laSalle
UNIVERSITAT RAMON LLULL

Shapley Values in Machine Learning

Elisabet Golobardes & Ángel Berián
La Salle – Universitat Ramon Llull

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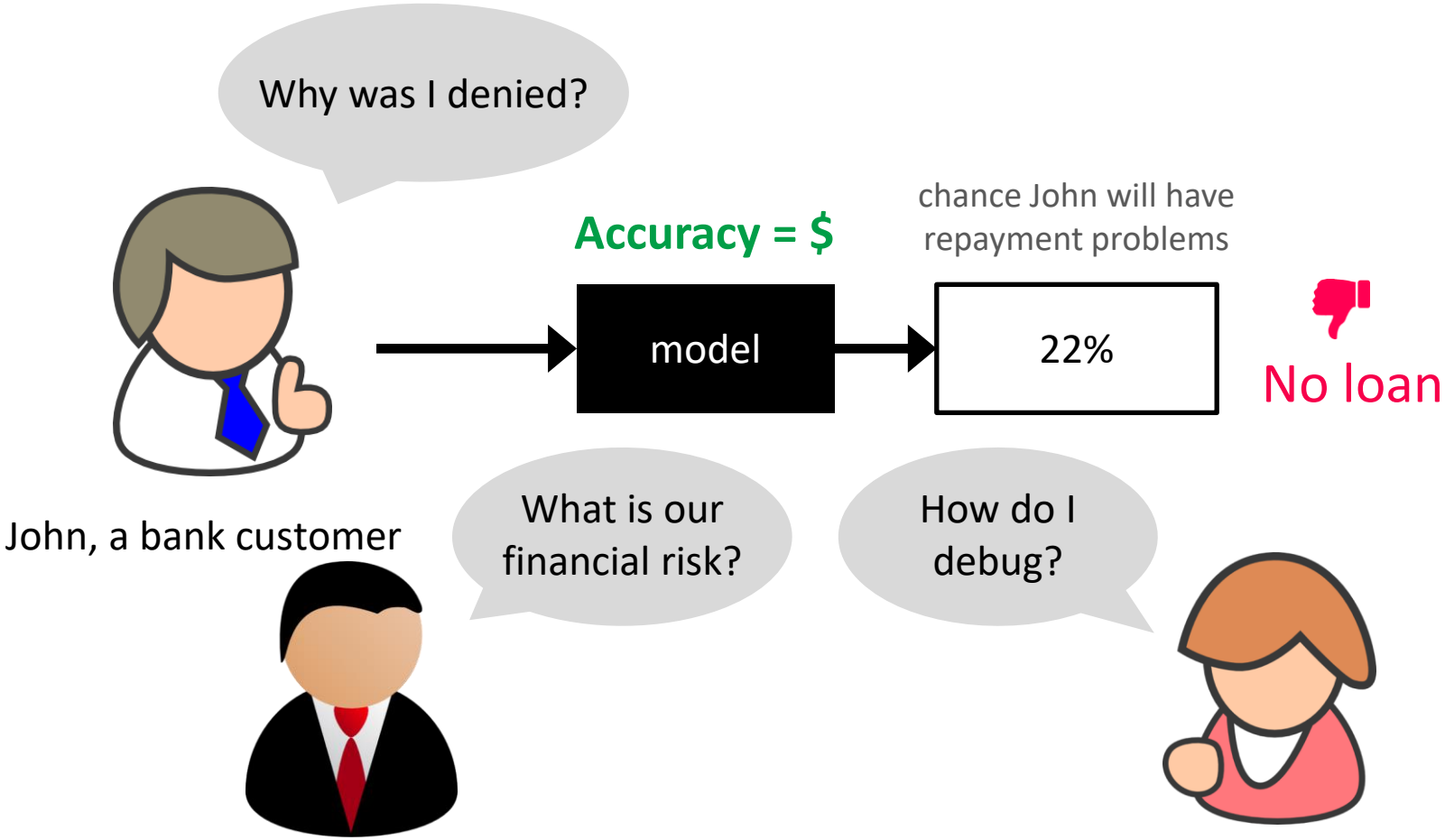
Explainable AI in practice

Model development

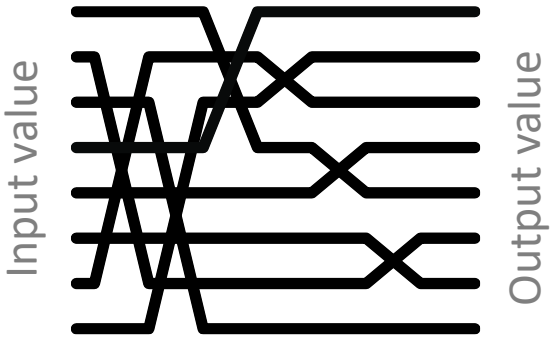

Why was I denied?
Accuracy = $
chance John will have repayment problems
model
22%
No loan
John, a bank customer
What is our financial risk?
How do I debug?

