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Feedback Influences Syllogistic Strategy: An Analysis based on Joint Nonnegative Matrix Factorization

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Syllogistic Reasoning

- One of the oldest domains of deductive reasoning research
- Two quantified premises with three terms: cooks, golfers, monks
- Four possible quantifiers: All (A), Some (I), No (E), Some ... not (O)
- Goal is to deduce quantified relation between the end terms (cooks, monks) or "No Valid Conclusion" (NVC)

No cooks are golfers.
Some golfers are not monks.

What, if anything, follows?

→ We investigate the influence of feedback on syllogistic reasoning ability using a publicly available dataset[1] (no feedback, 1s, and 10s feedback).

[1] Dames, H., Schiebel, C., & Ragni, M. (in press). The role of feedback and post-error adaptations in reasoning. In *Proceedings of the 42nd Annual Conference of the Cognitive Science Society*.

Join Nonnegative Matrix Factorization (JNMF)

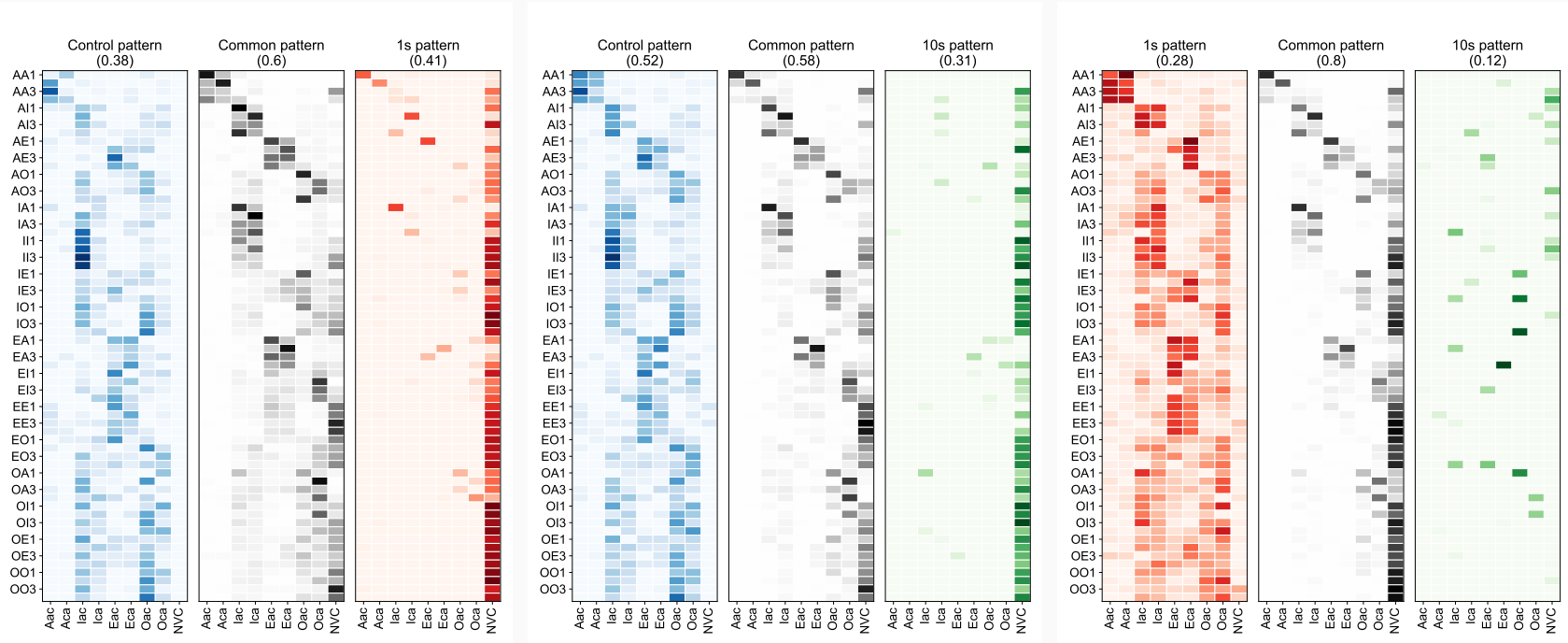
- JNMF[2] allows for the contrasting of data by factorizing two given datasets into k_c common and k_d distinct patterns
- Given two input data matrices X_1, X_2, JNMF decomposes the matrices into W_1, W_2 and H_1, H_2 so that for both $i \in [1, 2]$ the distance to the original data matrices is minimized:

$$X_i \approx W_i H_i^T$$

- The columns in W_i represent the k_c common and k_d distinct patterns
- The columns in H_i represent the pattern importances for the data observations

[2] Kim, H., Choo, J., Kim, J., Reddy, C. K., & Park, H. (2015). Simultaneous discovery of common and discriminative topics via joint nonnegative matrix factorization. In *Proceedings of the 21th ACM SIGKDD International Conference on Knowledge Discovery and Data Mining - KDD '15*.

Results



(a) control vs. 1s **(b)** control vs. 10s **(c)** 1s vs. 10s

Figure 1: *W* matrix patterns for contrasting between control-1s, control-10s, and 1s-10s, respectively.

- Most distinct difference with respect to the NVC response
- 1s pattern in between control and 10s patterns

Conclusions

- Feedback helps participants to acknowledge NVC responses
- Short feedback (1s) causes over-reliance on NVC responses
- Long feedback (10s) allows for a more refined NVC response behavior

$\rightarrow$ Feedback most strongly influences NVC handling and becomes more refined if presented for a longer duration.

- Instead of comparing two models, JNMF results in a contrasting model
- JNMF provides a theory- and hypothesis-agnostic analysis of the data

$\rightarrow$ Results suggest that feedback only influences NVC.