a secondary measure of HRV coherence and can be used to estimate the strength of intention when the amplitude is related to the degree of focused feelings of appreciation, gratitude and love.*

Estimations of coherence often rely on frequency domain estimates, primarily of VLF,LF and HF components of the fourier transform of the recorded HRV waveform. When an experimenter breathes more deeply and with a longer period of around 10 seconds, this tends to produce a resonant sine-wave HRV waveform but also a general increase in the amplitude of the HRV waveform. Amplitude changes in the recorded HRV waveforms can be estimated using the fourier approach. The high frequency (SumHF) component in the HRV picks up HR changes over a few seconds in the data, although it is sensitive to spikes and noise in the data.

During the research it was found that a time-domain estimate of amplitude correlated well with the fourier estimation of coherence with the advantage of quicker response time than those obtained through a relatively long window fourier transform. The MaxDiffHR measure of amplitude used in this research calculates the smoothed maximum absolute values of beat-to-beat changes in heart rate. Both measures were used to assess amplitude and relate this to the conventional coherence measure that is largely influenced by the low frequency component of the HRV.

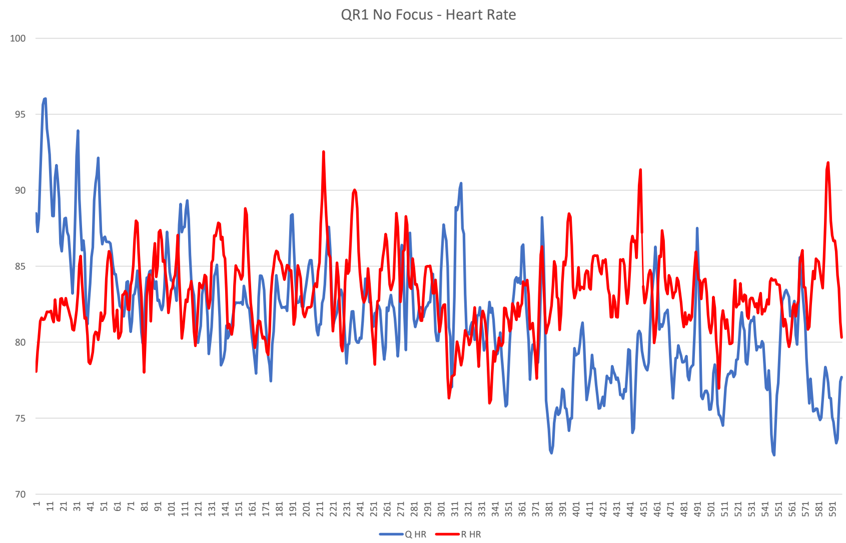


Figure 9

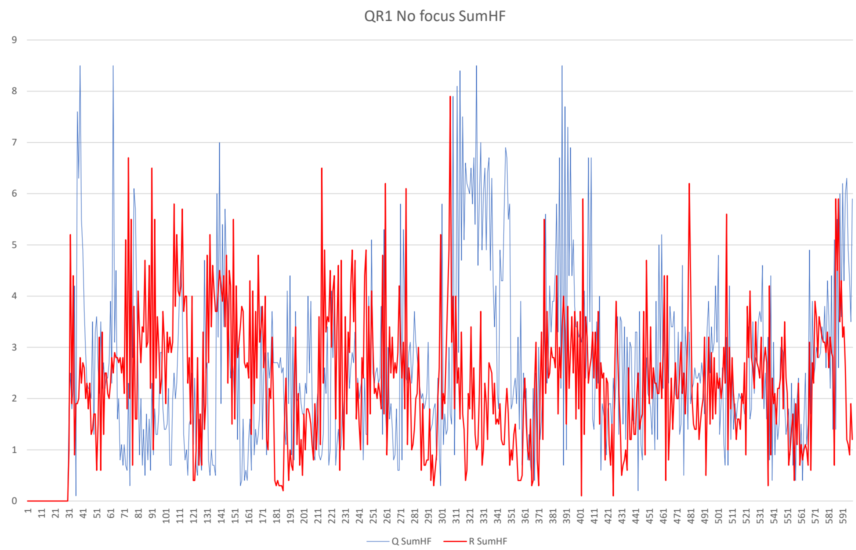
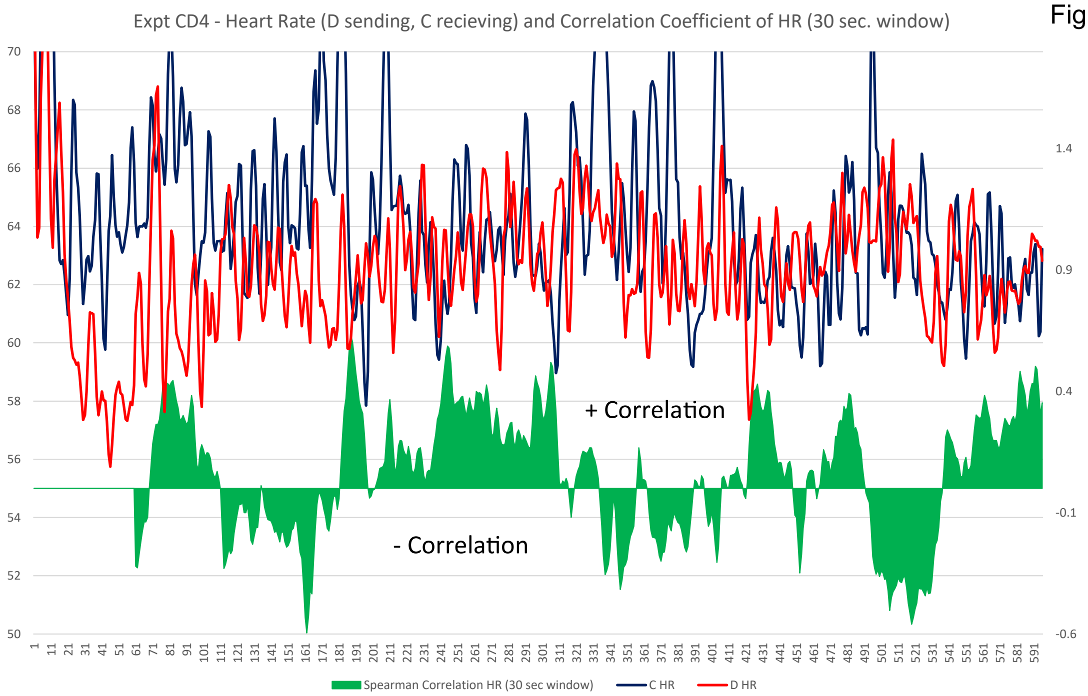


Figure 10

Figure 10 shows how the high frequency changes (SumHF) in heart rate variability can correlate even though these are not easily visible on the recorded heart rate chart (Figure 9). Notice obvious visual correlation in SumHF from 370 seconds to end of experiment as well as earlier in the experiment.

5 . ***Frequency Bands and HRV Synchronisation*** *HRV synchronisation measured as a correlation coefficient of an HRV measure is typically observed at several different frequency bands. It can occur within the ULF, VLF, LF or HF band. The correlation coefficients will also typically range from positive to negative during the course of a ten-minute experiment. These fluctuation mean that care must be taken in averaging correlation coefficients over long time periods as they will tend towards zero.*

Figure 11



Example of fluctuating correlation coefficient from positive to negative for heart rate. Spearman correlation using a 30 sec. sliding window. Note also VLF correlation with period of 1-2 mins. Spearman Correlation for whole session = 0.013 which appears small because of averaging affect across ten-minute experiment .