Interpretable **Accurate**

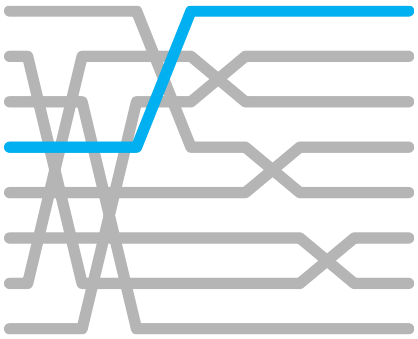
Complex model ← ?

Simple model ? →

Interpretable or accurate: **choose one**.



Complex models are inherently complex!



But a single prediction involves only a small piece of that complexity.

Base rate

16%

$E[f(X)]$

Prediction for John

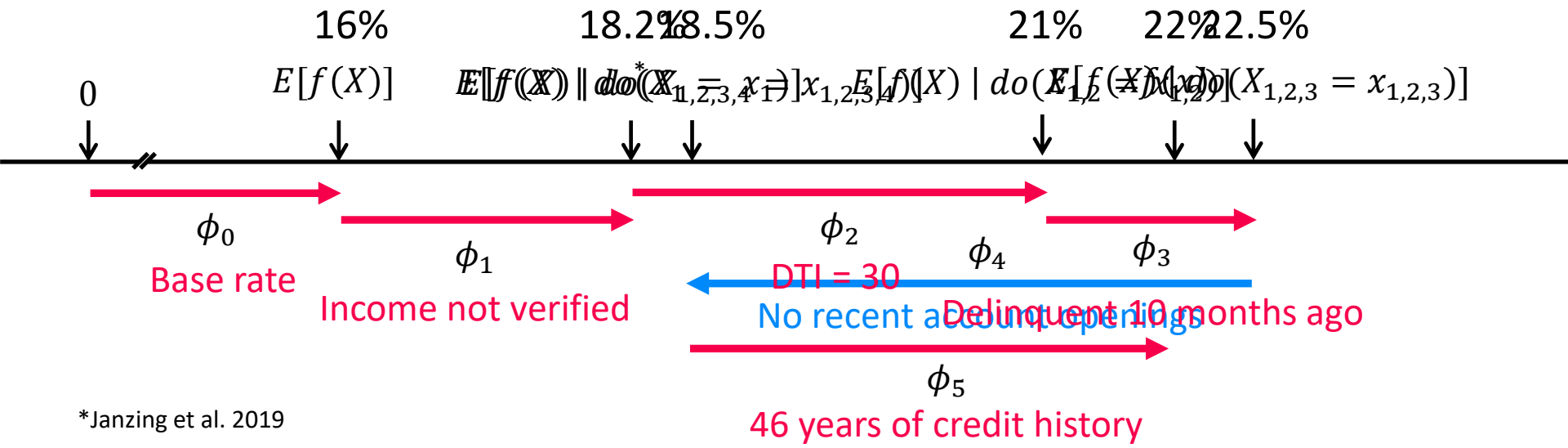
22%

$f(x)$

0

How did we get here?

The order matters!

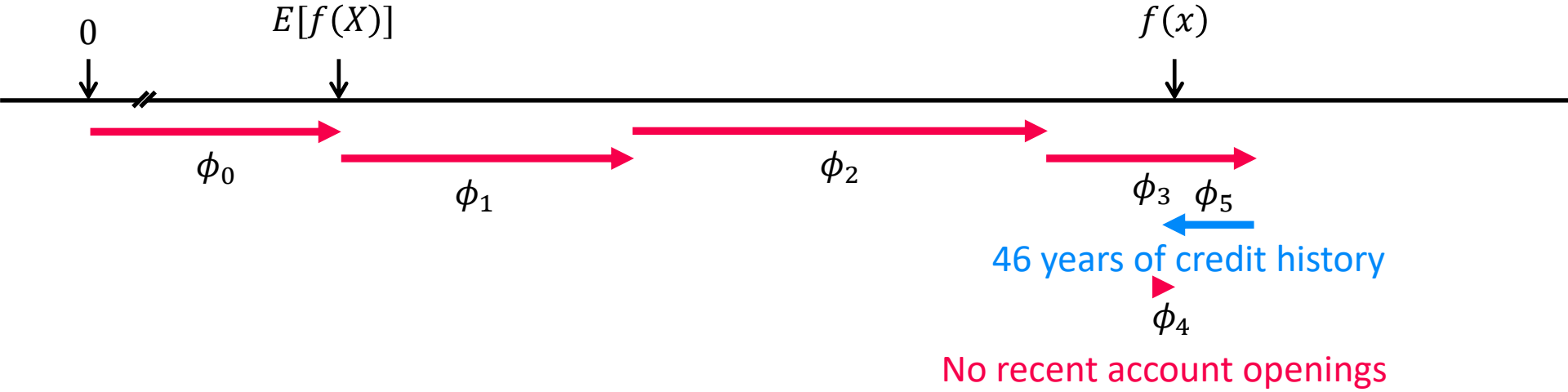


*Janzing et al. 2019

The order matters!

