Interpretable machine learning algorithms for understanding factors related to childhood autism

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Motivation and data for predicting childhood autism

- We have data from the National Survey of Children's Health.
- Each year a number of people fill out the survey (rows), and we have data for their responses (columns).
- One column, k2q35a "Autism ASD" (Yes or No) represents if the child has Autism.
- **Data pre-processing**: operations prior to machine learning.
- **Prediction accuracy in a given year**: can we predict this response (output/label/dependent), given the others? (inputs/features/independent)
- **Model interpretation / feature selection**: which inputs are most useful for prediction?
- **Similarity/difference between years**: Can we train on one survey year, and accurately predict on another?

Data pre-processing

Prediction accuracy in a given year

Model interpretation / feature selection

Similarity/difference between years

Discussion and Conclusions

Data pre-processing

TODO

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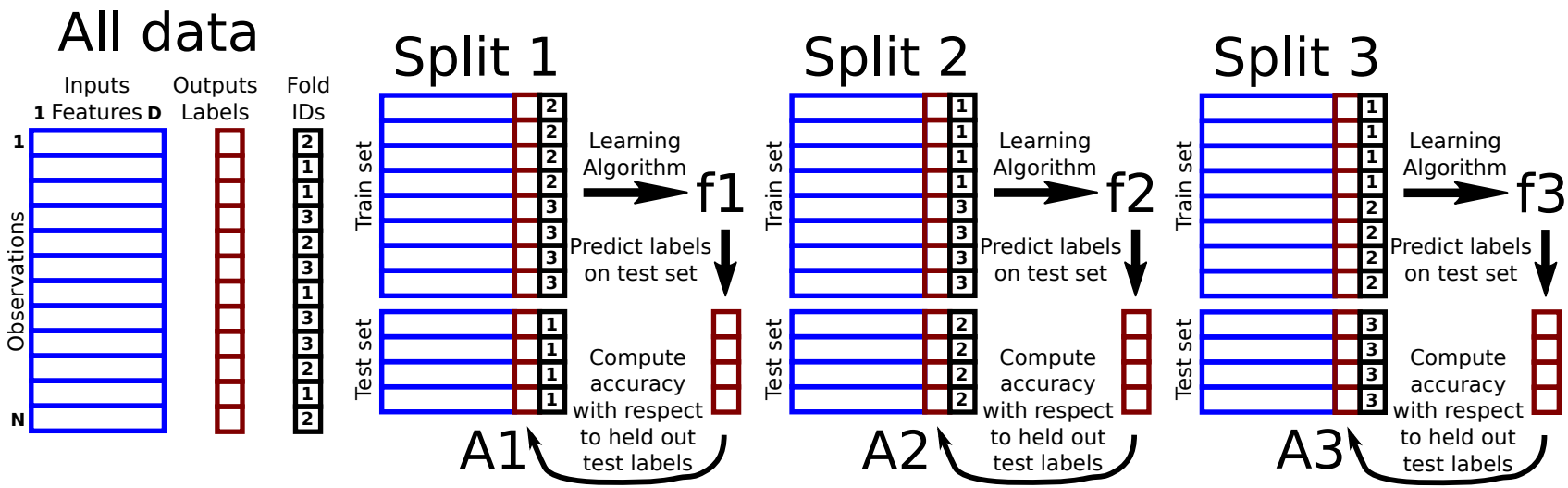
Cross-validation



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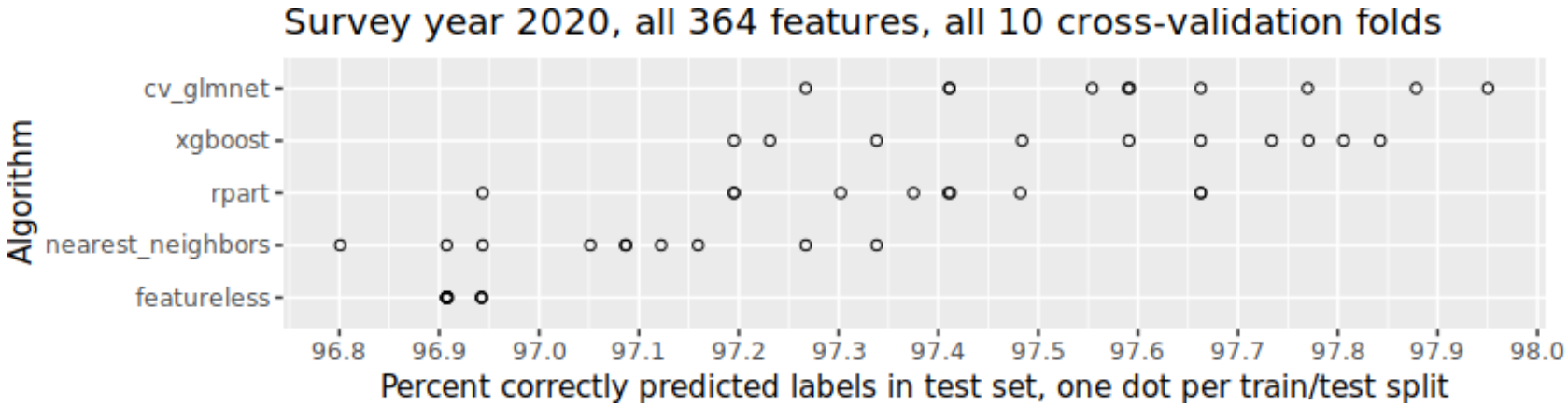