6 . ***Effect of Focus on HRV Synchronisation*** *HRV synchronisation was evident in the experiment where participants were asked not to focus on each other and were distracted by reading a book or magazine. The results from these experiments did not differ significantly from those where both experimenters focused on each other. This surprising result requires further research as it could indicate an unconscious level of communication, possibly resulting from the interaction of the electromagnetic fields of both experimenters or some other external field or a group synchronisation effect (see section 10). Many experimenters reported that they found HRV coherence and breathing so natural that they struggled* ***not*** *to engage in it during the no-focus instruction experiments. If coherence is a factor in HRV synchronisation this could account for this result.*

Figure 12

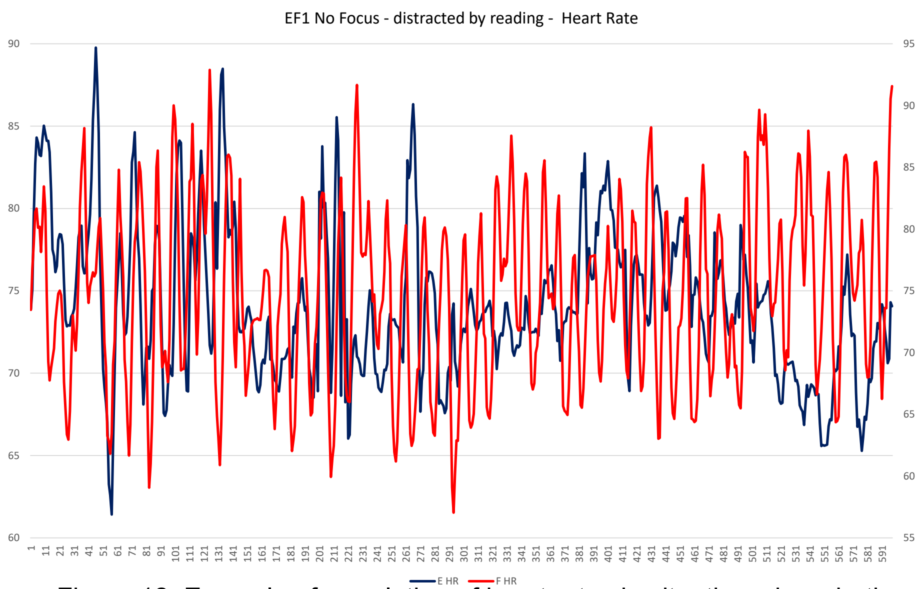


Figure 12. Example of correlation of heart rates in situation where both experimenters distracted. Correl. Coeff. = 0.054

7 . ***Coherence as Factor in HRV Synchronisation*** *A small positive relationship was found between the overall level of HRV coherence of the experimenters and the degree of HRV synchronisation, but this weak relationship may be a consequence of averaging across the experiments (see 5 above).*

Figure 13

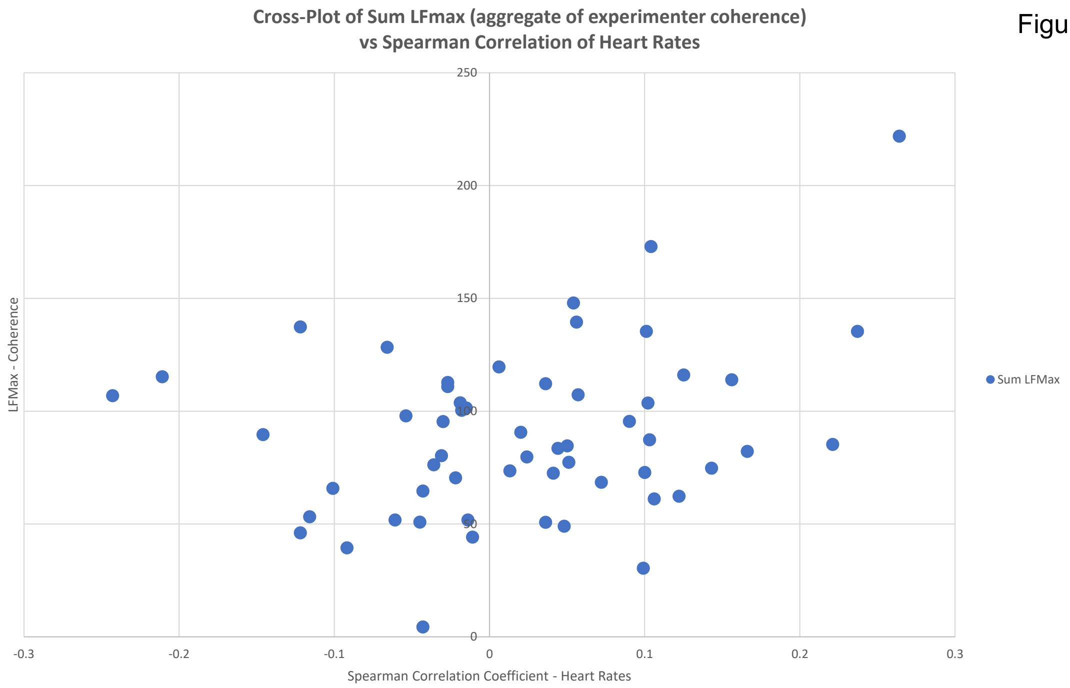
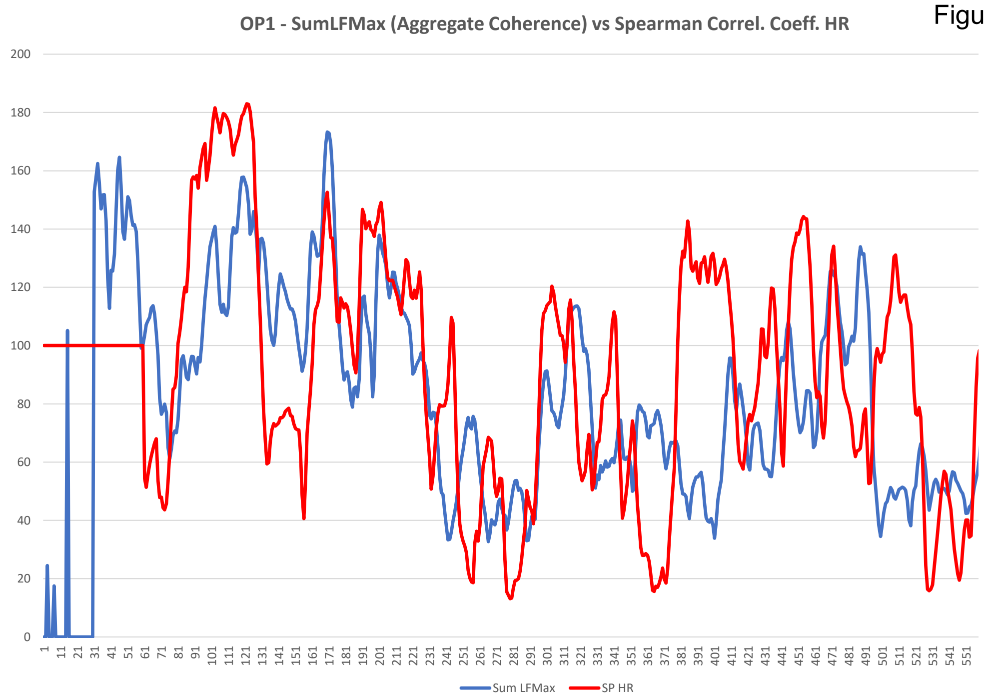


Figure 13 shows a cross-plot of Spearman correlation coefficients for heart rate against the aggregate Maximum of Low Frequency for both experimenters in each experiment. The LFmax was a measure of coherence in this research project. The slight positive relationship between these variables suggests only a small influence of coherence in HRV synchronisation when assessed in this way. However, a greater influence of coherence in HRV synchronisation was observed when the details of individual experiments were considered. Figure 14 shows an example of correlation of SumLFMax (aggregate of coherence for both experimenters) with correlation coeff. of heart rates for a pair from experiment 1. Spearman Correlation Coeff. (whole session) = 0.33 . This example shows that increased coherence corresponds to an increase in correlation of heart rates, supporting the hypothesis that coherence is a key factor in HRV synchronisation. Other results from different experimenter pairs showed similar correlations.

