

Scalable, Interpretable QNLP

An implementation on trapped ions

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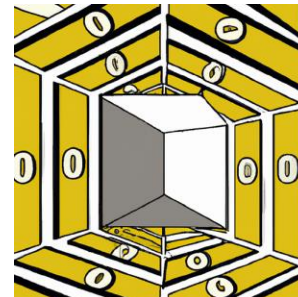
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Universiteit
Leiden



Alice walks north.
Bob walks south.
Bob follows Alice.
⋮

Is Bob going in the same
direction as Alice?



Compositional Model

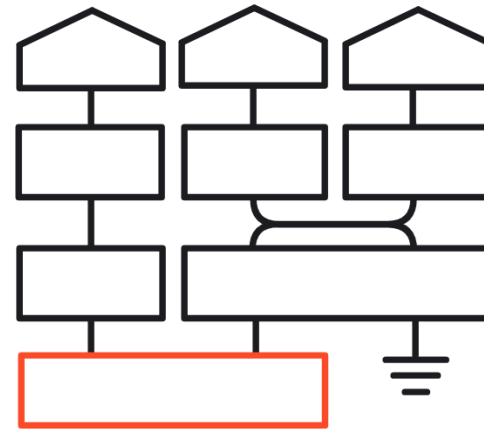
DisCoCirc

arXiv: 2301.10595

DisCoCirc

Alice walks north.
Bob walks south.
Bob follows Alice.
⋮

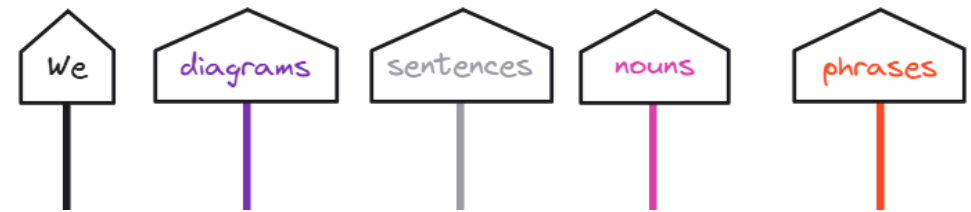
Is Bob going in the same
direction as Alice?



We convert *sentences* into DisCoCirc *diagrams*.

The *sentences* with shared *nouns* compose sequentially.

Unrelated *phrases* are separated.

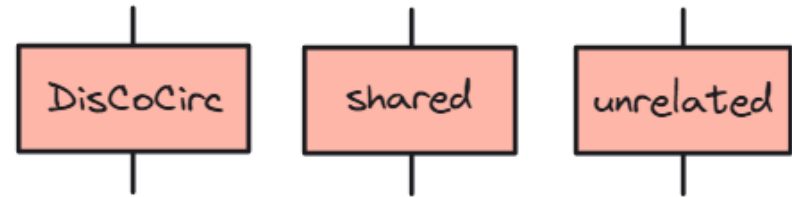


We convert sentences into **DisCoCirc** diagrams.

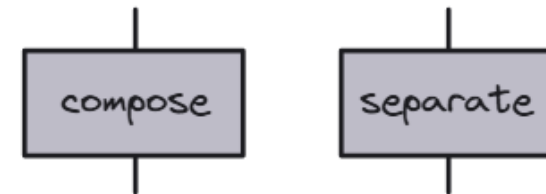
The sentences with **shared** nouns **compose** sequentially.

Unrelated phrases are **separated**.

Adjectives



Intransitive verbs

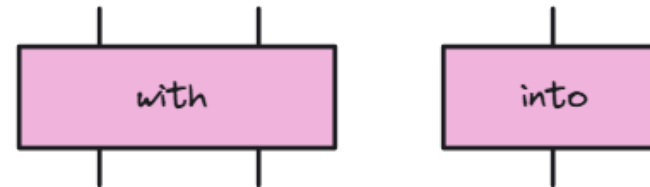


We **convert** sentences **into** DisCoCirc diagrams.

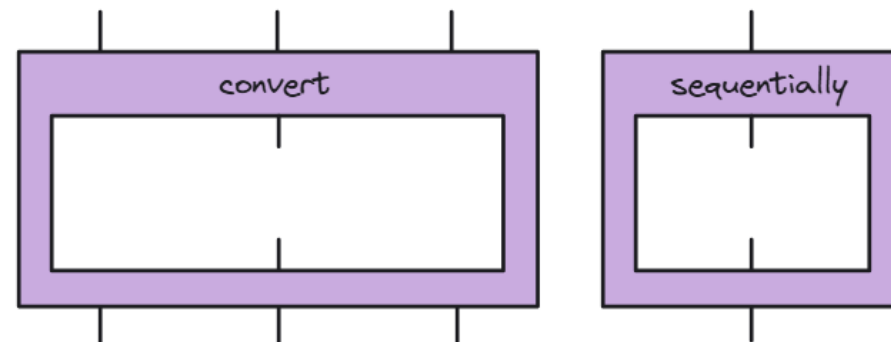
The sentences **with** shared nouns compose **sequentially**.

Unrelated phrases are separated.

Prepositions



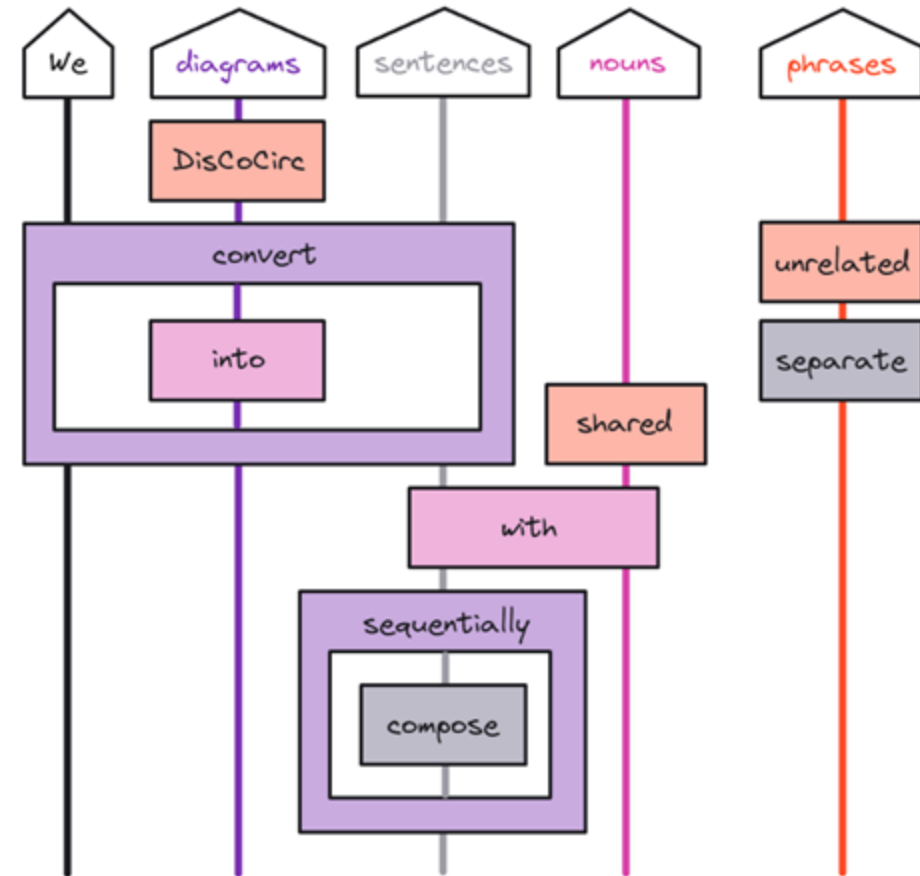
Higher-order



We convert sentences into DisCoCirc diagrams.

The sentences with shared nouns compose sequentially.

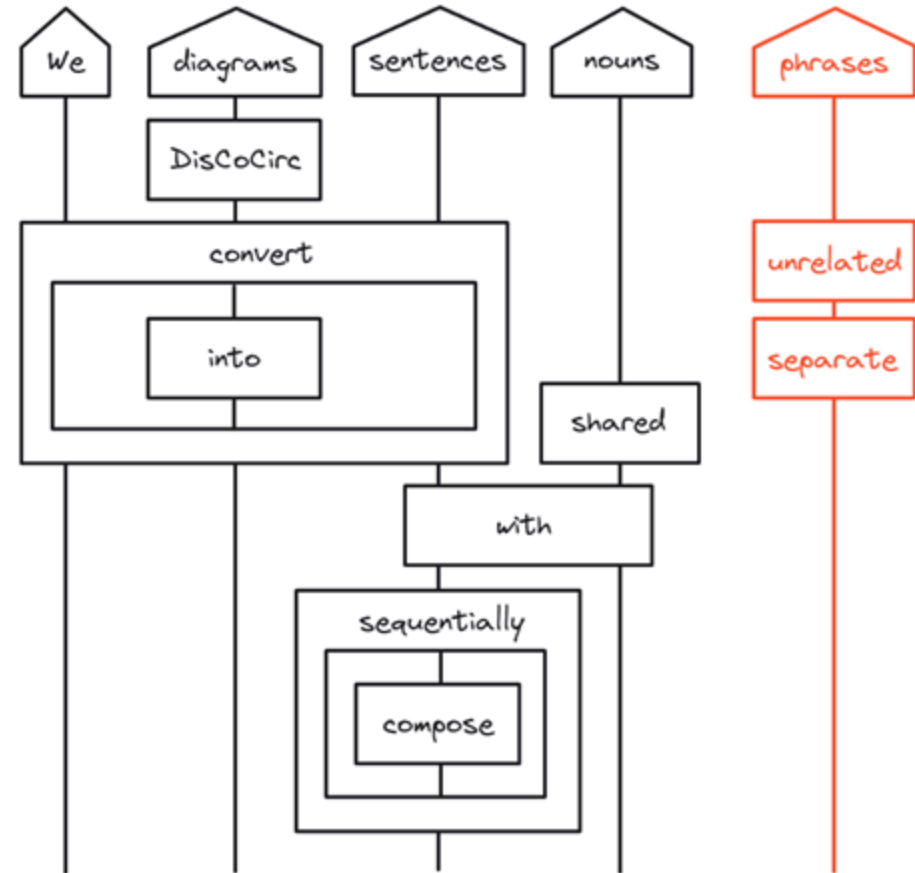
Unrelated phrases are separated.



