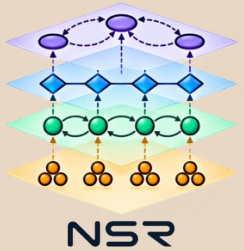
NeurIPS 2026

Neural Structural Reasoner



A Brain-inspired Architecture for Reasoning over Structured Knowledge

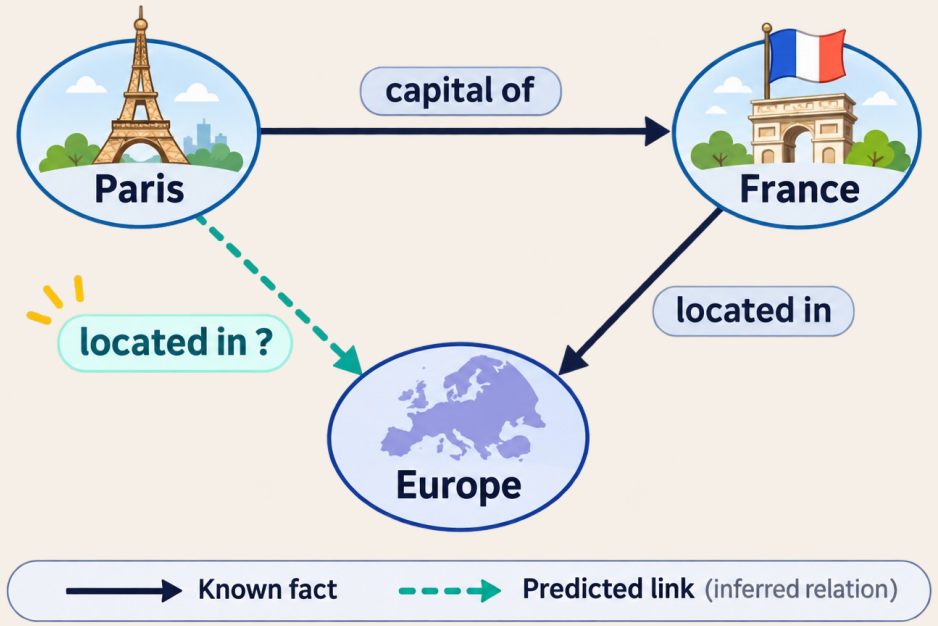
Zixing Jia[1234]* Yuhang Pan[123]* Ni Ji[123]†

[1] Beijing Institute for Brain Research, CAMS & PUMC
[2] Chinese Institute for Brain Research, Beijing
[3] Beijing Key Laboratory of Brain Science and Brain-Machine Interface
[4] Sun Yat-sen University

* Equal contribution † niji@cibr.ac.cn

NSR keeps relational structure explicit

Knowledge graph



Embedding-based models

Candidate triple

(Paris, located in, Europe)