Figure 14



One, possibly significant relationship was identified during the cross-plotting of the amount of receiver coherence (LFMax) against the degree of heart rate correlation. The cross-plot in figure 15 shows that the correlation in heart rate for pairs of experimenters in the intention experiments was generally increasing with increased receiver coherence (LFMax). When analysing the intentional experiments with a sender and receiver, there is a tendency to focus on the sender's coherence to see how this affects the receivers HRV measures, but this chart points to the importance of considering the receiver's coherence. In any synchronisation experiment it is difficult to differentiate between the sender's and receiver's influence on the correlation of the data, but a receiver's ability to receive is a factor that should be considered in any future investigations.

Figure 15

Although a correlation between LFMax and the other measures of coherence used in this research project was observed this does not prove that a high coherence causes synchronisation. The increased low frequency power and higher HRV amplitudes may be a result of a deeper breathing pattern that accompanies appreciative/loving focus. More sophisticated experiments would need to be designed and run to test causation more fully.

8. ***Intention Experiments*** *In a number of the intentional experiments an association between the sender's HRV amplitude (Smoothed Maximum Difference in HR - MaxDiffHR) and the receiver's heart rate was observed.*

The second hypothesis during the research day was to test if an experimenter's intention could influence the degree of HRV synchronisation of the paired experimenters. This was tested in experiments 3,4 and 8, 9 where senders and receivers were specified. Receivers were reading during the experiment and asked not to focus on their partner, while senders focused appreciation, gratitude and love and attempted to gain coherence.

There was a large diversity in the results from the intentional experiments, perhaps indicating that expertise or confidence in 'connecting' and being present may be a factor in HRV synchronisation. The wide range of correlation values for different senders and receivers meant that the average values across experiments were not considered a reliable test of the hypothesis. Individual pairs were therefore analysed, particularly those showing high values of HRV correlation during intentional experiments.

Figure 16

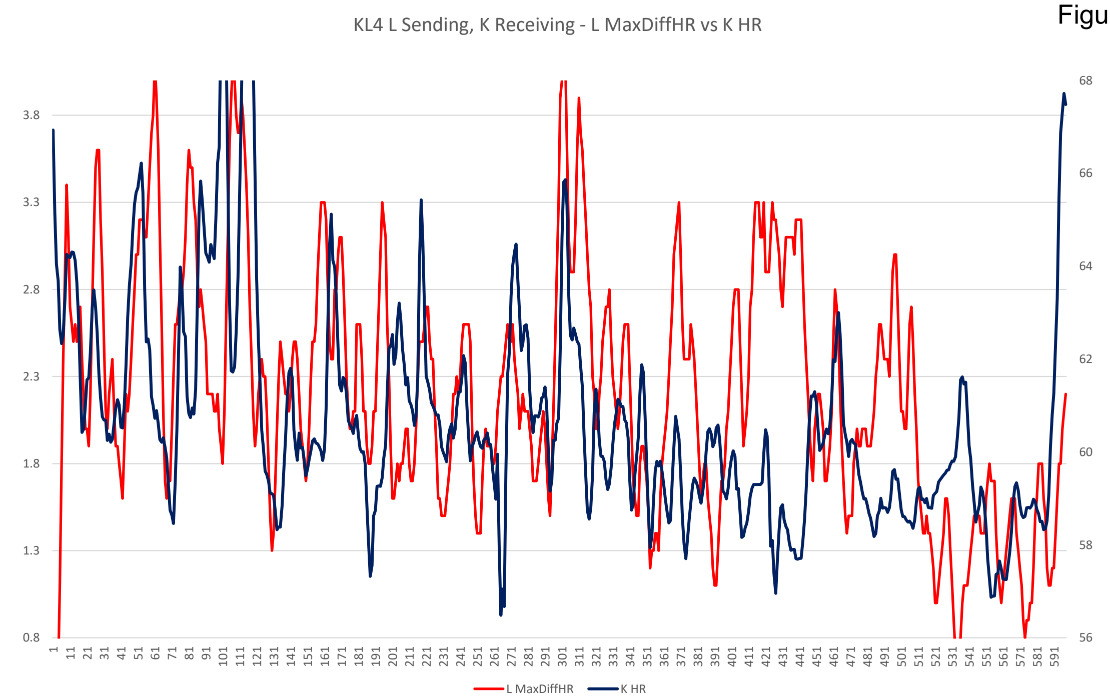


Figure 16 shows the amplitude (MaxDiffHR - red) of sender L and the corresponding heart rate of receiver K – blue. It appears that L is raising K's heart rate by raising their own heart rate during a period of focused coherence. Spearman Correl. Coeff. = 0.26

Figure 17 (QR8) shows the heart rates for the sender (blue) and the receiver (red) where the sender was asked to gain more coherence and focus their positive intention on the receiver, following a sign from the front put up and down by the lead researcher. No timings for the sign movement were taken but it is likely that the higher amplitudes and peaks in the LFMax correspond to the periods of increased intention. Notice how the periods of raised and lowered heart rates synchronise, suggesting that the sender is influencing the receiver's heart rate.

