

# Collaborative Signal Detection: Human-human and Human-computer teams

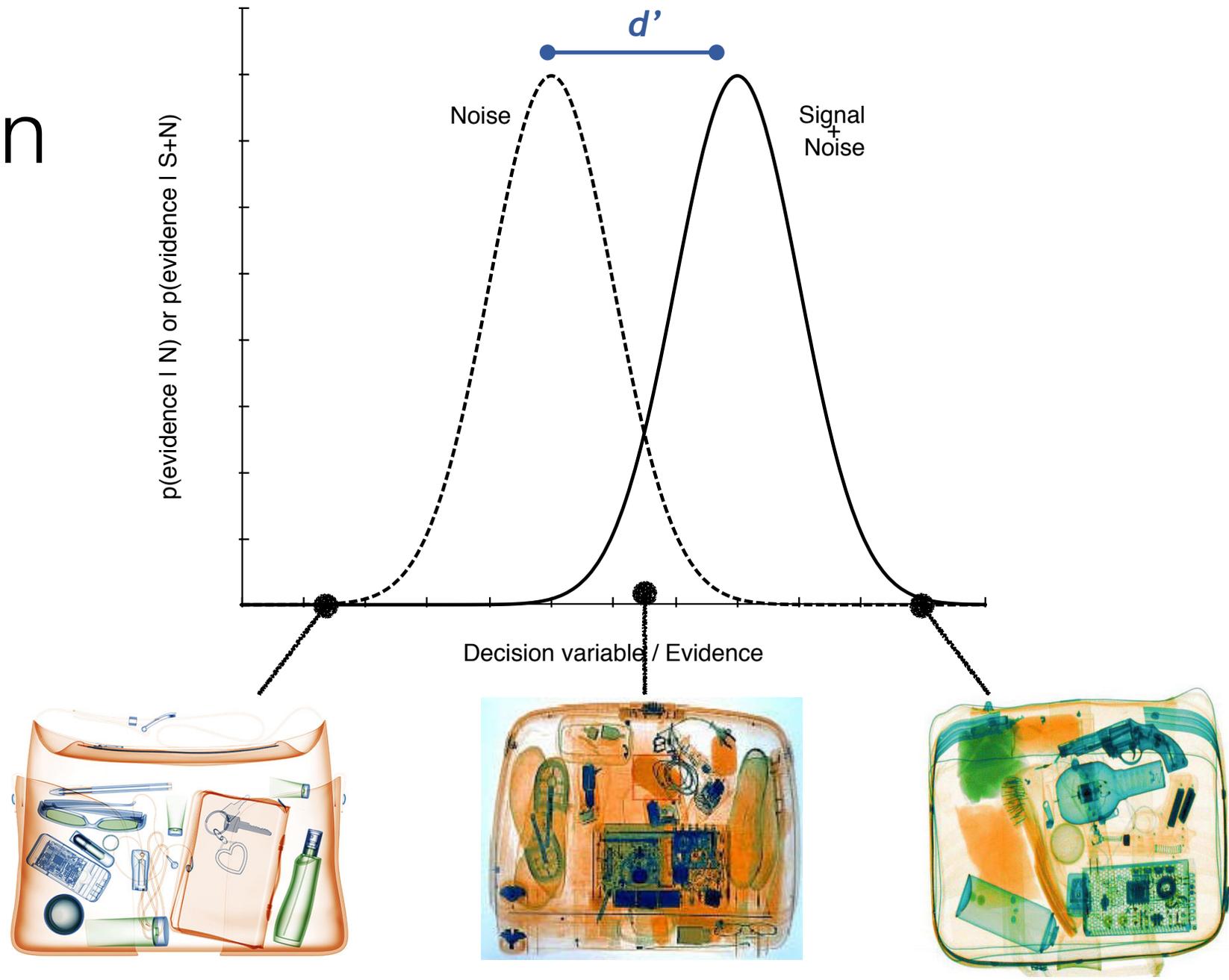
Jason S. McCarley

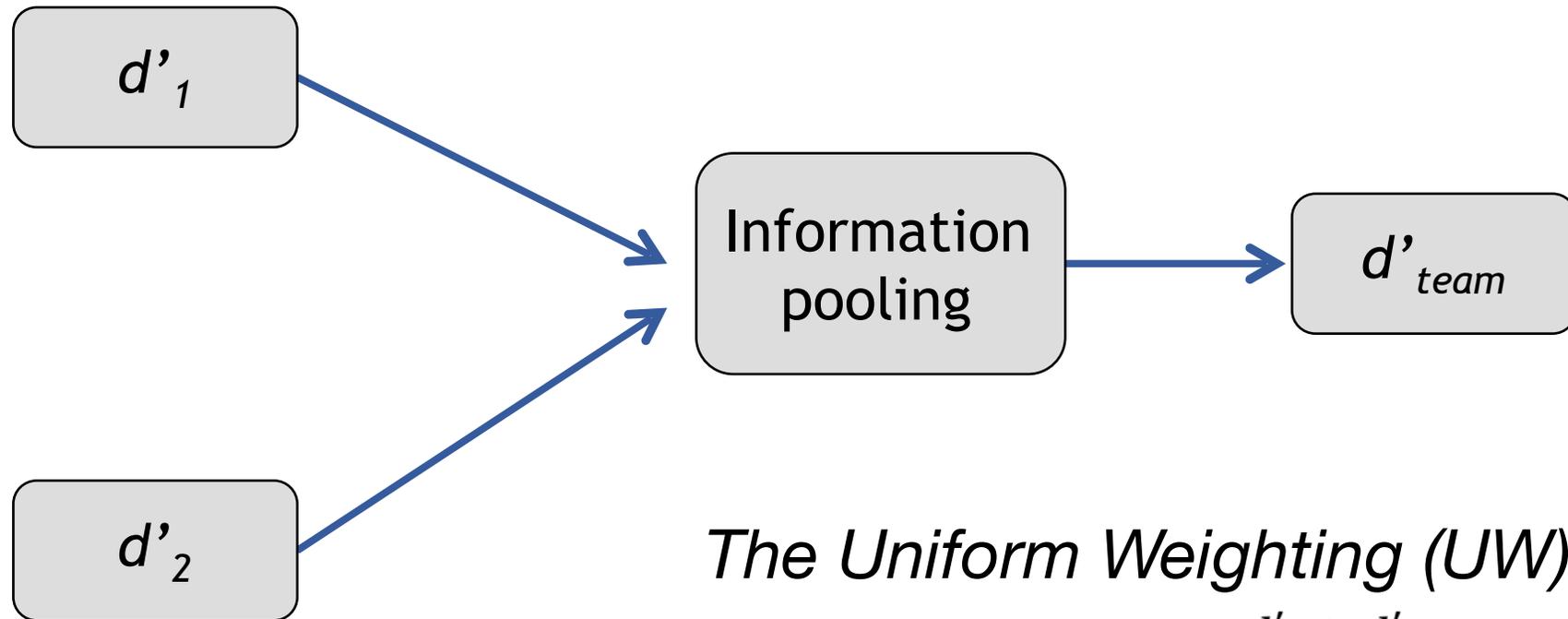
Ali Enright

Megan Bartlett



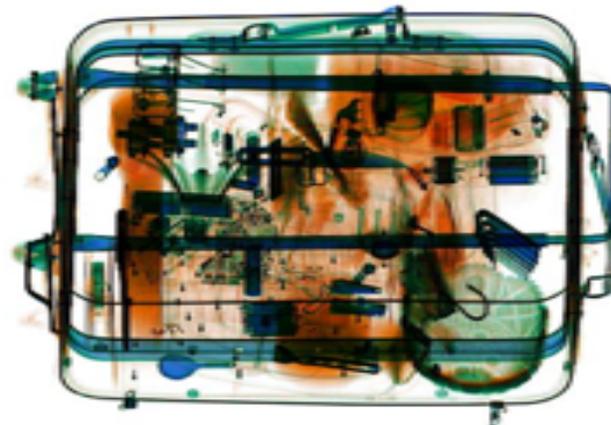
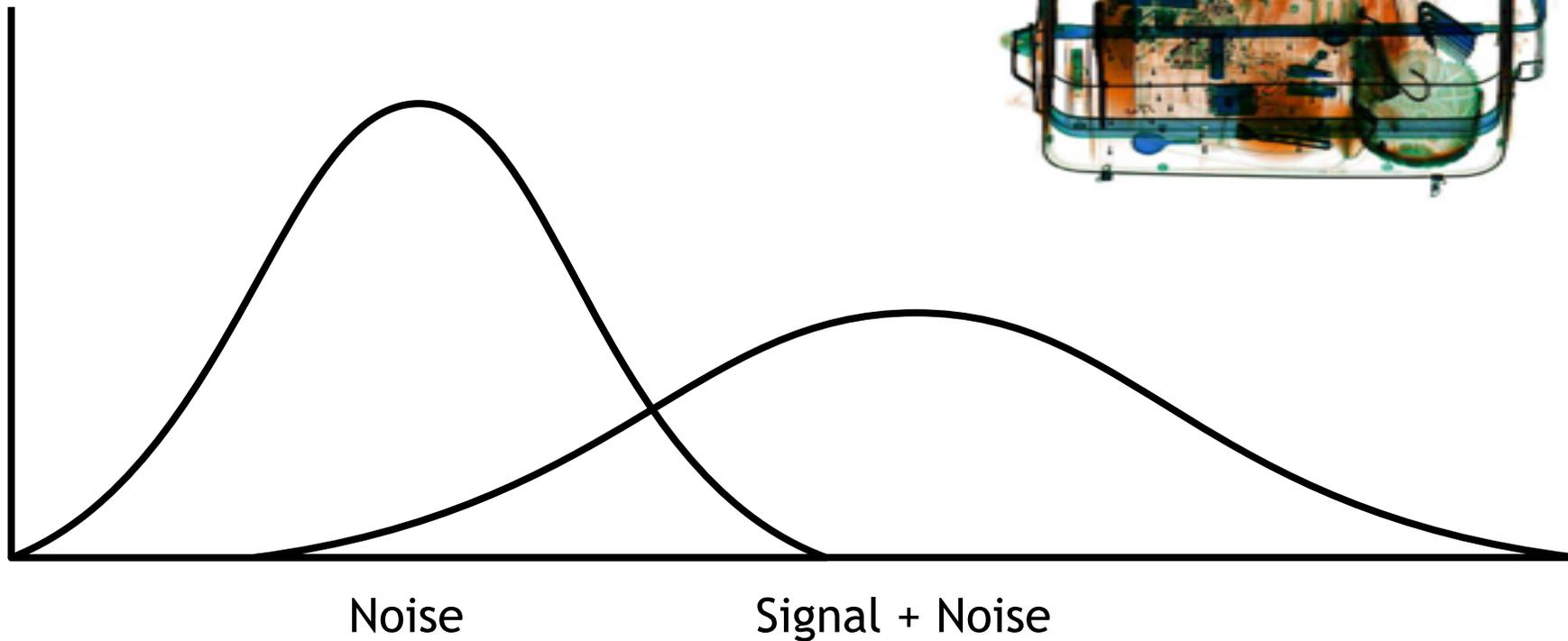
# Signal Detection Theory