h Paris

r located in

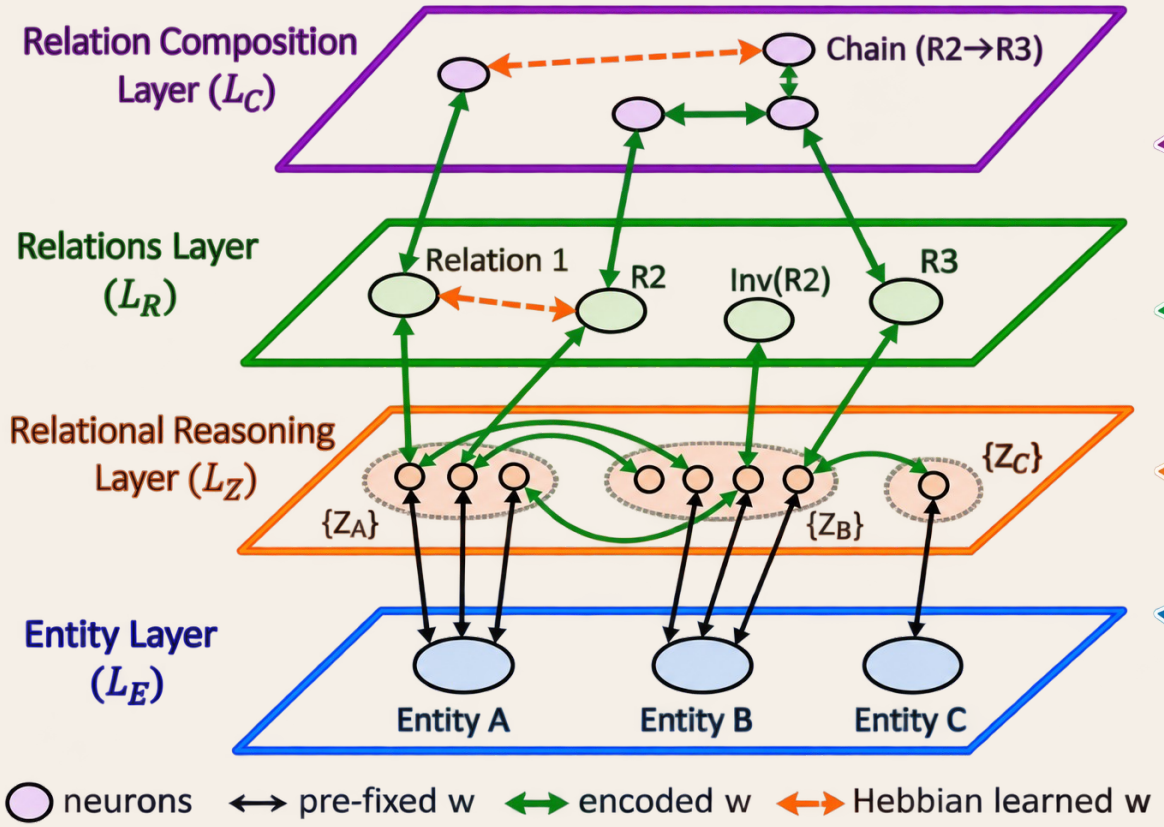
t Europe

→ TransE score $\|h + r - t\|_2$

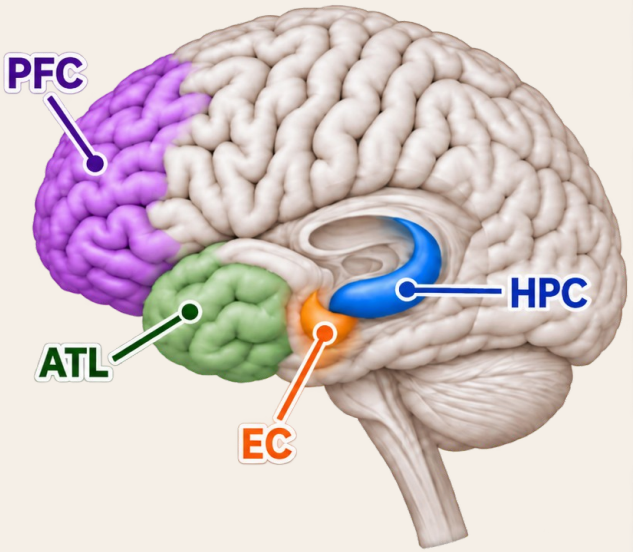
Relational structure stays implicit.

