

Poster

Can We Predict Depression From the Asymmetry of Electrodermal Activity?

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Abstract

Background: Historically, diagnosing and tracking depressive symptoms has been accomplished by assessing subjective diagnostic criteria, either from the Diagnostic and Statistical Manual of Mental Disorders (DSM) or from standardized rating scales. Though useful for semantic and billing purposes, this approach has limited utility for (1) determining subtypes of depression, (2) capturing variations over relatively short time periods (eg, over the course of a day), and (3) predicting the course of the illness. Despite recent research efforts, no clinically useful, non-invasive, inexpensive biomarkers for the diagnosis and prognosis of depression have been identified.

Objective: There is a critical need to identify and discover objective biomarkers for the diagnosis, prognosis, and treatment of depression. Brain imaging and recent findings have led us to hypothesize that depression, especially of the anxious type, might lead to larger right amygdala activation than left in most right-handers and that this would map to larger electrodermal activity (EDA) on the right than on the left.

Methods: We monitored EDA on both inner wrists of 9 patients diagnosed with depressive episode without psychotic features, aged 18-80, undergoing transcranial magnetic stimulation (TMS) at the Massachusetts General Hospital. Three patients attended 36 daily TMS sessions and six patients attended 72 sessions lasting 25-45 minutes each. In addition, a clinician, blinded to the EDA, assessed severity of depression every 10 TMS sessions using the following psychometric scales: Hamilton Depression Rating Scale, Quick Inventory of Depressive Symptoms (QIDS), and Patient Health Questionnaire. We obtained an objective measure of laterality by (after noise filtering) calculating the average EDA on each wrist for every session and subtracting the left from the right hand mean value (EDAR-L). We used a linear mixed-effects model with random intercepts and slopes to assess the relationship between the EDAR-L and the depression measures (as assessed by the blinded clinician), delayed by 3 days using the following model: $QIDS_i = \beta_0 i + \beta_1 i \times EDAR-L_i + \epsilon_i$, where $EDAR-L_i$ = mean difference between EDA signal on the right and left wrist; $QIDS_i$ = QIDS score for i -th person delayed by 3 days; 0_i = i -th person intercept; $\beta_0 i = \beta_0 + \mu_0 i$ and $\mu_0 i \sim N(0, \sigma_0^2)$; $\beta_1 i = \beta_1 + \mu_1 i$, and $\mu_1 i \sim N(0, \sigma_1^2)$; and ϵ_i = i -th person error, and $\epsilon_i \sim N(0, \sigma^2)$.

Results: We tested the model by varying the delay between -11 and 11 days. The corresponding slopes were always positive ($0.2 < \beta_1 < 5.8$) and usually not statistically significant ($P > .1$). However, a delay of 3 days was significant with a value for intercept (β_0) 13.9 and for slope (β_1) 2 ($P = .03$). This indicates that QIDS score follows the pattern of the EDA asymmetry with a delay of 3 days—when the EDA on the right hand becomes more (less) dominant, the depression worsens (improves).

Conclusions: Initial findings show that asymmetry of the EDA signal from wrists measured during TMS sessions may indicate depression. These data have the potential to provide objective biomarkers to advance the understanding and treatment of depression. The results, if confirmed in a larger population, may potentially contribute to early diagnosis and monitoring of depression.

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KEYWORDS

depression; biomarker; electrodermal activity




This poster was presented at the Connected Health Symposium 2016, October 20-21, Boston, MA, United States. The poster is displayed as an image in [Figure 1](#) and as a PDF in [Multimedia Appendix 1](#).

Figure 1. Poster.

Can we predict Depression from the asymmetry of Electrodermal activity?

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Posters that speak to you.

Introduction

What are the limitations of the methods for depression diagnosis?

- Though useful for semantic and billing purposes, DSM-based or depression rating scale-based approaches have limited utility for 1) determining subtypes of depression; 2) capturing variations over relatively short time periods (i.e., over the course of a day), and 3) predicting the course of the illness.

Surprising recent findings

- Amplitude activation has been shown to elicit ipsilateral Electrodermal activity (EDA) [6] which provides a fine measure of sympathetic nervous system arousal [1-2].
- Brain imaging [5] and recent findings [4] have shown that depression might lead to larger right amygdala activation.

Therefore we hypothesize that some types of depression may cause patients to have larger electrodermal activity (EDA) on the right than on the left palm.

If validated, this may lead to an objective biomarker for the diagnosis, the prognosis, and the treatment of depression.