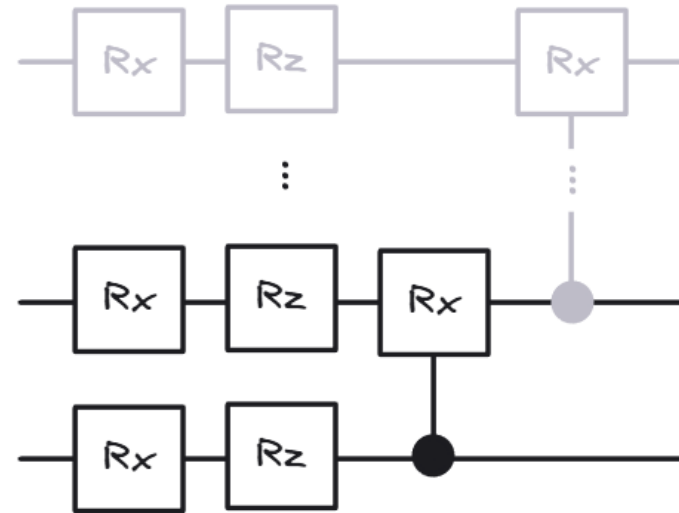
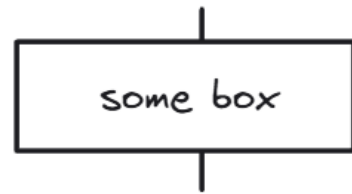
We convert sentences into DisCoCirc diagrams.

The sentences with shared nouns compose sequentially.

Unrelated phrases are separated.



Quantum DisCoCirc





Task

“Following” Dataset



Alice



Bob



...



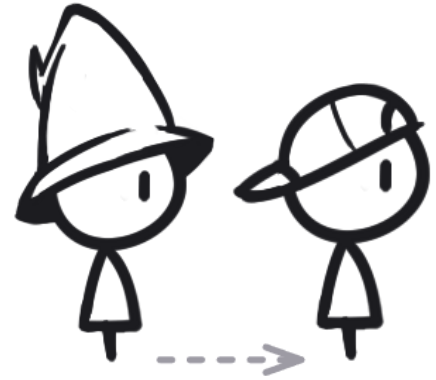
2
directions



Alice walks south
north
east
west



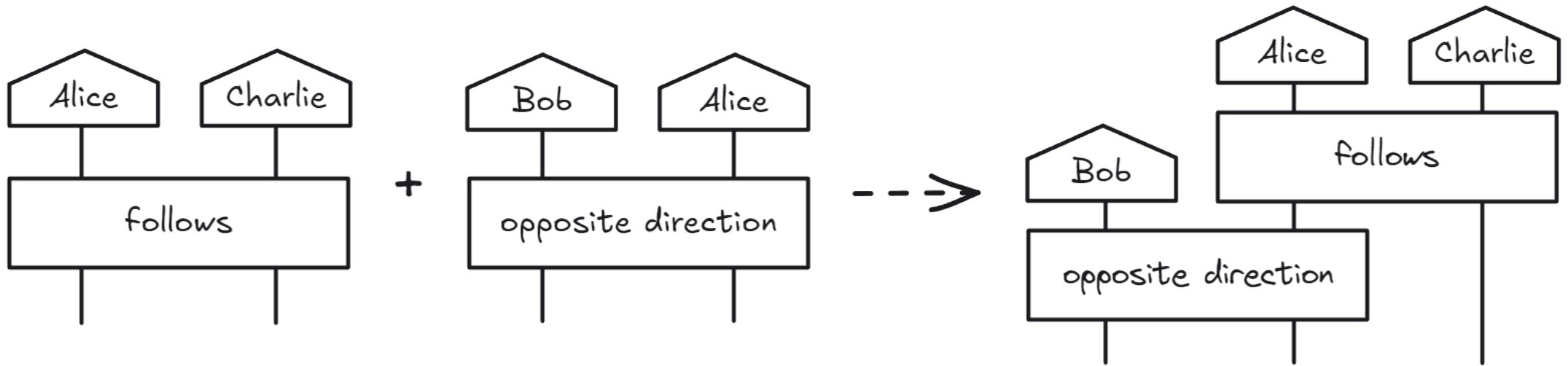
Alice turns around
left
right



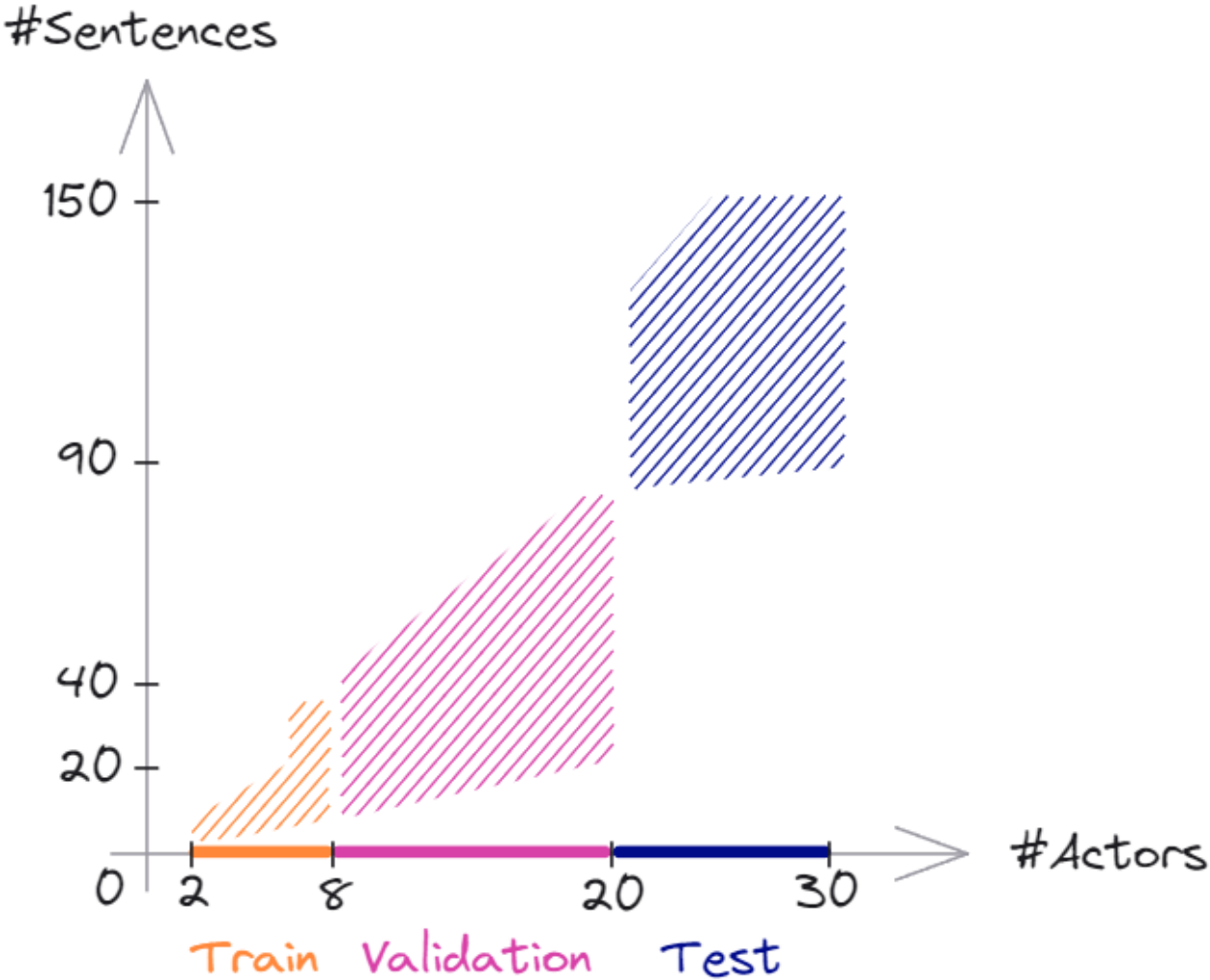
Alice follows Bob.
goes in
the opposite
direction of