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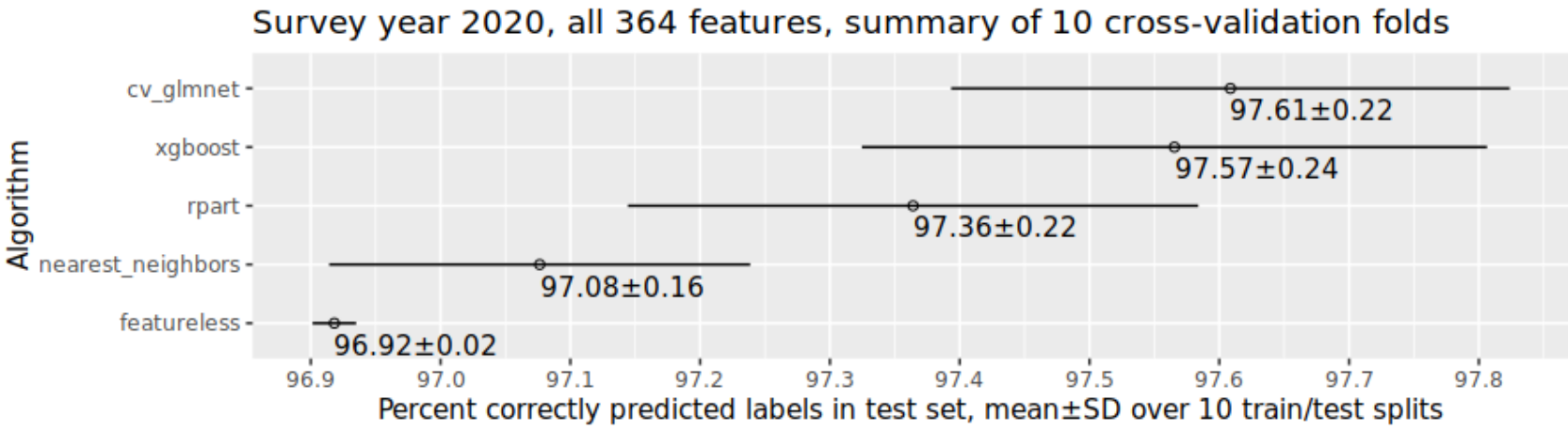
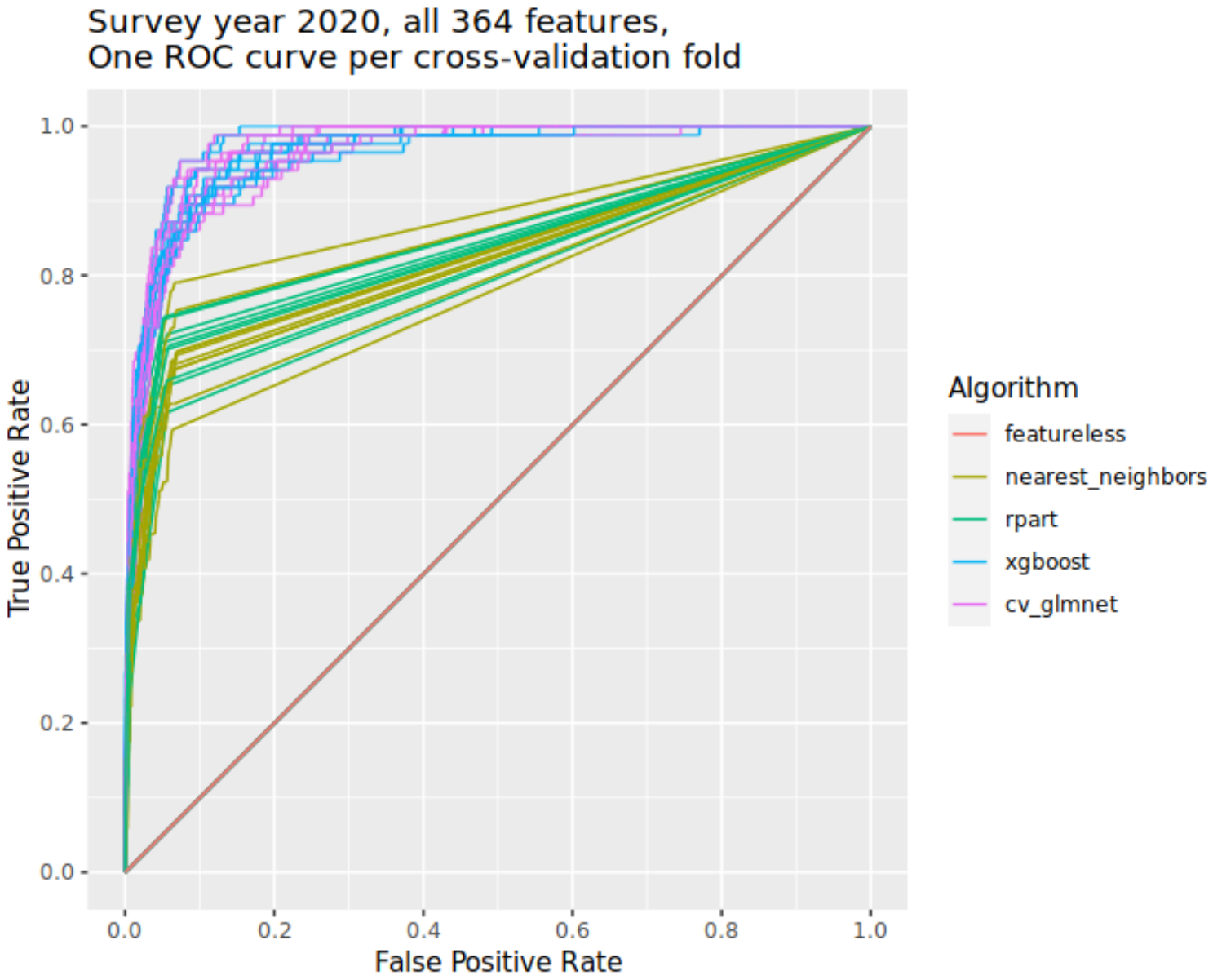


