

## Rethinking the Effects of Working Memory Training on Executive Functions in Schizophrenia: A Machine Learning Approach

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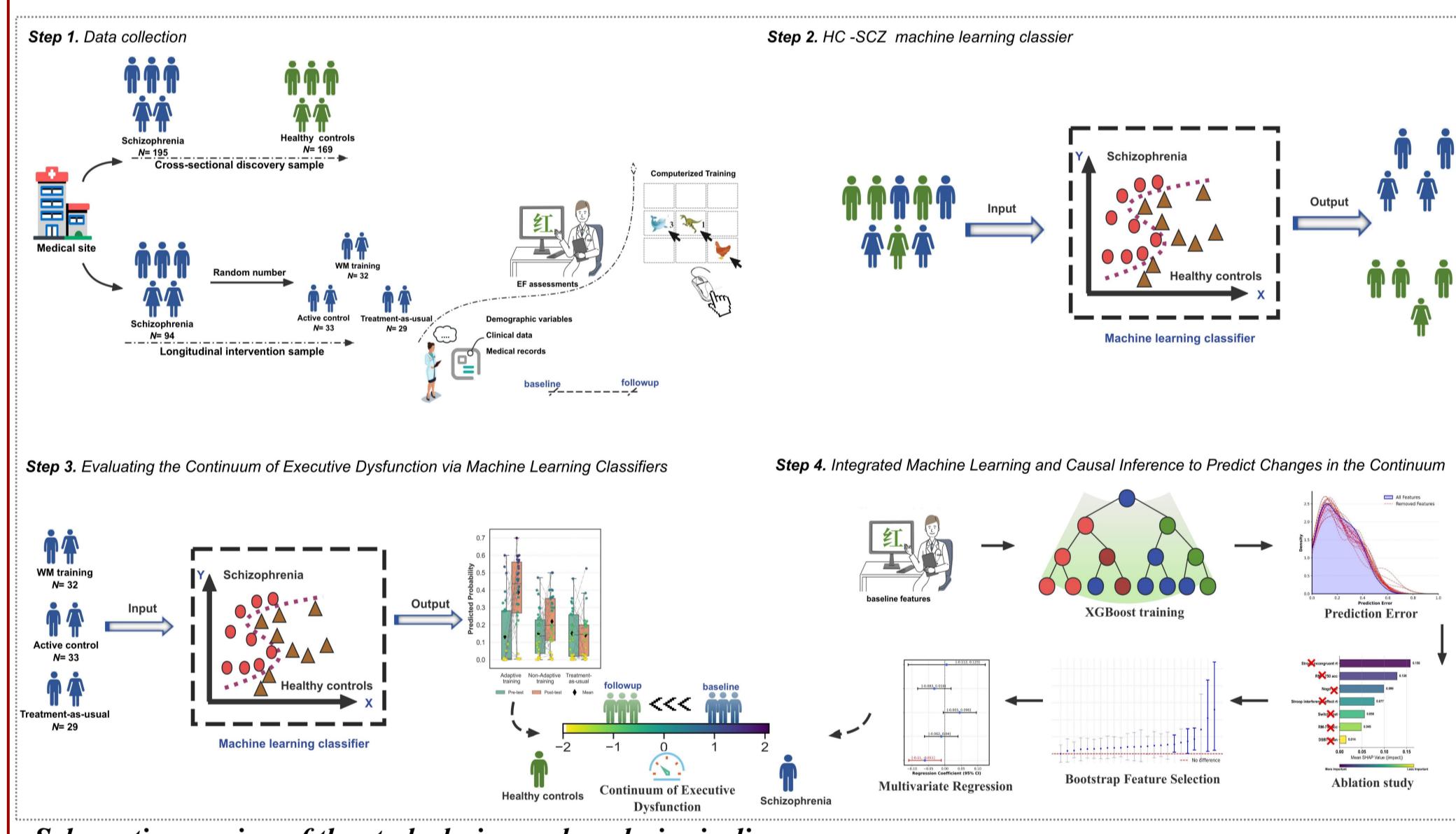
### Background

- Executive dysfunction—characterized by deficits in planning, memory, and decision-making—significantly disrupts the daily functioning of individuals with schizophrenia and is often insufficiently addressed by medication alone.
- Computerized cognitive training shows promise as an adjunctive intervention for improving executive function in individuals with schizophrenia.
- Conventional evaluations of cognitive training outcomes often rely on binary “effective” versus “ineffective” classifications; such dichotomies fail to capture the nuanced continuum of executive function, which ranges from nearly intact to severely impaired.