4
directions

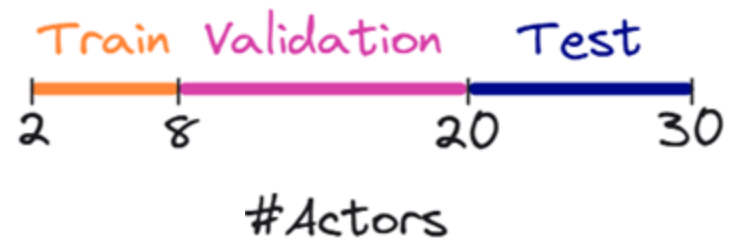
Productivity



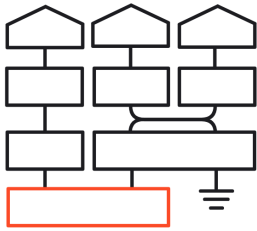
Dataset Split



Pipeline



Pipeline

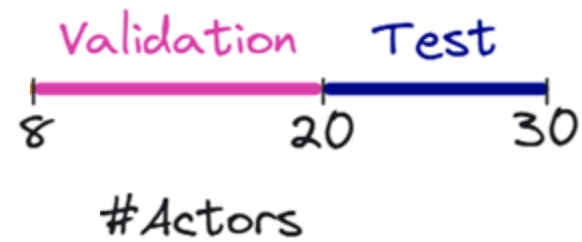
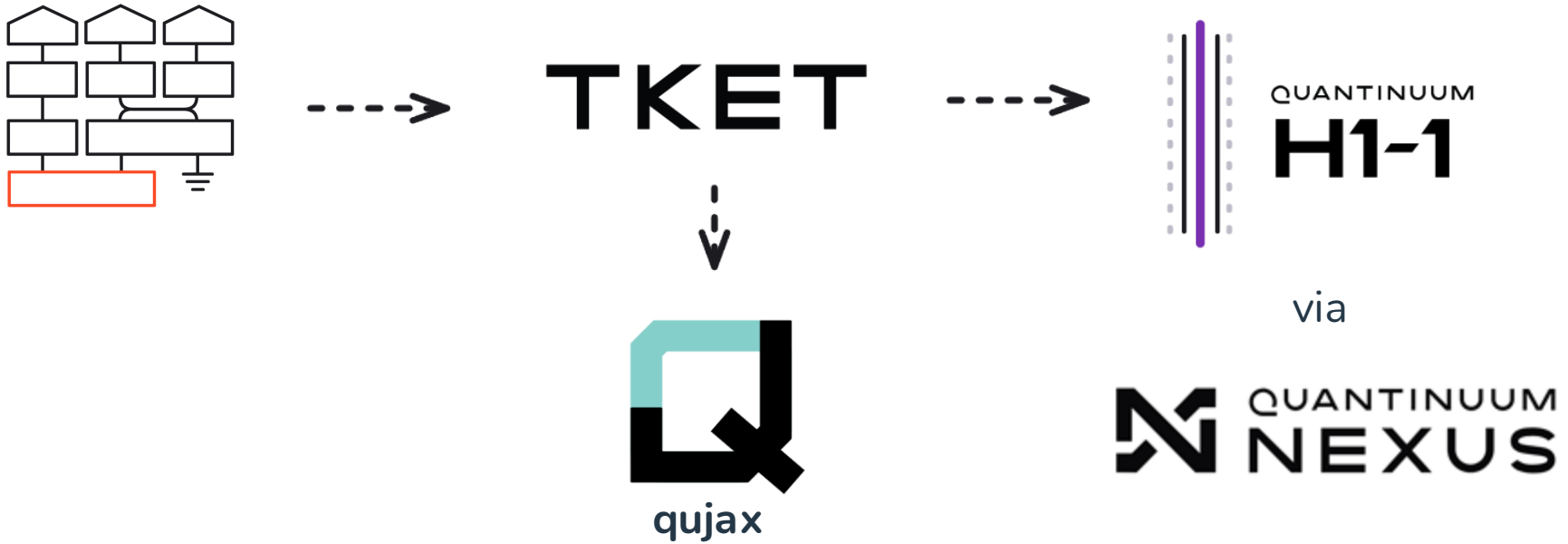


 Tensor
Network

 PyTorch



Pipeline



Compositional Generalisation

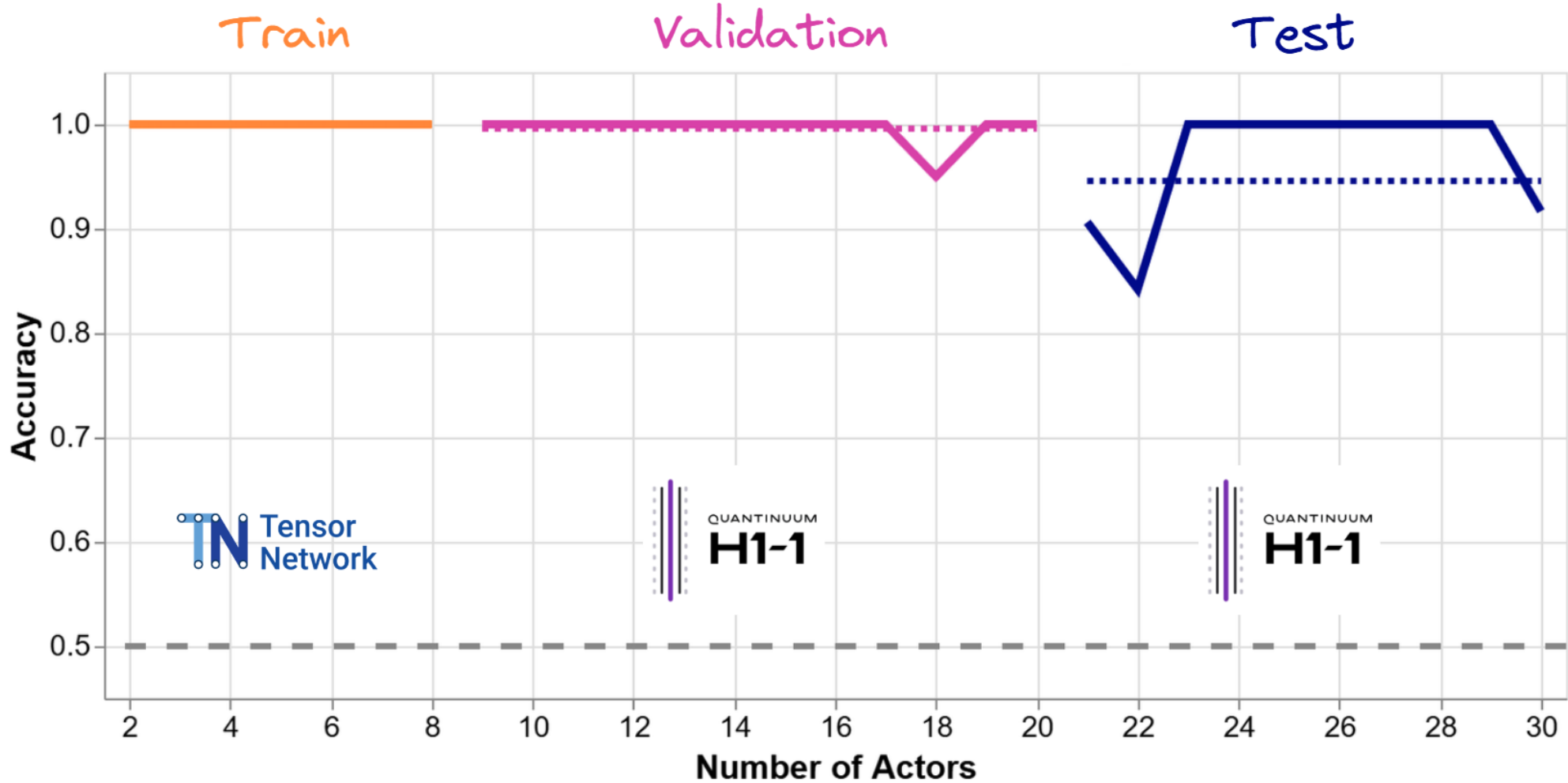
“train small, test big”