Confusion matrix and error rates

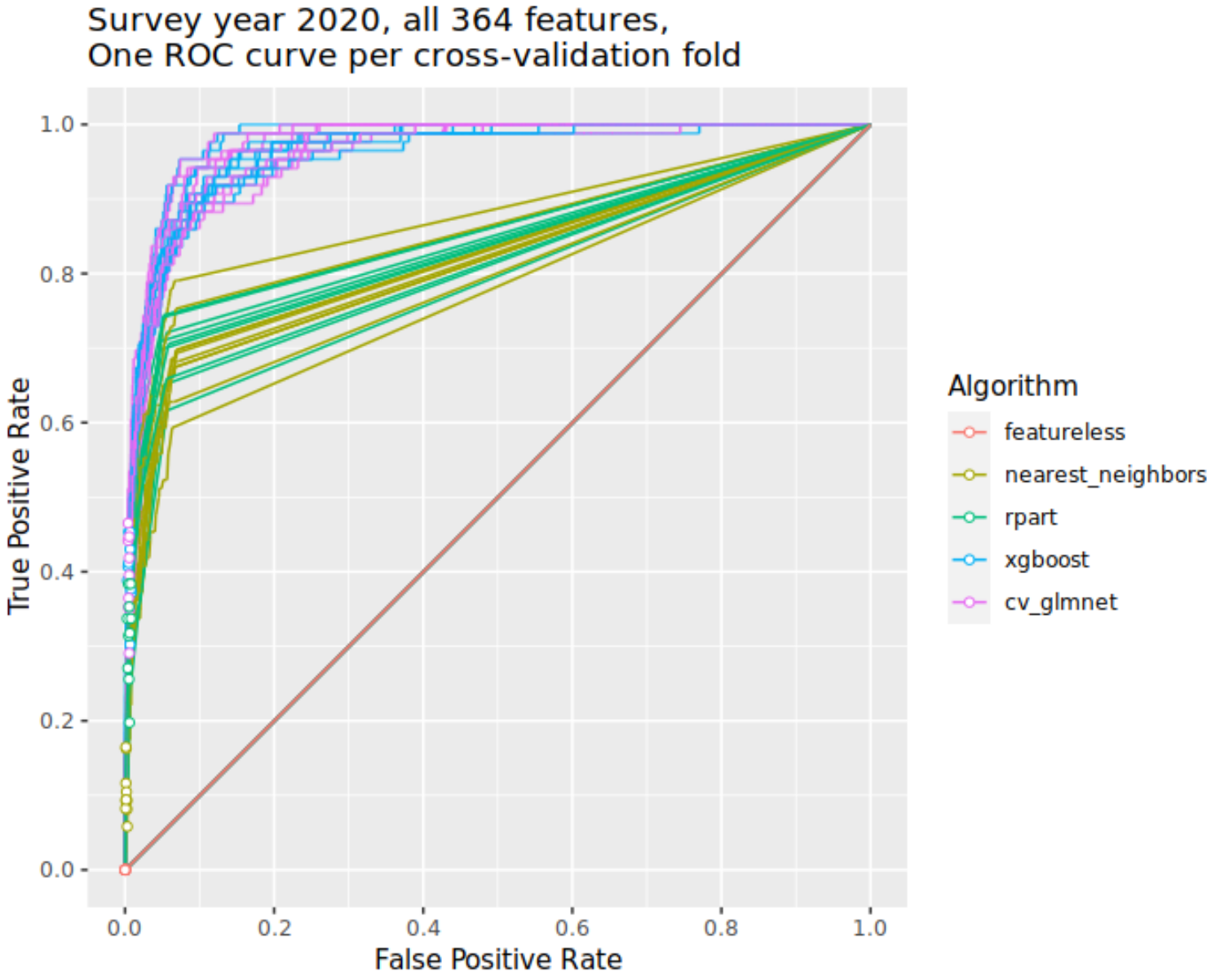
	Label 0	Label 1
Predict 0	True Negative (TN)	False Negative (FN)
Predict 1	False Positive (FP)	True Positive (TP)

- Each has a corresponding rate which is a proportion between zero and one, for example FPR=False Positive Rate.
- Rates are related, TPR=1-FNR quantifies accuracy for positive labels, and TNR=1-FPR is for negative labels.
- TN/TP are good (want to maximize), whereas FP/FN are bad (want to minimize).
- Ideal rates are FPR=0 and TPR=1 but that is not possible to achieve in most real data.
- Receiver Operating Characteristic (ROC) curves trace TPR as a function of FPR, for every threshold of the learned prediction function $f(x)$.