Lloyd Shapley

Nobel Prize in 2012

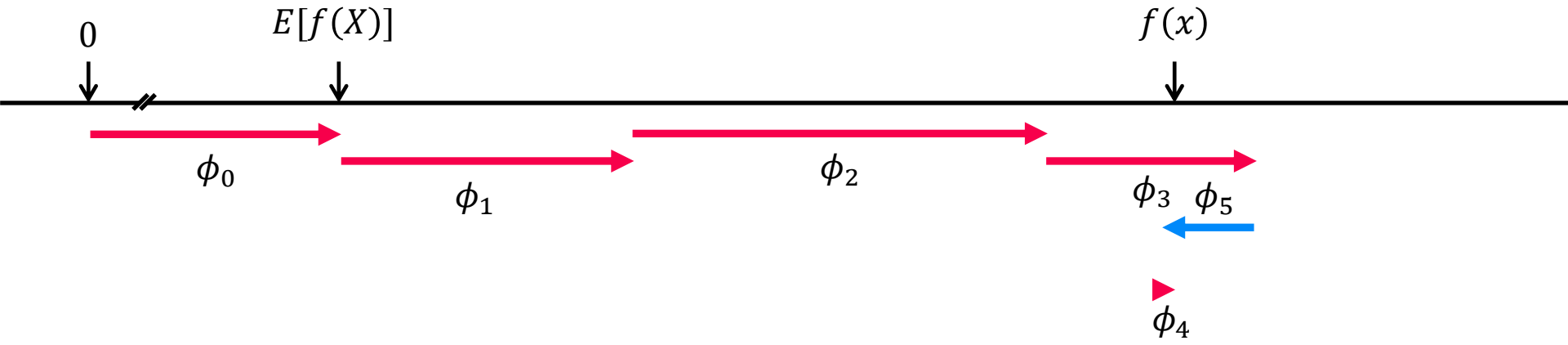


Shapley properties

1

Additivity (local accuracy) – The sum of the local feature attributions equals the difference between the base rate and the model output.

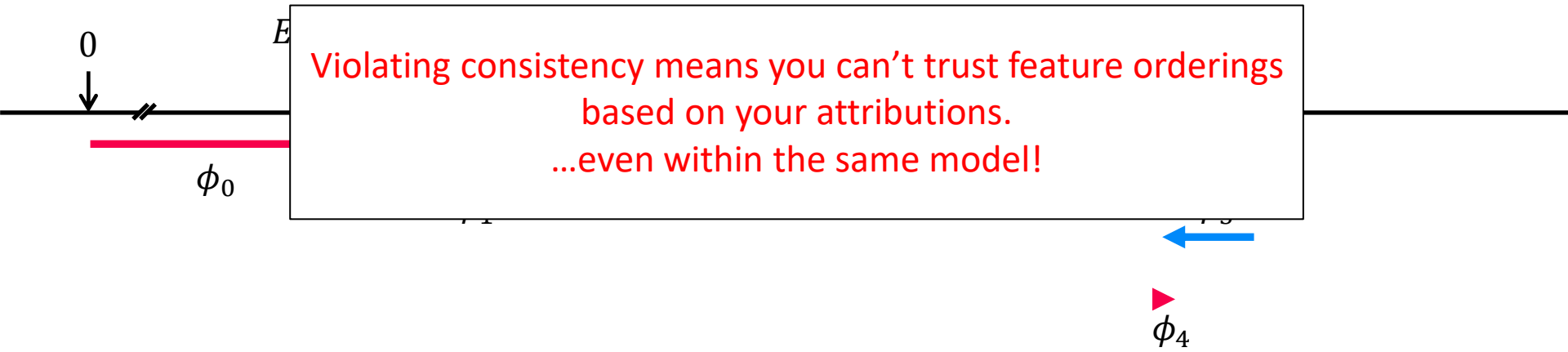
$$E[f(x)] + \sum_{i=1}^{M} \phi_i = f(x)$$