Figure 17

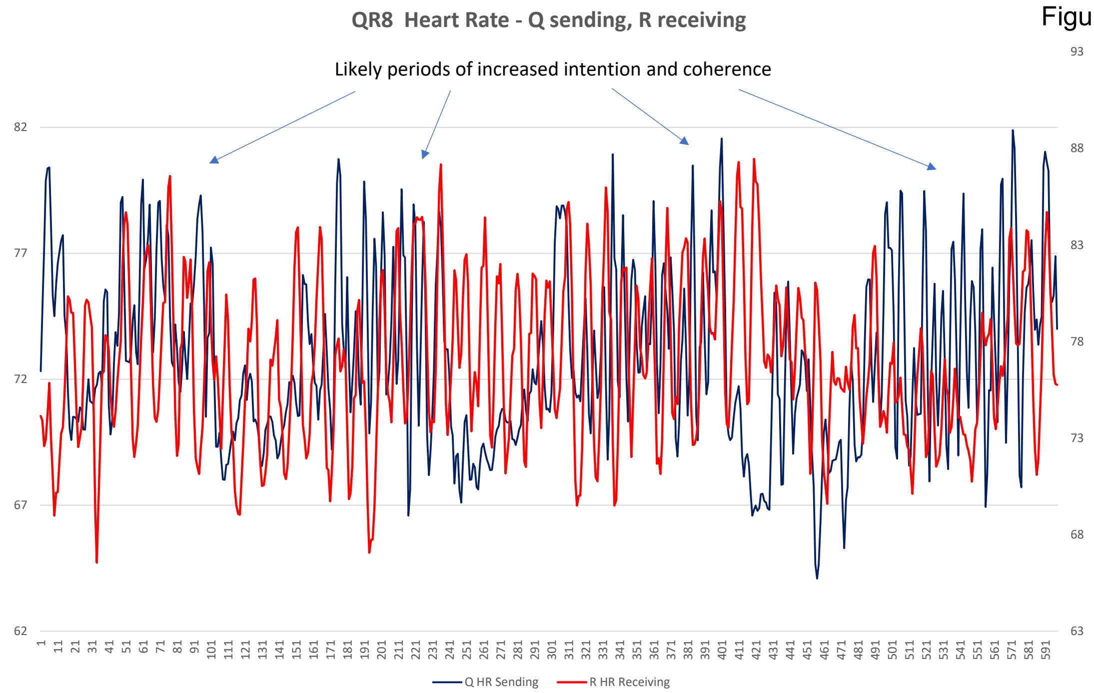


Figure 18

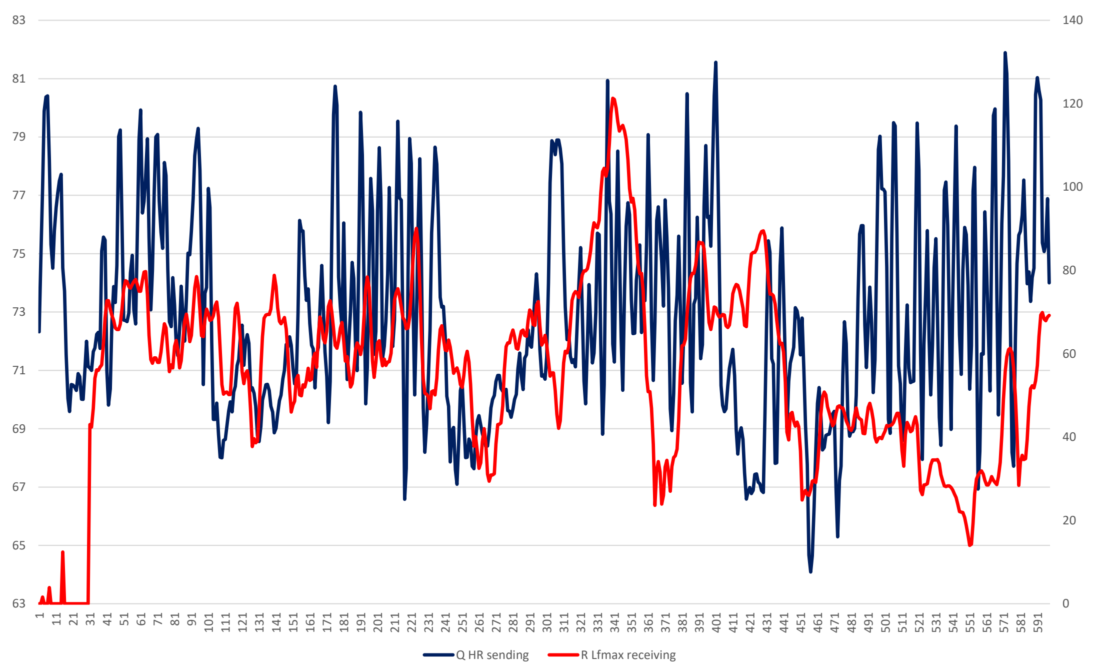


Figure 18. Note clear visual correlation of Q HR sending vs R LFmax receiving, showing that there is an association of coherence with synchronisation.

Figure 19

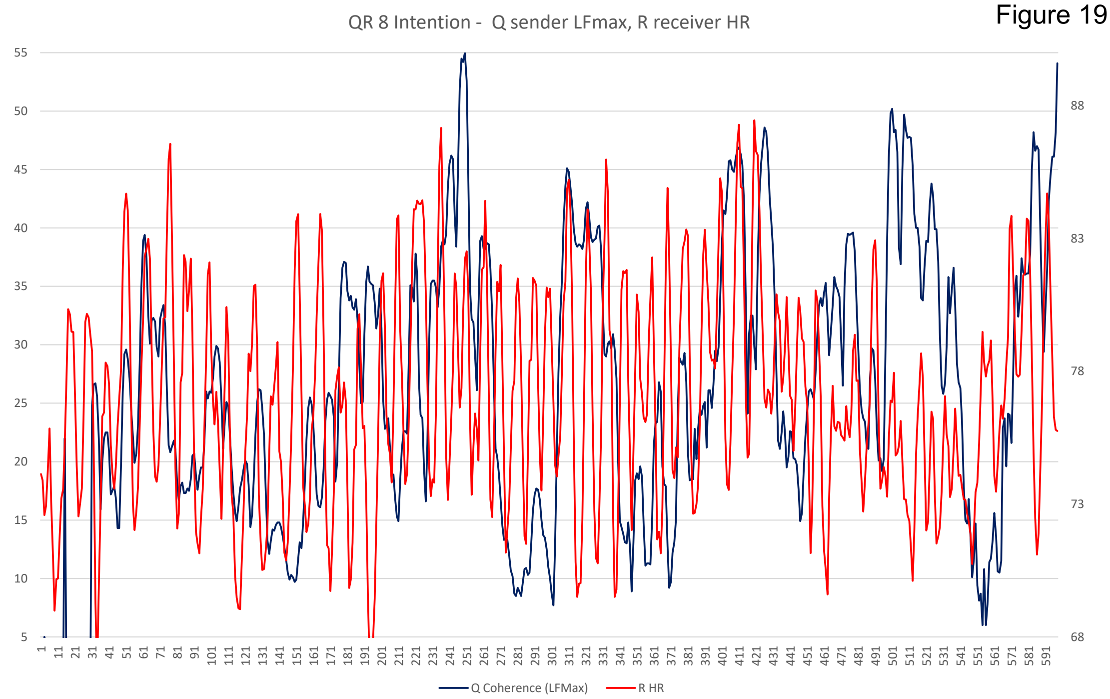


Figure 19. Shows same experiment QR8 as above but with LFMax, a measure of coherence of the sender against the heart rate of the receiver. The research showed that both the power in the low frequency band and the amplitude of the HRV waveform are useful measures of intention.

*9. **Expertise in HeartMath Techniques** It was evident that certain pairs of experimenters had higher HRV synchronisation than others. Several of these pairs included participants with high levels of HeartMath experience and an ability to maintain a coherent HRV and it may be that the presence of this expertise in a pair is resulting in greater synchronisation. One example of consistently high correlations was a mother/daughter pair with medium/ low HearthMath experience, suggesting that familial relationships with high levels of bonding may facilitate HRV synchronisation.*

Participants in the research day were asked to grade themselves in terms of HeartMath technique expertise - low/medium/high. These were given corresponding scores of 1, 2 and 3. The expertise was cross-plotted against the correlation coefficients for the various HRV measures analysed.

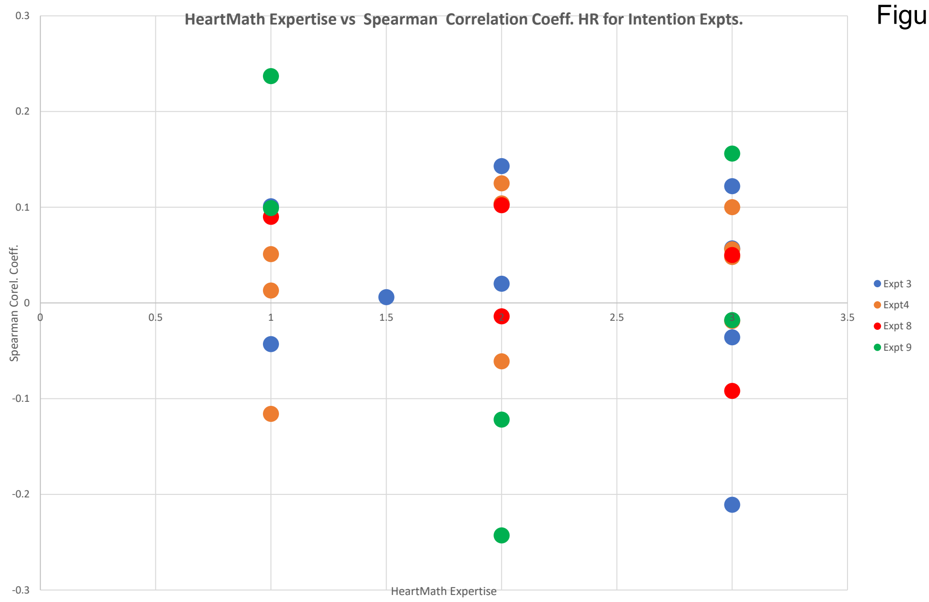


Figure 20

The cross-plot above (Fig 20) shows that there was a wide range of synchronisation across the participants in terms of heart rate correlation in relation to their expertise when they were sending. The same was true for the correlation of coherence estimated using the maximum power of the low frequency (MaxLF).