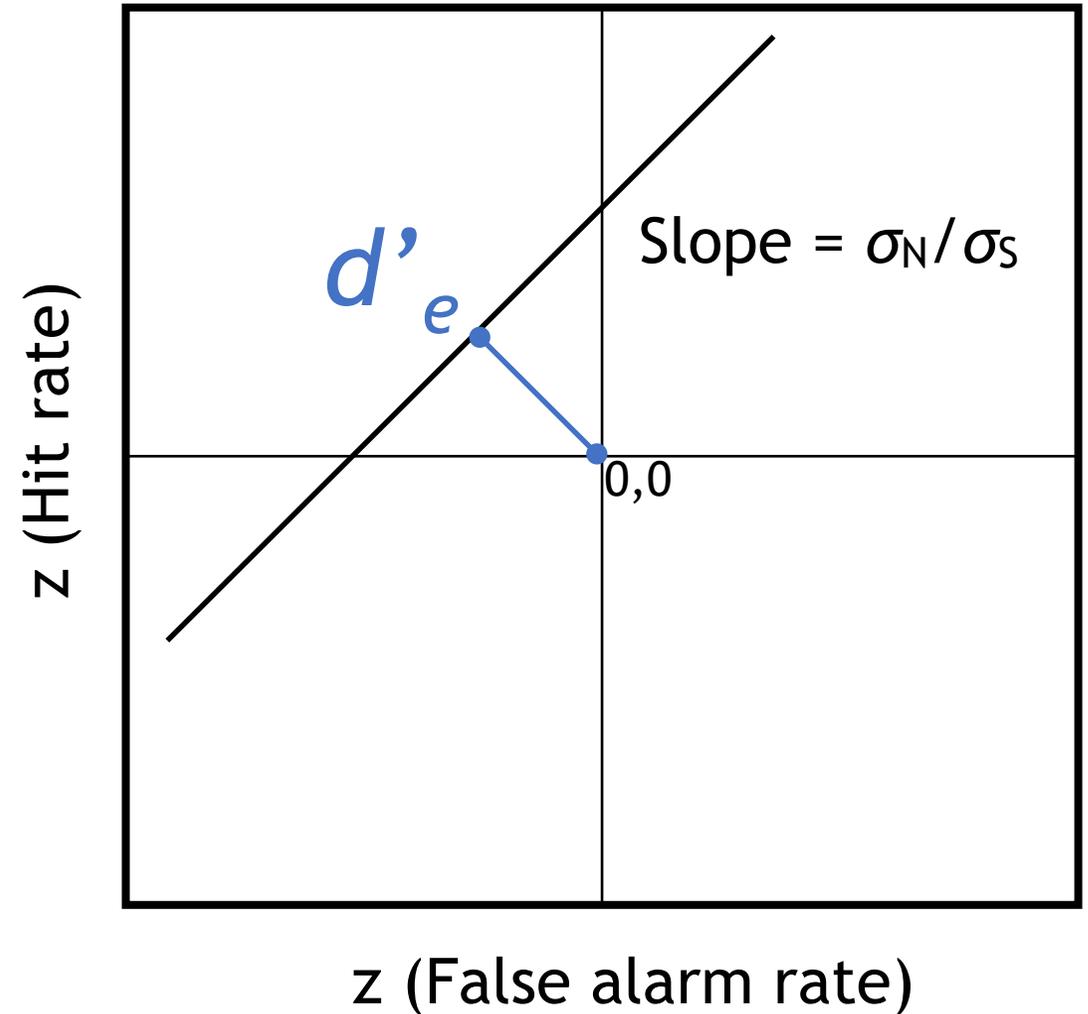
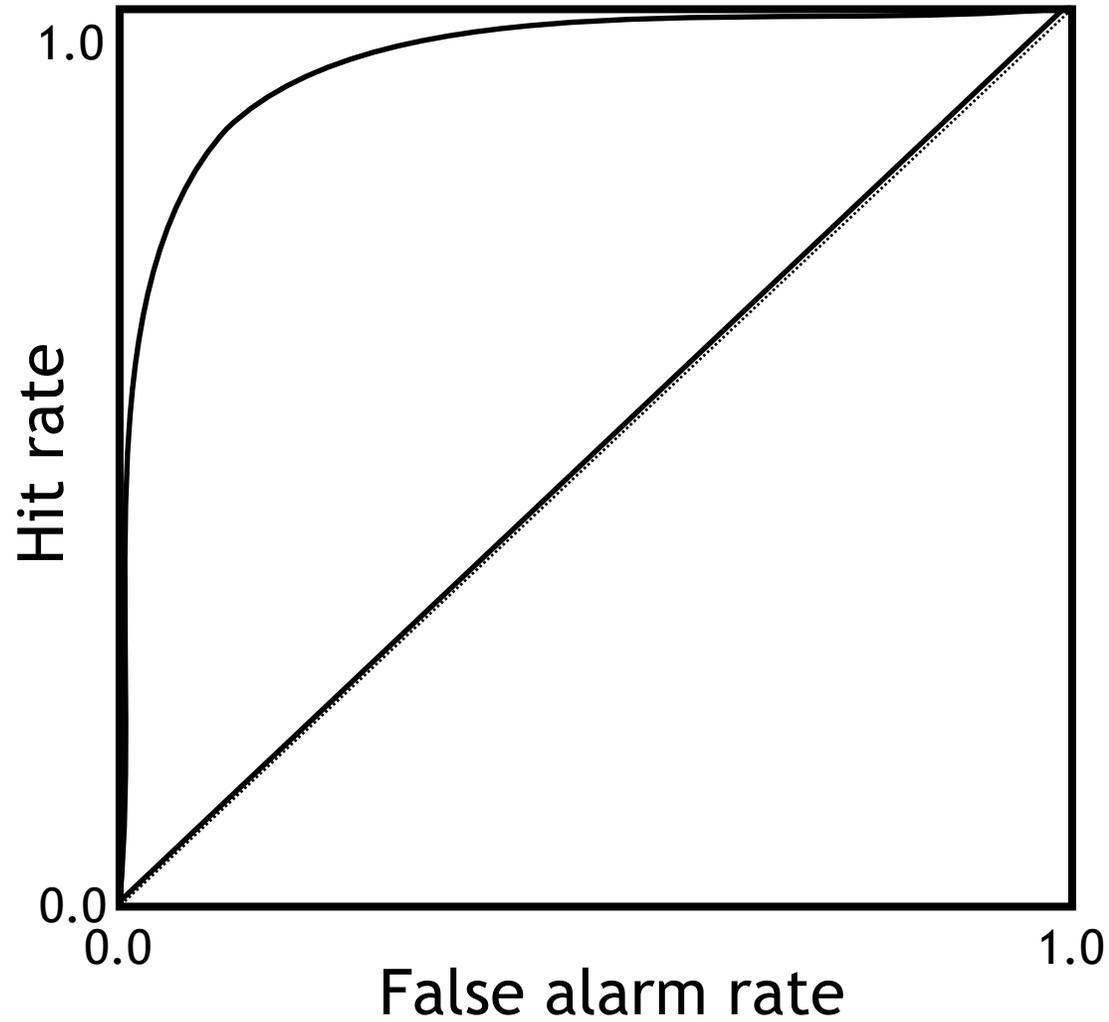


*The Uniform Weighting (UW) Model*

$$d'_{UW} = \sum \frac{d'_1 + d'_2}{\sqrt{2}}$$



# The ROC & the Z-ROC



## A problem

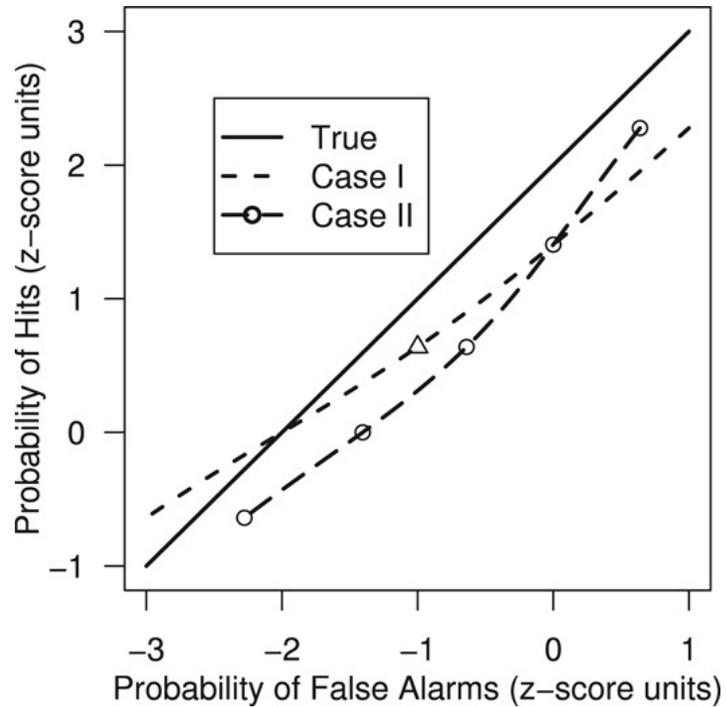
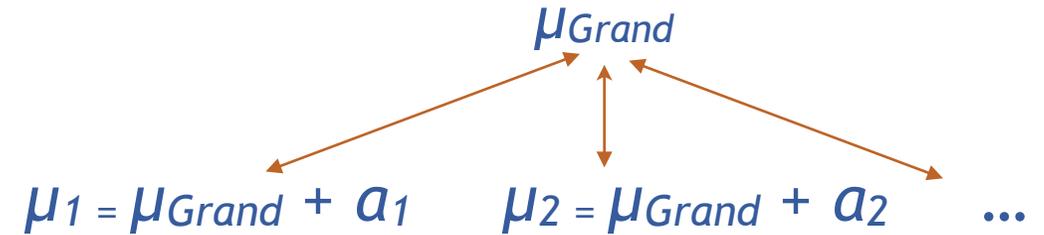


Fig. 2. The effects of aggregation on  $z$ ROC curves. The straight line labeled “True” corresponds to a signal detection model with  $d' = 2$  and  $\sigma = 1$ . The curve labeled “Case I” results from aggregating over items with different  $d'$  values. The curve labeled “Case II” results from aggregating over items with different criteria.