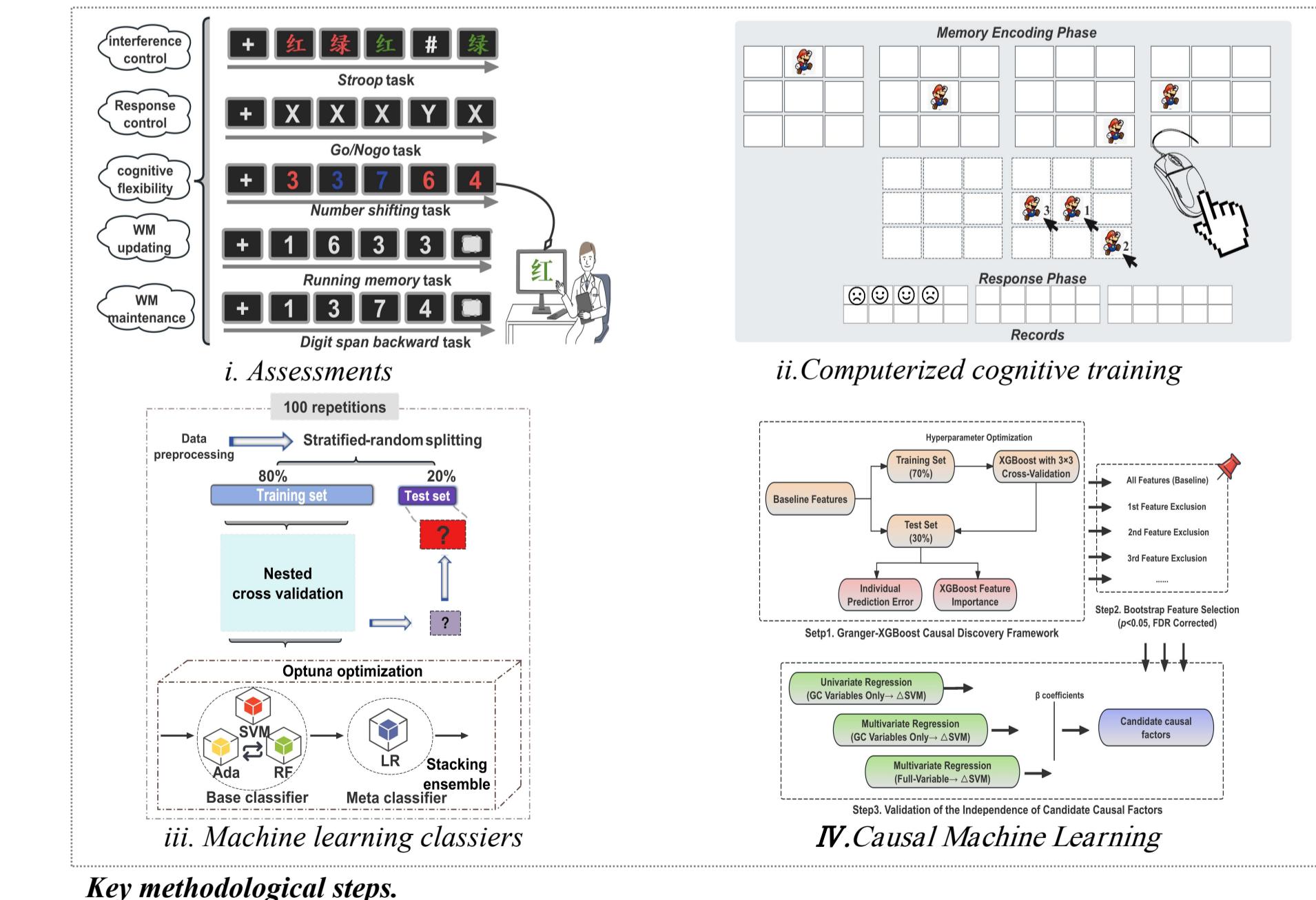
### Objectives

- Leverage machine learning to quantitatively characterize shifts in executive-functioning profiles of individuals with schizophrenia along the psychosis–health continuum following computerized cognitive-training interventions.