Brain region functions inspired NSR's architecture

Neural Structural Reasoner (NSR)



Brain regions involved in relational reasoning



Prefrontal Cortex (PFC)
Especially RLPFC
- Relational integration
- Multi-step inference

Anterior Temporal Lobe (ATL)
- Concept meanings
- Semantic associations

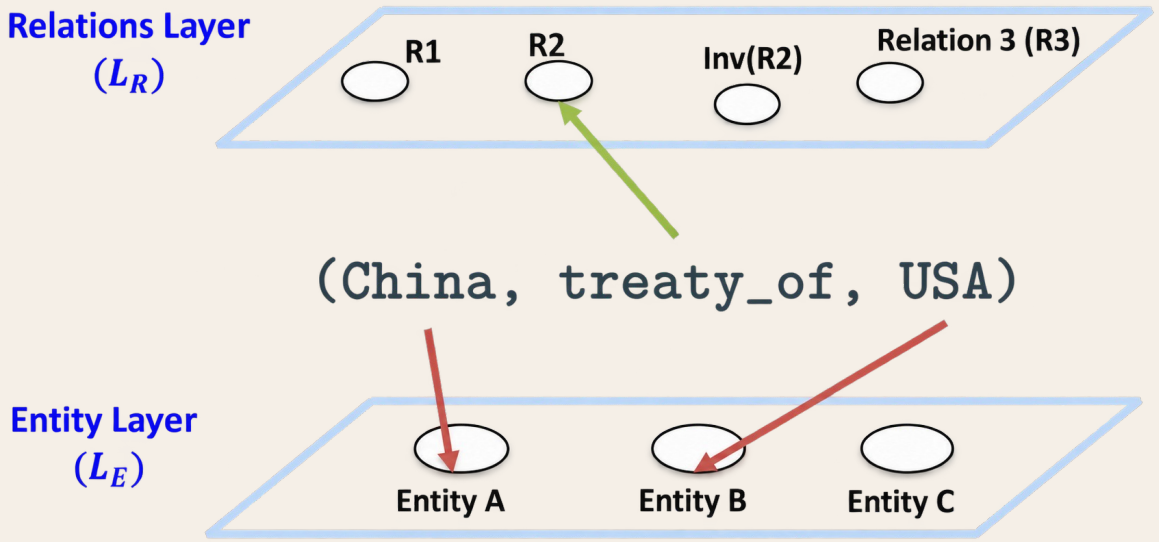
Entorhinal Cortex (EC)
- Relational maps
- Grid-like coding

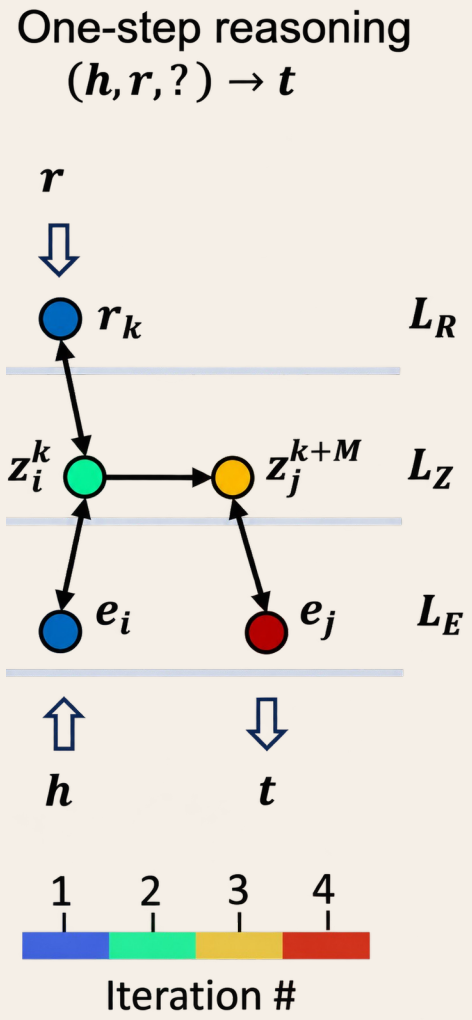
Hippocampus (HPC)
- Relational memory binding
- Memory-based inference