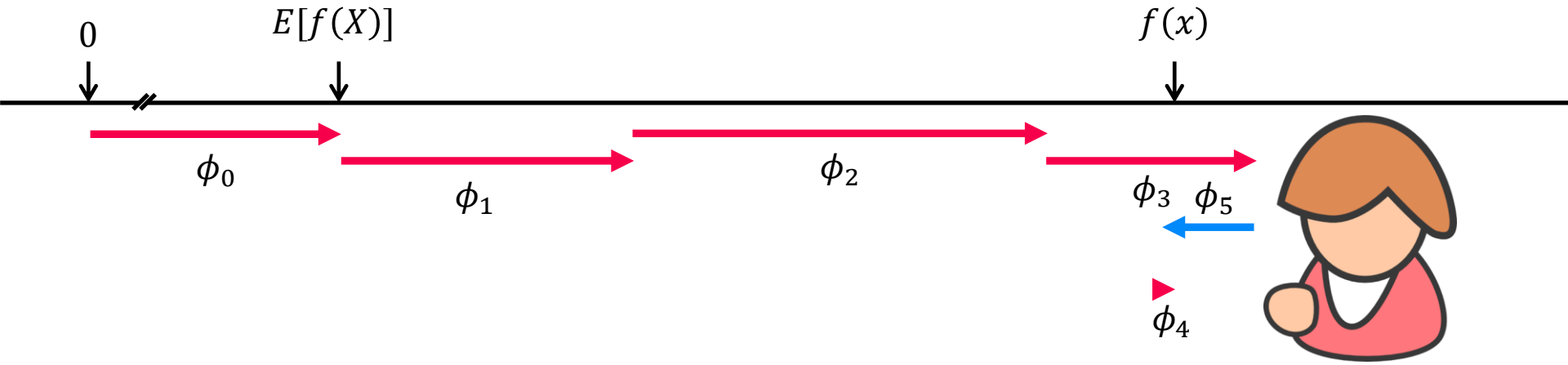
Shapley properties

2

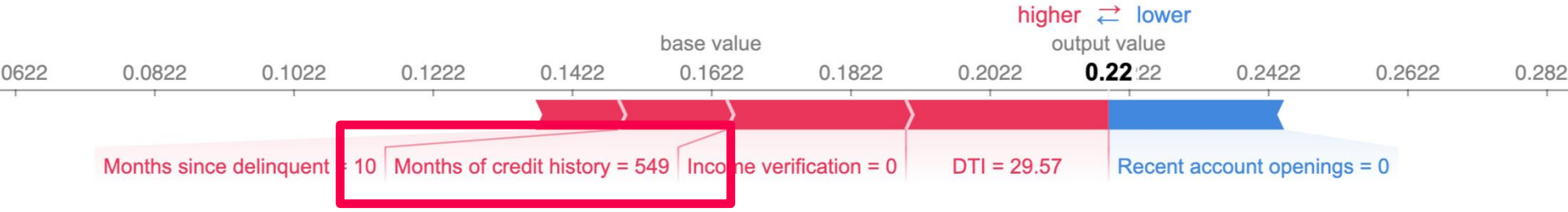
Monotonicity (consistency) – If you change the original model such that a feature has a larger impact in every possible ordering, then that input's attribution should not decrease.



Shapley values result from **averaging over all N! possible orderings**.



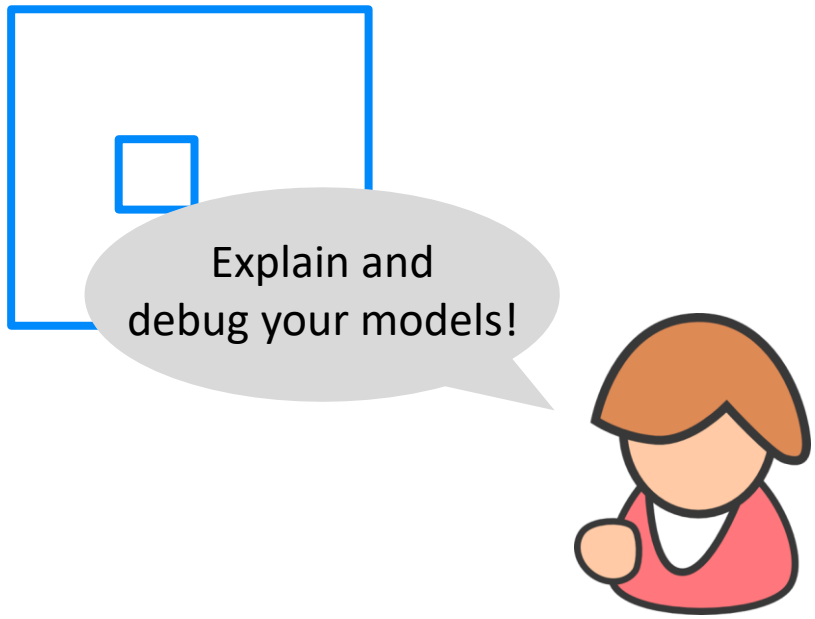
```
ex = shap.TreeExplainer(model, …)
shap_values = ex.shap_values(X)
shap.force_plot(                                                    ])
```



Why does 46 years of credit history increase the risk of payment problems?

```
shap.dependence_plot                                    , X)
```

The model is identifying retirement-age individuals based on their long credit histories!