ROC curves show all tradeoffs between TPR and FPR



Default prediction threshold can be viewed as a dot



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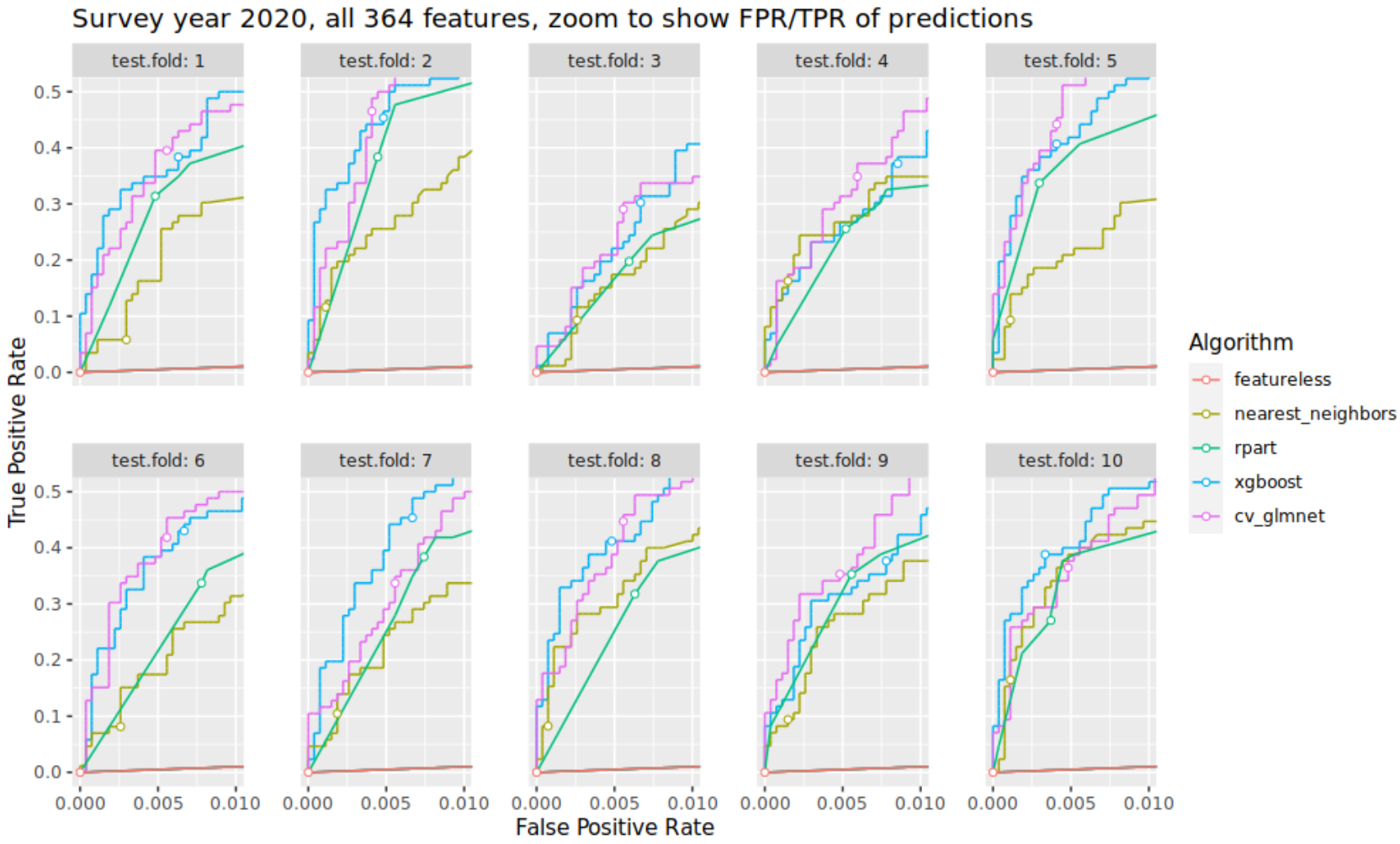
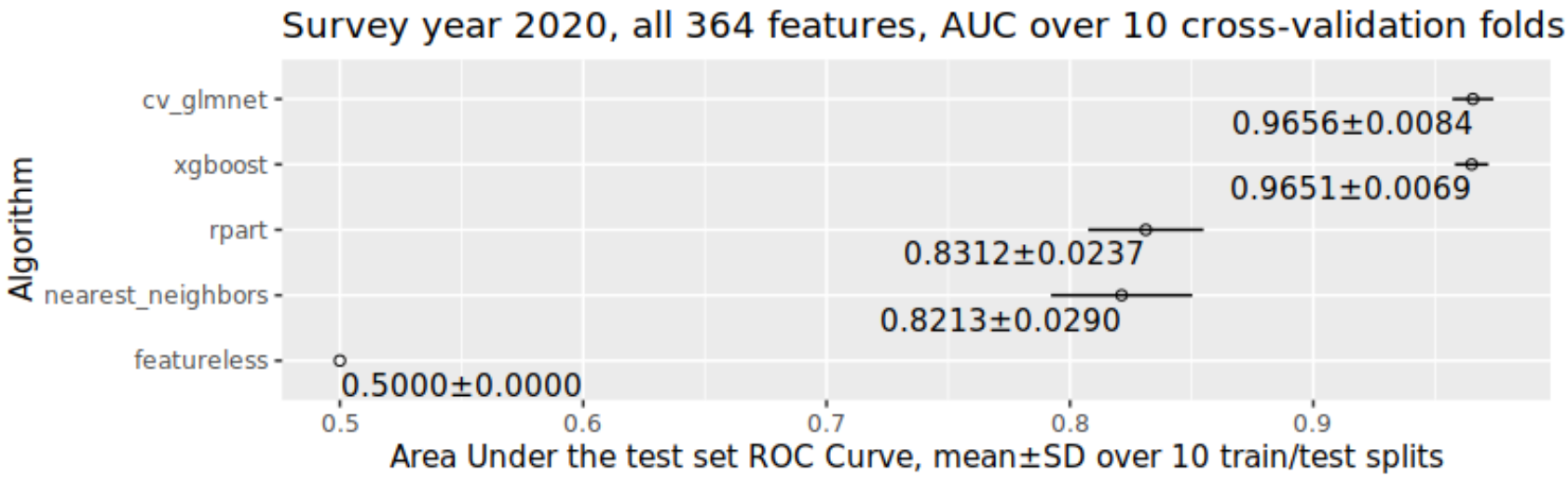


Relatively small FPR because there are so few positive labels (Autism=Yes TODO number in 2020).

Area Under ROC Curve (AUC) quantifies accuracy over all thresholds



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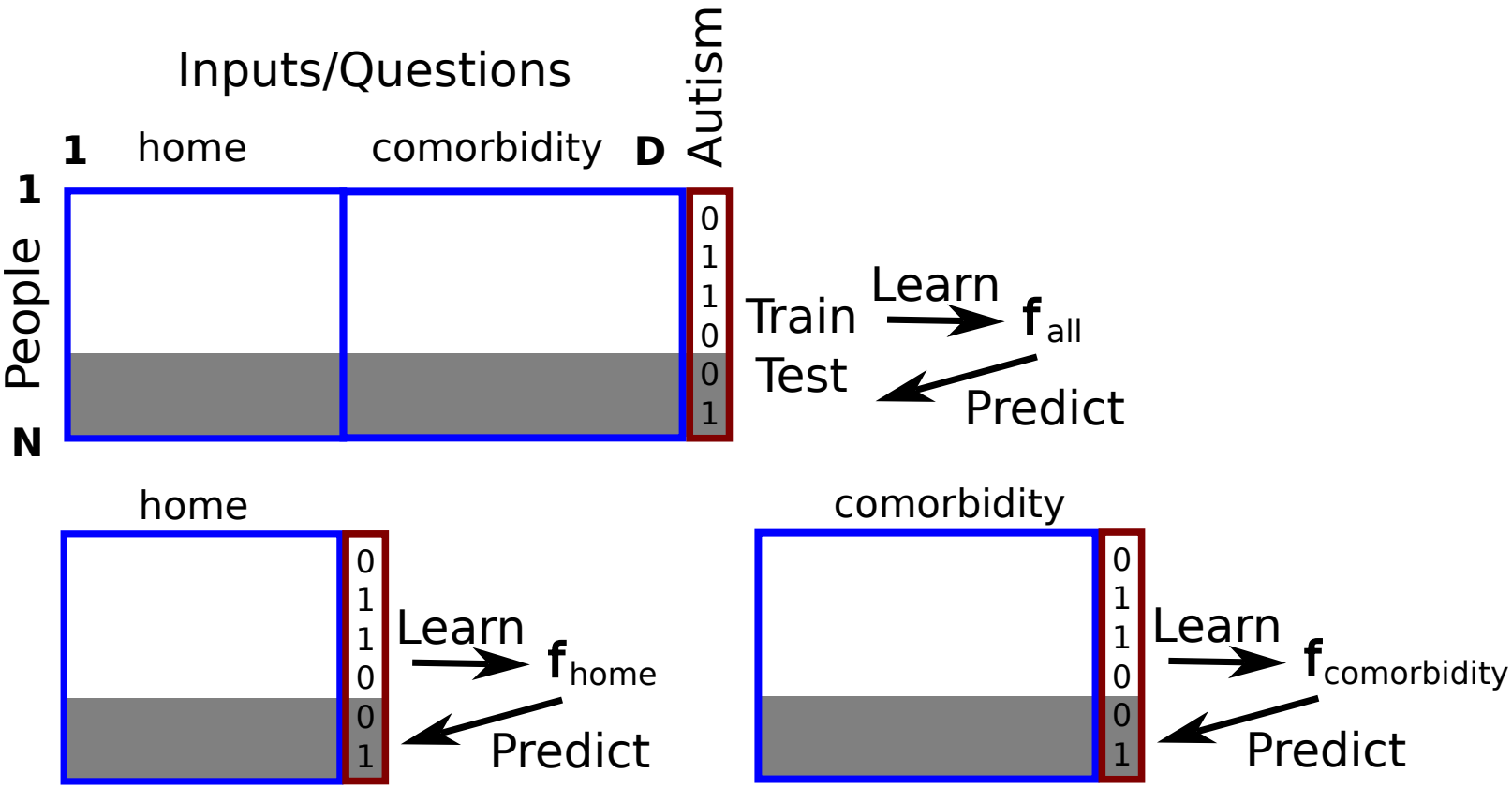

