Location Patterns from Phone Sensors May Help Predict Depressive Symptoms: A Longitudinal Pilot Study

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Hypothesis

Location patterns from phone sensors are correlated with clinical depressive symptoms.

Conclusions

- Depression severity (measured with HDRS) is positively associated (p=.0393) with the % of time spent in home
- Time in transition decreases with depression severity (p=.057)

Background

- Major depressive disorder (MDD) is a serious and prevalent disease with a variable course.
- Ubiquitous smartphone technology has the potential to inform and improve clinical care by monitoring patients' symptoms and behavioral patterns.The extent to which the changes in depressive symptoms can be predicted with cell phone data remains unknown.

Study Protocol

- Participants: *n=18* MDD & *n=4* healthy controls
- Monitoring time: 8 weeks
- Phone measurements: 24/7 measurement of locations using WiFi, GPS & cellular network
- Clinical measurement: Biweekly assessment using the Hamilton Depression Rating Scale (HDRS)

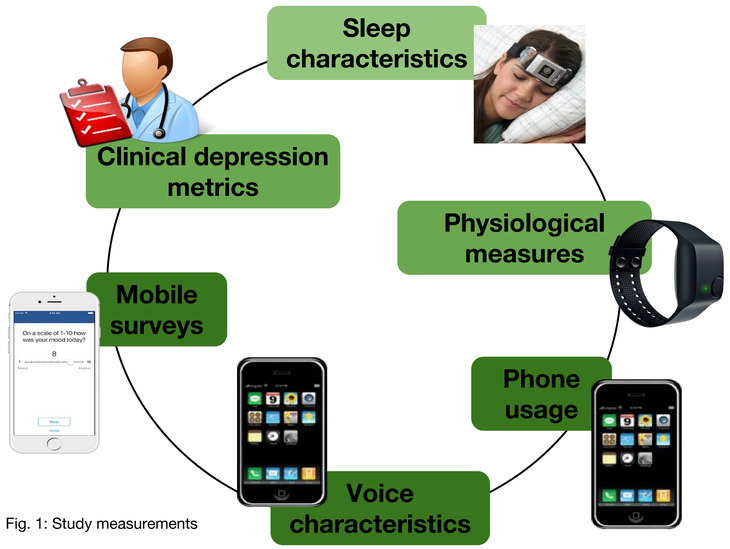


Fig. 1: Study measurements

Methods

- The variable *Transition Time* represents the percentage of each day during which a participant was in a non-stationary state (moving faster than 0.3 m/s). We calculated the median of the *Transition Time* for each week prior to the HDRS assessment.
- The variable *Home Stay* represents the percentage of time a participant spent at approximated home location (median location between 12am-6am), relative to other location clusters. We calculated the median of the *Home Stay* for each week prior to the HDRS assessment dates.

Model Selection

We used the linear mixed-effects model with random intercepts and slopes to assess relationship between the HDRS and a) the Transition Time (Model 1) b) Home Stay (Model 2) using the following model:

$$HDRS_i = \beta_{0i} + \beta_{1i} * LOC_i + \varepsilon_i$$

Where:

$HDRS_i$ – HDRS value for i-th person

LOCi - Location metric (Transition Time for Model 1 and Home Stay for Model 2) for i-th person)

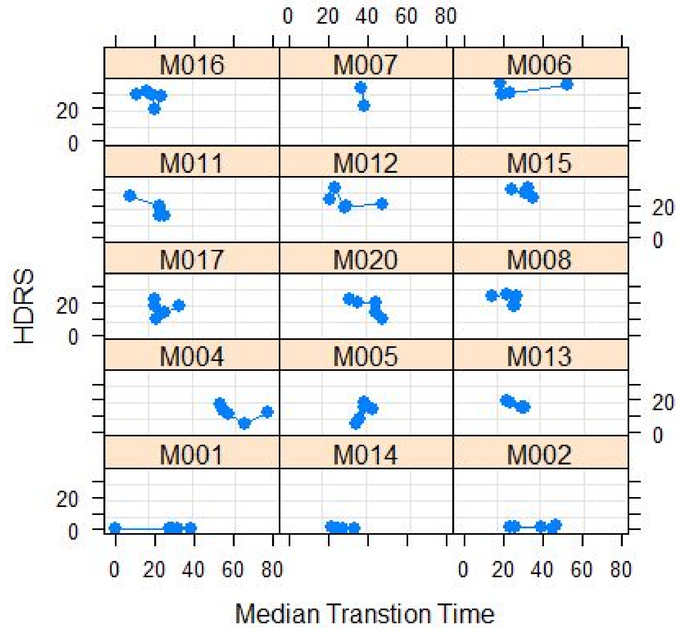
β_{0i} – i-th person intercept, $\beta_{0i} = \beta_0 + \mu_{0i}$, and $\mu_{0i} \sim N(0, \sigma_0 2)$

β_{1i} – i-th person slope, $\beta_{1i} = \beta_1 + \mu_{1i}$, and $\mu_{1i} \sim N(0, \sigma_1 2)$

ε_i – i-th person error, and $\varepsilon_i \sim N(0, \sigma 2)$

Results

There was a negative relationship trending towards significance between the median of the Transition Time metric calculated over the week prior to the assessment (*p*=.057) and HDRS total scores (M1 model).



There was a statistically significant positive relationship between the median of the Home Stay metric calculated over the week prior to the assessment (sample includes only MDD, *p*=.0393) and HDRS total scores. For all the participants p=.098. (M2 model).