NSR makes relational inference traceable

Query

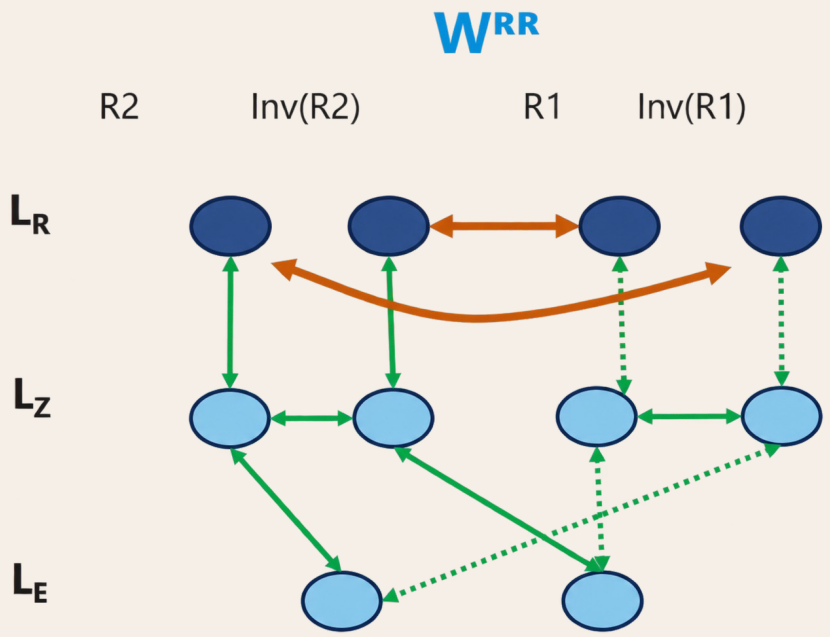
(head, relation, ?)