Despite the diversity shown above, some pairs had higher correlation values across the range of experiments and HRV measures. The three highest correlation pairs were AB, KL , QR and XY. An example is shown below.

Both AB and QR had one experimenter with high and one with low HeartMath technique expertise and QR, a mother/daughter pair had one medium and one low expertise. Experimenter A had a relatively low heart rate and low coherence and this meant the AB data plotted as outliers on the cross-plots of heart rate. The link between HeartMath expertise, coherence and HRV synchronisation correlation requires further study.

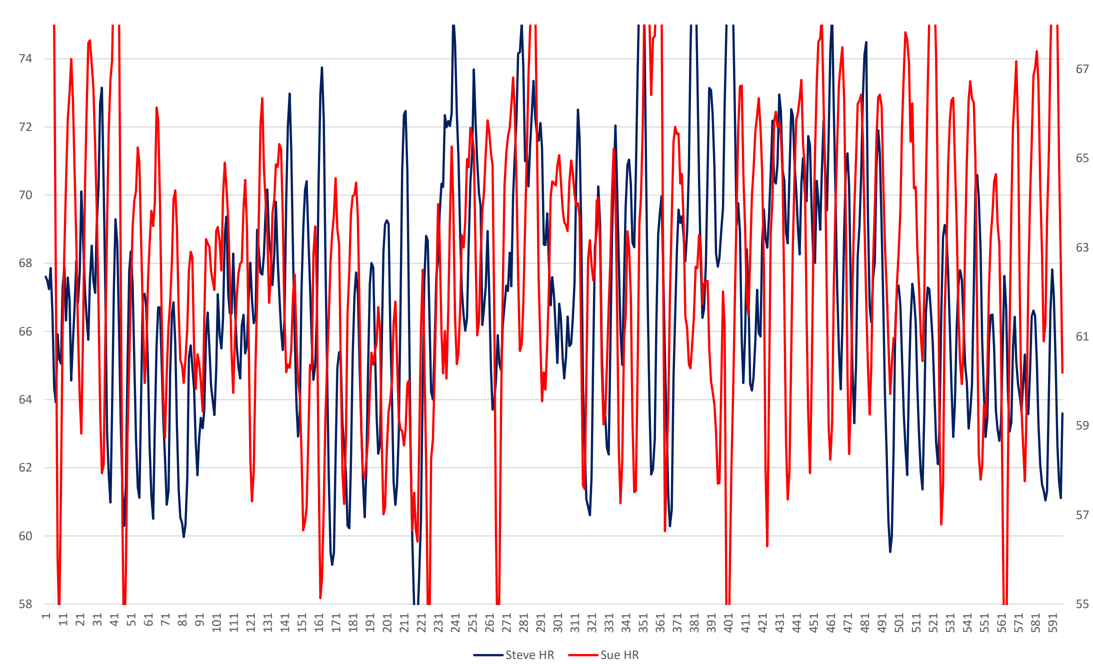


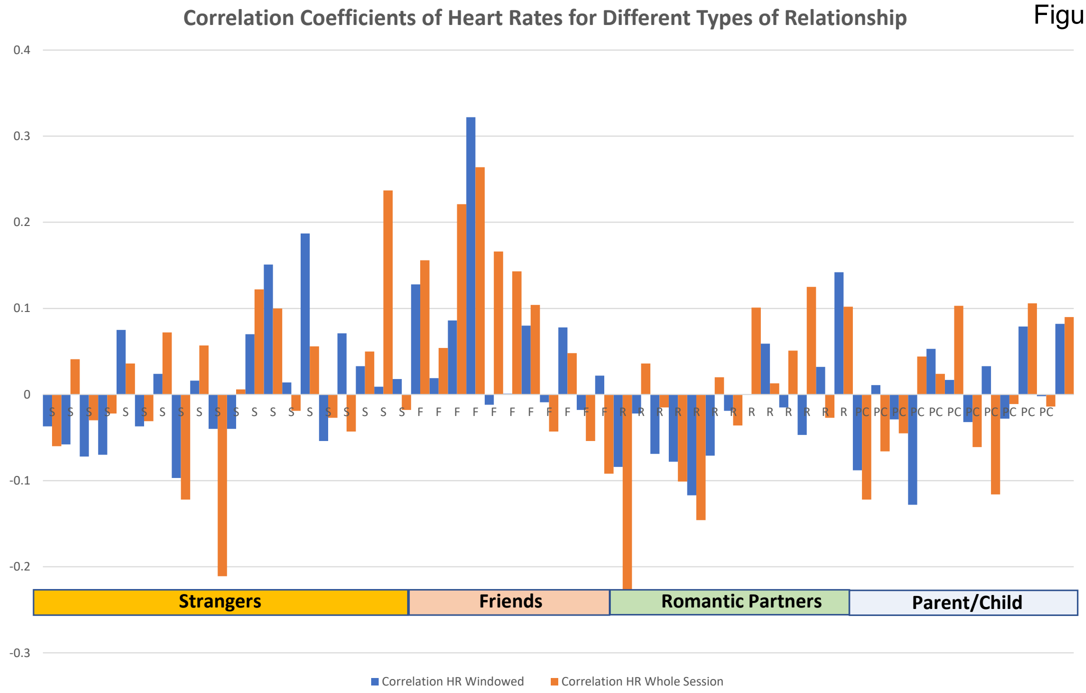
Figure 21

Figure 21 shows an example where both experimenters had a high level of HeartMath experience. This is evident from the sinusoidal coherence pattern on the HRV waveforms. Sender (X - blue) appears to be raising the heart rate of the receiver (Y - red) through intention, leading to heart rate synchronisation. These intention periods were prescribed by a visual signal from the lead researcher. There are also periods where it appears that the breathing/baroreflex coherence waveform synchronises. Interestingly, these two experimenters were strangers at outset of research.

9. ***Type of Relationship and HRV Synchronisation*** *Friendship pairs were observed to have the highest levels of heart rate variability synchronisation, although this dataset had a small sample size so this observation may not be statistically reliable.*

Participants in the research day were asked the type of relationship they had with their research partner in order to assess if the style of bonding influenced the HRV synchronisation correlations. Figure 22 shows the Spearman correlation coefficient for all the experiments carried out during the research day annotated for relationship type. It should be noted that some of the categories have very small numbers of samples (2 pairs for parent child, 3 pairs for romantic partners) so care should be taken drawing conclusions from this data.
There does however appear to be a pattern of highest correlation for friends. This might be due to less performance anxiety in friends – something we have observed in our earlier research with an expectation of bonding and heart connection in some romantic relationships causing anxiety. This needs more research.

