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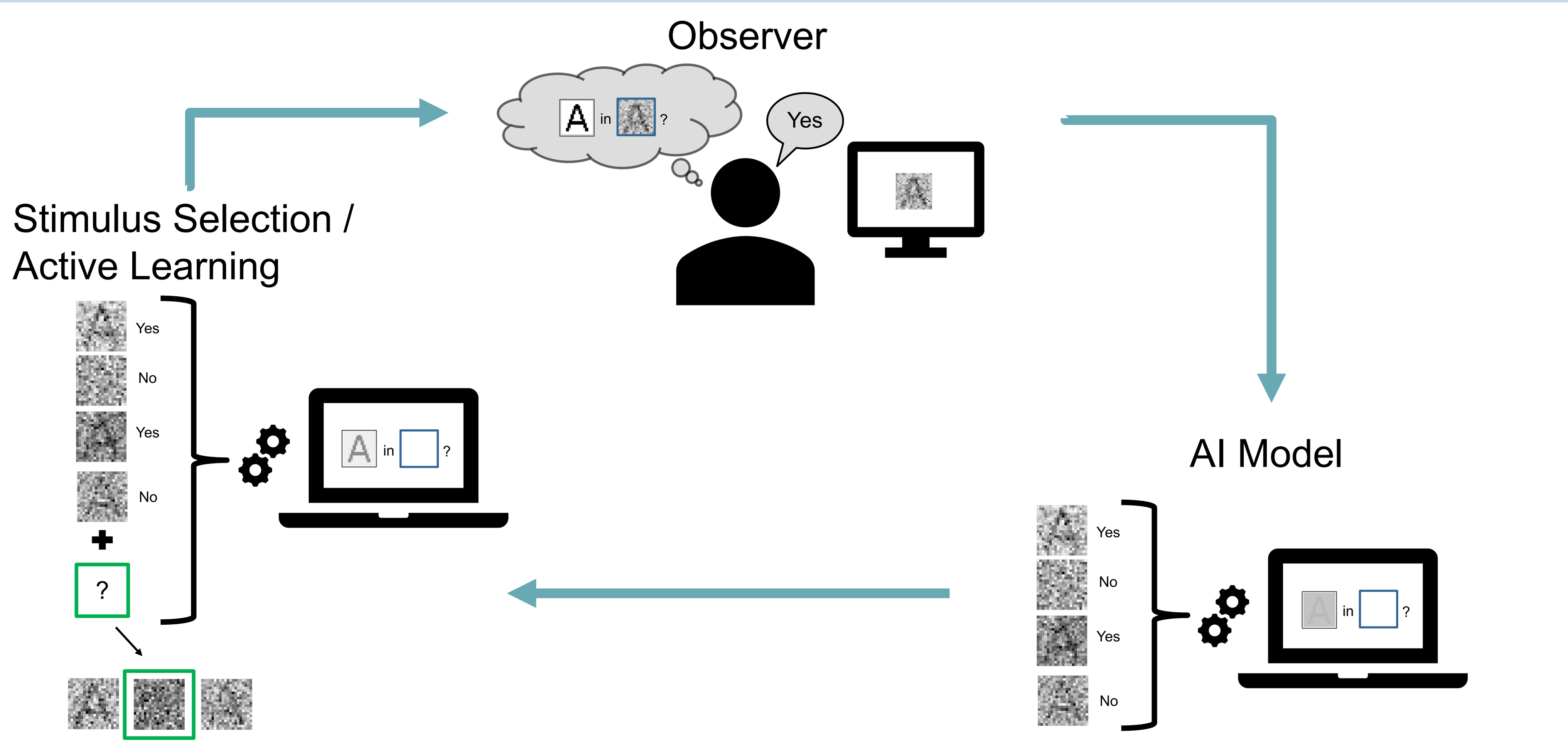
# Applying Active Learning to Experiments with Humans

In machine learning tasks input data is often abundant but labels are costly to come by. The field of Active Learning addresses this problem. It develops methods that intervene in the learning process and determine for which input to request a label next, so that it can learn most from it. Adaptive methods are the counterpart to this in studying human behavior. Instead of presenting predefined stimuli in a fixed or random order, an algorithm chooses the next stimuli dependent on the participant's preceding responses. Adaptive methods for problems with few behavioral parameters exist. However, there are currently no methods to adaptively choose stimuli in high-dimensional parameter spaces. I aim to develop adaptive methods for these experiments by transferring knowledge from active learning.