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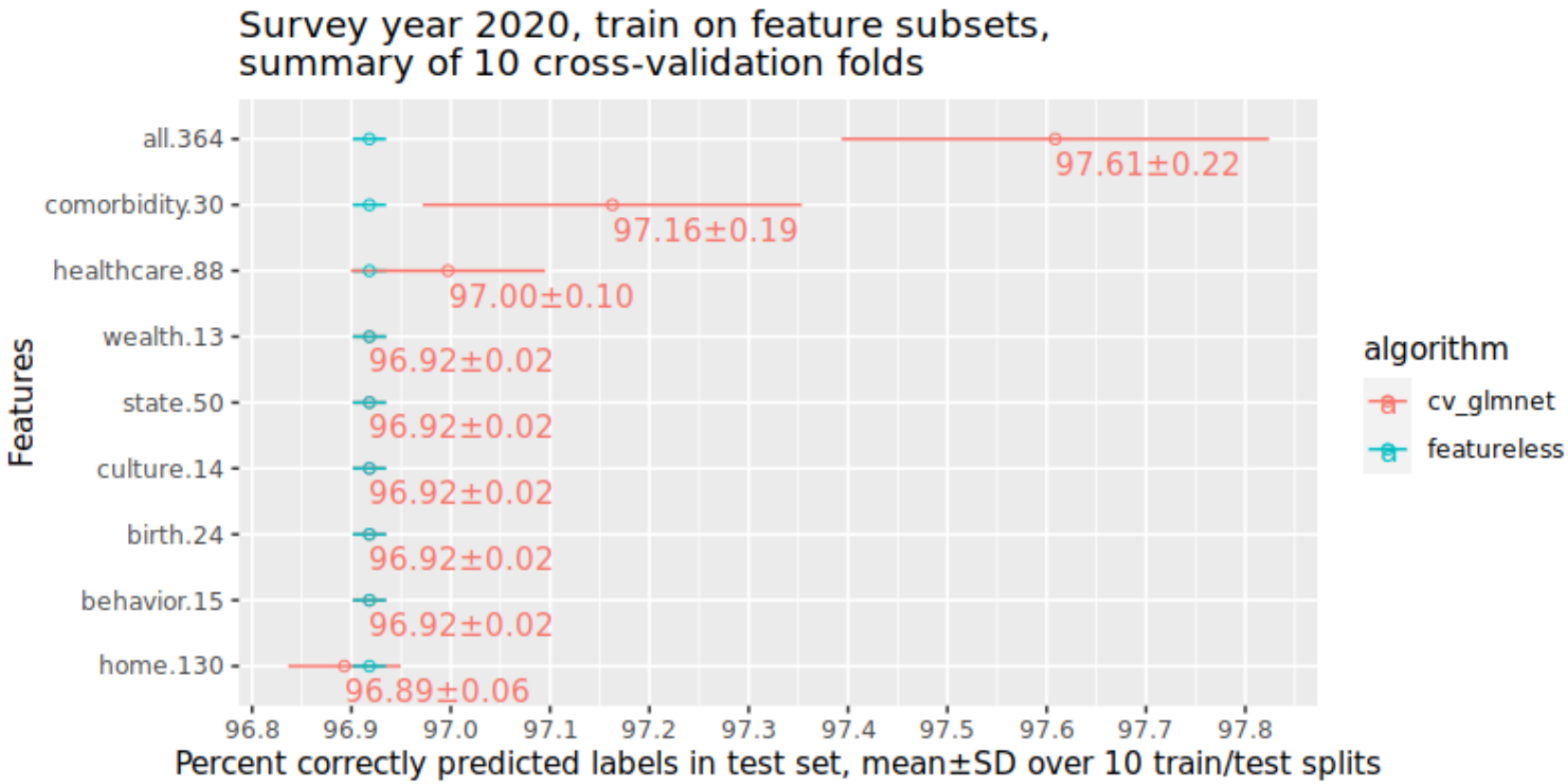