Figure 22



10. ***Group HRV Synchronisation*** *Group HRV synchronisation was observed during the research day. Only visual analysis of the correlation was carried out, but this indicated that both heart rates and high frequency components of the HRV series exhibited correlation.*

One of the experiments involved 6 pairs focusing appreciation/gratitude/love on the whole group. The rest of the group (who did not record their data) also focused positively on the group for ten minutes. Significant HRV correlation was seen between the existing pairs during this experiment and visual correlation was observed between neighbouring experimenters. Numerical assessment of correlation across all 6 pairs has not been carried out but this is recommended (using HeartMath group correlation algorithms that are in development).

The observation of group-wide synchronisation suggests that HRV synchronisation in a group or societal setting may be extremely complex. Much more research is required to better understand group HRV synchronisation.

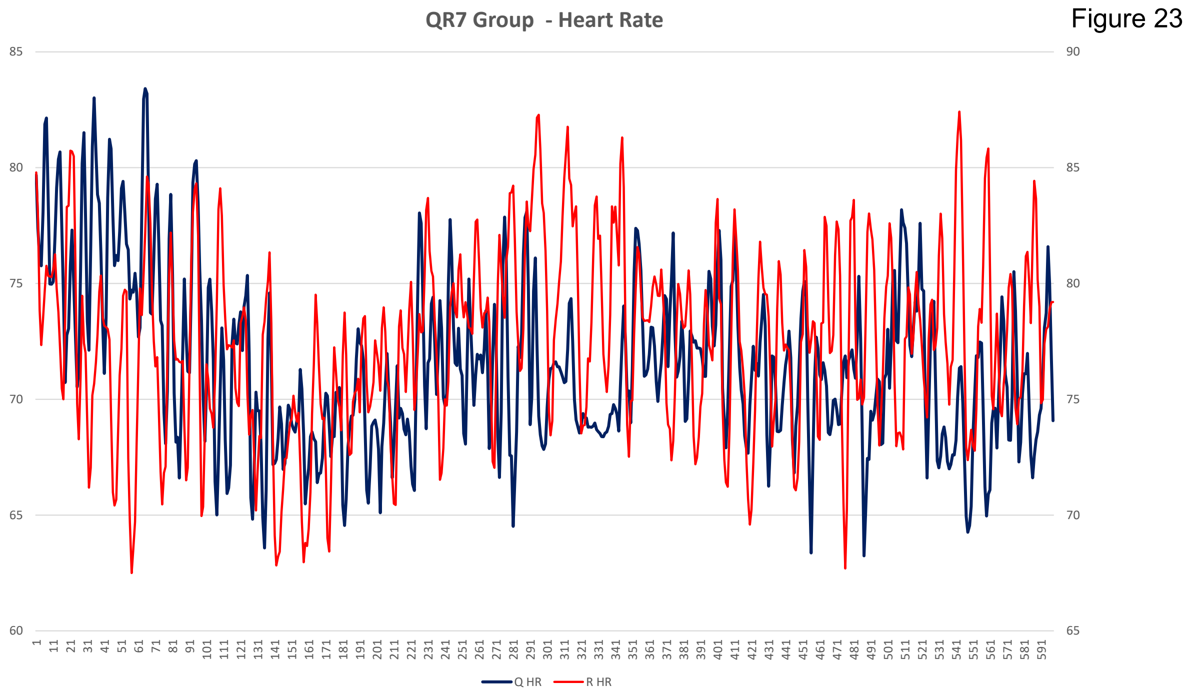


Figure 23 shows an example of a mother/daughter pair from the Group Focus experiment 7. Spearman Correl. Coeff. whole session = 0.106 This shows clear visual HR correlation (VLF, LF, and HF) across the ten minutes with some breathing RSA/baroreflex correlation and a change in frequency on both HR waveforms around 300 seconds.

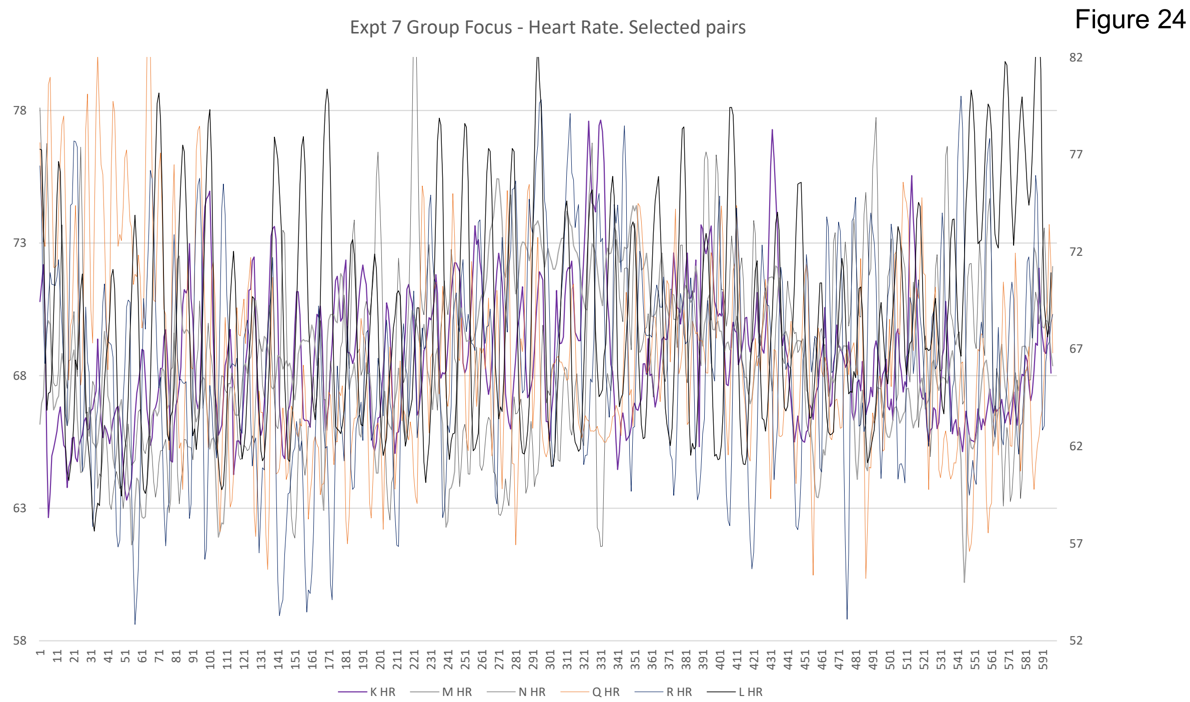


Figure 24 shows a selection of 6 experimenters (out of 12) from the Group Focus experiment 7. Note general synchronisation of heart rate and gradual rising and falling of HR across the experiment, as seen in figure 22.

Figure 25 Group Focus. SumHF (a measure of short period changes in HR) for all 12 experimenters. Notice the bunching of the data and distinct notches in minimum of SumHF e.g. time = 205. This shows that all 12 experimenters shared a raised minimum SumHF at this time.