## Main Idea




## Methods

Simulations of yes-no experiment with linear template observer:

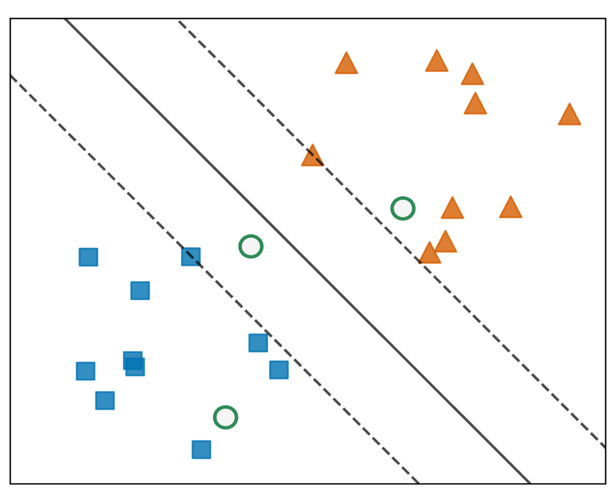
$$p(yes|x) = \sigma(w^T x + b)$$

Goal:

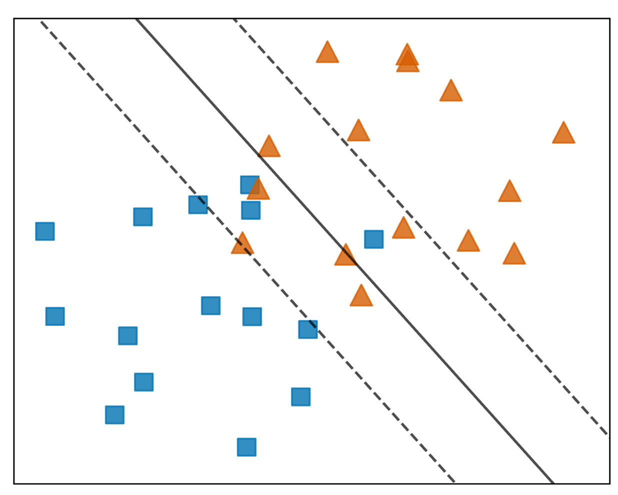
- Retrieve the template $w$ from yes-no responses.
- Compare trial efficiency of different experimental approaches.

## Uncertainty Sampling Heuristic

Separable data



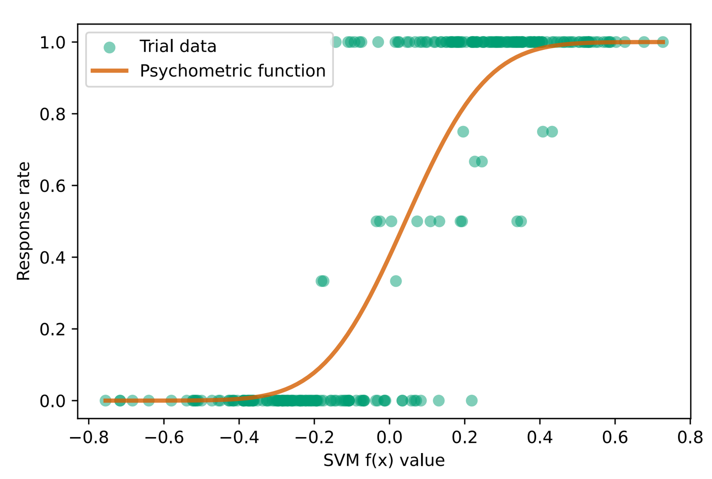
Non-separable data



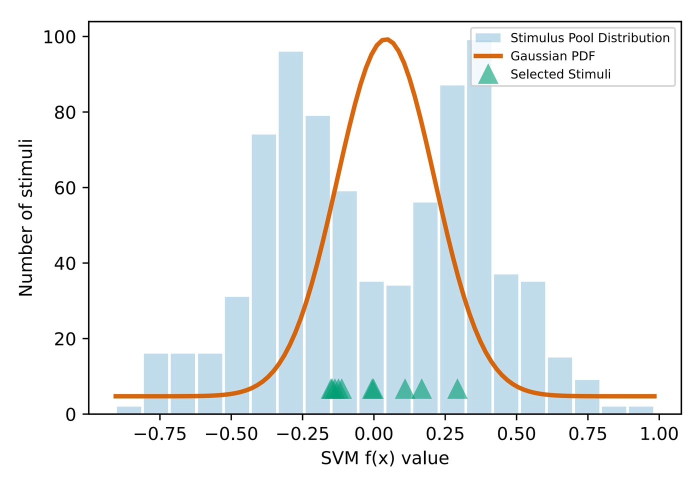
Uncertainty sampling for Support Vector Machines: Sample inside the margin (left).