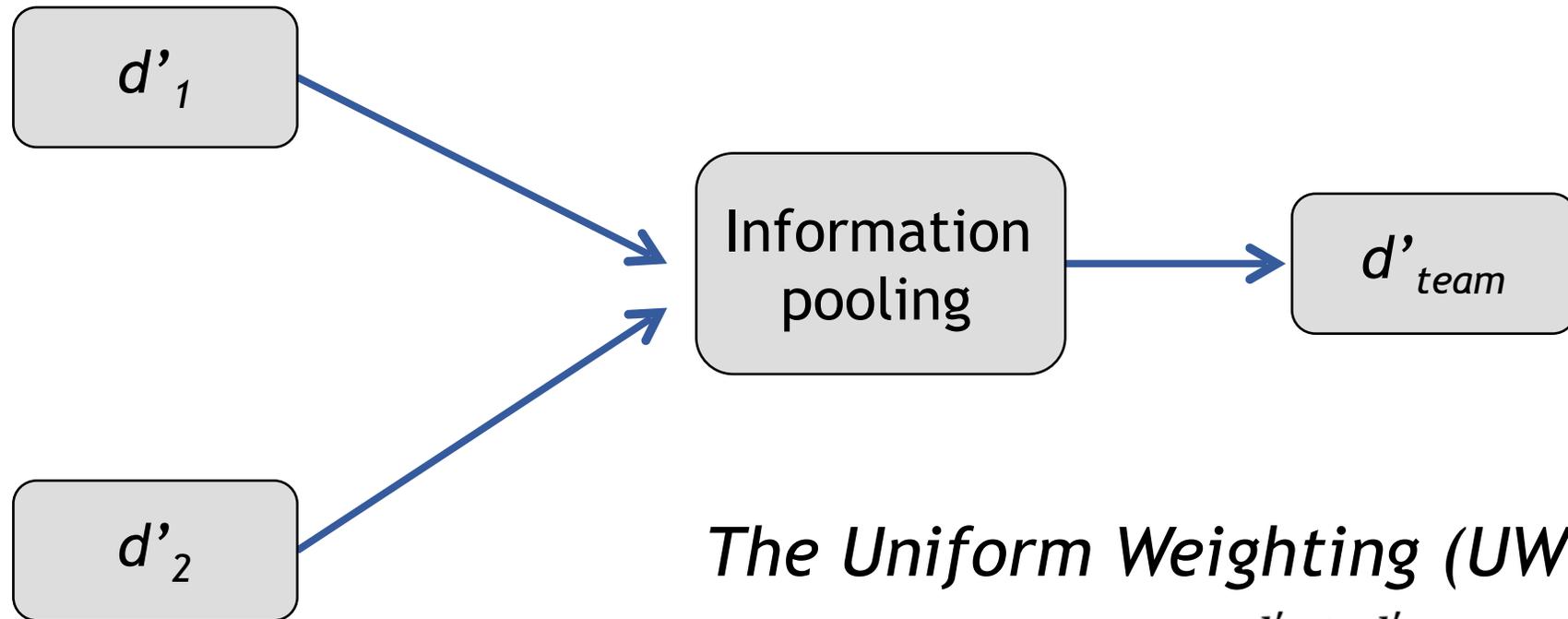
## A solution

Hierarchical ROC modeling



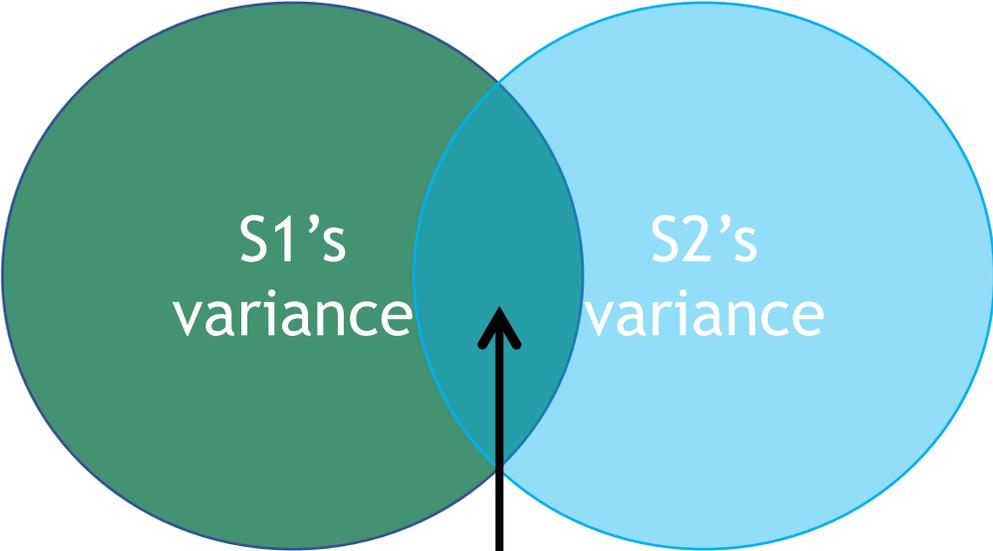
Fit ROC with Bayesian sampling procedure from vague priors.

Produces a posterior distribution for model parameters.

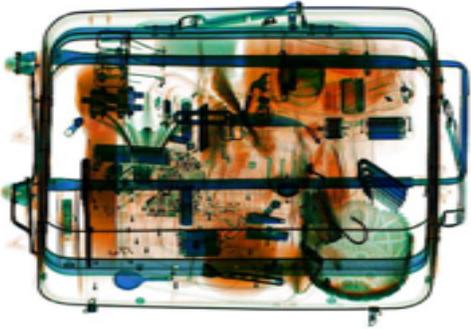


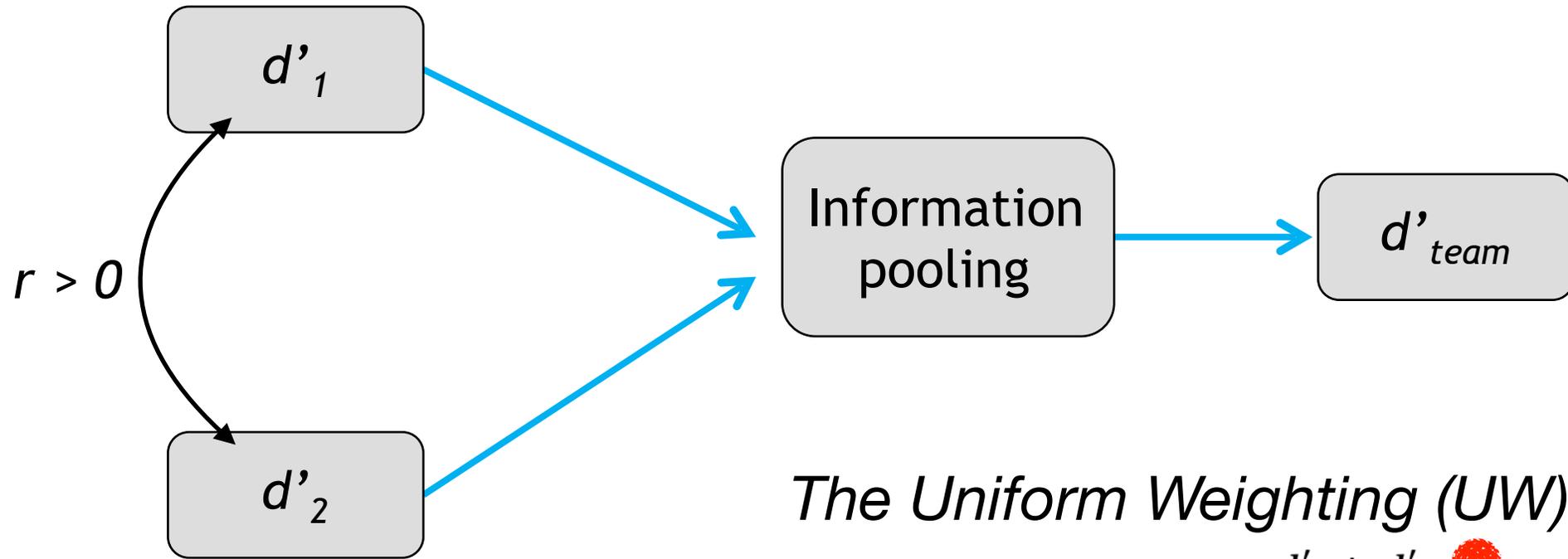
*The Uniform Weighting (UW) Model*

$$d'_{UW} = \sum \frac{d'_1 + d'_2}{\sqrt{2}}$$



Shared variance





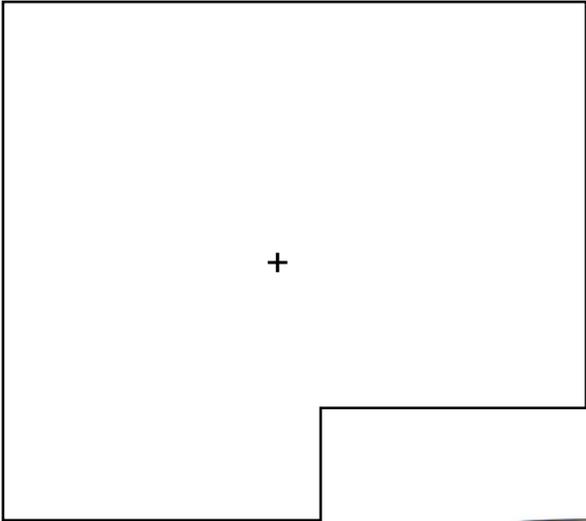
*The Uniform Weighting (UW) Model*

$$d'_{UW} = \sum \frac{d'_1 + d'_2}{\sqrt{2}}$$


How efficiently do people collaborate  
in a naturalistic search task?