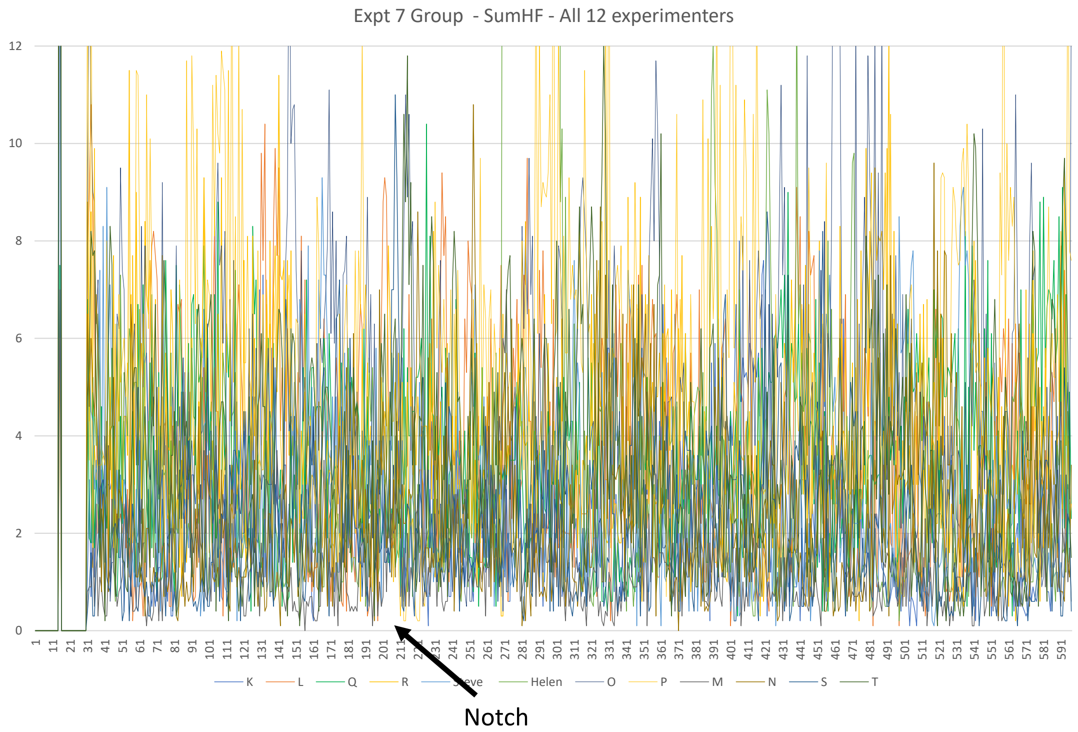


Figure 25

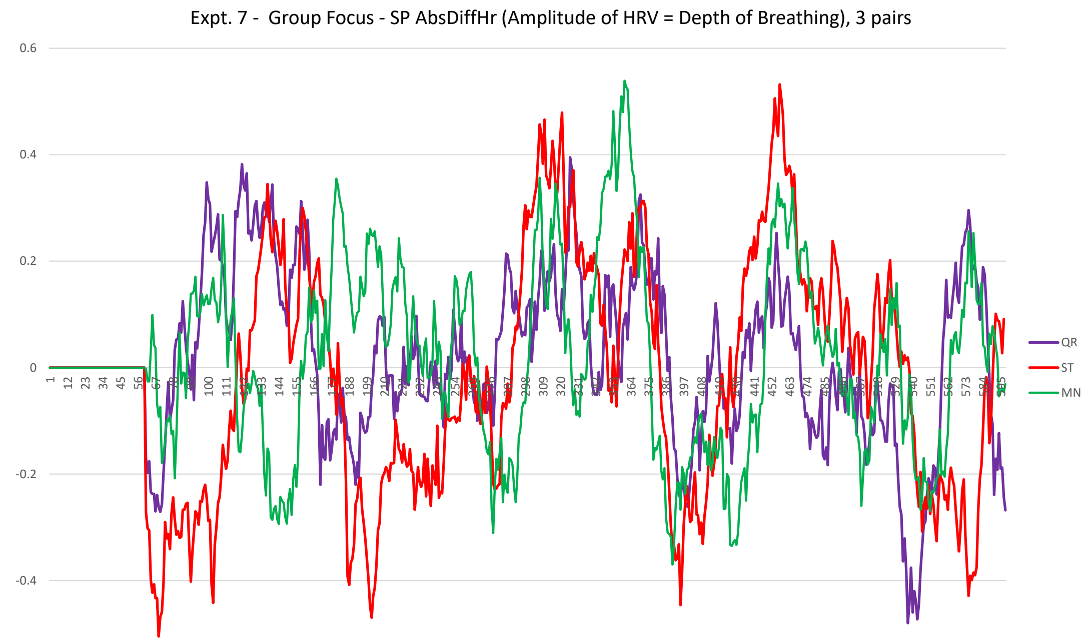


Figure 26

Figure 26. This chart shows three pairs from the group focus experiment 7. Note the synchronisation of the pair-wise correlation coefficients in the second half of the experiment. This indicates that the 3 pairs in the group were synchronising at similar times. This data now needs numerical estimation of group-wise correlation.

Figure 27

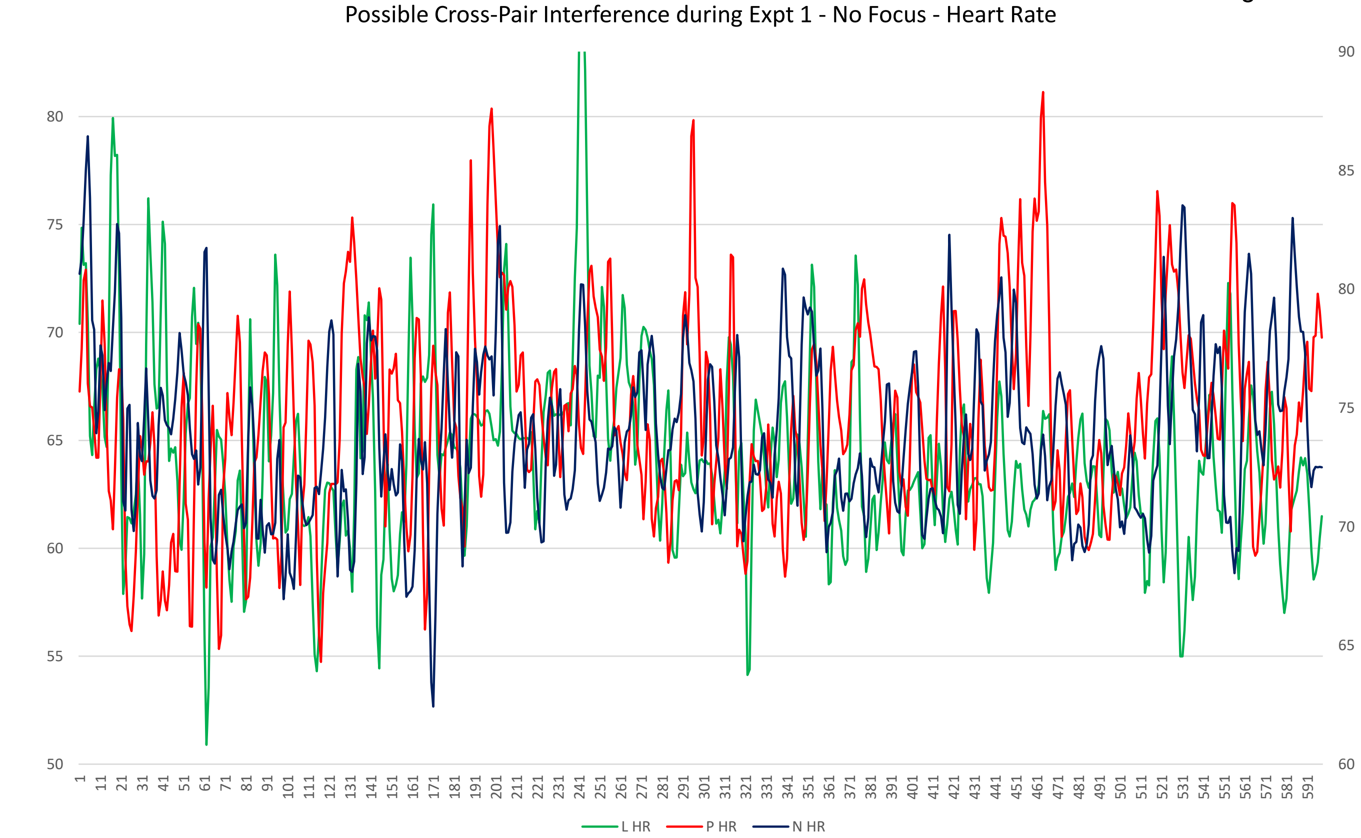


Figure 27. This chart shows heart rate for three experimenters taking part in Expt. 1, where there was no deliberate focus on the pair partner. These experimenters are in three different pairs and appear to show some visual correlation. Expt. 1 was effectively a group experiment and this result suggests that there was some cross-pair interference in this and possibly other experiments run during the research day.