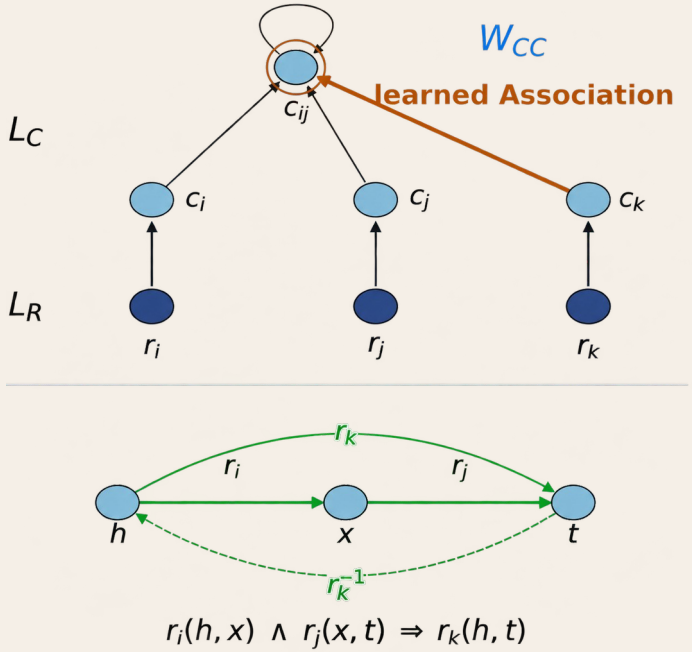


Biologically plausible learning without BP

Local Hebbian updates

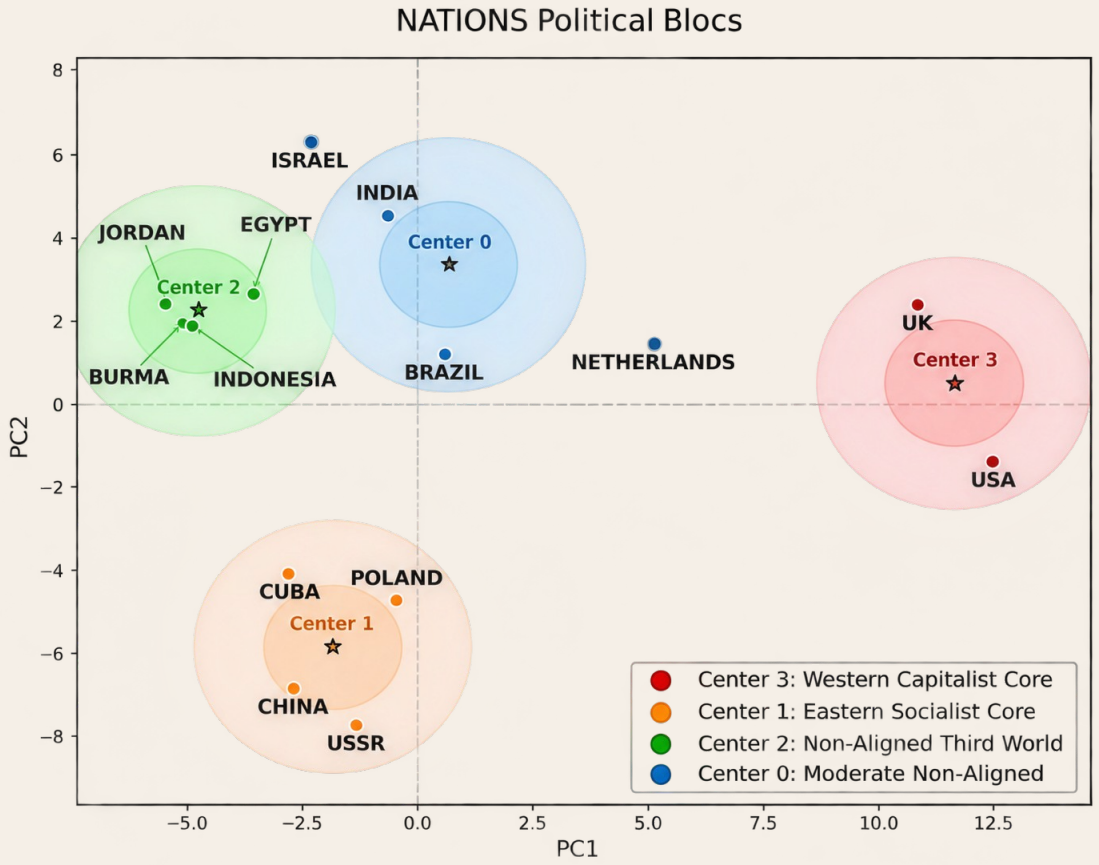


Learn relation compositions