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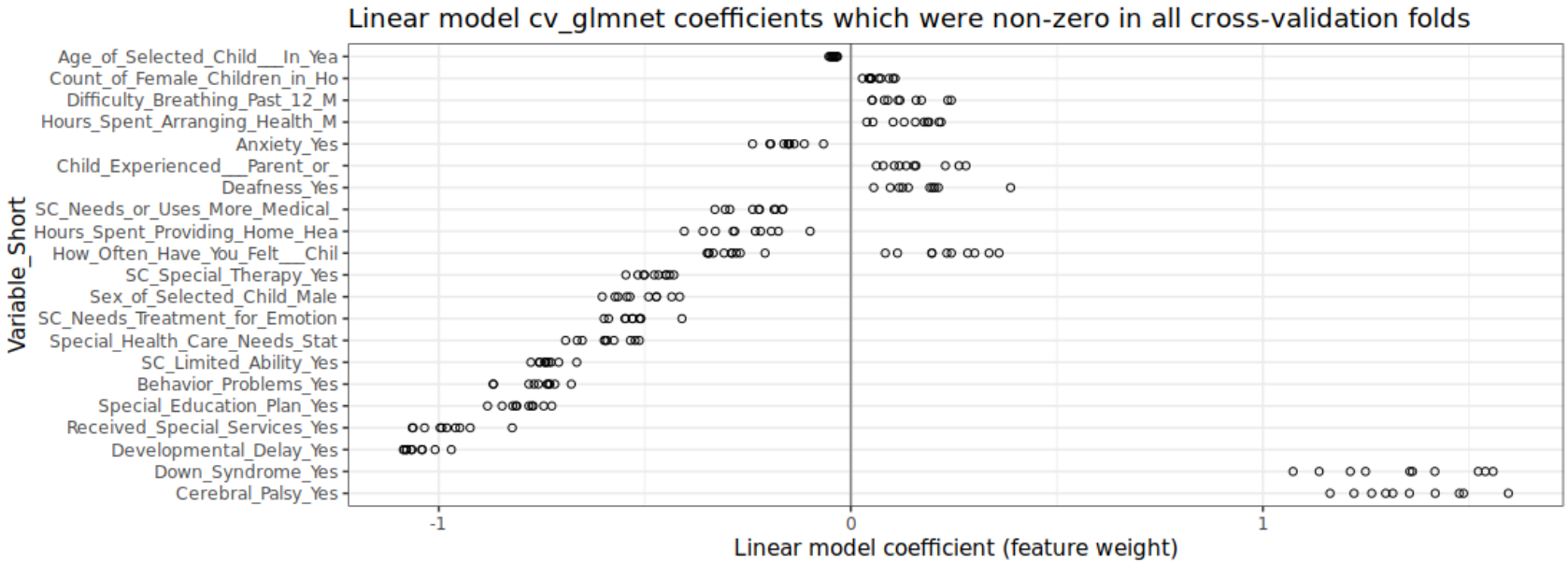

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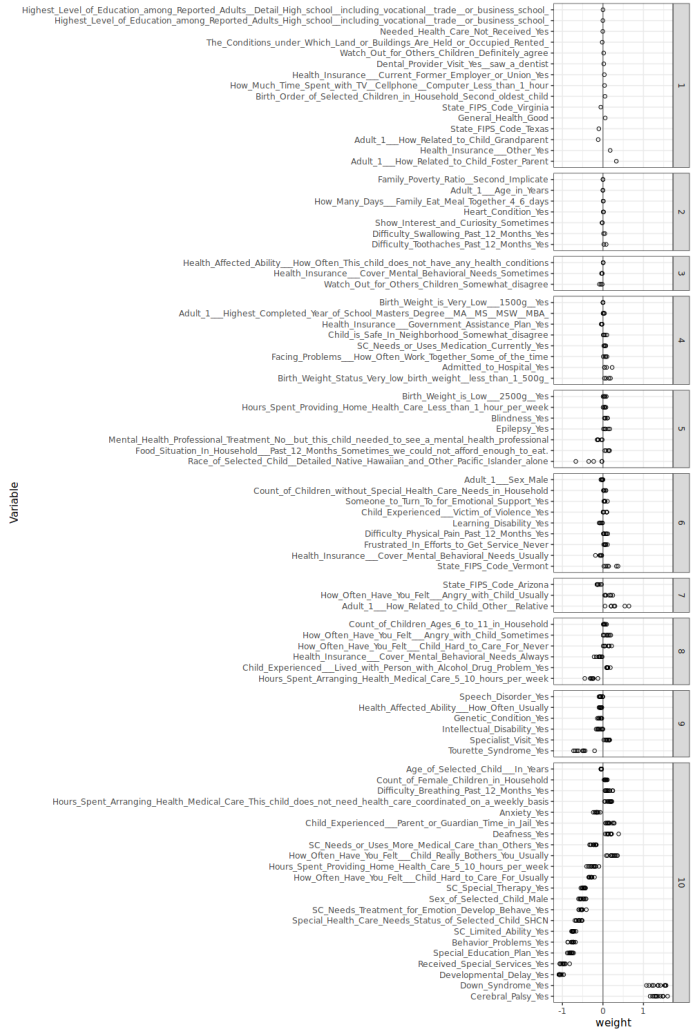

View full figure online, `https://github.com/tdhock/2024-01-ml-for-autism/blob/main/download-nsch-mlr3batchmark-registry-glmnet-coef.png`

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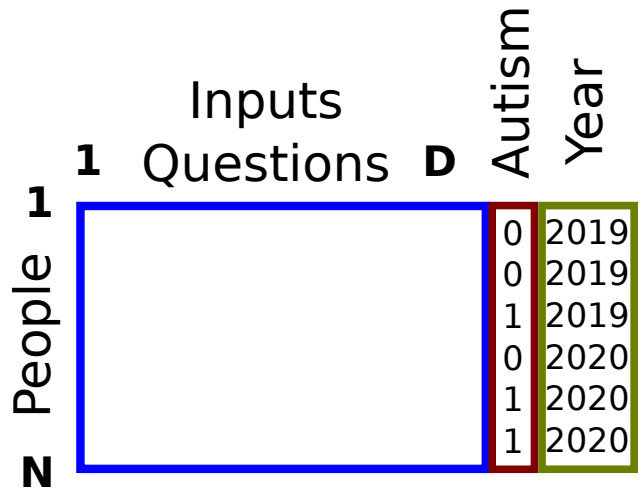