2

directions



Compositional generalisation

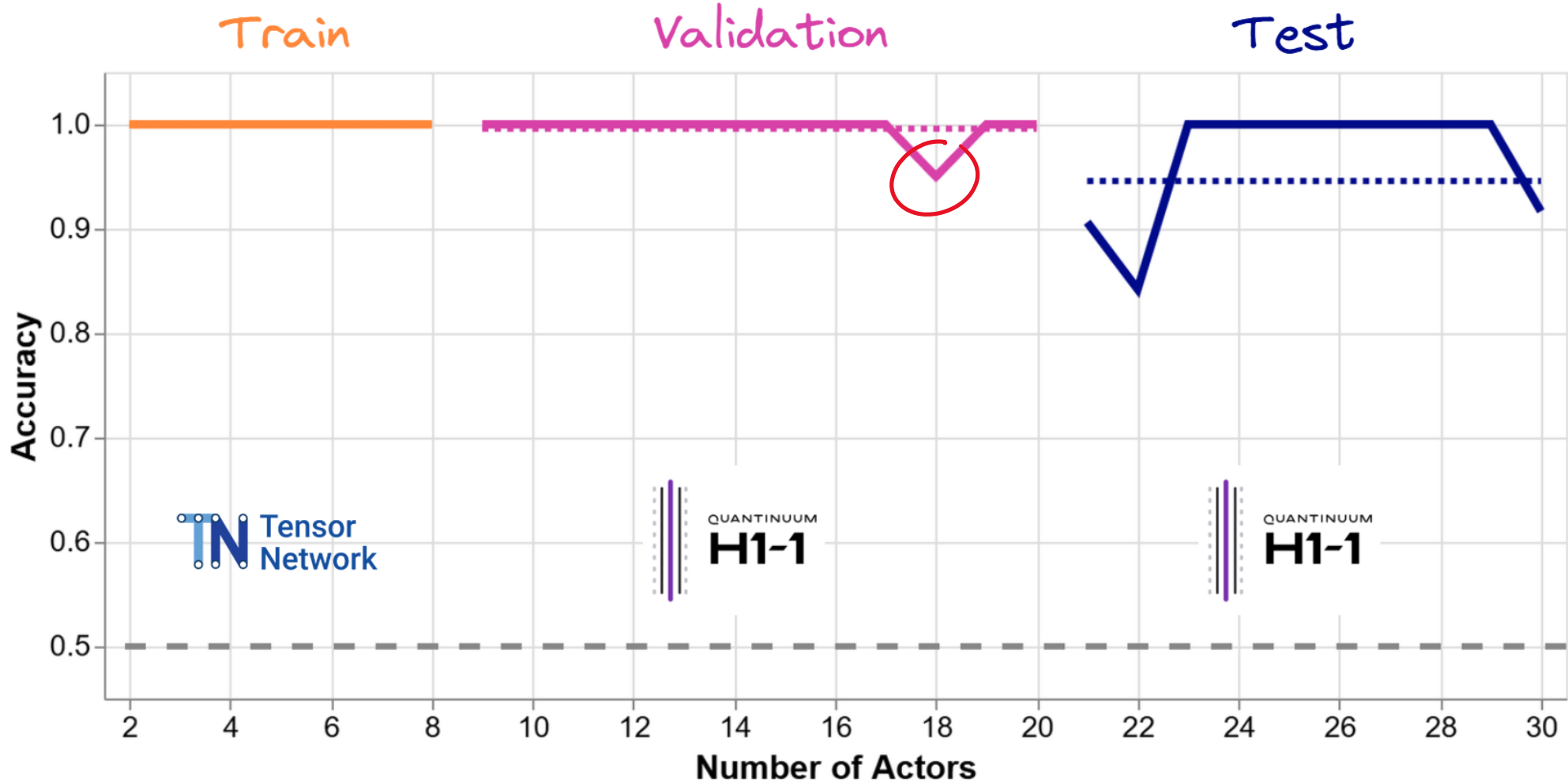


2

directions



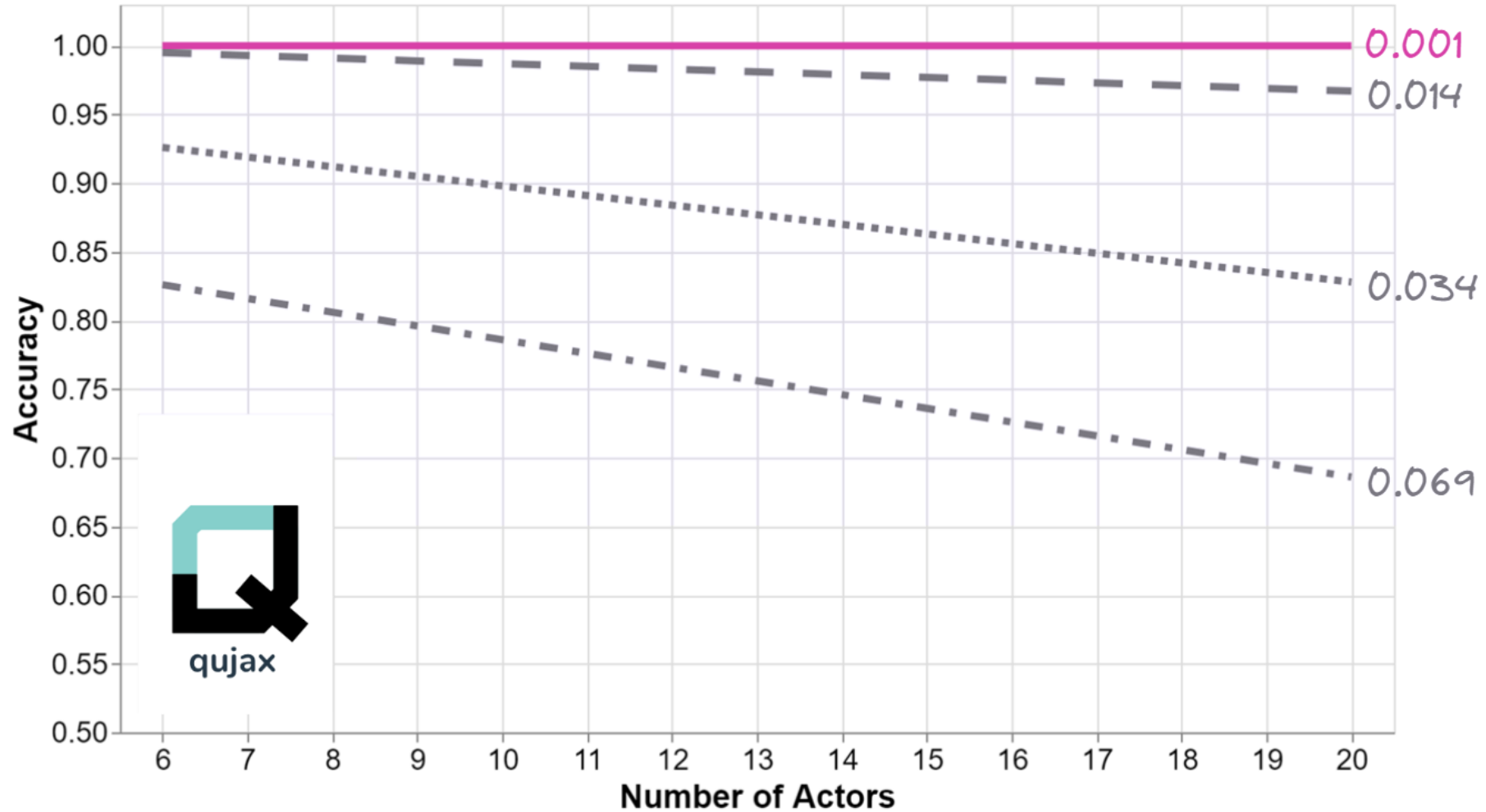
Compositional generalisation



2 directions



Noise Simulations on Validation dataset

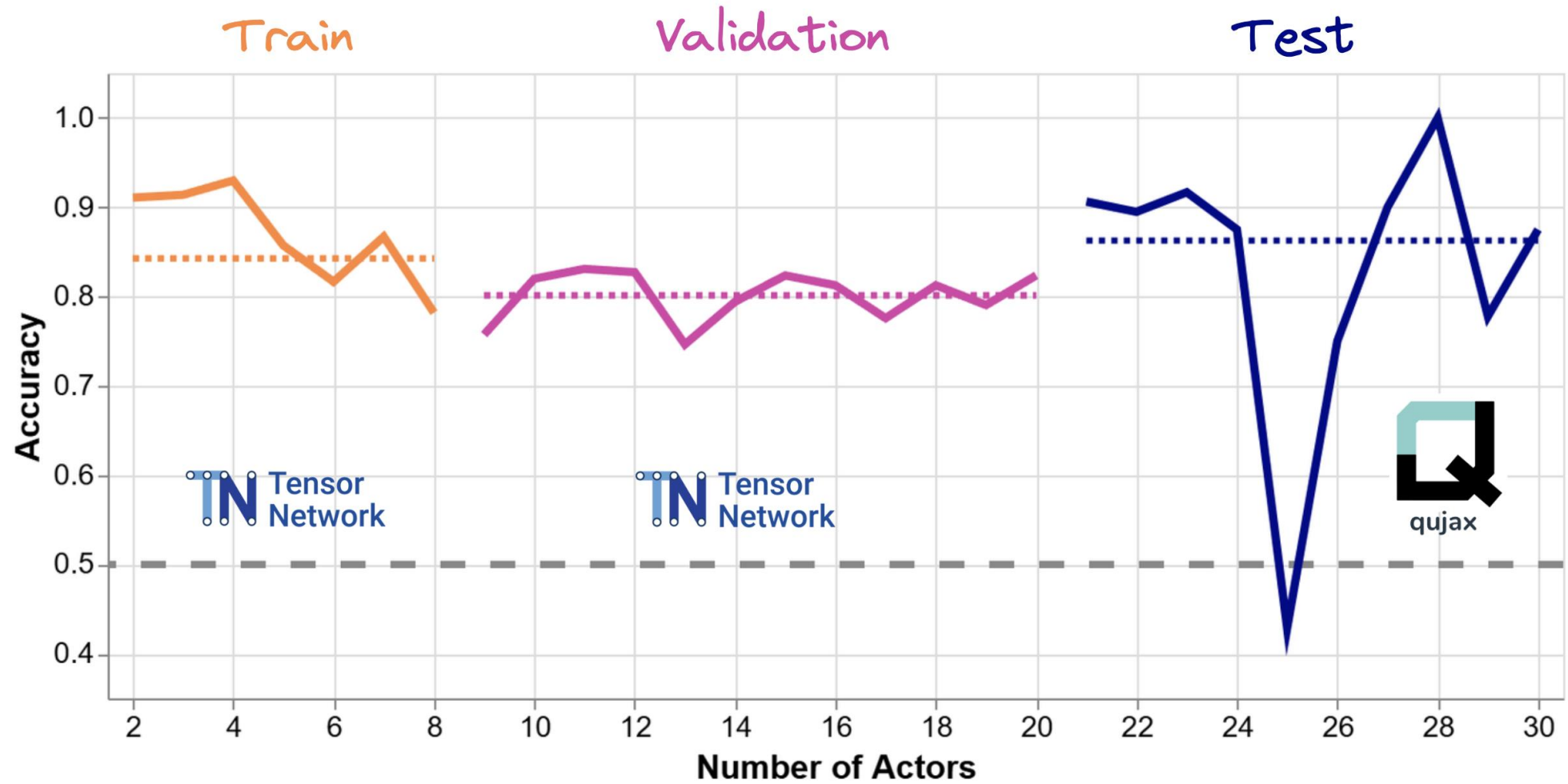


4

direction:



Compositional generalisation

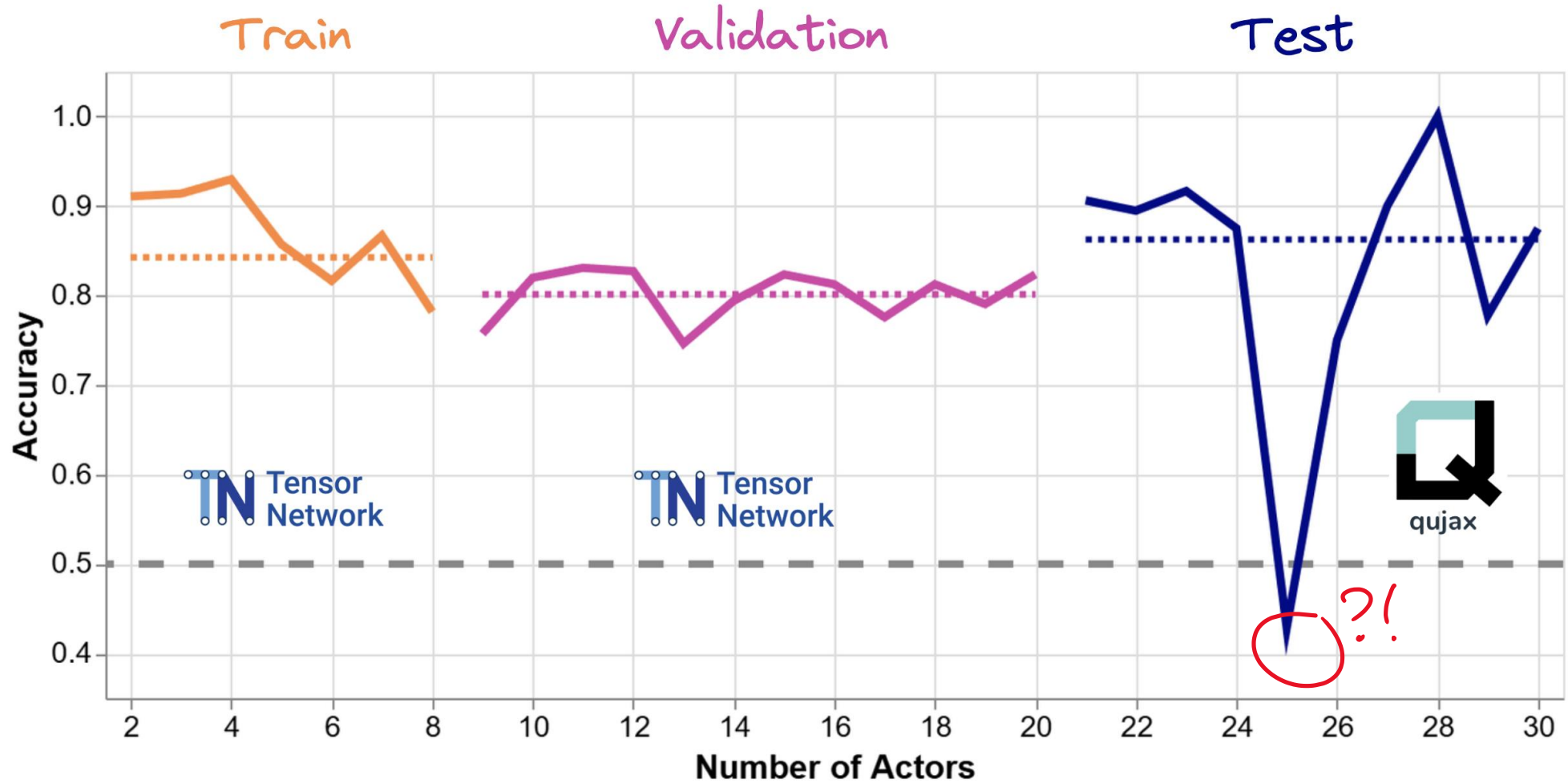


4

directions



Compositional generalisation

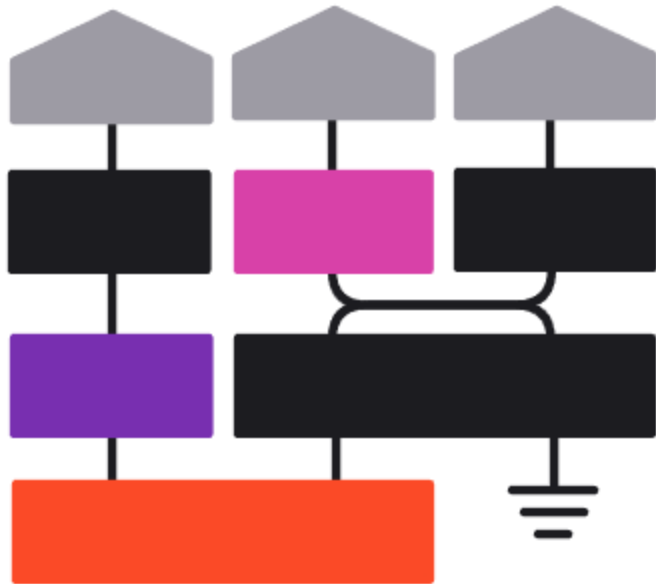




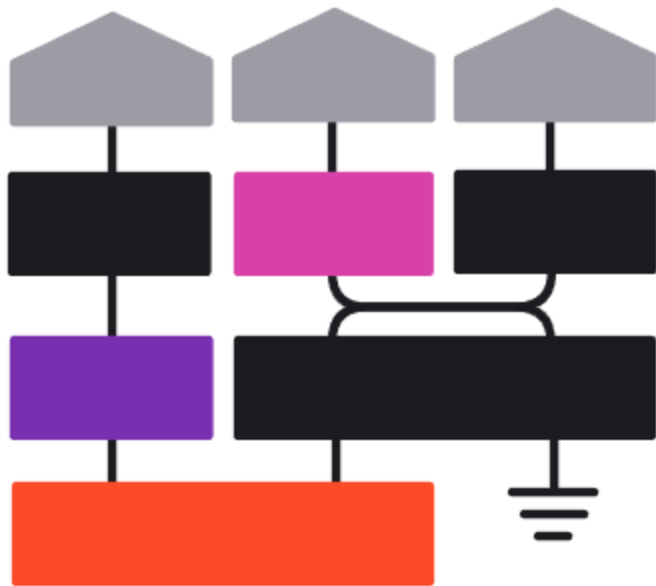
Compositional Interpretability



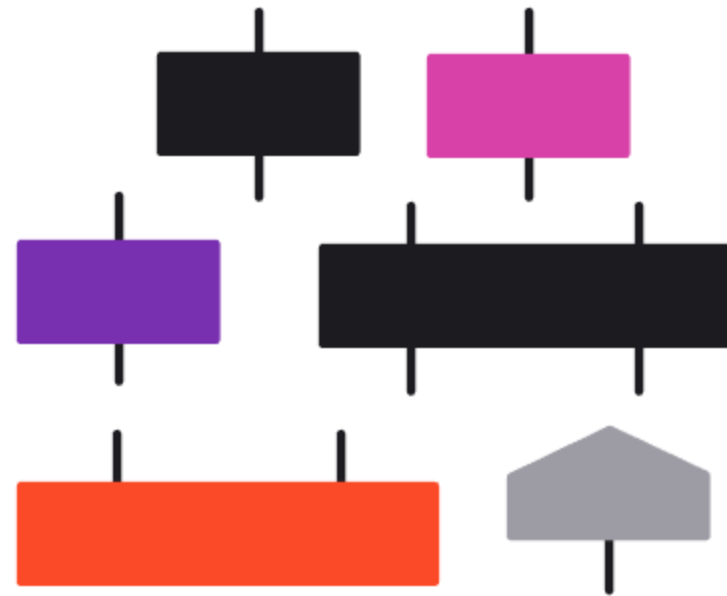
Black Box



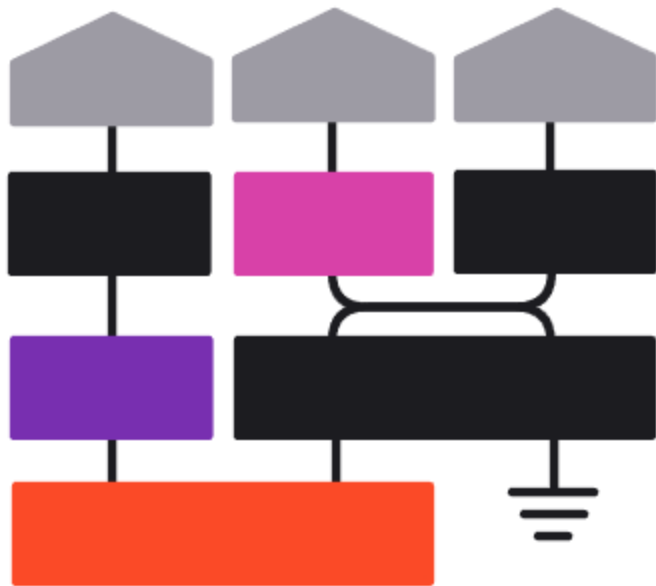
