RWD43

# Early Symptom Change Contributes to the Outcome Prediction of Cognitive Behaviour Therapy for Depression Patients: A Machine Learning Approach

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## Background

- Evidence regarding the association between early symptom change and later outcome of cognitive behavioral therapy (CBT) is limited.
- It is also unclear whether non-linear, data-driven and show better performance than traditional linear regression methods.

## Objective

- To apply machine learning algorithms to predict continuous treatment outcomes based on pre-treatment predictors and early symptom changes.
- To uncover whether machine learning approach could explain additional variance compared to regression methods.

## Methods

**Study Design:** A retrospective inception cohort study.
**Source of Data:** Data were from a large mental health outpatient clinic in the Netherlands.
**Subjects:** Depression patients who were offered at least ten treatment sessions from March 2017 to April 2019 (N=1975).
**Primary outcomes:** Outcomes were measured with the 48 items self-report symptom questionnaire (SQ-48) after tenth session ($SQ_{(t2)}$ ).
**Predictors:** Demographic predictors were gender, age, level of education, work status, living situation; Baseline diagnosis information was stage of the depression by DSM-IV; Therapy-related predictors were level of care, baseline severity (SQ48 at baseline), early symptom change ( the difference of SQ48 scores between baseline and after fifth session).
**Data preparation:** The baseline analysis was a complete case approach and SMOGN[1] approach was used to deal with imbalance data.
**Machine learning analysis pipeline:** Four machine learning algorithms were trained: random forest, support vector machine (SVM), extreme gradient boosting (XGboost), and neural network. The performance of each algorithm was measured by the predictive $R^2\left(R^2_{pred}\right)$ on the testing dataset.

## Results

- Machine learning explained between 48.8% and 51.2% of the total variance in treatment outcomes, this was 4.1% more than linear regression.

Table 1. Prediction of the symptom questionnaire score (SQ48) at the tenth session by the linear regression model, additional variance explained beyond the benchmark model by machine learning models, and total variance explained.

| | Prediction $R^2$(%) | Model gain (%) | 95% CI (%) |
|---|---|---|---|
| Benchmark (linear regression) | 47.1 | - | 46.5-47.8 |
| Random forest | 51.2 | 4.1 | 49.9-52.3 |
| SVM | 51.1 | 4.0 | 49.6-52.6 |
| Neural Networks | 49.0 | 1.9 | 47.2-50.7 |
| XG-boost | 48.8 | 1.7 | 46.8-50.6 |

- Early symptom change and baseline symptom score were the only significant predictors. Models with early symptom change explained 22.0% to 23.3% more variance than those without early symptom change.

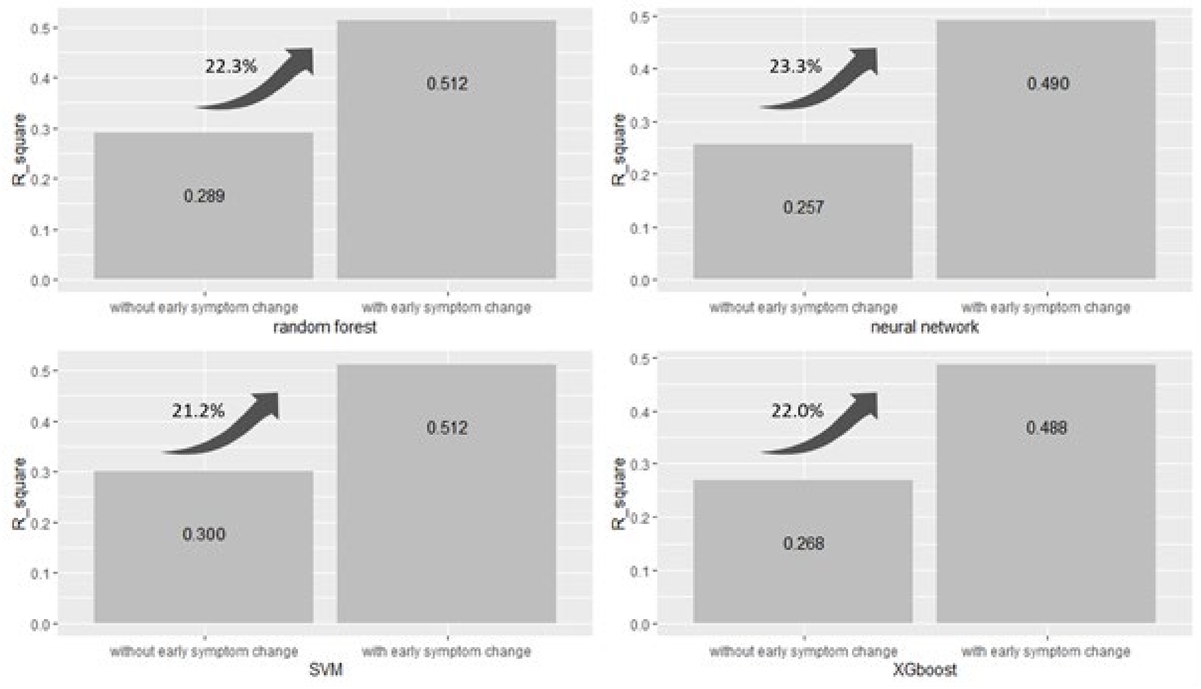


Figure 1. The increment of $R^2$ after adding early symptom change as a predictor in all models. SVM= Supportive vector machines; XGBoost= eXtreme Gradient Boosting

## Discussion

- Early symptom change in week-five contributed substantially to outcome prediction for CBT.
- Applying more sophisticated preprocessing and learning methods did not substantially improve performance.
- Continuous early symptom change seemed to outperform its use as a categorical variable in predicting treatment outcome.

[1] Branco, P., Torgo, L., Ribeiro, R.P., 2017. SMOGN: a pre-processing approach for imbalanced regression, First international workshop on learning with imbalanced domains: Theory and applications. PMLR, pp. 36-50.

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