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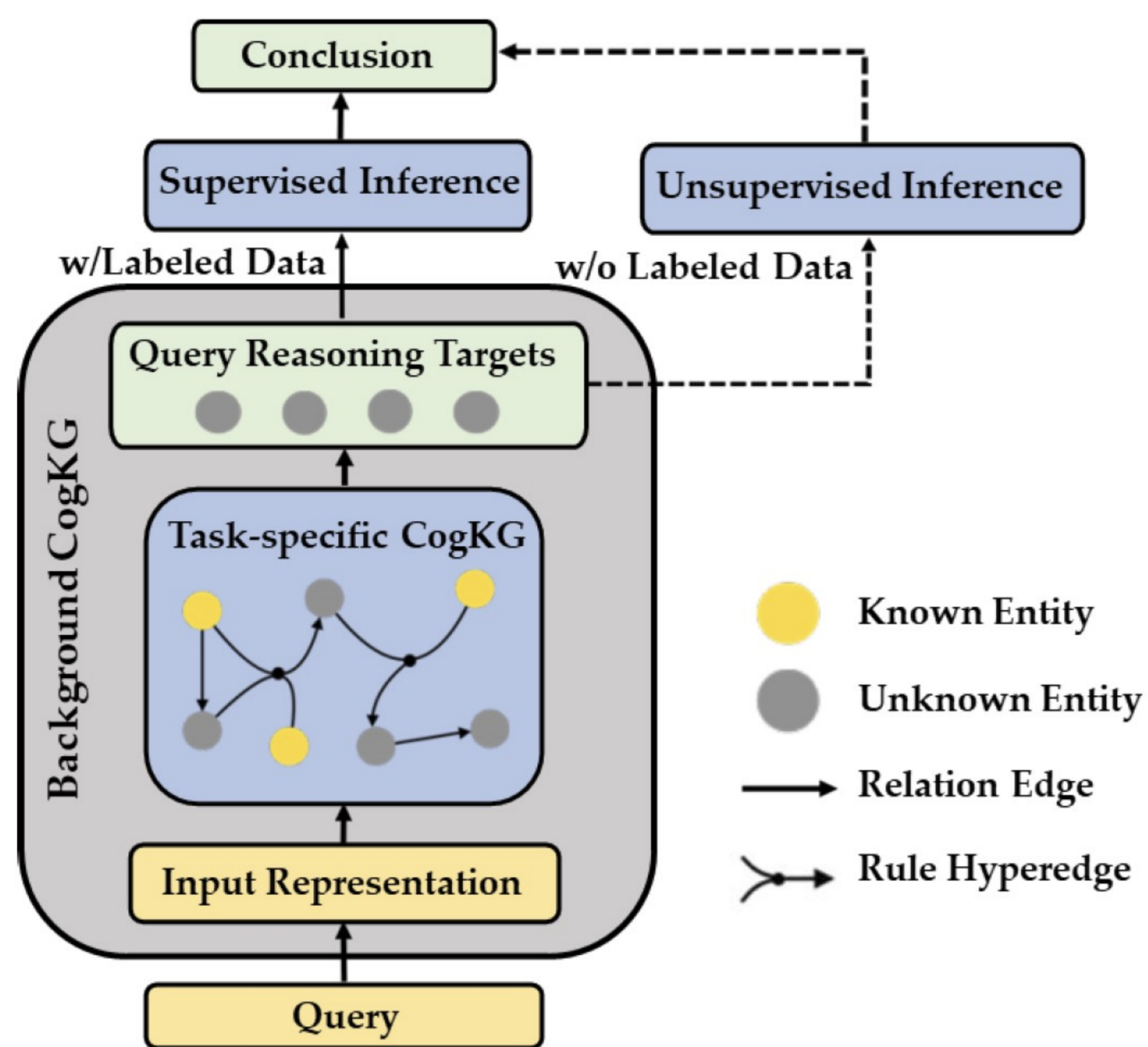


Fig. 1: The general CogInfer framework.