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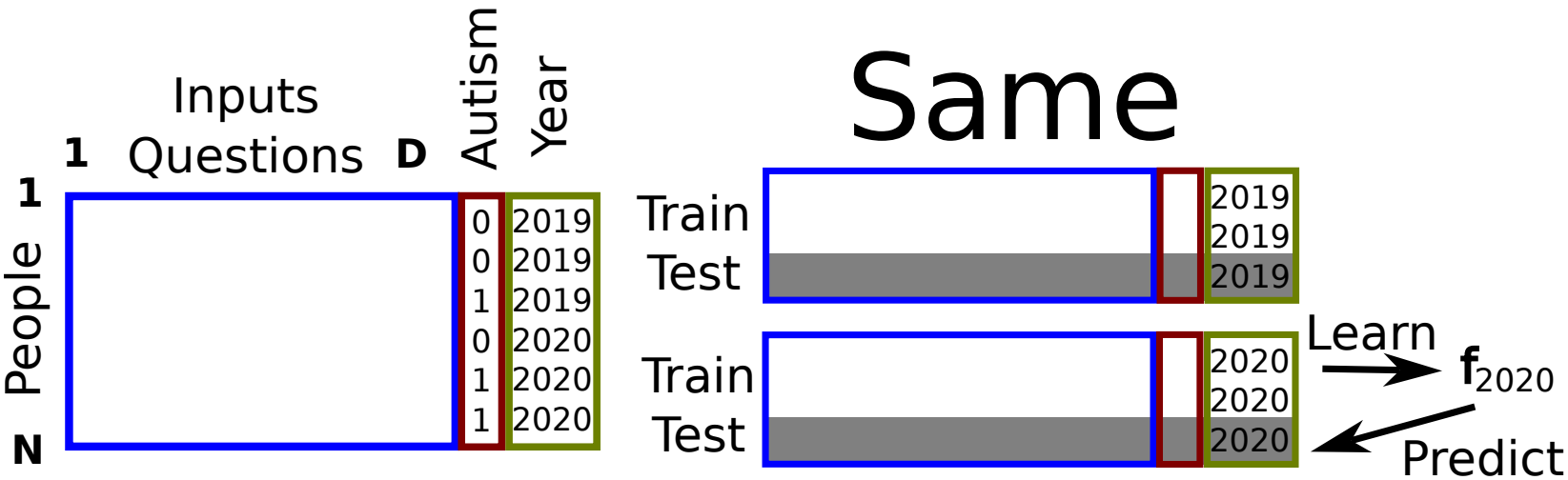

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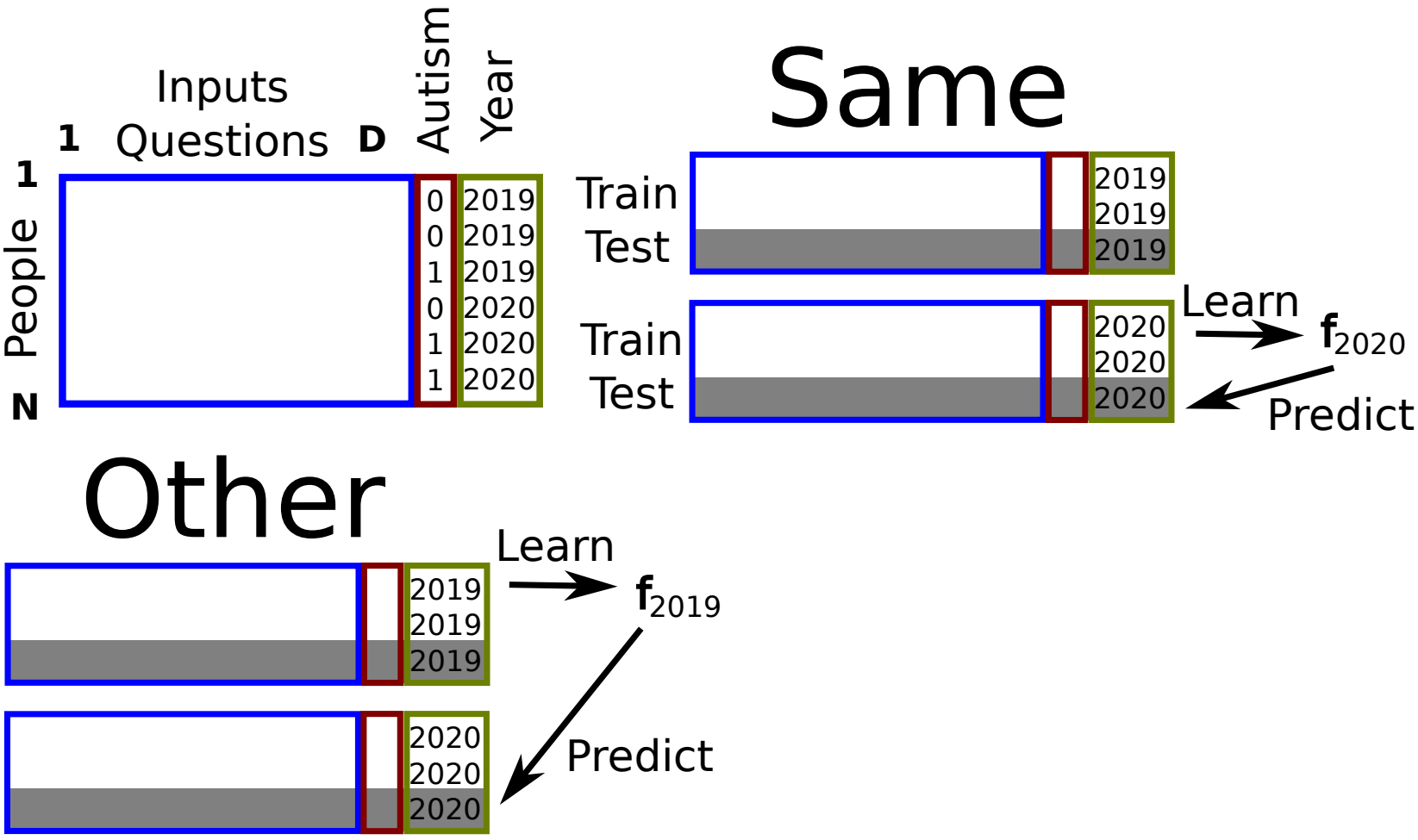