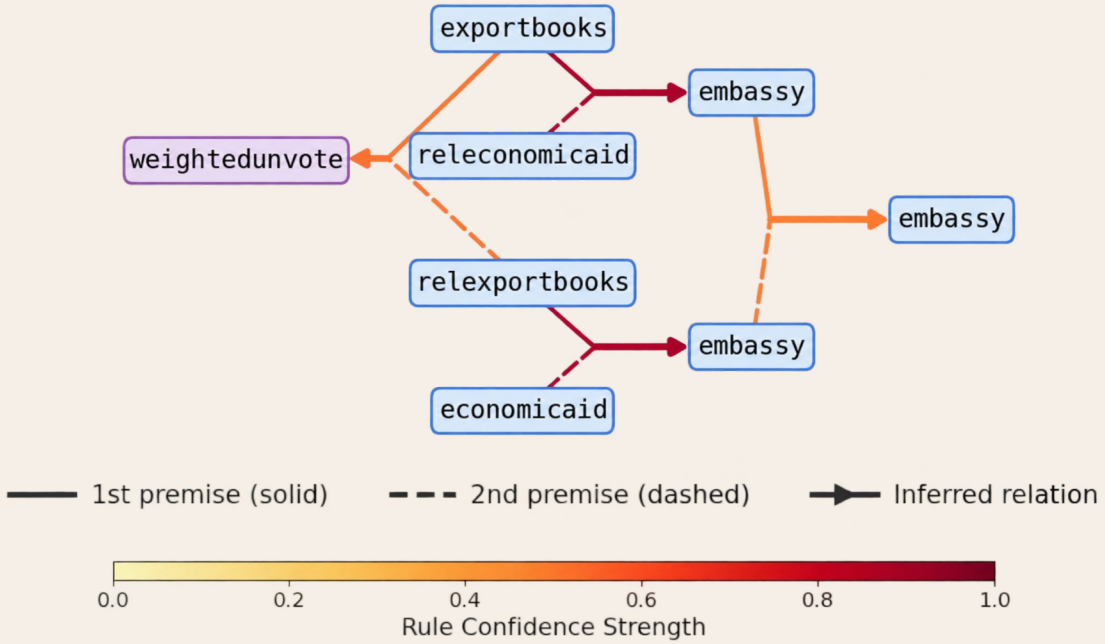


Neurons — Fixed connection — Encoded connectivity — Hebbian-learned link

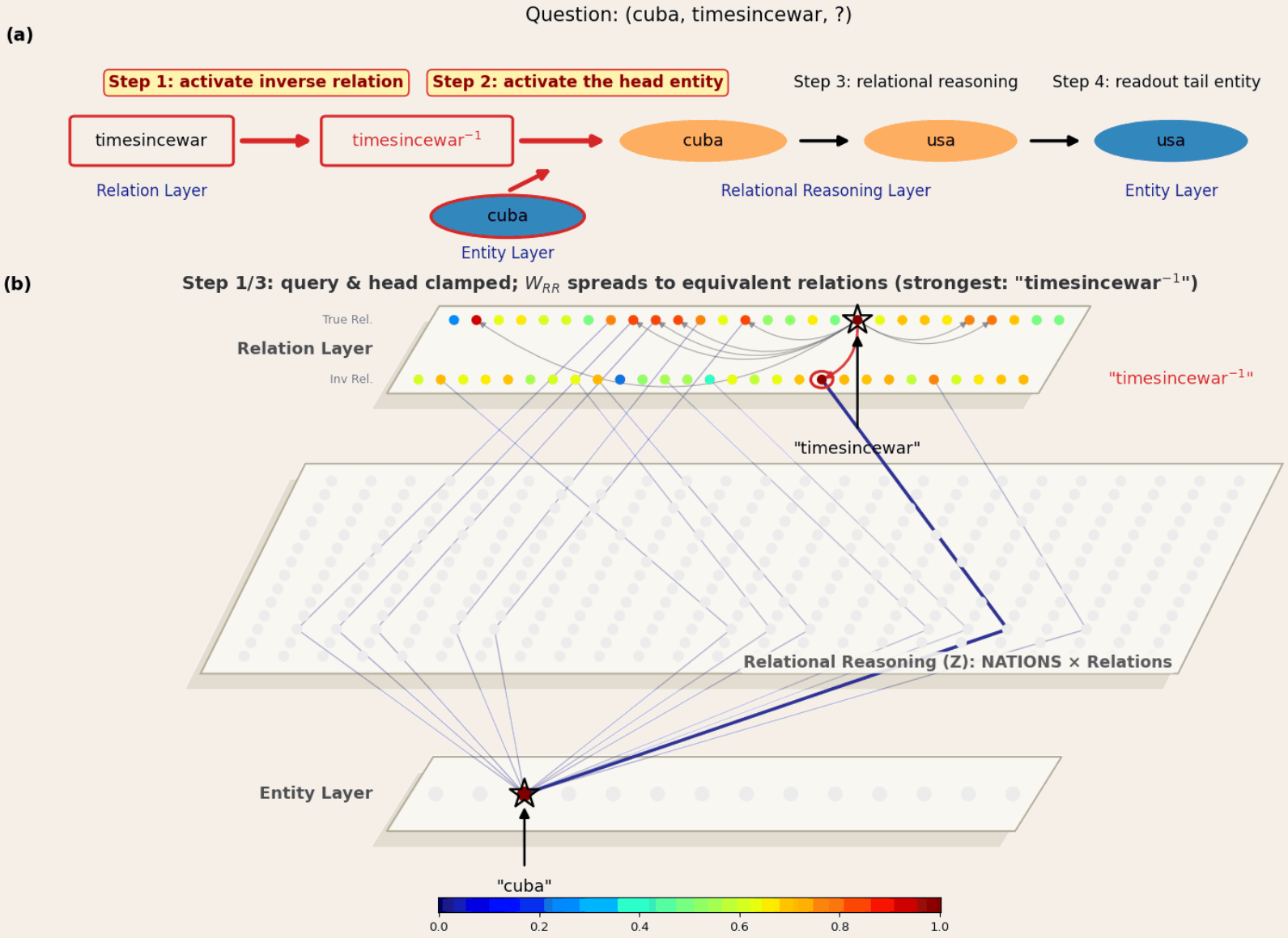
NSR reveals political blocs and learns reusable rules



