The Question: Is there a relationship between heart rate variability and the brain that is exemplified in schizophrenic versus non-schizophrenic patients?

Background

Studies show that Heart Rate Variability, or HRV, is an indicator of a person’s health. HRV refers to how the time between heartbeats is always changing, or varying. While beating steadily, a healthy heart will demonstrate slight variability in the times between beats, whereas an unhealthy heart will keep an unusually constant time between beats.

A variable heart is robust, and reacts well to external stimuli. A more regular, or unhealthy heart has limited HRV, which implies low adaptability. Studies show that HRV drops with age or illness.

Furthermore, we know that schizophrenia is a particularly interesting mental disorder which is characterized by a weak connection to reality and abnormal social behavior. It is a disorder that is not particularly easy to diagnose.

Process

1. Our data of schizophrenic and non-schizophrenic brain signals was acquired by MEG, or magnetoencephalography. This data was provided by the NIMH MEG Core facility - Intramural Research Program.

2. Independent Component Analysis was run on the MEG data to isolate the 273 channels of data into 32 distinct signals. One of these signals was the heartbeat, itself.

3. The heartbeat signal was visually identified and extracted from the 32 signals.

4. The HRV curve was generated from the heartbeat signal. This was achieved by taking the delta time between “R peaks” in the heartbeat signal. This process is visualized by the 2 graphs above. The left is the heartbeat signal, with the R peaks highlighted with green points. By finding the delta time between each pair of R peaks, we plotted these R-to-R values, producing an HRV curve like that on the right.

5. The HRV curve was then cross-correlated against the 31 other MEG signals. A high correlation could suggest a significant relationship between the heart and the brain.

Results

Several correlation tests were run on data from multiple patients. The results displayed the correlation type, the signal being correlated (1-31), the segment in time (1-10), the correlation factor, and lag value.

- Correlation Type: the types of datasets that are correlated; some examples include power-power (the power of the HRV vs the power of the signal), phase-power (the phase of the HRV vs power of the signal), and so on.
- Signal: the HRV was correlated once with each of the 31 MEG signals.
- Segment: the time series was split into 10 20-sec intervals; the correlation test ran one segment at a time.
- Correlation Factor: the factor by which the two datasets are correlated.
- Lag Value: the value, in seconds, by which the HRV correlated well with an offset in time.

We obtained high correlation values of 0.50 and upwards. There was also a lag between the HRV and MEG signals, meaning that the heart reacted some time later than the brain in general. The table below shows some of the results for a non-schizophrenic patient.

<table>
<thead>
<tr>
<th>Correlation</th>
<th>Signal</th>
<th>Segment</th>
<th>Corr. Factor</th>
<th>Heart lag (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>power:power</td>
<td>2</td>
<td>7</td>
<td>0.58459</td>
<td>-6.7</td>
</tr>
<tr>
<td>power:power</td>
<td>23</td>
<td>3</td>
<td>0.51316</td>
<td>-7.7</td>
</tr>
<tr>
<td>phase:freq</td>
<td>24</td>
<td>3</td>
<td>0.56621</td>
<td>-7.9</td>
</tr>
</tbody>
</table>

For the same patient, the HRV (top) and Signal 23 (bottom) in blue. The red plots are Hilbert transforms of these signals. Looking at these plots helps visualize the correlations.

Conclusions and Further Research

Our results show high correlations between HRV and the brain in both schizophrenic and non-schizophrenic patients. This suggests that a relationship between the brain and heart should exist. However, the nature and predictability of this relationship is far from answerable.

The lag is also interesting to note, and could be the subject of future research in this subject.

Though our research is incomplete and we can only draw few conclusions from our data, this is an unexplored field with many possibilities. Through studies, we know that HRV has been associated with health and death, so understanding the relationship between HRV and the brain could have applications in the medical field and beyond.

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