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Physiological Correlates of Emotion Recognition

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Overview

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The autonomic nervous system (ANS) controls the activity of the body's internal organs and regulates changes in their activity depending on the current environment. The vagus nerve, which innervates many of the internal organs, is an important part of the system. When our brain senses danger, vagal tone is inhibited, leading to a set of changes in the body designed to make us more prepared to fight or flee; for example, our heart rate increases, our pupils dilate, and we breath more quickly. Conversely, when the vagal system is activated, these physiological responses are inhibited, leading to a calmer state. The vagus nerve, then, acts as a kind of "brake" on our arousal. One interesting consequence of this calmer state is that it tends to promote social interaction-when we are not tensed and afraid of our immediate environment we are instead receptive to interacting with others. Poor functioning of this regulatory mechanism, therefore, may be associated with difficulties in social behavior.

One index of autonomic regulation is heart rate variability (HRV). HRV is a measure of how much the gap between one beat and the next varies over time. High HRV means there are continual fluctuations in the heart rate over time, a reflection of successful autonomic regulation. Low HRV means there is consistency of the heart rate over time, a condition associated with poor autonomic regulation.

In this study we will test the hypothesis that increased HRV is associated with more accurate categorization of emotional stimuli.[1,2] Following a study by Park *et al*., we will measure HRV and test its association on a task that measures skill at perceiving facial emotions.[3]

Procedure

1. Recruit 40 participants.

1. Participants should have normal or corrected-to-normal vision to ensure they will be able to see the stimuli properly.
2. Participants should not consume alcohol, caffeine, or other drugs for at least 6 hrs prior to the experiment.
3. Participants should have no history of neurological, psychiatric, or cardiac disorders.

2. Pre-experiment procedures

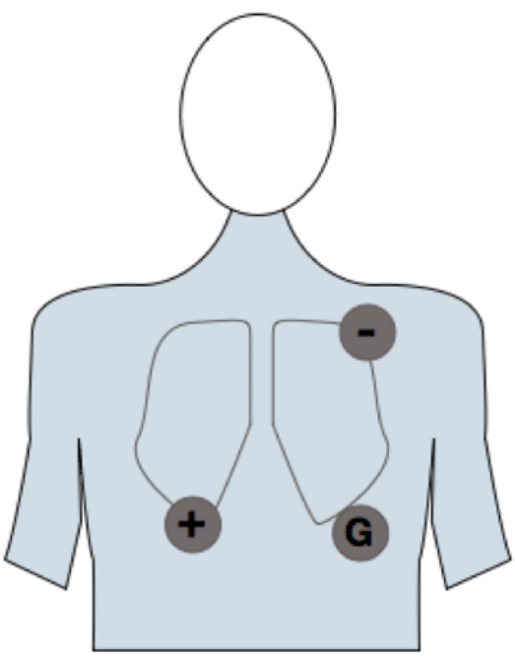

Figure 1: Electrode placement. Place the positive electrode below the heart, near the rib cage on the right side of the body. Place the negative above the heart, just below the left collarbone. Place the ground electrode below the heart, near the rib cage on the left side.

1. Attach three electrodes to the chest to record the heart rate (**Figure 1**). The electrodes should be pre-gelled. Check to make sure that the gel is not dried.
    1. Fix the positive electrode below the rib cage on the right side.
    2. Fix the negative electrode below the left collarbone forming a diagonal across the heart with the positive electrode.

3. Fix the ground electrode below the rib cage on the left side.

2. Record a resting baseline of heart rate variability (HRV) for 5 min.
    1. The electrodes are connected to equipment that amplifies the signal and sends it to a computer for monitoring and recording.
    2. Verify the quality of the measured cardiac signal.
    3. Record the cardiac signal at sample rate of 1000 Hz.

3. Provide instructions for the participant.

1. Tell the participant that a series of faces will appear on the screen. Their task is to decide if the face is a fearful face or not. They should press the F key on the keyboard if the face is fearful, or the J key if it is not.
2. Instruct participants to respond as quickly and as accurately as they can.

4. Perform the facial emotion recognition task.

1. Each trial begins with a fixation cross that remains on the screen for 500 ms.
2. A face then appears and remains on the screen for 200 ms.
3. Half of the faces display a fearful expression, and half display a neutral expression. The order of faces is randomized for each participant.
4. The face is replaced by a fixation cross which remains on the screen for 2 s.
5. Present 120 trials.

5. Analyze the data.

1. Calculate the HRV measure from the recorded cardiac signal.
    1. Use automated software to identify the peak of each cardiac cycle known as the R wave.
    2. Visually inspect the data to ensure that each R wave is properly identified and make any adjustments that are necessary.
    3. Calculate the time from each identified R wave to the next, and record these values.
    4. Use specialized software to calculate high-frequency HRV power, which corresponds to the degree of HRV within the 0.15 to 0.4 Hz range.

2. Analyze behavioral performance on the facial emotion recognition task.
    1. Calculate accuracy separately for fearful and neutral faces.

3. Analyze the relationship between HRV and emotion recognition.
    1. Compute the correlation between HRV and accuracy at identifying fearful and neutral faces, separately.

Results

Performance on the facial emotion recognition task is typically very high; in our data overall accuracy was 92.5%. Participants were more accurate in identifying neutral faces (94.1%) compared with fearful faces (90.9%). Importantly, high frequency HRV power correlated significantly with accuracy in identifying fearful faces **(Figure 2**). Individuals with high HRV were more accurate in identifying fearful faces (r = 0.36). HRV power did not correlate with accuracy in identifying neutral faces, indicating that the association is emotion-specific.

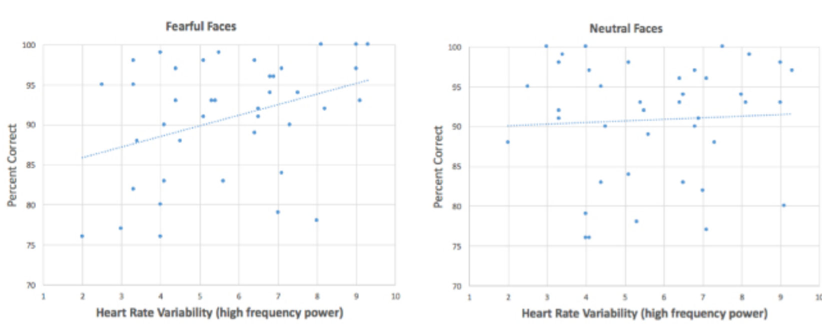

Figure 2: HRV correlates with facial emotion accuracy. HRV high frequency power correlated with accuracy for fearful faces (left) but not for neutral faces (right). Please click here to view a larger version of this figure.

These data demonstrate an association between individual differences related to activity in the autonomic nervous system and skill for identifying socially relevant emotions in visual stimuli. This finding confirms the link between successful autonomic self-regulation and social behavior; individuals who are more successful in pumping the brakes on their physiological arousal appear to be better at tasks requiring emotional regulation and social interaction.

Applications and Summary

This experiment demonstrates the power of physiological data to provide insight into human cognition. The finding that measurements from the heart can be used to understand psychological functioning reminds us of the intimate connection between the brain and the body. An index of healthy cognitive control and emotion regulation, heart rate variability may serve as a relatively non-invasive biomarker for mental health. For example, low HRV is associated with anxiety disorders[4] and depression,[5] and also correlates with depression severity. Low HRV may also predict susceptibility to PTSD.[6] This simple measure of the autonomic nervous system therefore serves as a window into the emotional health of the brain and body.

References

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