The Cognitive Inference Problem

- **Motivation:** With a knowledge graph (KG) and a set of if-then rules, can we reason about the conclusions given a set of observations w/ or w/o any labeled data?
- To answer the above question, we formally introduce the **Cognitive Inference Problem**, a novel task that calls for research towards unifying the representations of different forms of knowledge to perform complex inference.
- The challenges inherited in the problem prompt an ideal general inference framework, namely **CogInfer**, bridging the supervised and unsupervised inference (See Fig. 1).

Implementation of the CogInfer

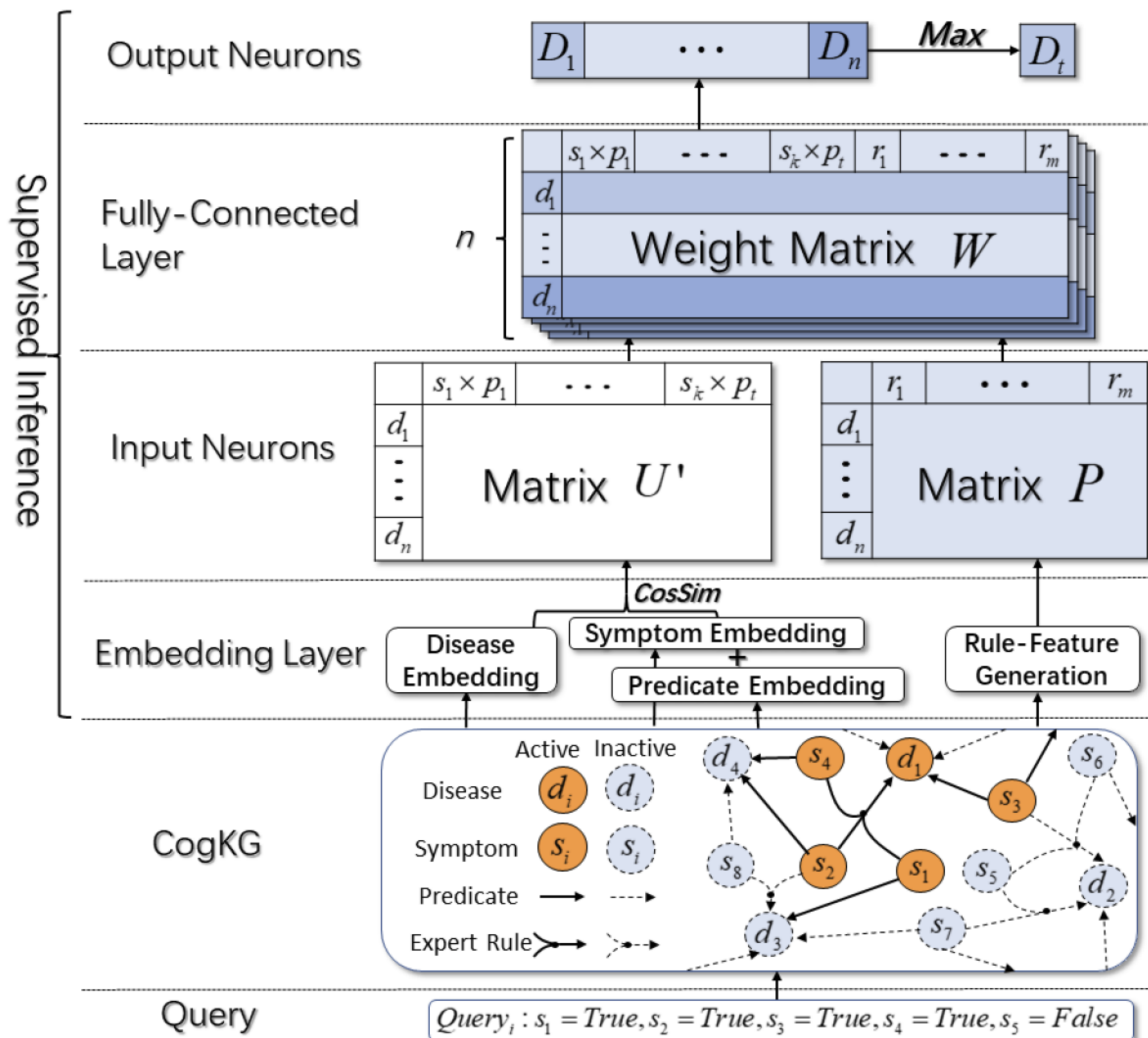


Fig. 2: The trainable implementation of CogInfer.
 (A proof of concept of possible solutions to the introduced problem)

Experimental Results

Main Result

| Models | Capability | | | | Muzhi | | | MDD | | |
|---------------|------------|-------|--------|------|--------------|--------------|--------------|--------------|--------------|--------------|
| | Facts | Rules | Train. | Exp. | Hits@1 | Hits@2 | MRR | Hits@1 | Hits@2 | MRR |
| MAJORITYGUESS | ✗ | ✗ | ✗ | ✓ | 0.225 | 0.465 | 0.496 | 0.065 | 0.065 | 0.225 |
| MYCIN | ✗ | ✓ | ✗ | ✓ | 0.197 | 0.197 | 0.398 | 0.278 | 0.287 | 0.342 |
| PURELINK | ✓ | ✗ | ✗ | ✓ | 0.563 | 0.732 | 0.718 | 0.528 | 0.602 | 0.631 |