Many Black Boxes



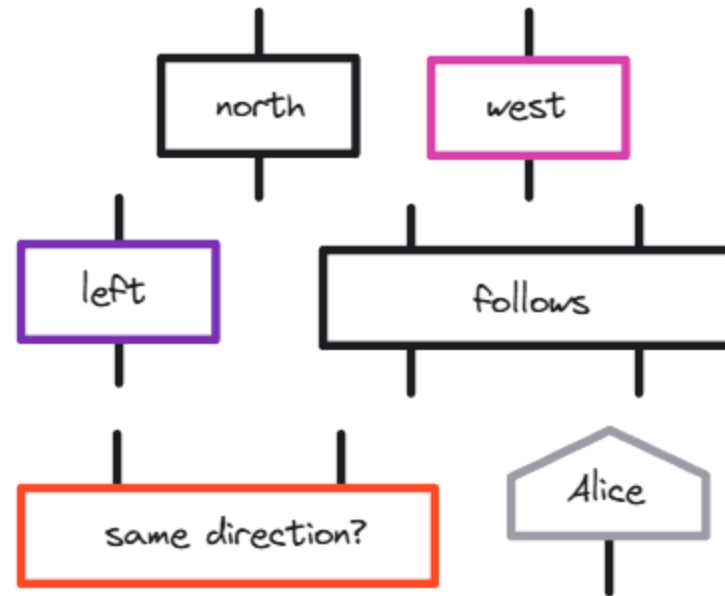
Many Black Boxes



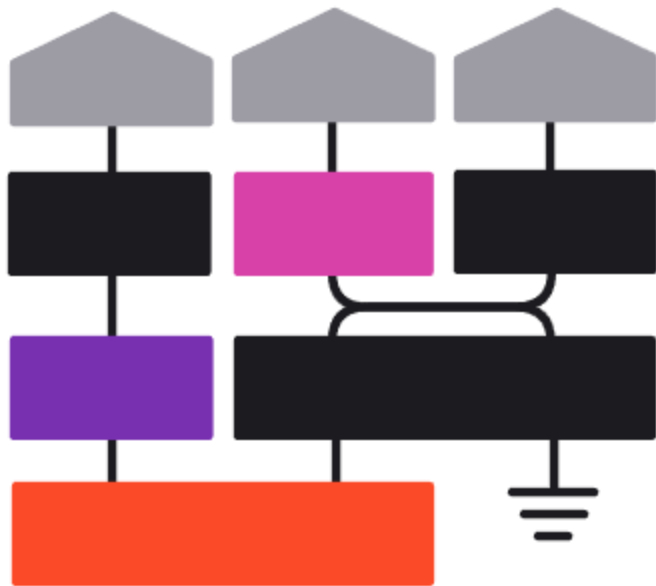
...decomposed!



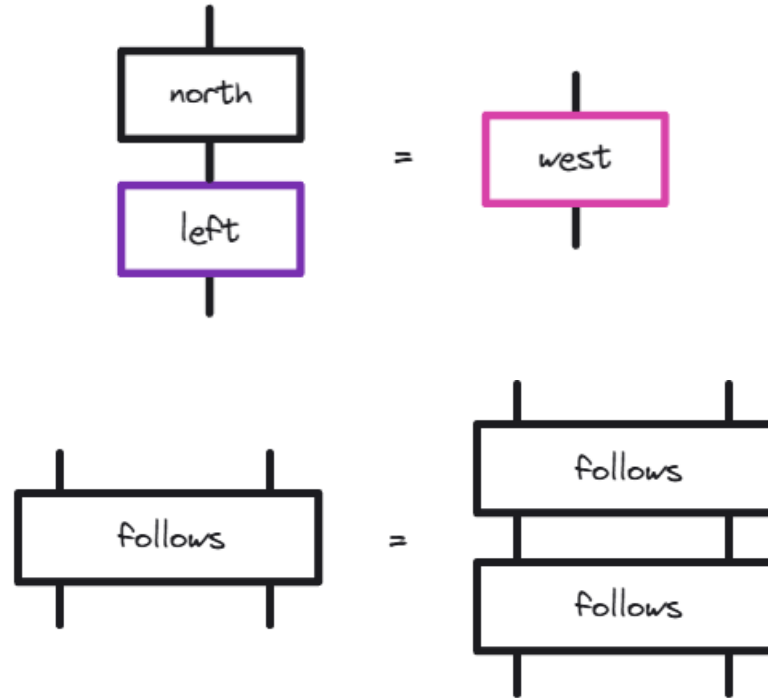
Many Black Boxes



...decomposed!

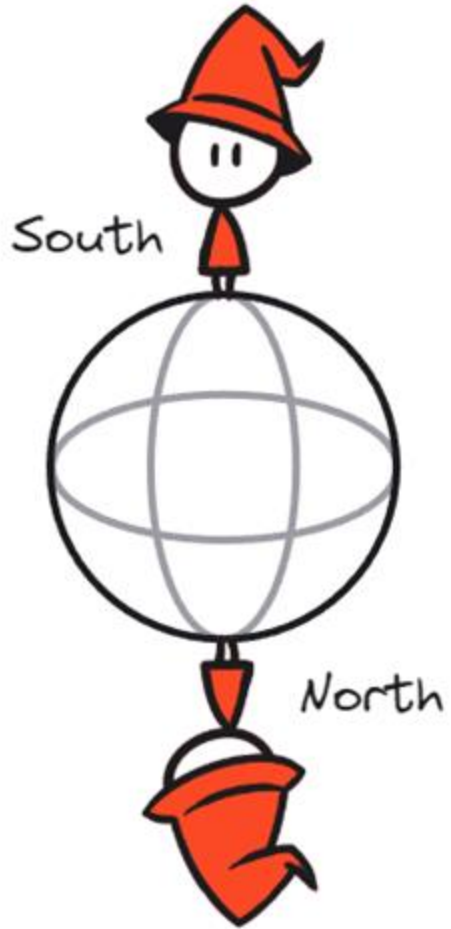


Many Black Boxes

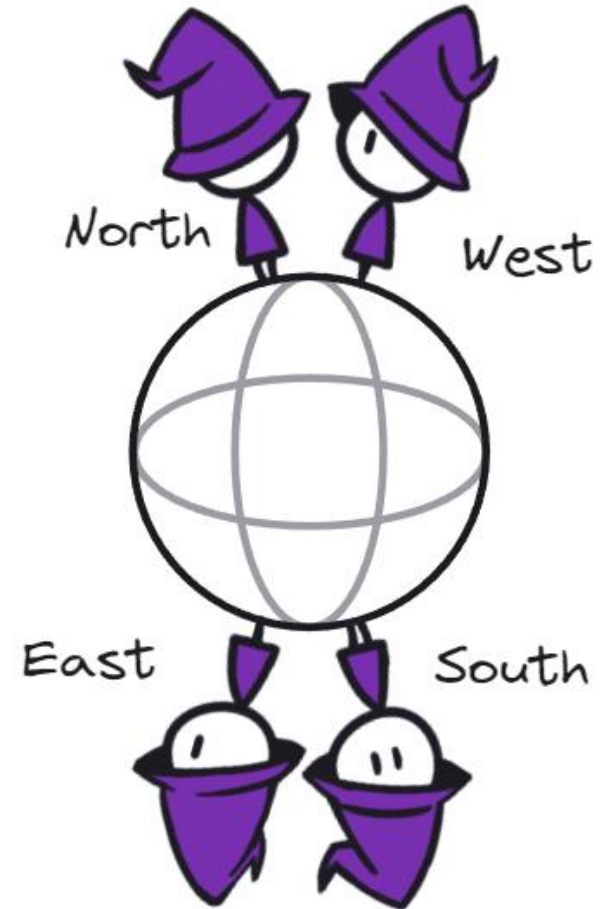


...recomposed!