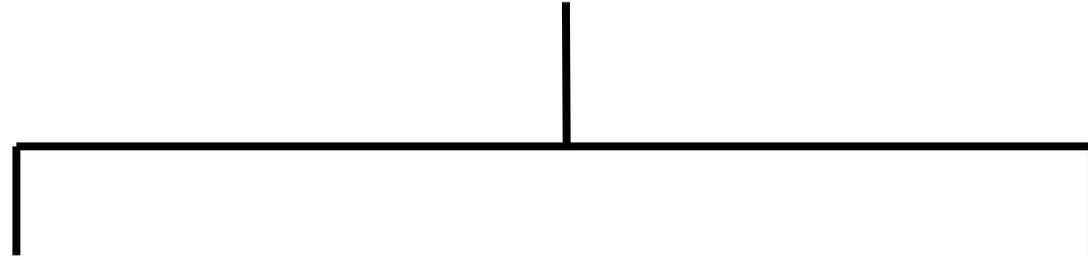


Time



You found a threat!

500 trials



250 trials (150-, 100+)

Single Observer

Worked alone

Same order of trials  
to extract correlations

250 trials (150-, 100+)

Team

Worked together

# Comparisons

- Single-person search
- Team search
- UW,  $\rho = 0$ 
  - Predicted from formula based on individual searchers  $d'_e$  scores
- Mock UW
  - $(\text{Rating}_{S1} + \text{Rating}_{S2}) / 2$
  - Incorporates correlations between judgments

# Experiment 1

Individual search

Room 1



Room 2



Team search

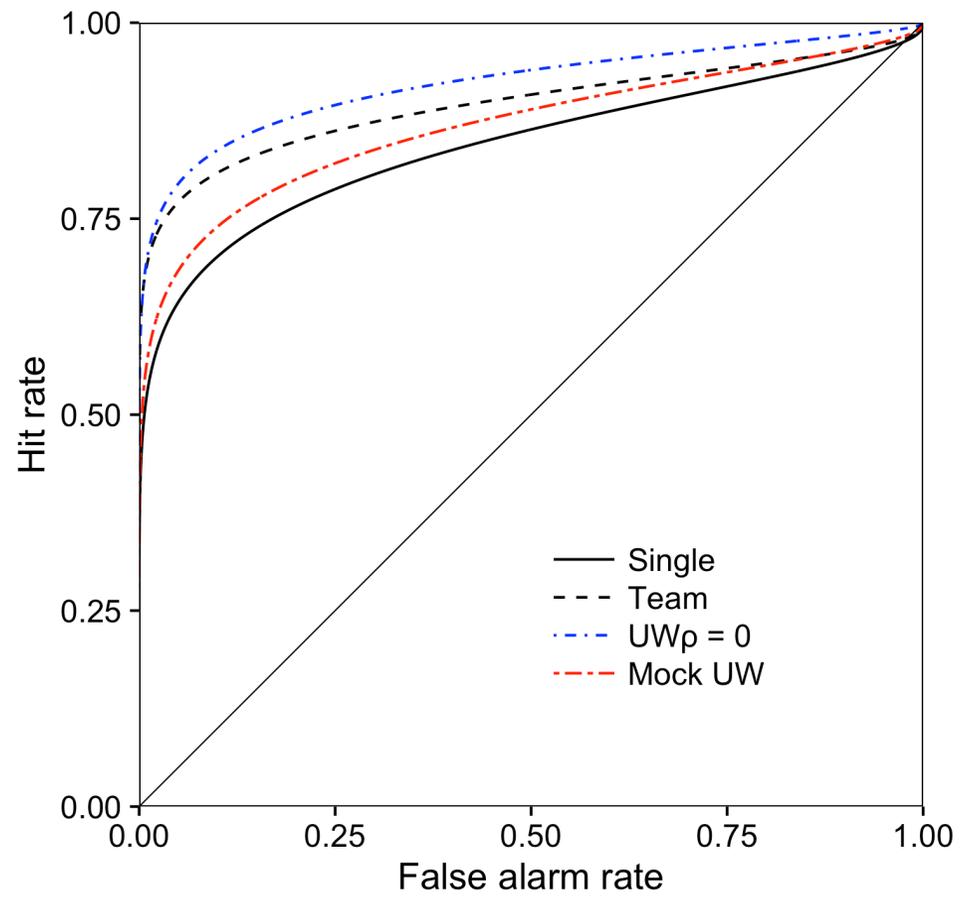
Room 1

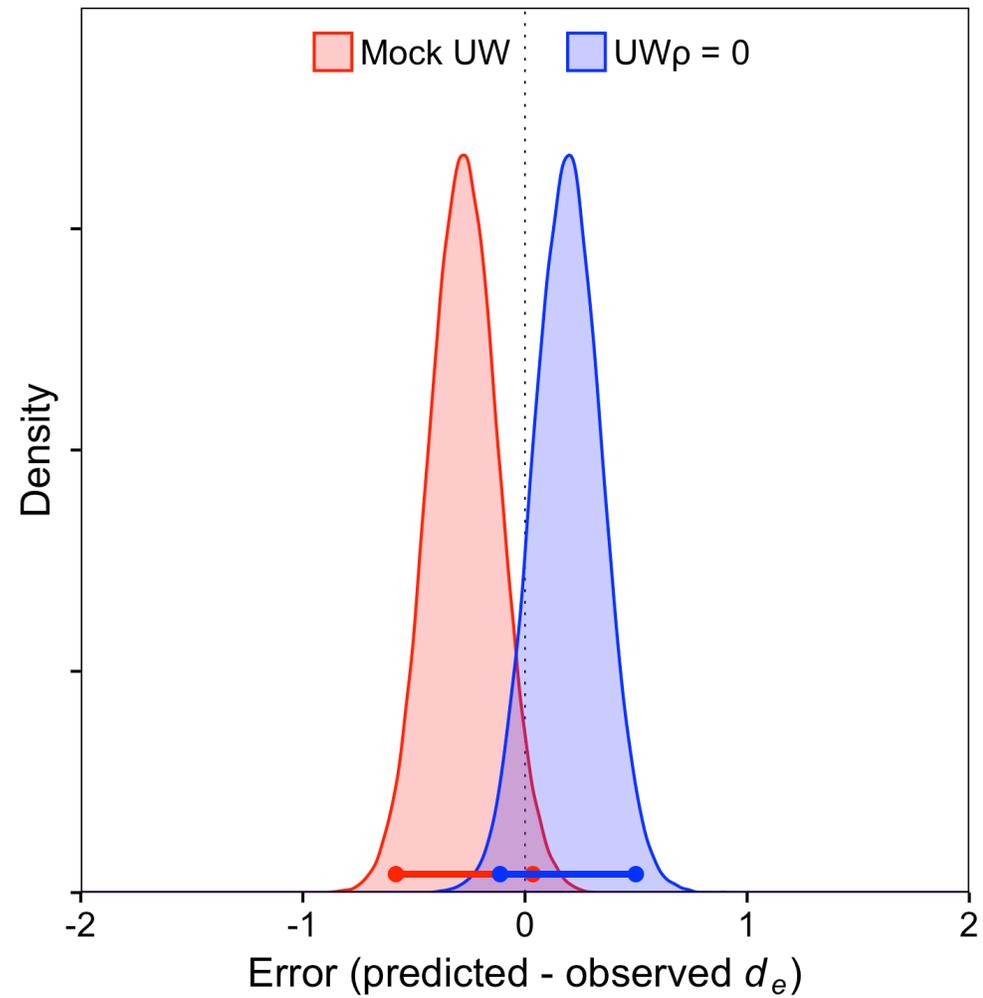
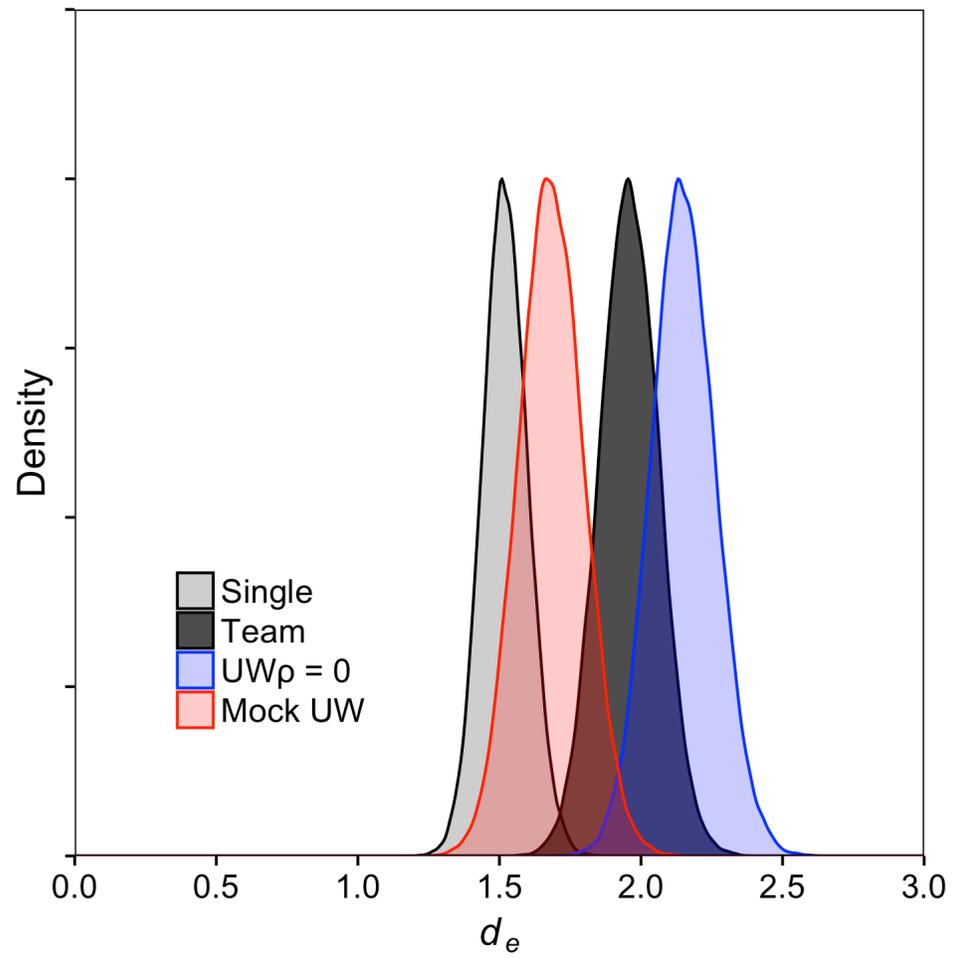