- Integrate causal inference with machine learning approaches to identify robust baseline predictors that causally influence these training-induced shifts in executive functioning.

### Methods



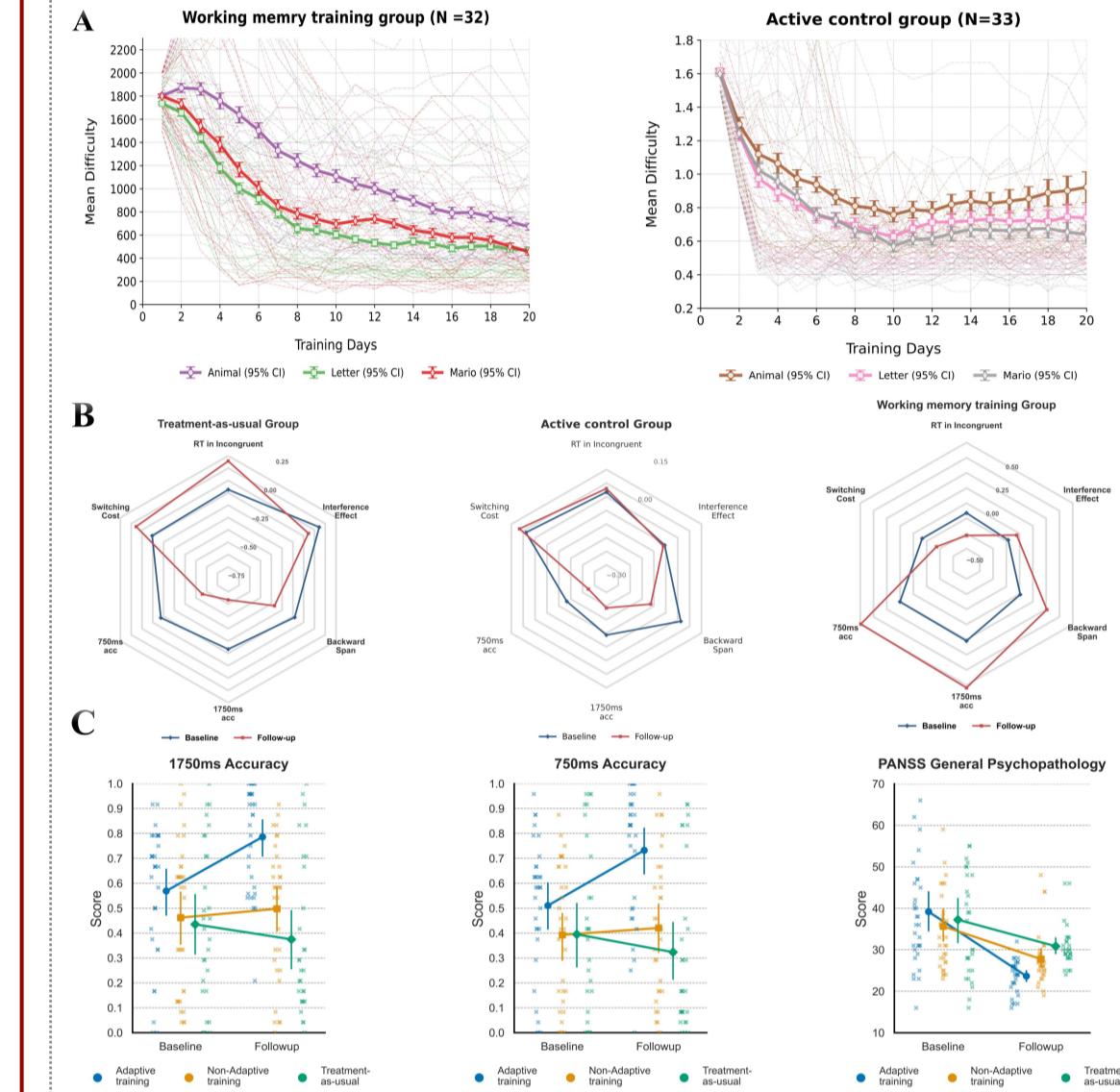
Schematic overview of the study design and analysis pipelines.