2
directions



4
directions

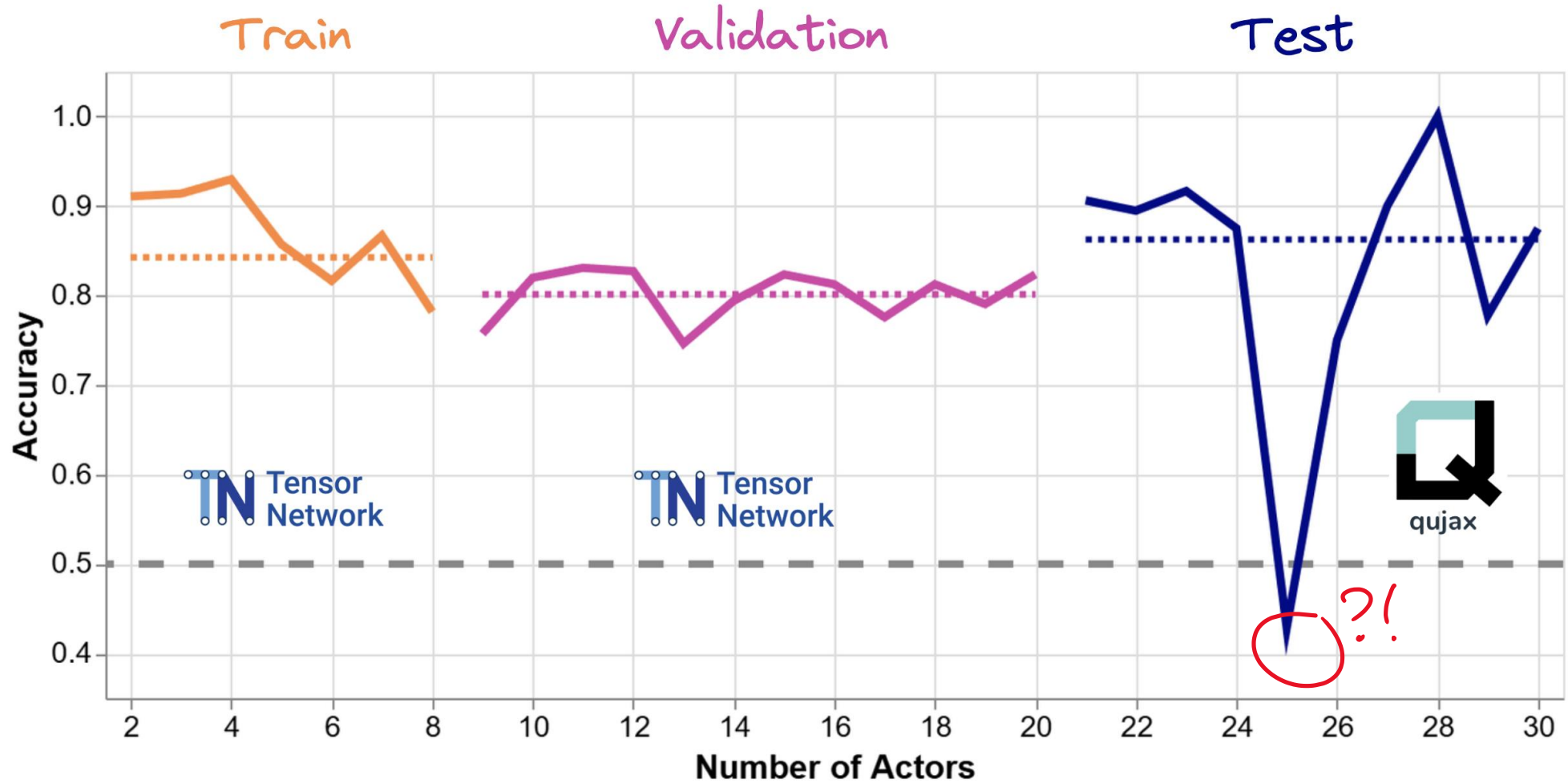


4

directions



Compositional generalisation

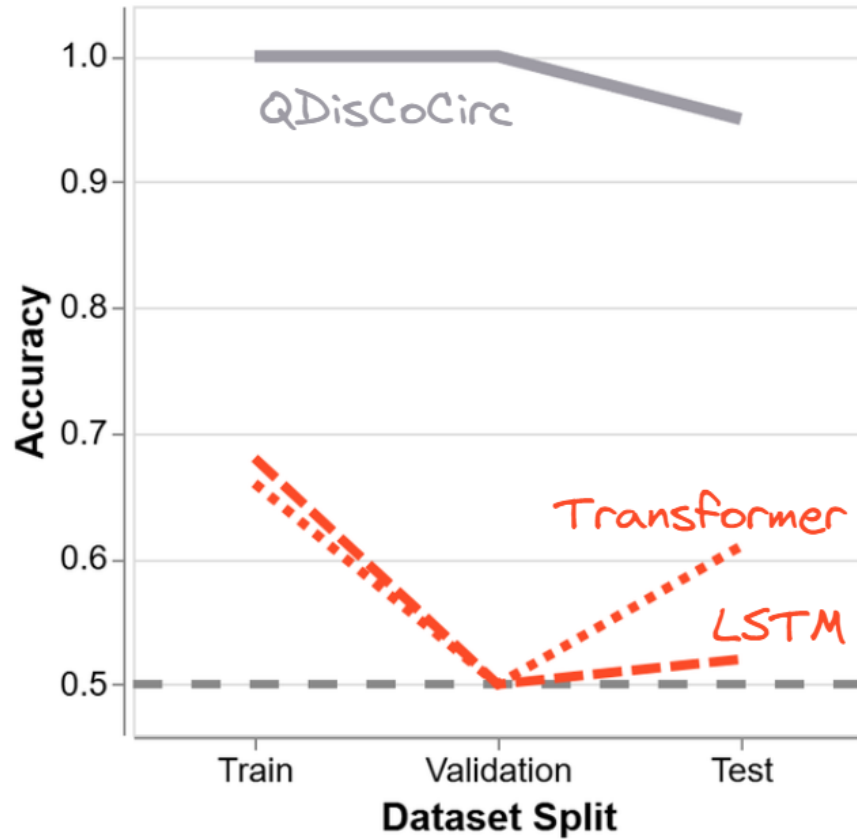




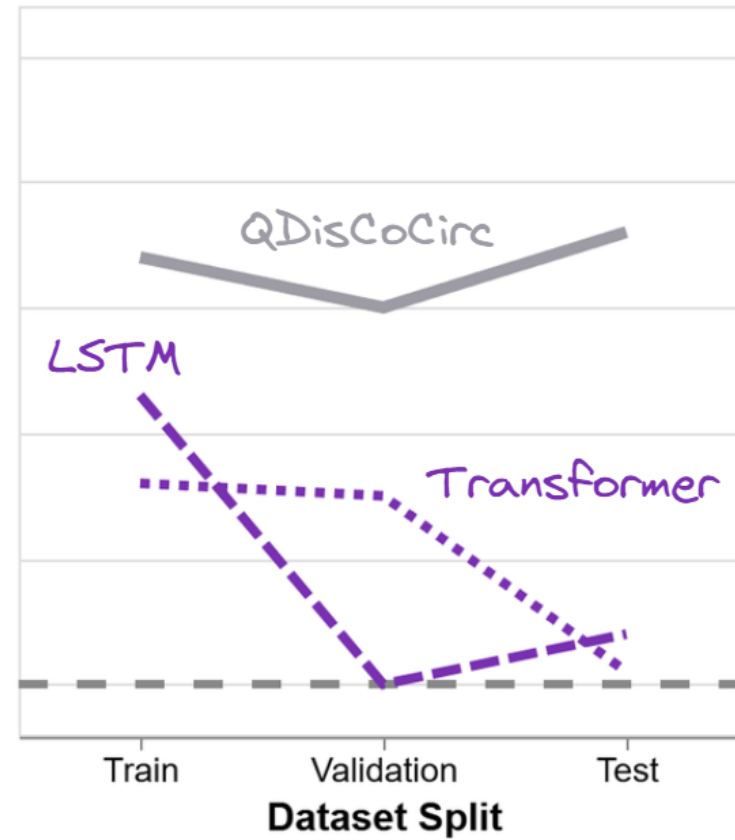
Classical Baselines

Accuracy Summaries

Two Directions



Four Directions



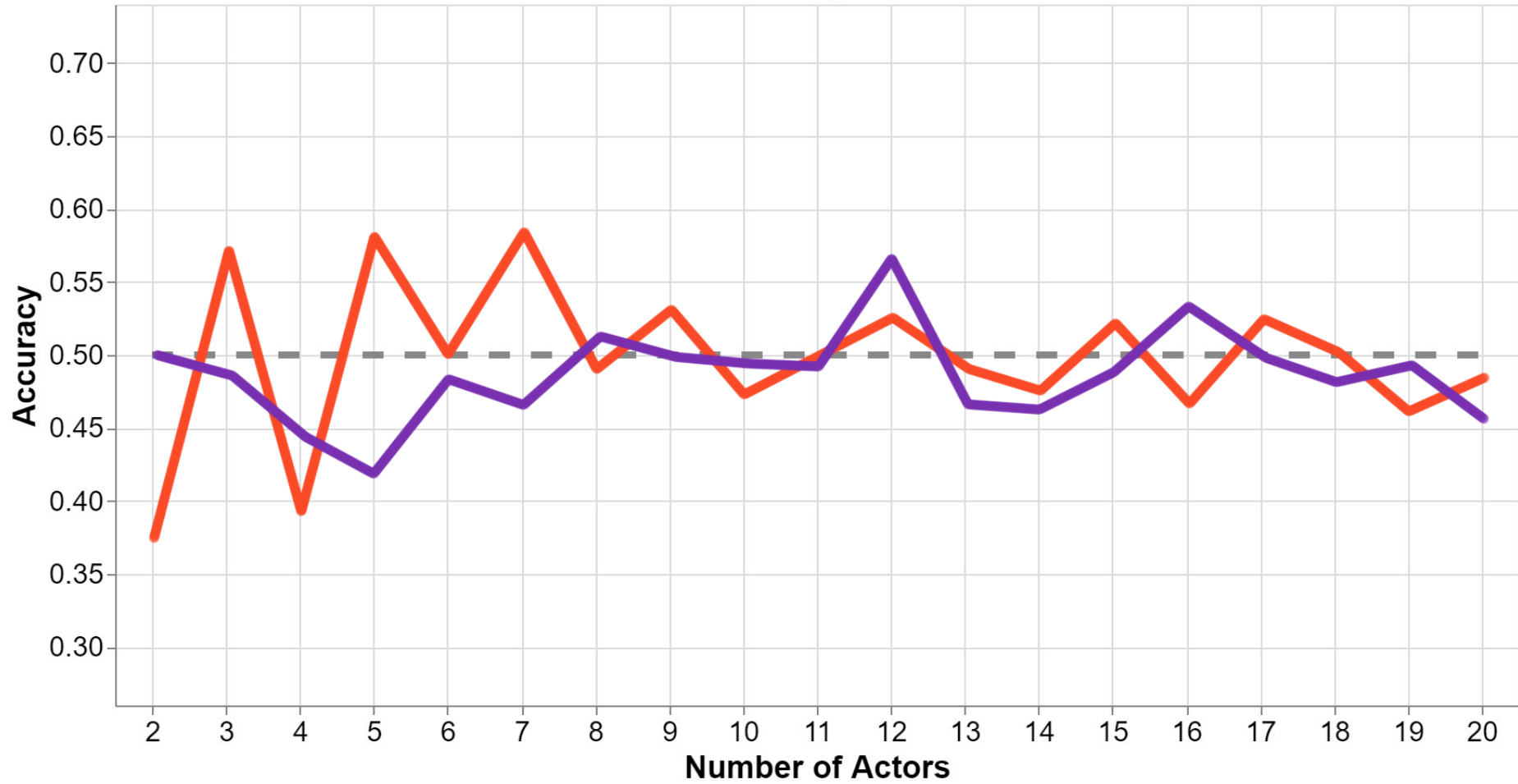
2
directions

4
directions

GPT-4

2
directions

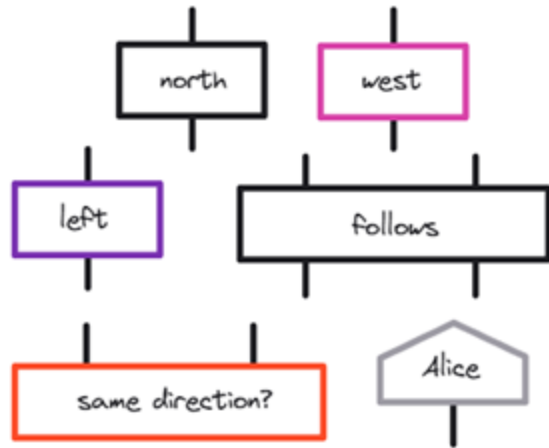
4
directions



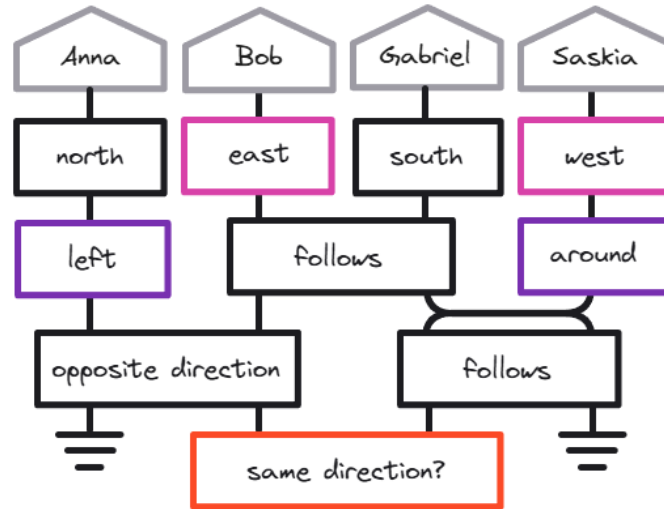
Accessed on 25th April 2024.