Explainable AI in practice

Model development

Debugging/exploration

Monitoring

Encoding prior beliefs

Human/AI collaboration

Customer retention

Decision support

Human risk oversight

Regulatory compliance

Consumer explanations

Anti-discrimination

Risk management

Scientific discovery

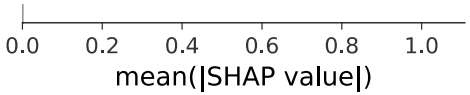
Population subtyping

Pattern discovery

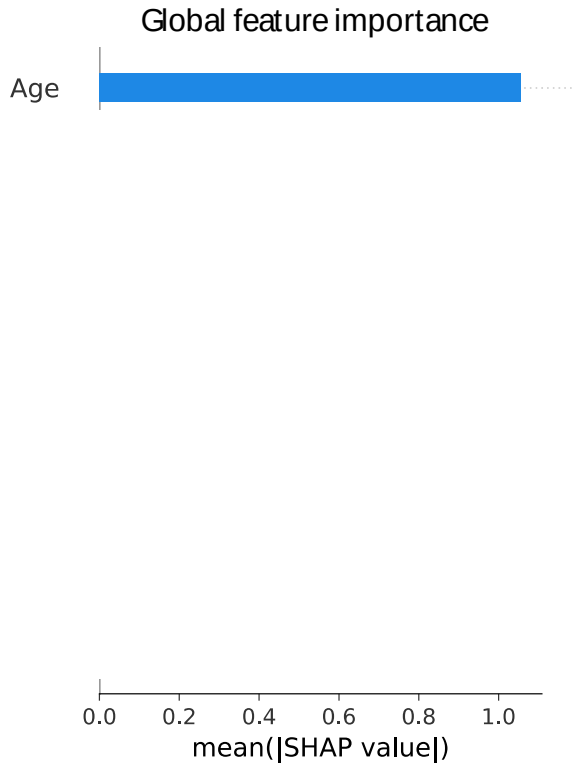
Signal recovery

Mortality risk model

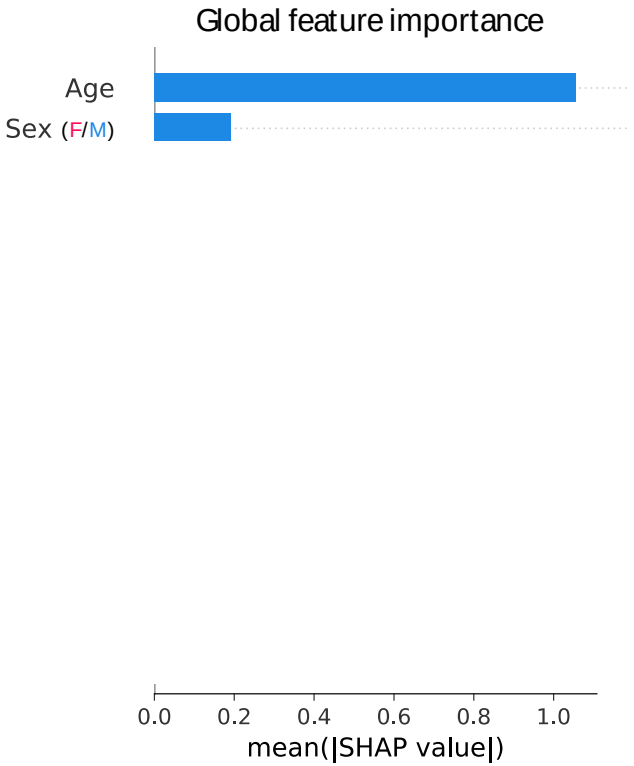
Global feature importance



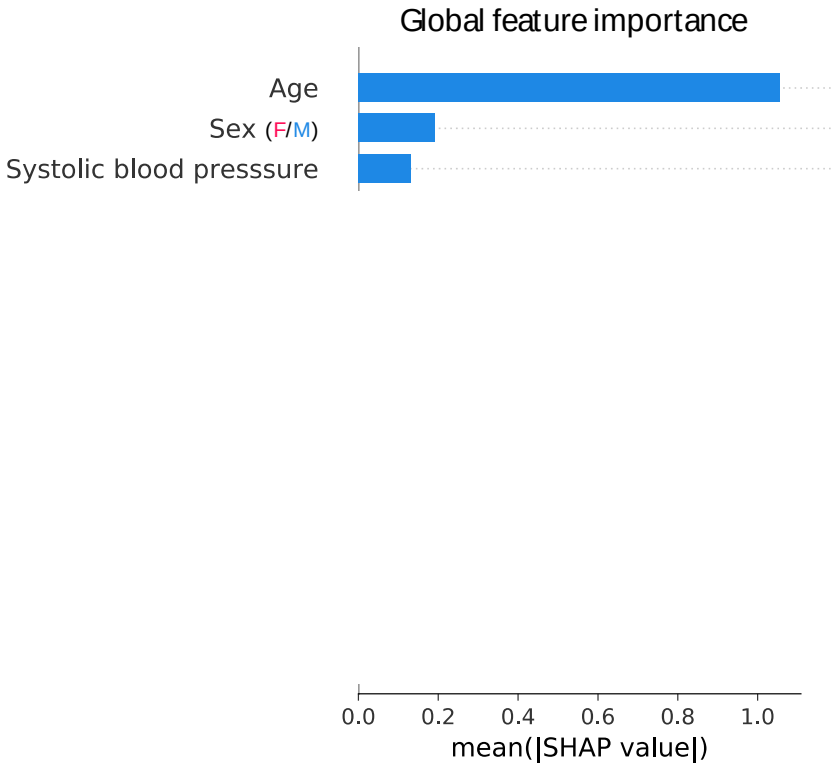
Mortality risk model