Room 2



Free viewing





# Experiment 2

Individual search

Room 1



Room 2



Team search

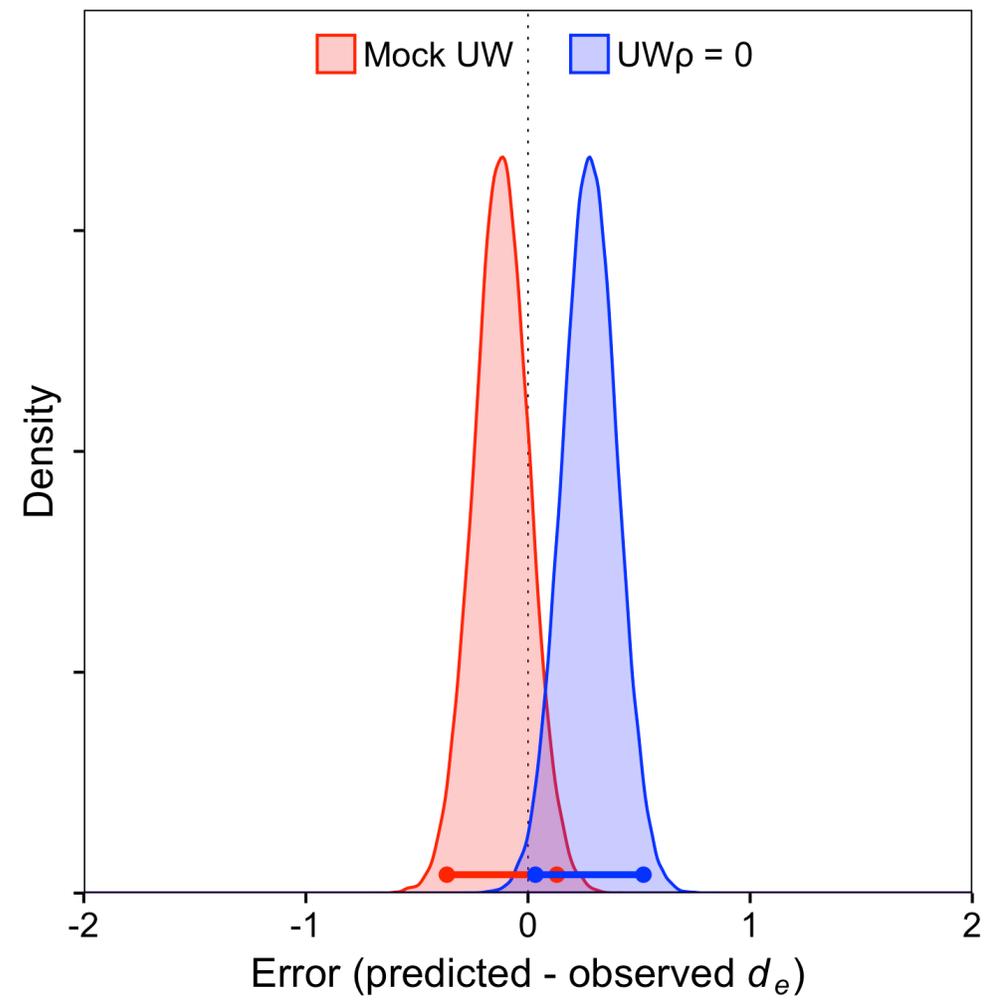
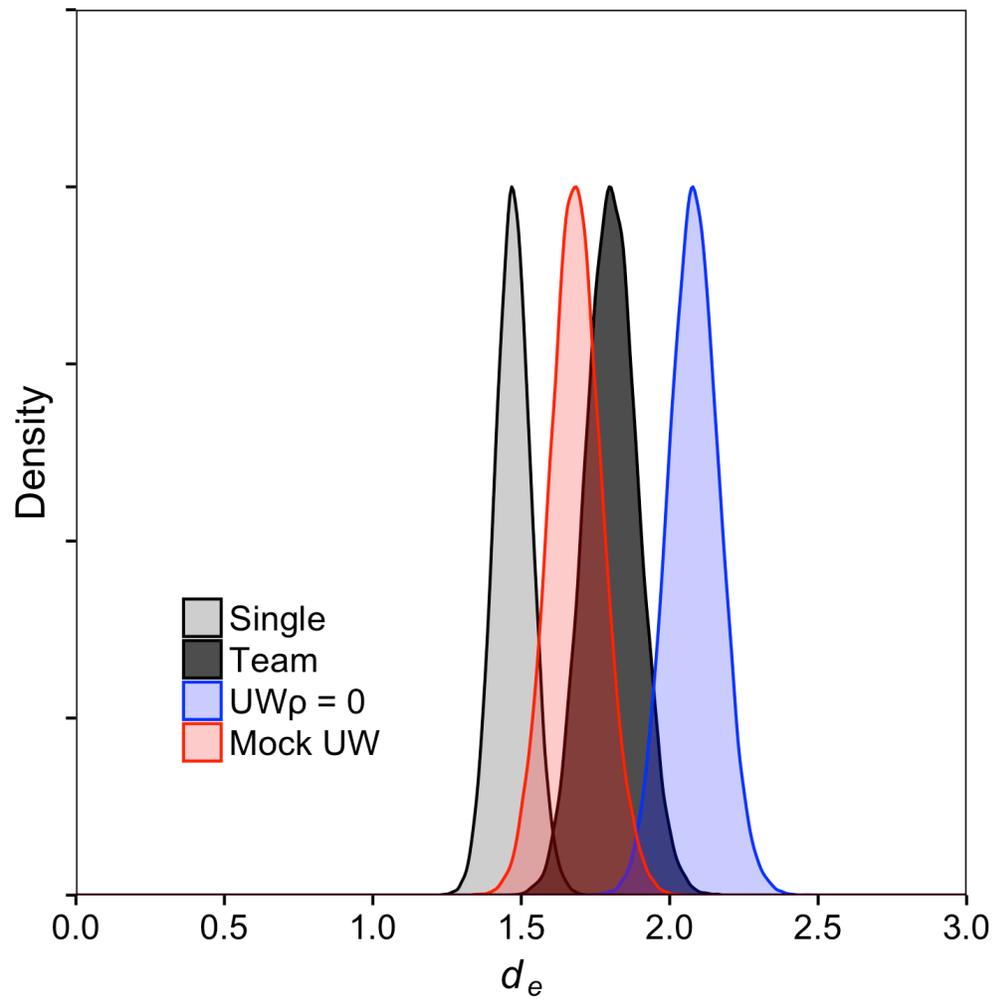
Room 1