Key methodological steps.

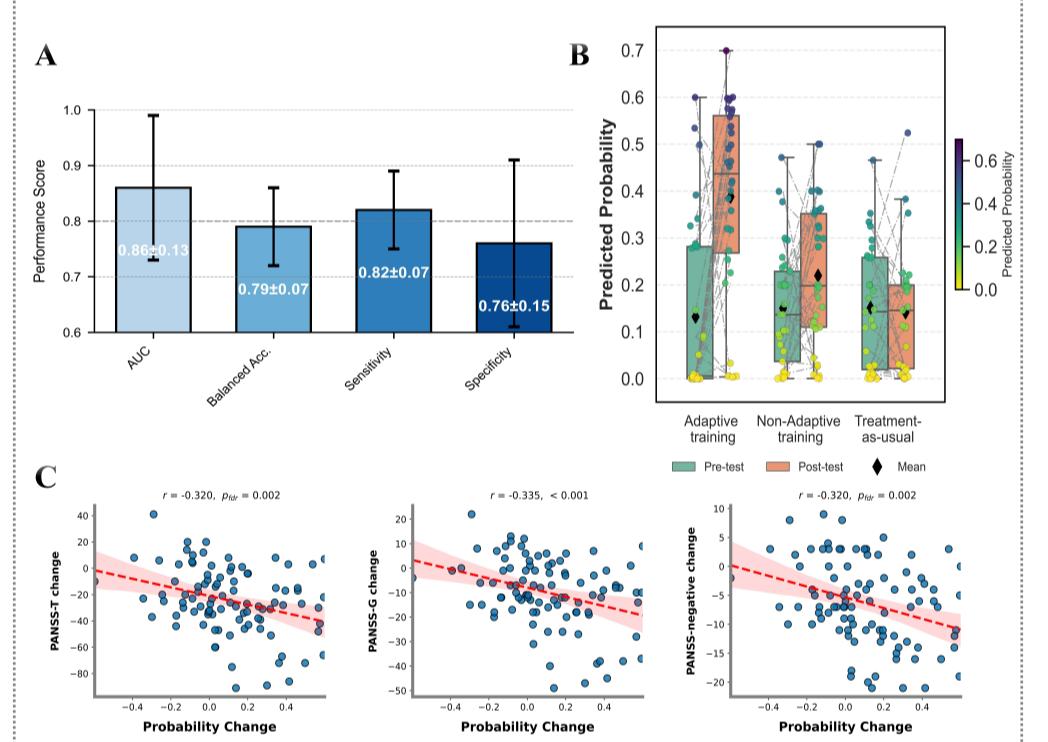
### Results

#### i. Conventional Outcome-Evaluation Methods



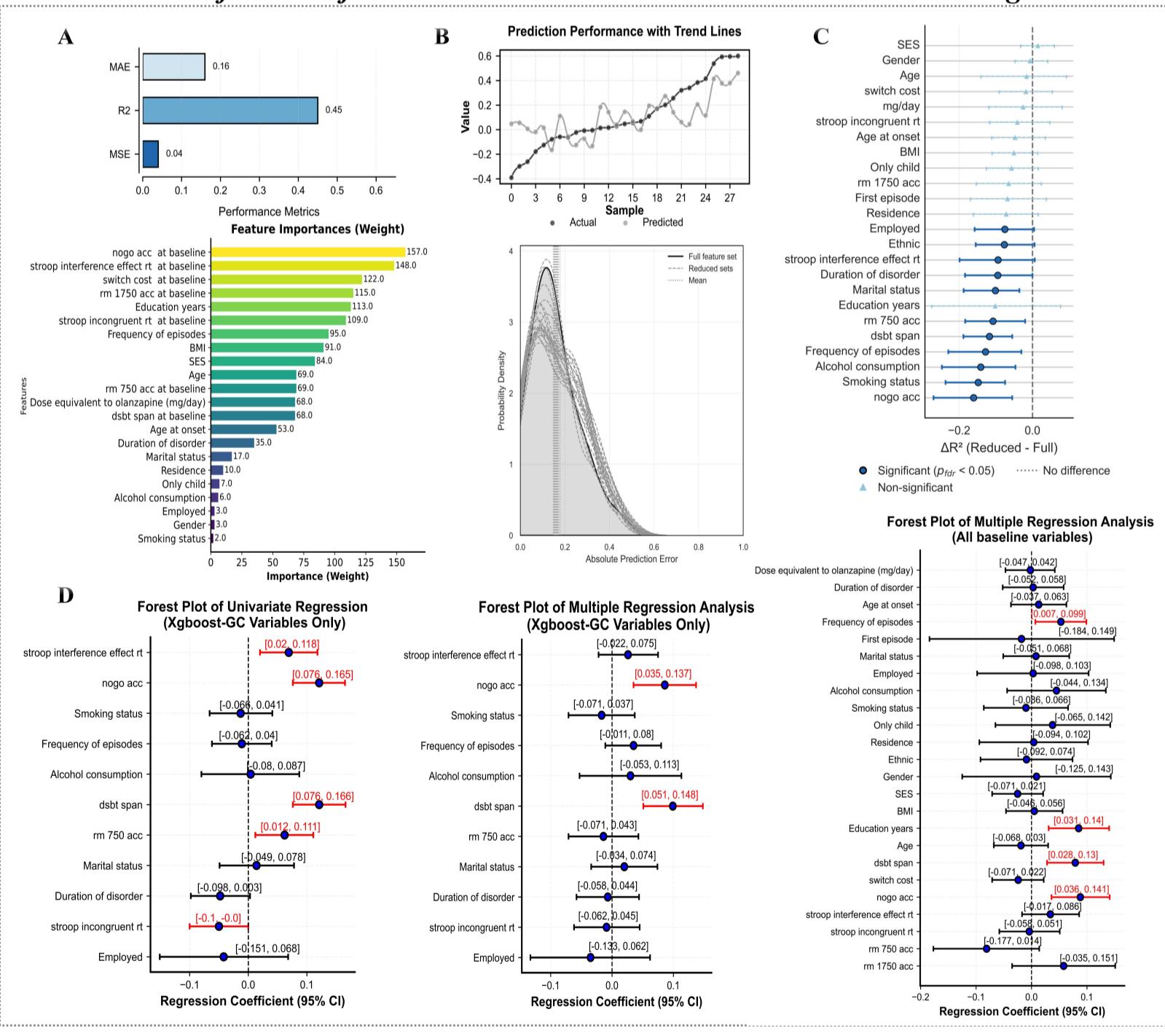
- Adaptive working memory training resulted in significant near-transfer effects on untrained working memory updating tasks and reduced general psychopathology symptoms ( $p_{\text{fdr}} < 0.05$ ).

#### ii. Novel Machine-Learning Classification Approach



- The probability of being classified as having a neurotypical EF profile increased substantially in the adaptive training group (from 13.21% at baseline to 38.79% at follow-up,  $p_{\text{fdr}} < 0.001$ ), with these changes correlating with symptom reduction.

#### iii. Identification of Candidate Predictors via Causal Machine Learning



- Working memory maintenance and response inhibition emerged as robust causal predictors of treatment response.

### Conclusion

- Working memory training can effectively shift executive functions in individuals with schizophrenia towards healthier patterns, and this shift is closely associated with symptom alleviation.
- The classifier-based approach provides a more refined assessment of cognitive gains than traditional binary measures, and the causal analysis identifies specific executive function EF dimensions that predict treatment response.