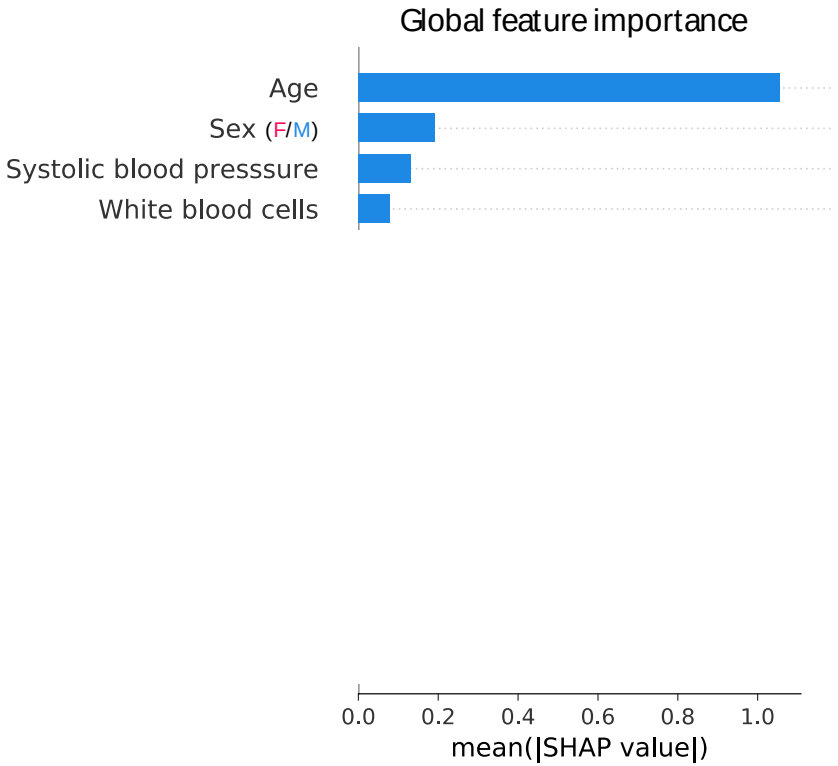
Mortality risk model



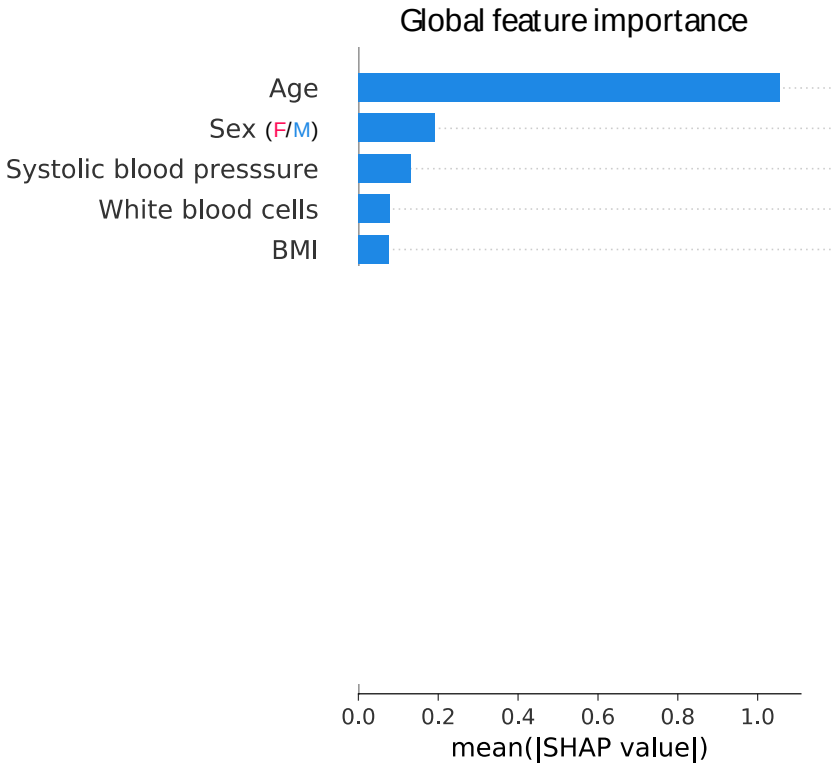
Mortality risk model



Mortality risk model

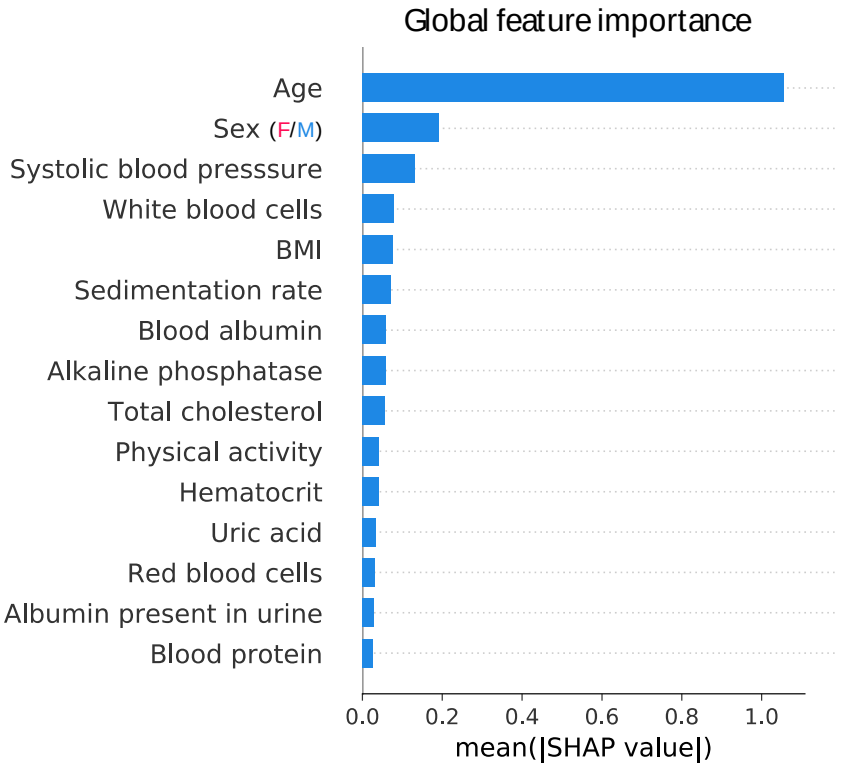


Mortality risk model



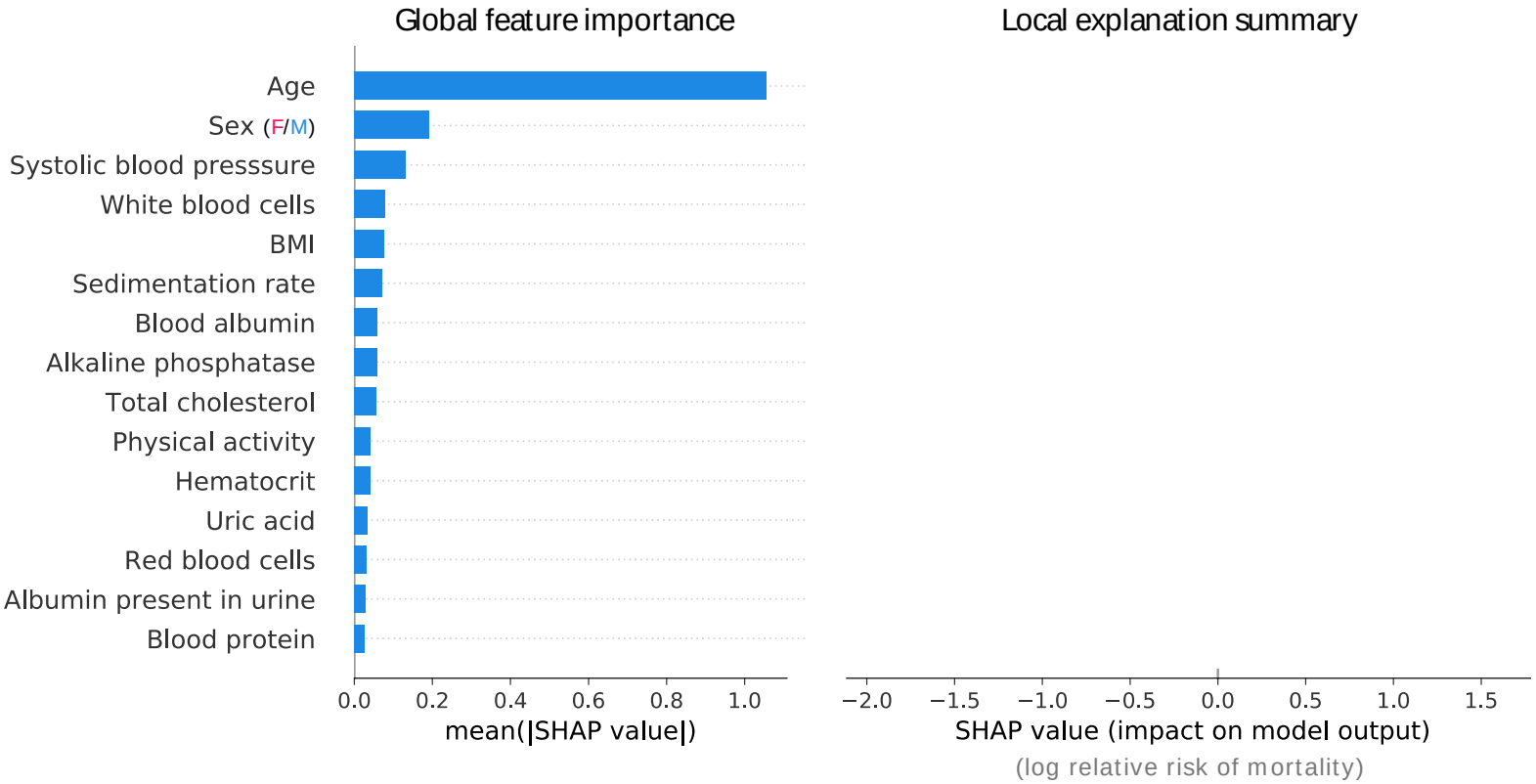
Mortality risk model