The research room was set up and the experimental protocol designed to maximise the number of experiments recorded during the day, but it is recognised that running simultaneous experiments in close-proximity could have exaggerated any cross-pair interference effect. Not only were experimenters close to each other physically, there could have been visual as well as other sensory cues picked up between different pairs of experimenters. Further research would be required to assess the degree of any cross-pair interference effects, with more focus on running experiments where experimenters were screened and shielded from each other, or by running experimental pairs separately.

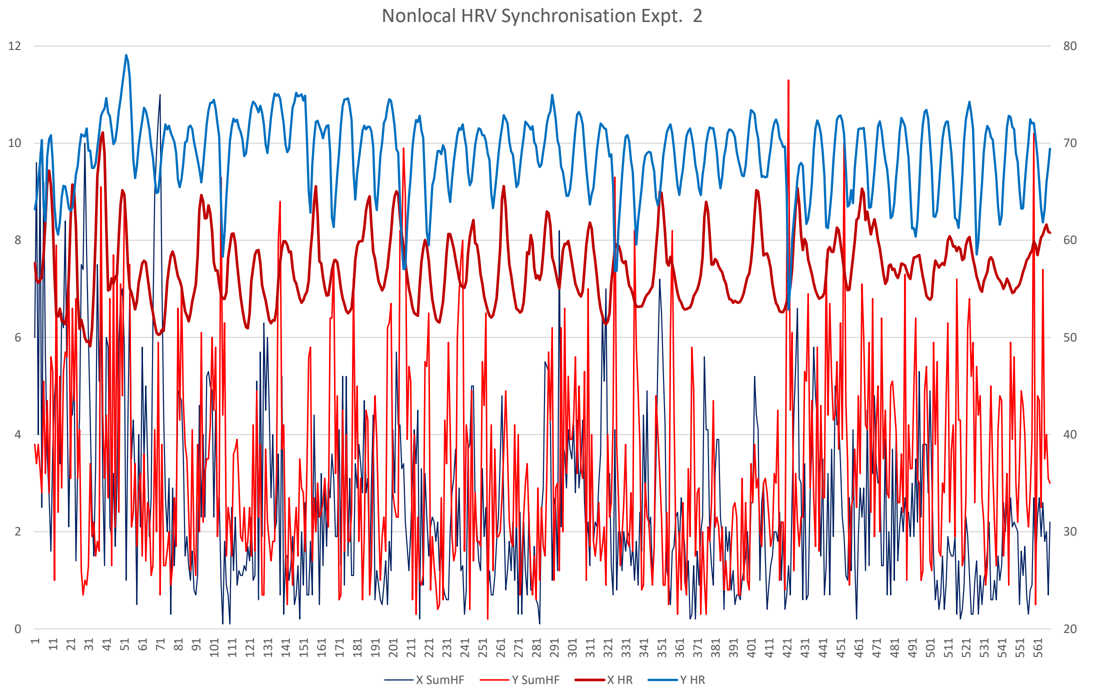
Given that the mechanism for HRV synchronisation is still debated, one important question to consider is - ‘what constitutes a truly controlled experiment HRV synchronisation’. Careful consideration should be made to isolate experimenters from both sensory cues as well as from electromagnetic fields (generated in environment and by experimenters) or other environmental influences.

11. ***Nonlocal HRV Synchronisation*** *Evidence of nonlocal HRV synchronisation was observed during the research project.*

One nonlocal HRV synchronisation experiment was conducted during the research day and one the day after, by two of the experimenters who we using the Firstbeat Bodyguard 24-hour HRV monitors. Correlation was evident during both of these experiments.

Figure 28 shows an example of nonlocal correlation of SumHF (beat to beat changes in HR) for experiment recorded with a separation of 52 kilometres, with no access to communication devices. Spearman Correl. Coeff. = 0.079 of SumHF. Another example of nonlocal correlation is shown in the Appendix.

Figure 28



Distance of separation = 52 Km

Conclusions

1. Synchronisation of a number HRV measures (including heart rate) was observed during the research with a range of coefficients of correlation. The data showed that local HRV synchronisation is likely to be a commonly observed effect as all pairs of experimenters exhibited some correlation.

2. A significant association between low frequency power (a measure of coherence)/ HRV amplitude and coherence of paired HRV measures was observed in many experiments. Although these results support the first hypothesis that HRV coherence with feelings of appreciation/ gratitude/love is a factor in HRV synchronisation, the experimental procedures used were not sufficient to determine if these factors were causal.

3. Significant HRV synchronisation was observed in the experiment where pairs were seated close to each other but were distracted by reading. This result needs further investigation and replication to assess if there is an unconscious sensing or other influence in HRV synchronisation .

4. A significant association between sender intention (with appreciation/gratitude/love) and the HRV measures of the receivers was seen in several experiments supporting the second hypothesis that there is an intentional influence in HRV synchronisation. It was apparent that some experimenter pairs obtained consistently high levels of synchronisation and this may be caused by the presence of at least one with expertise in HRV coherence techniques. There was also some evidence that friends with bonded relationships and familial relationships lead to a higher degree of synchronisation.

5. Group HRV synchronisation was observed and this suggests that HRV synchronisation is a complex and changing dynamic in settings of multiple people. There was some evidence that cross-pair HRV synchronisation was present in the non-group focus experiments due to the fact that the paired experiments were run simultaneously and in close-proximity.

6. Nonlocal HRV synchronisation was observed in two experiments that were conducted during the research.

7. The results from the social coherence research day are similar to those obtained by Peter Granger during his pilot studies into both local and nonlocal HRV synchronisation.

Recommendations for Further Research

1. Devise controlled experiments that test for a causative relationship between HRV coherence and HRV synchronisation.

2. Further investigate the intentional association observed during the research. Make use of the realtime app that has been developed to study this effect and log intentional periods more accurately.

3. Investigate mechanism behind HRV synchronisation - for instance, electromagnetically shield experimenters or simultaneously measure other physiological or neurological variables at same time as HR. Comparison with geomagnetic and environmental fields would also be recommended to assess the role of environmental influences on the synchronisation.

4. Investigate the nonlocal HRV synchronisation and compare with local HRV synchronisation.

5. Study pairs that showed consistently high levels of synchronisation to identify the controlling factors in both local and nonlocal HRV synchronisation.

6. Numerical analysis of correlation from the group experiment recorded during the research day is required as well as an investigation of possible cross-pair interference.

6. Seek academic involvement/partnership in furthering the research and developing applications.

Acknowledgments

We would like to express our gratitude to the volunteer experimenters for giving up a day of their time and entering into the research with such willingness and commitment. Thanks are also extended to Dr. Carla Stanton and Claire Berry for assisting during the research day. Thank you also to the HeartMath Institute for processing the FirstBeat data.

Peter Granger and Gavin Andrews