| COGINFER | ✓ | ✓ | ✗ | ✓ | 0.592 | 0.704 | 0.722 | 0.606 | 0.713 | 0.710 |

Table 1: Comparison with knowledge-driven methods (unsupervised setting).

| Models | Capability | | | | Muzhi | | | | | | MDD | | | | | | |
|-----------|------------|-------|--------|------|-------|--------------|--------------|--------------|--------------|------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| | Facts | Rules | Train. | Exp. | Pre. | Rec. | F1 | Hits@1 | Hits@2 | MRR | Pre. | Rec. | F1 | Hits@1 | Hits@2 | MRR | |
| W/o CogKG | KNN | ✗ | ✗ | ✓ | ✗ | 0.651 | 0.637 | 0.615 | 0.592 | 0.915 | 0.776 | 0.808 | 0.805 | 0.798 | 0.787 | 0.870 | 0.851 |
| | EBM | ✗ | ✗ | ✓ | ✓ | 0.707 | 0.707 | 0.697 | 0.690 | 1.0 | 0.845 | 0.823 | 0.818 | 0.813 | 0.810 | 0.912 | 0.883 |
| | MLP | ✗ | ✗ | ✓ | ✗ | 0.750 | 0.741 | 0.729 | 0.718 | 0.986 | 0.857 | 0.833 | 0.835 | 0.829 | 0.829 | 0.903 | 0.890 |
| | LASSO LR | ✗ | ✗ | ✓ | ✗ | 0.777 | 0.776 | 0.769 | 0.761 | 0.986 | 0.878 | 0.832 | 0.834 | 0.828 | 0.829 | 0.921 | 0.894 |
| | LR | ✗ | ✗ | ✓ | ✗ | 0.782 | 0.769 | 0.769 | 0.761 | 0.972 | 0.876 | 0.842 | 0.839 | 0.833 | 0.833 | 0.931 | 0.897 |
| W/ CogKG | COGINFER | ✓ | ✓ | ✓ | ✓ | 0.820 | 0.811 | 0.797 | 0.789 | 1.0 | 0.894 | 0.877 | 0.861 | 0.857 | 0.856 | 0.931 | 0.908 |

Table 2: Comparison with data-driven methods (supervised setting).