Reveal rare, high-magnitude mortality effects

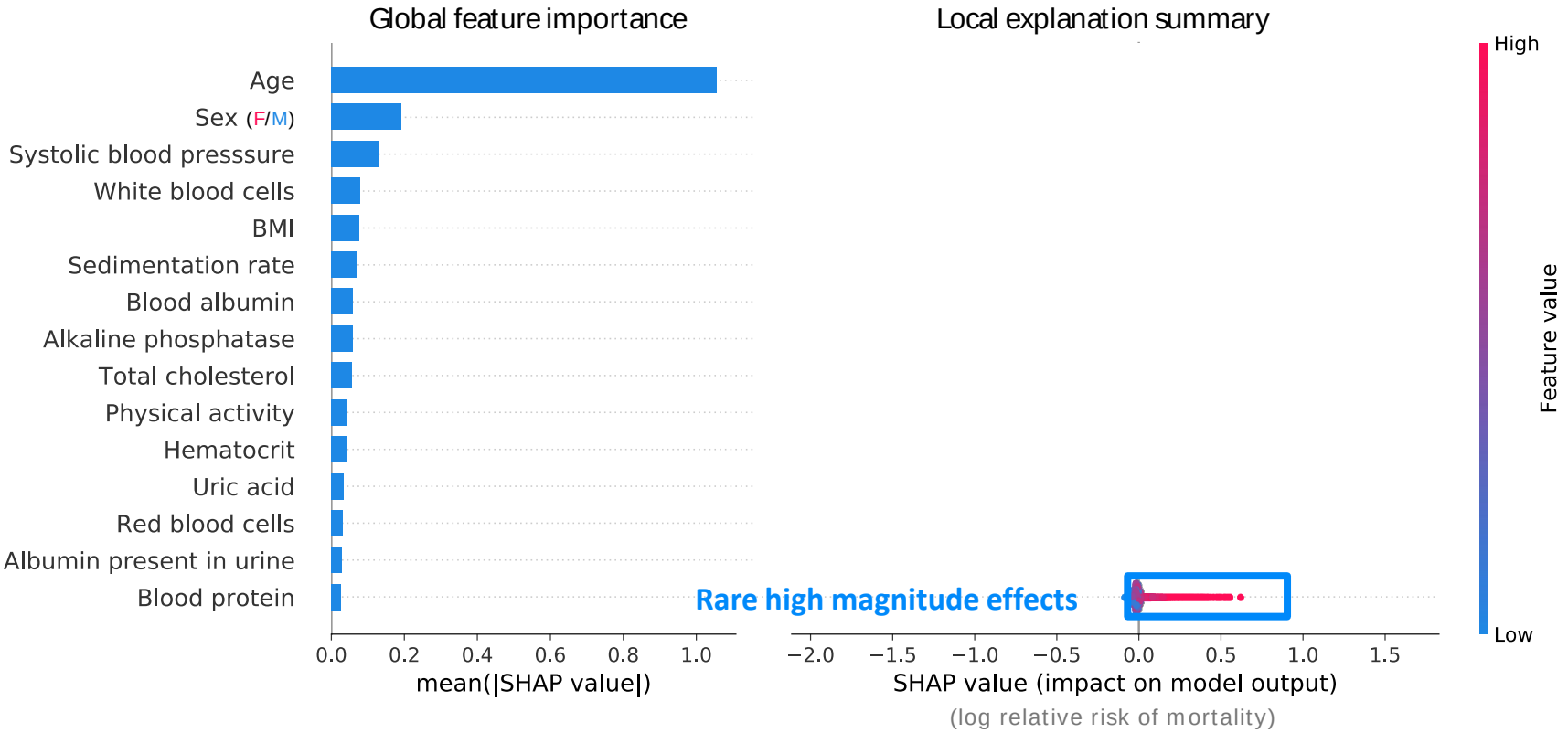


Conflates the
prevalence of an effect
with the
magnitude of an effect

Reveal rare high-magnitude mortality effects



Reveal rare high-magnitude mortality effects



Reveal rare high-magnitude mortality effects