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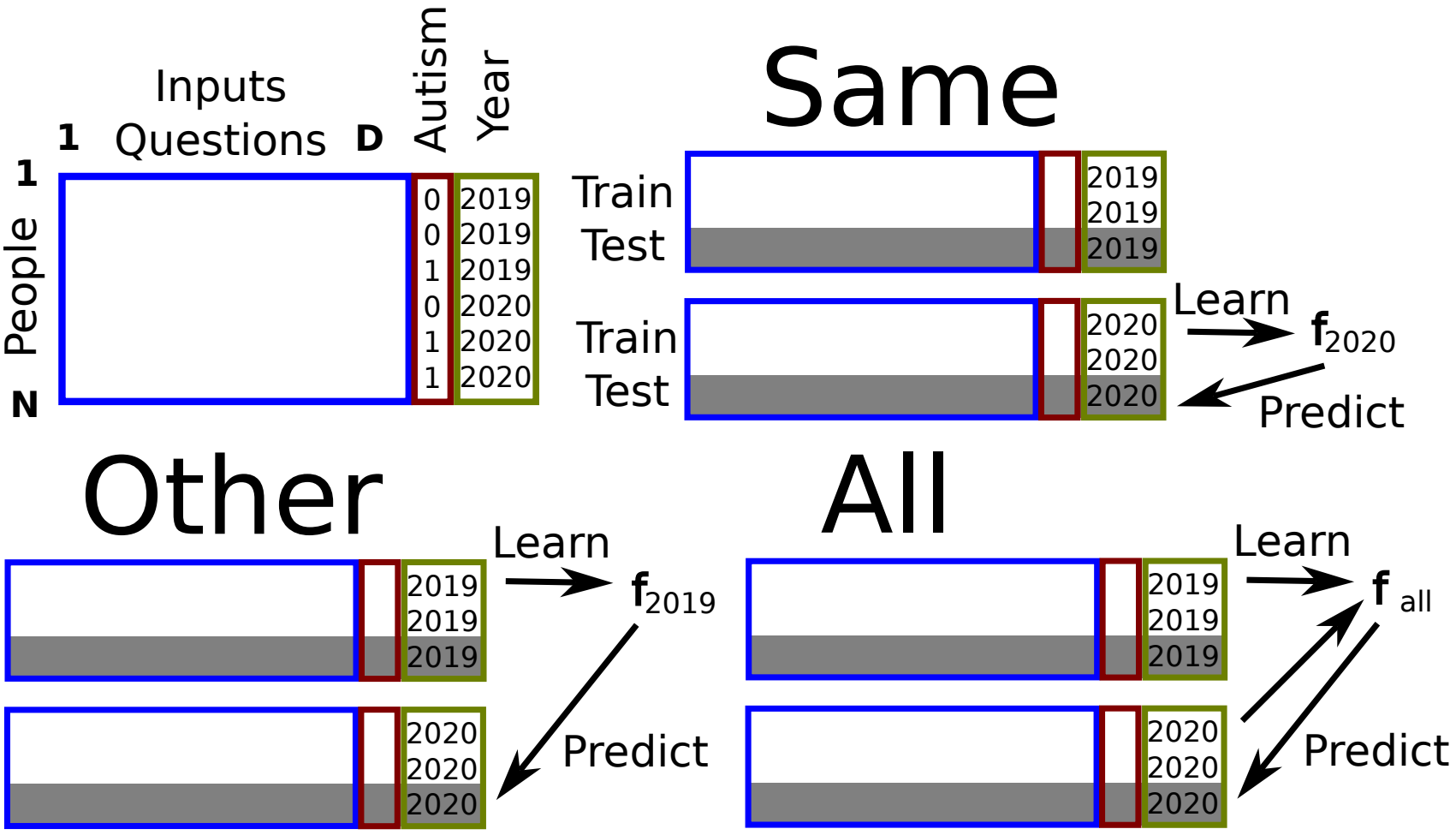

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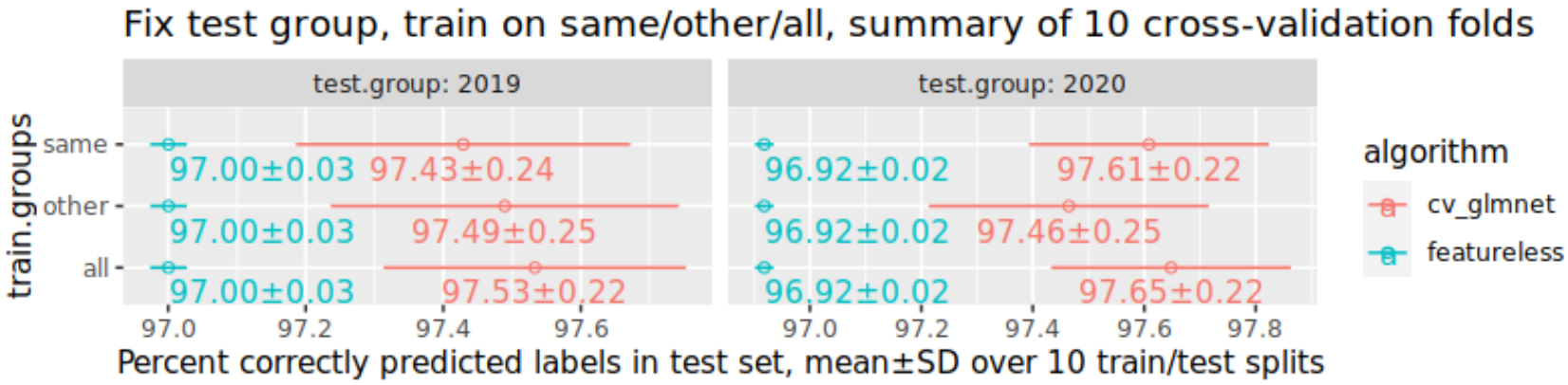

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- Often we want to know if we have similar or different patterns in different groups (train on one year, predict on another).
- Cross-validation can be used to determine the extent to which we can train on one group, and accurately predict on another.
- Machine learning algorithms like L1 regularized linear models (LASSO/cv_glmnet) are additionally interpretable in terms of which features are used for prediction (can be compared between models trained on different groups).
- Free/open-source software available: mlr3resampling R package on CRAN and `https://github.com/tdhock/mlr3resampling`
- Let's collaborate! Contact: toby.hocking@nau.edu, toby.hocking@r-project.org