For non-separable data the uncertain region is harder to define (right).

Psychometric function fitting

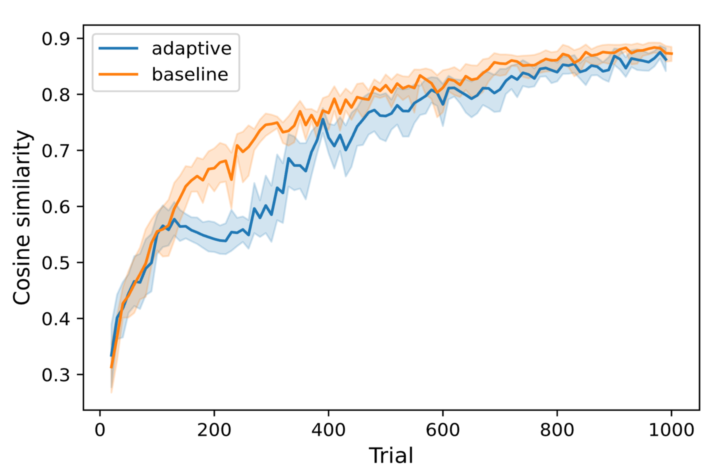



Stimulus sampling

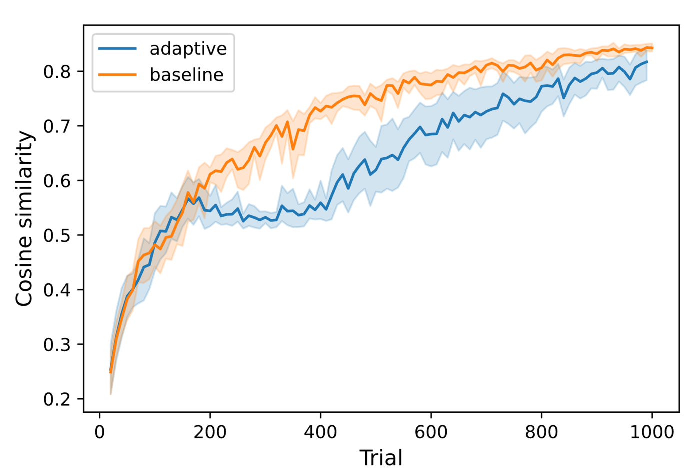



Use response behavior to define probabilities for uncertainty sampling.

Stimulus intensity 18

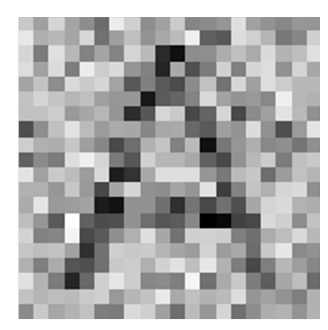



Stimulus intensity 15

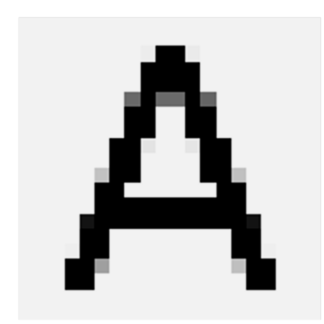



Results: The uncertainty heuristic does not perform better than random stimulus sampling in finding the correct decision boundary.

## Limits of Fixed Stimulus Pool



Expected classification image for a fixed stimulus pool with 400 noise patterns.



Expected classification image for randomly sampled noise.

- The observer‘s template is often approximated with classification images.
- For normally distributed noise the expected value of a classification image is proportional to the observer‘s template [1].

## Outlook

- Check influence of bigger or changing stimulus pool
- Test influence of overlap of signal and noise distribution on the performance of the uncertainty sampling heuristic → Does it work if there is no overlap at all, i.e. if we have separable data?

[1] Murray, R. F., Bennett, P. J., & Sekuler, A. B. (2002). Optimal methods for calculating classification images: Weighted sums. *Journal of Vision*, 2(1), 6-6.