Reusable composition rules in Nations



Neural dynamics expose the inference path



NSR is competitive across benchmarks

	Nations			Kinship			YAGO3-10			FB15k-237		
Method	**MRR**	**Hits@1**	**Hits@3**	**MRR**	**Hits@1**	**Hits@3**	**MRR**	**Hits@1**	**Hits@3**	**MRR**	**Hits@1**	**Hits@3**
ConvE	0.8029	69.05	89.45	**0.7927**	**68.11**	**88.45**	**0.6365**	**59.03**	**71.28**	0.4095	31.61	44.89
RotatE	0.5351	33.23	66.02	0.7598	63.37	86.26	0.1812	9.98	21.04	0.3368	27.07	41.51
AnyBURL	0.7994	69.15	89.55	0.6768	54.10	76.63	0.5589	50.78	60.16	0.332∗	24.7∗	—
AMIE	**0.8559**	**77.11**	**92.54**	0.6767	55.03	76.26	0.5473	49.58	59.27	0.2170	16.57	23.07
NeuralLP	0.6841	52.74	81.59	0.6072	47.30	68.06	—	—	—	0.3166	24.45	34.31
NCRL	0.4571	25.37	55.22	0.6050	45.81	68.99	0.380∗	27.40∗	—	0.300∗	20.90∗	—
RNNLogic	0.7216	61.65	83.06	0.6690	54.94	77.60	0.5625	49.56	61.80	0.3276	23.49	38.60
PRA / PathRank	0.5933	38.31	77.61	0.6296	46.83	73.56	0.4678	37.39	55.22	0.0972	6.35	10.72
MINERVA	0.5865	44.28	73.13	0.6253	46.37	73.46	—	—	—	0.2734	19.77	30.34
NBFNet	0.7479	62.19	84.08	0.7445	62.38	83.61	0.4946	37.96	55.54	**0.5114**	**41.64**	**55.95**
NSR	0.8142	71.64	88.16	0.6515	54.21	70.67	0.5893	52.80	64.32	0.3649	28.45	39.74

Best Second best

NSR achieves competitive training times

Method	Nations	Kinship	YAGO3-10	FB15k-237
ConvE	26 s	64 s	10.3 h	991 s
RotatE	<u>24 s</u>	84 s	1.5 h	1.5 h
AnyBURL	64 s	63 s	1000 s	1000 s∗
AMIE	0.6 h	**2 s**	**83 s**	**8 s**
NeuralLP	40 s	26 s	—	11.9 h
NCRL	134 s	99 s	—	—
RNNLogic	32 s	82 s	4.5 h	0.6 h
PRA / PathRank	34 s	86 s	<u>239 s</u>	<u>229 s</u>
MINERVA	0.9 h	1.2 h	—	3.3 h
NBFNet	29 s	77 s	2.3 h	10.4 h
NSR	**3 s**	<u>11 s</u>	0.3 h	0.6 h

Best <u>Second best</u>

Take Home!

Facts and rules in neural connectivity

Local learning of relations and compositions

without backpropagation !

Inference steps visible in neural dynamics

Concept-like organization from relational structure