Room 2



Free viewing

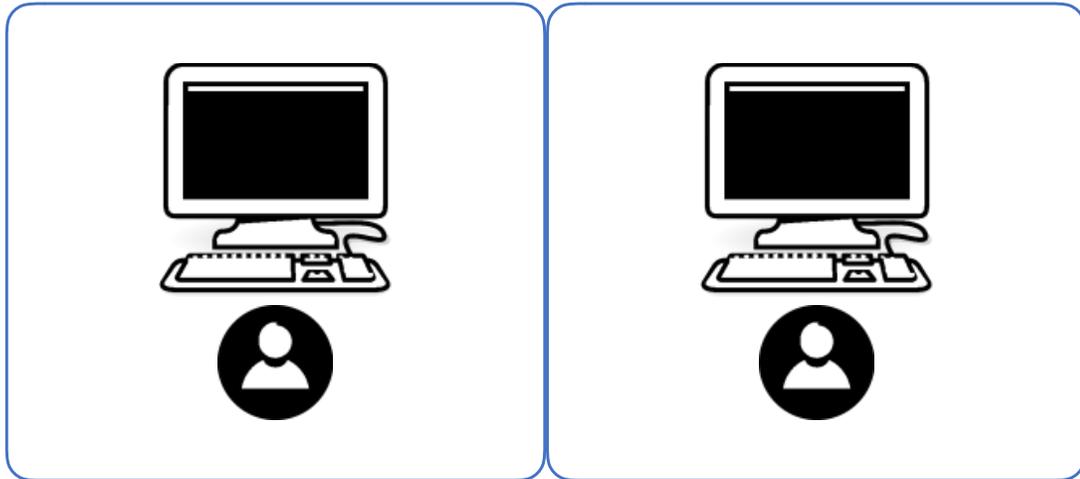


# Experiment 3

Individual search

Room 1

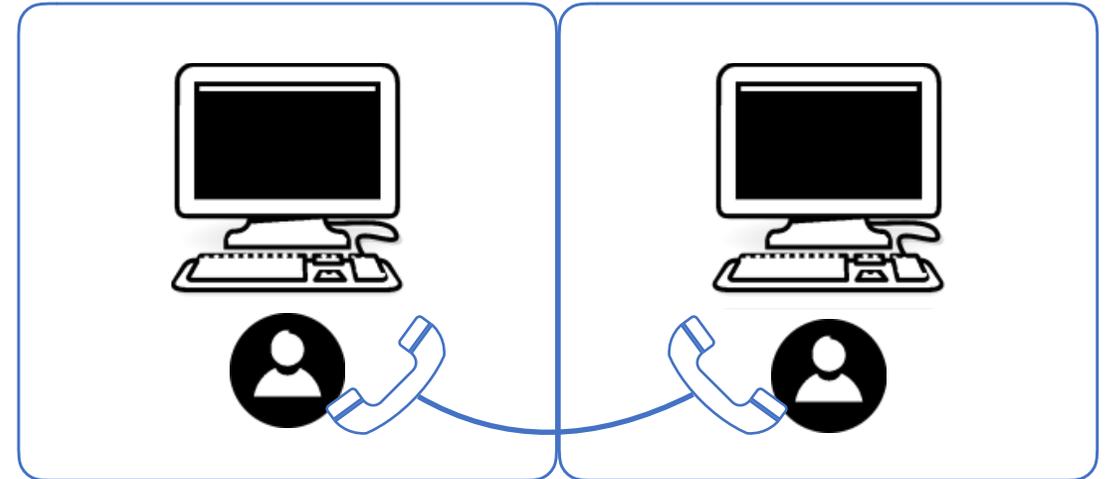
Room 2



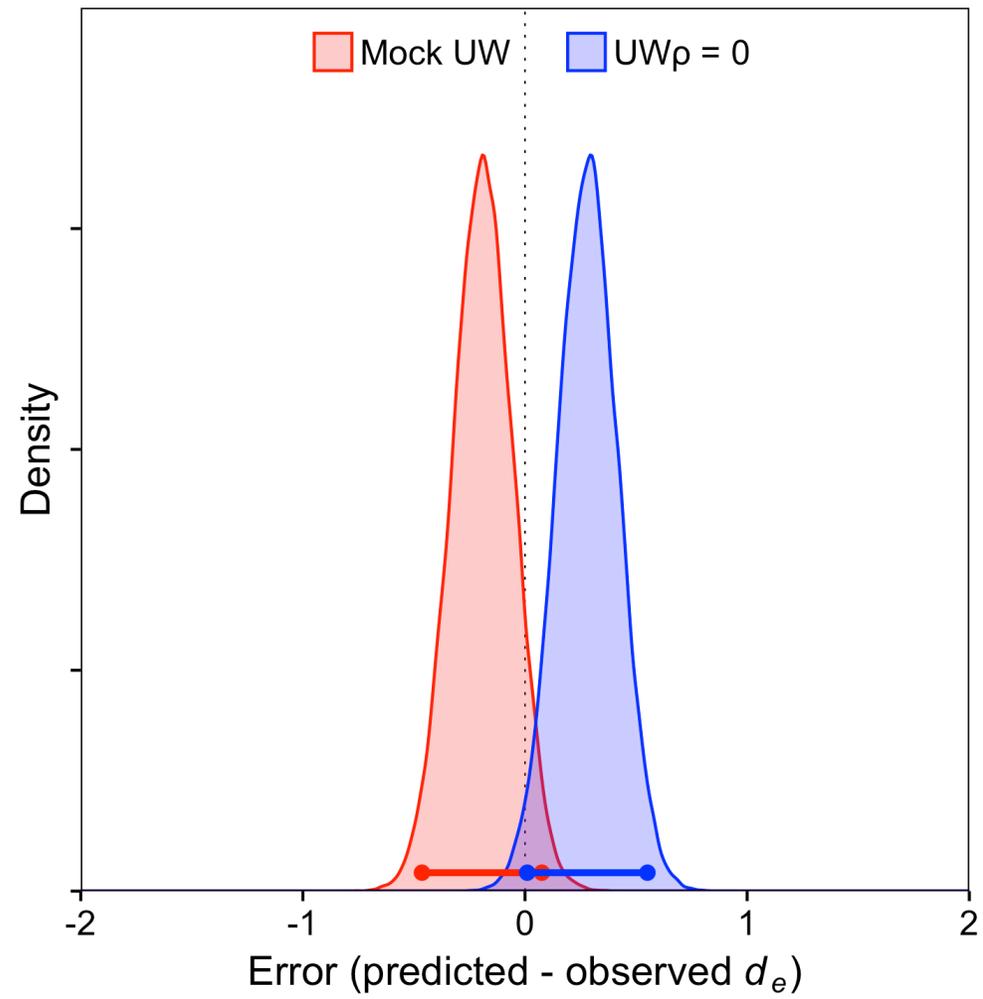
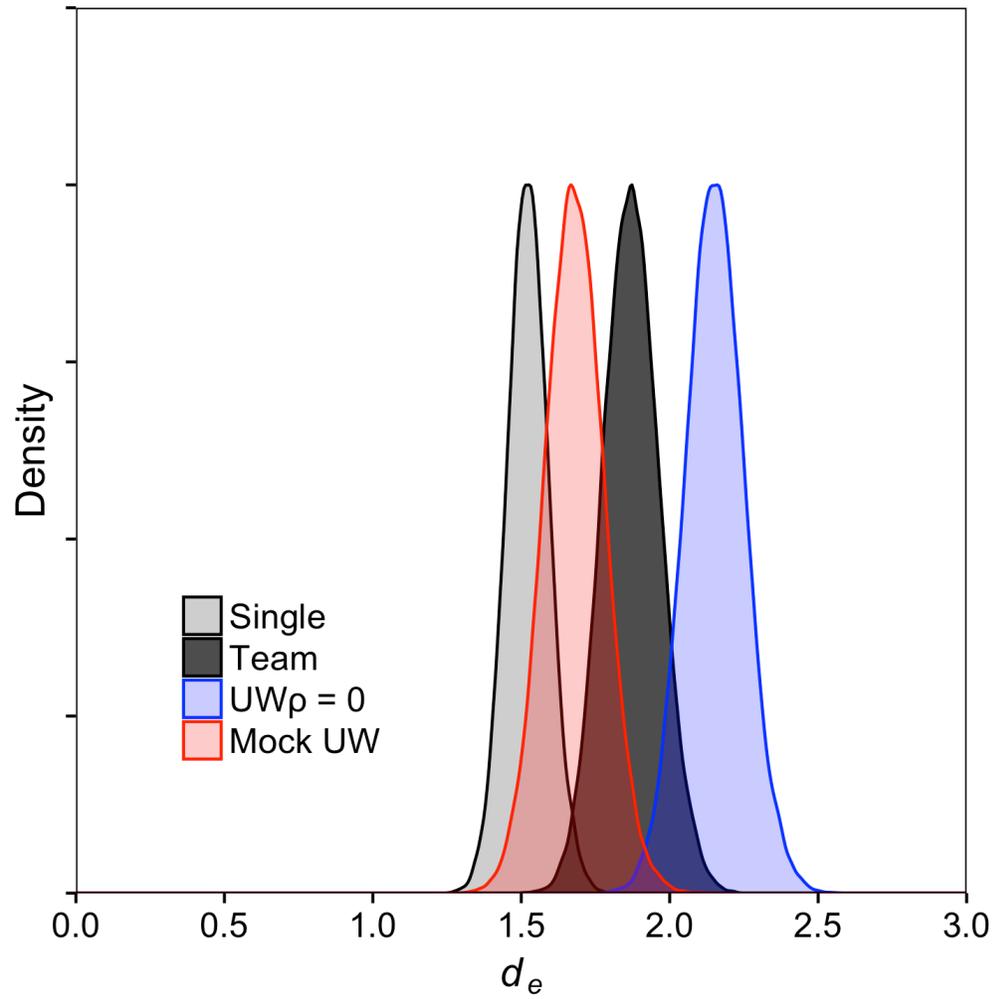
Team search