Methods & Analysis

Participants

- 9 adults with Major Depressive Episode, undergoing Transcranial Magnetic Stimulation (TMS)

Procedure

- 3 participants attended 36, and 6 participant attended 72 daily TMS sessions lasting 20-37 minutes each.
- Symptom severity was measured at the baseline and throughout the treatment (every 10 sessions) by a clinician blinded to the EDA.

Devices

- During the experiment the users wore on both palms the Q sensor, a wireless non-invasive sensor.

Measures

- Q sensor measures EDA, motion (actigraphy), and temperature.
- Clinician collected symptom severity scales once after every 10 sessions: 28-item Hamilton Depression Rating Scale (HAM-D28); Quick Inventory of Depressive Symptoms (QIDS); Patient Health Questionnaire (PHQ-9).

Data analysis

- We evaluated the relationship between the two-palm EDA signals during TMS sessions on the days leading up to a depression measure. We applied a low-pass filter to each EDA raw signal (1024-point Hamming window, 3Hz cut-off frequency) to reduce the motion artifacts and the electrical noise. Then we calculated an average EDA level on each palm for every session and subtracted the left hand from the right hand mean value to obtain a mean difference (EDA_{diff}).
- We used the linear mixed-effect with random intercepts and slopes to assess the relationship between the mean EDA difference from the palms and depression measures using the following model:

$$Dep_{sc} = \beta_0 + \beta_1 \cdot EDA_{diff} + \epsilon_i$$


Where:

- Dep_{sc} - depression scale value for i-th person
- β_0 - i-th person intercept, $\beta_0 \sim N(\mu_{\beta_0}, \sigma_{\beta_0}^2)$ and $\beta_1 \sim N(0, \sigma_{\beta_1}^2)$
- β_1 - i-th person slope, $\beta_1 \sim N(\mu_{\beta_1}, \sigma_{\beta_1}^2)$ and $\mu_{\beta_1} \sim N(0, \sigma_{\mu_{\beta_1}}^2)$
- ϵ_i - i-th person error, and $\epsilon_i \sim N(0, \sigma^2)$

Motivations

- The EDA signal changes during depression [5] and understanding its patterns is very important to study depression.
- Previous studies [4] have shown that the EDA signal has a strong right-dominant asymmetry around the events associated with anxiety and sadness – the emotions often experienced during depression
- Validation of the EDA signal asymmetry may lead to a discovery of a new depression biomarker which can transform practice of the diagnosis, the prognosis and the treatment of depression

Results



LEGEND: 6 weeks of TMS treatment

Biweekly assessment of depression with HAM-D, QIDS, PHQ-9

Measurement of EDA on palms during daily TMS/ECT treatment

Fig. 1. Depressed patients wore Q sensors on both palms during the daily TMS sessions.




Fig. 2. Example of EDA recordings from the left (light blue) and right (dark blue) hand palm during a TMS session when right dorsolateral prefrontal cortex was stimulated.

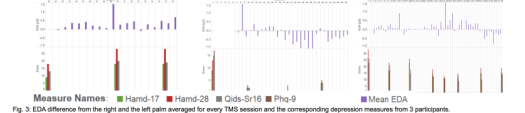


Fig. 3. EDA difference from the right and the left palm averaged for every TMS session and the corresponding depression measures from 3 participants.

Conclusions

The relationship between the EDA and the depression measures

Initial findings show that an asymmetry of the EDA signal from both palms measured during the TMS session has a pattern associated with the depression measures. We compared the QIDS scores and the mean EDA difference from palms from the session 3 days before the QIDS, using the described linear mixed-effect model. We obtained the value for intercept (β_0) 13.9 and for the slope (β_1) 2 ($p = .03$). This indicates that there is a significant increase in EDA asymmetry three days in advance of the evaluation of the depression score. When the EDA on the right hand becomes more (less) dominant, then the subsequent QIDS shows the depression worsens (improves).

Implications and limitations of findings

These data show that EDA may contain information with the potential to provide an objective biomarker to advance understanding, diagnosis and prognosis of depression. A limitation is that this is only nine participants over 540 days and we have a lot of interactions that remain to be examined. We will extend our analysis to a larger population and to ambulatory measurements. Results, if confirmed, will enable early diagnosis and monitoring of depression.

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Disclosure: Picard is a full professor at MIT and also a shareholder in Affective, the company that made the sensors used in this study, and in Emotiv, a company that makes a similar sensor sold today. She participates fully in MIT's monitoring of conflict-of-interest procedures.

Multimedia Appendix 1

Poster.

[\[PDF File \(Adobe PDF File\), 861KB-Multimedia Appendix 1\]](#)

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