Summary

Compositional...

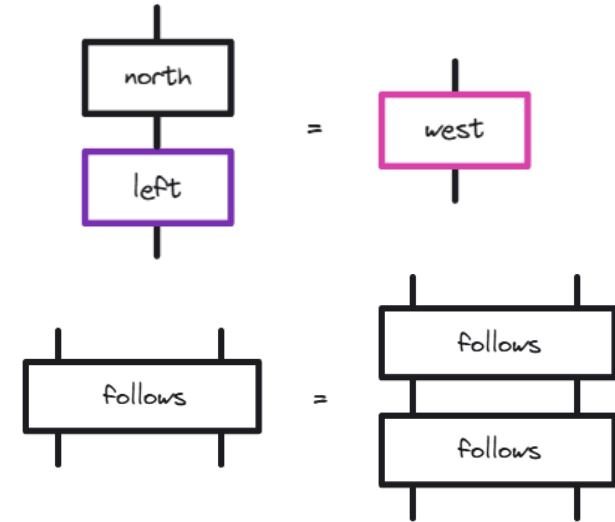


Model



Generalisation

+

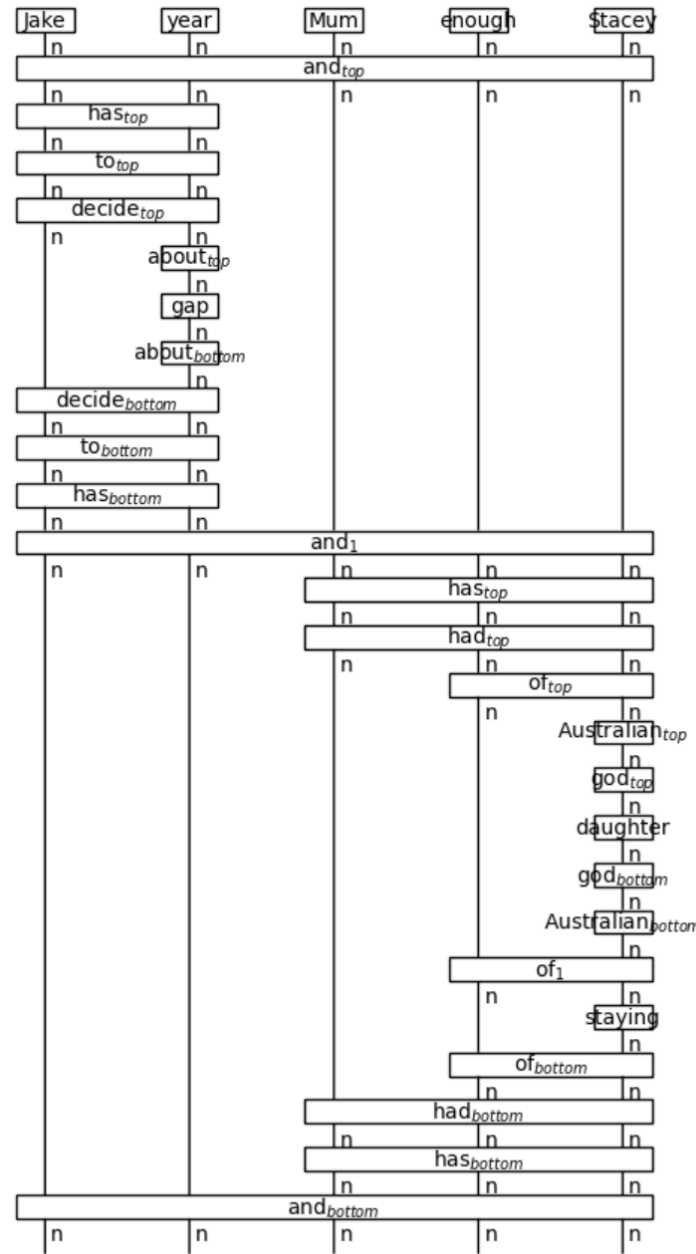
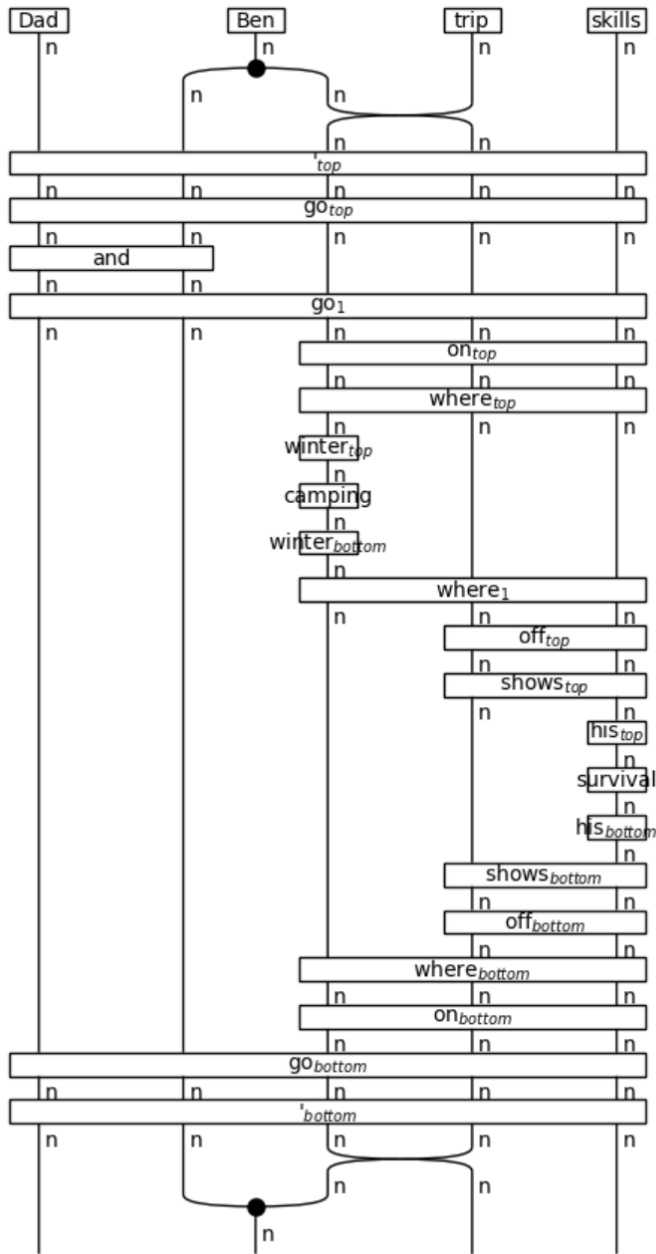


Interpretability



LAMBEQ

Natural Language Processing on
Quantum Computers

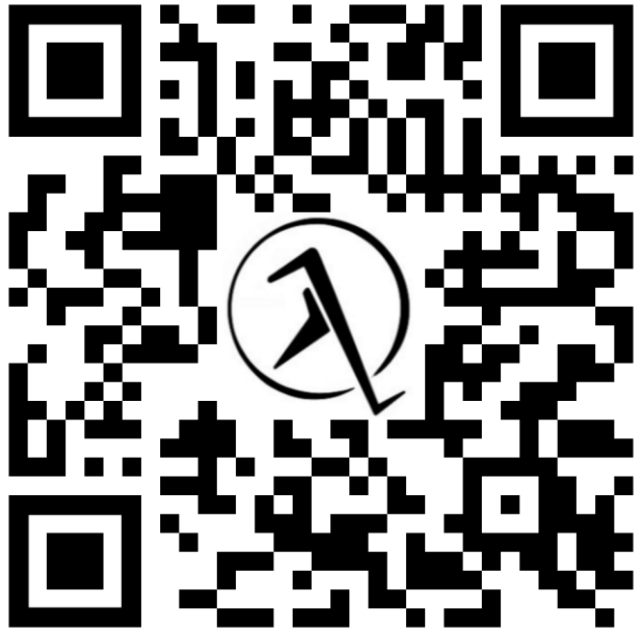


Real Data

“Dad and Ben go on a winter camping trip, where Ben shows off his survival skills. Jake has to decide about a gap year, and Mum has had enough of Australian god-daughter Stacey staying.”

- BBC Synopsis Dataset

Try it yourself!



```
> pip install lambeq
```

DisCoCirc

2301.10595

Interpretability

2406.17583

I. Theory

2408.06061

II. Experiment

2409.08777

Blog post

<https://www.quantinuum.com/blog/talking-quantum-circuits>