Room 1

Room 2



Free viewing



# Experiment 4

Individual search

Room 1



Room 2



Team search

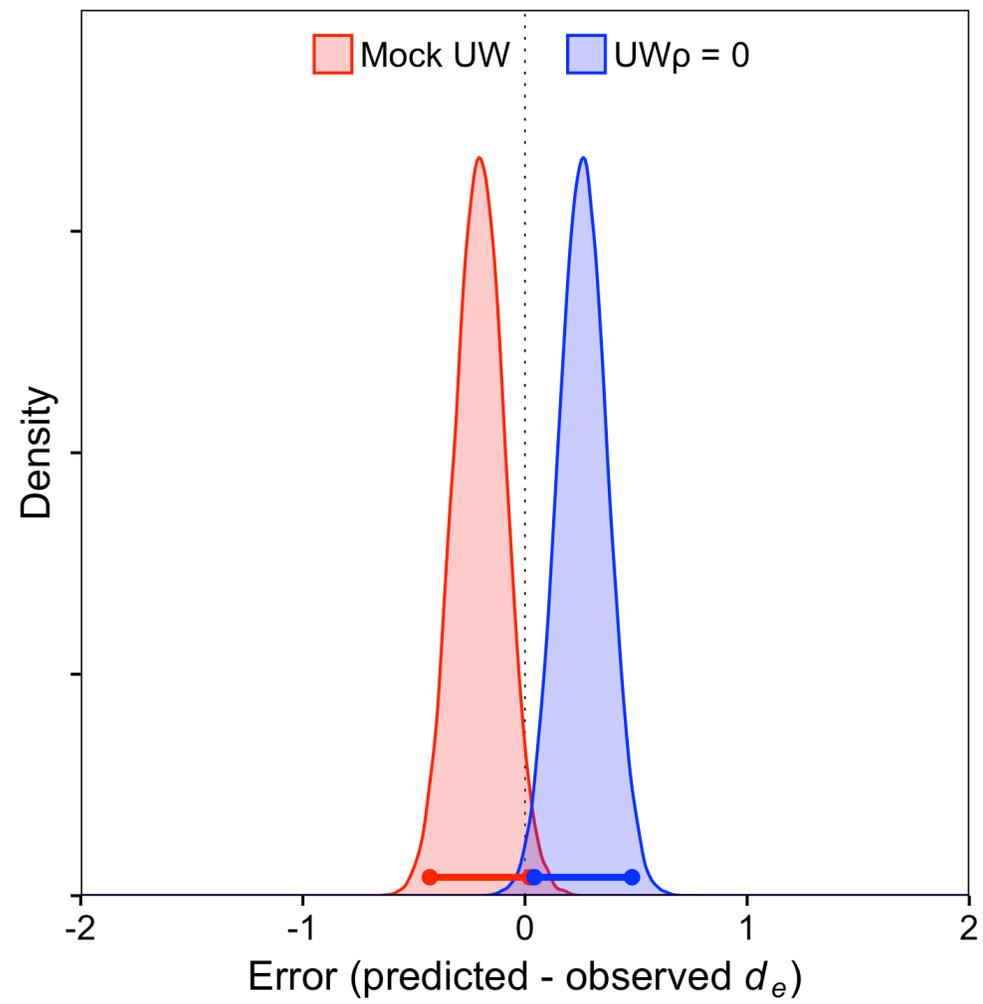
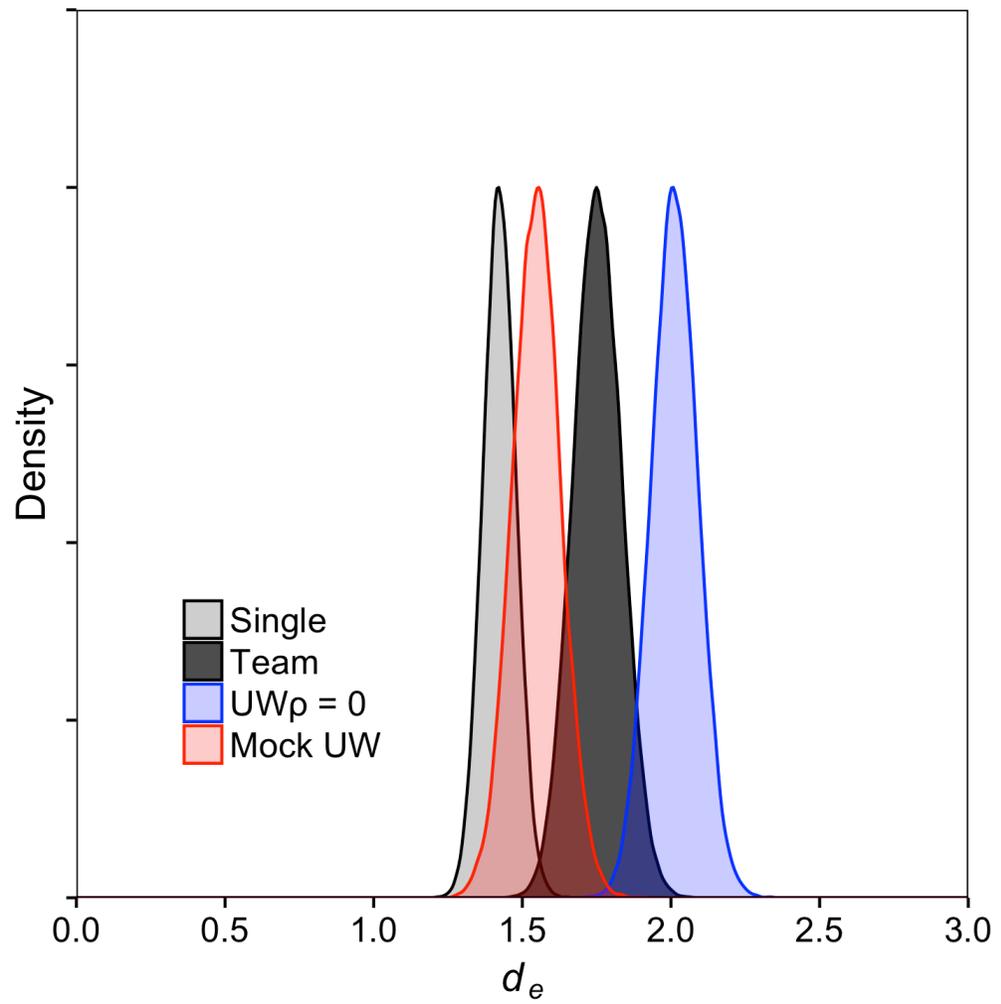
Room 1



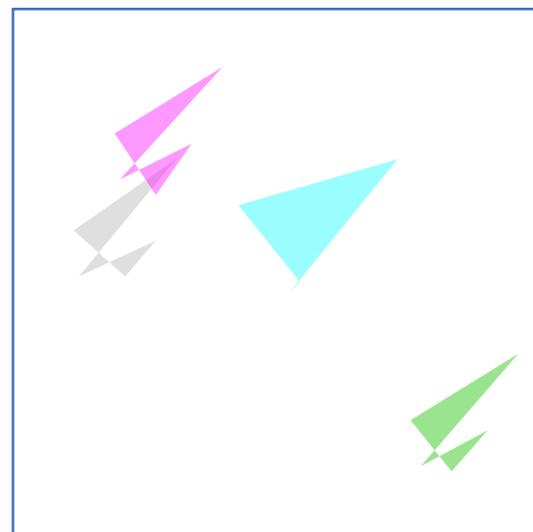
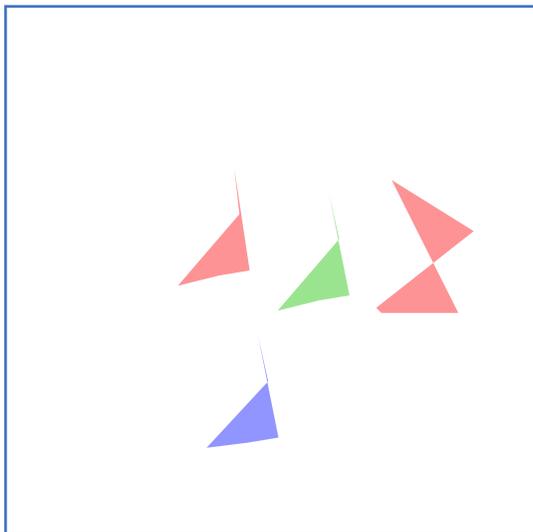
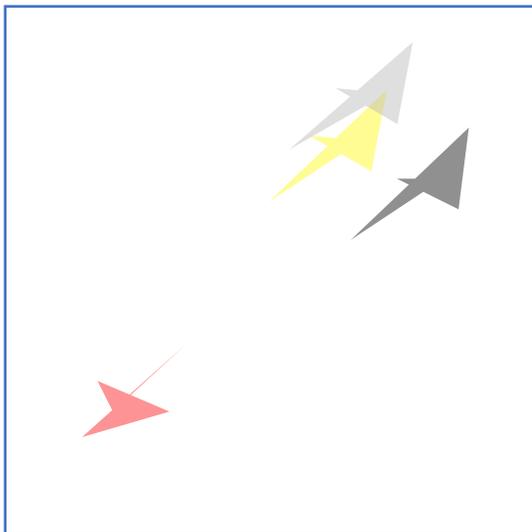
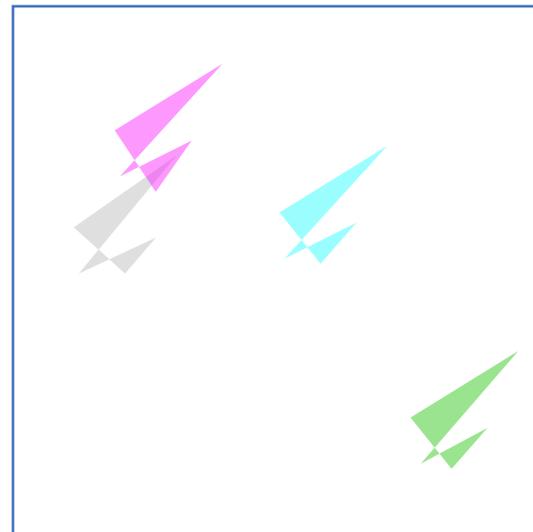
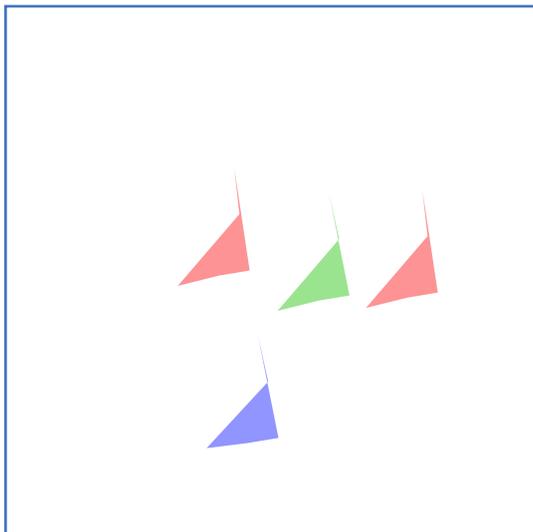
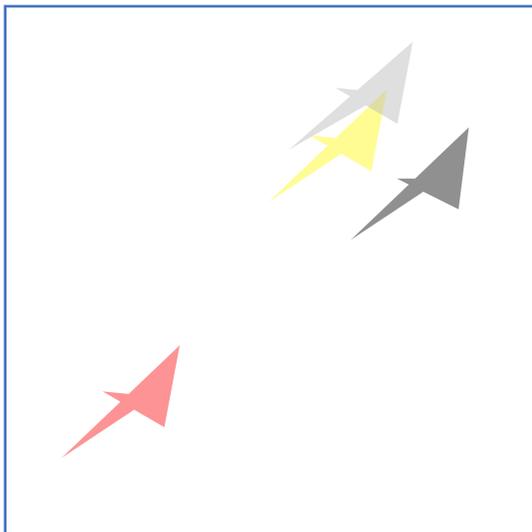
Room 2