Interpretability Study

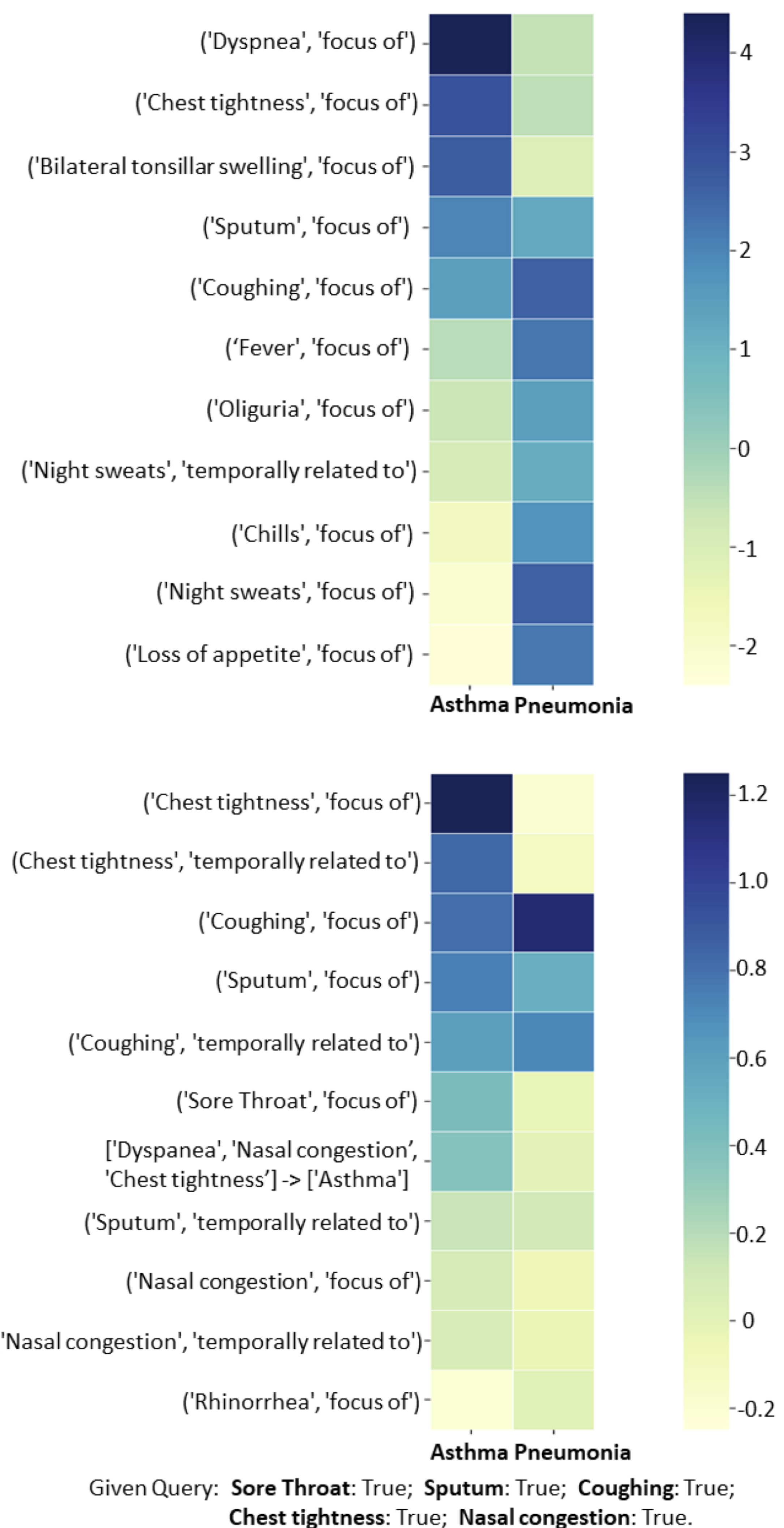


Fig. 3: Visualization of Weight Matrix W.