Viewing time = 3 sec



# Experiment 5



# Experiment 5

Individual search

Room 1



Room 2



Team search

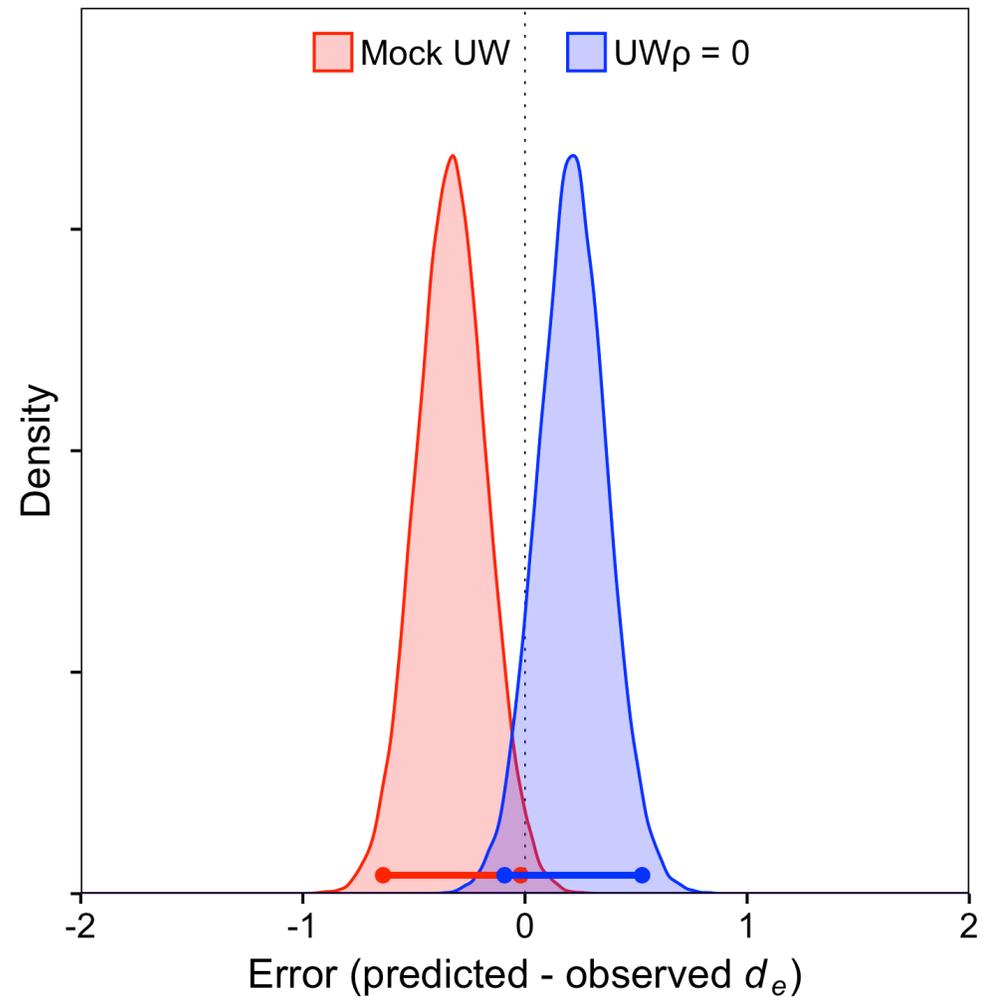
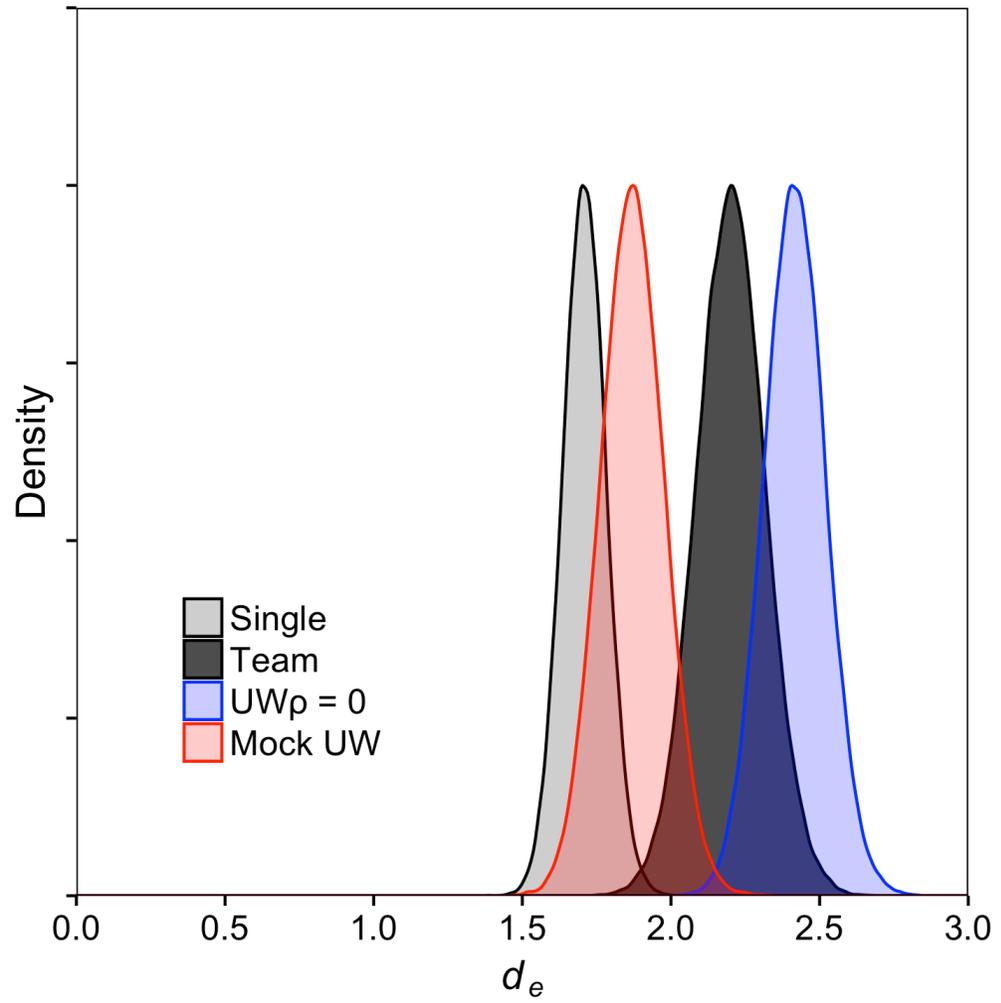
Room 1



Room 2

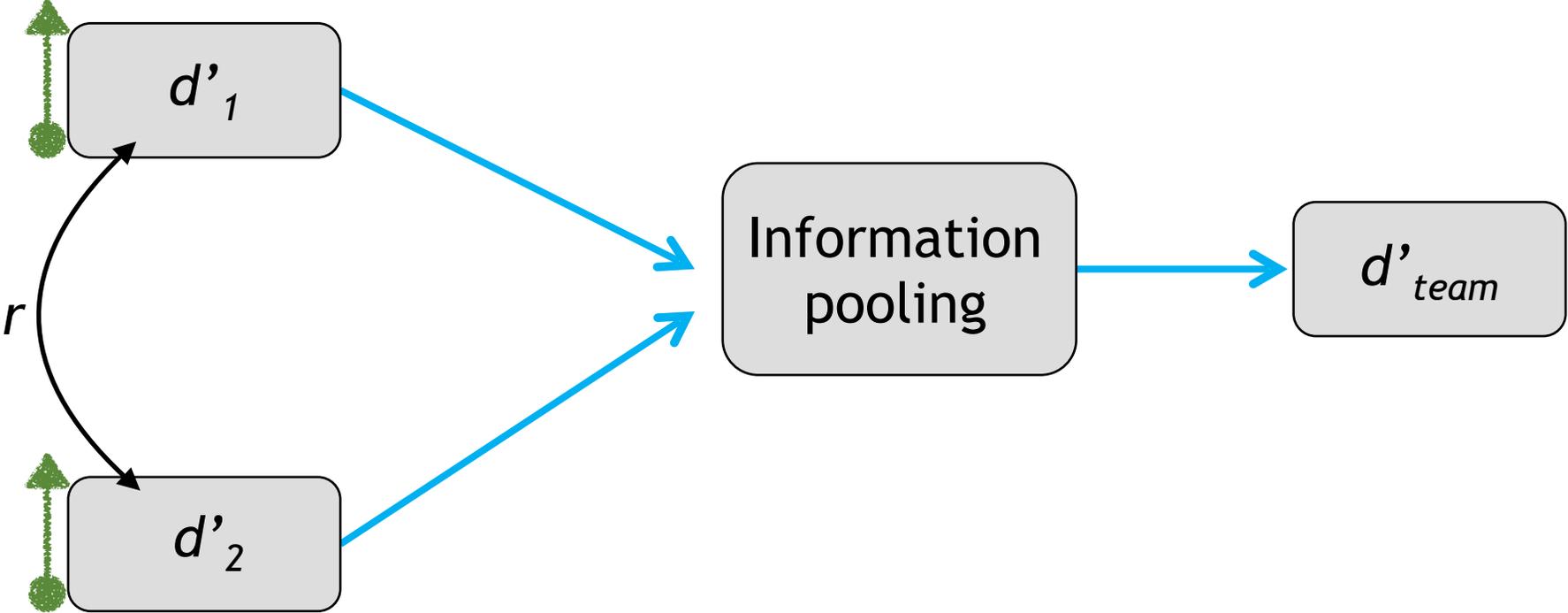


Free viewing

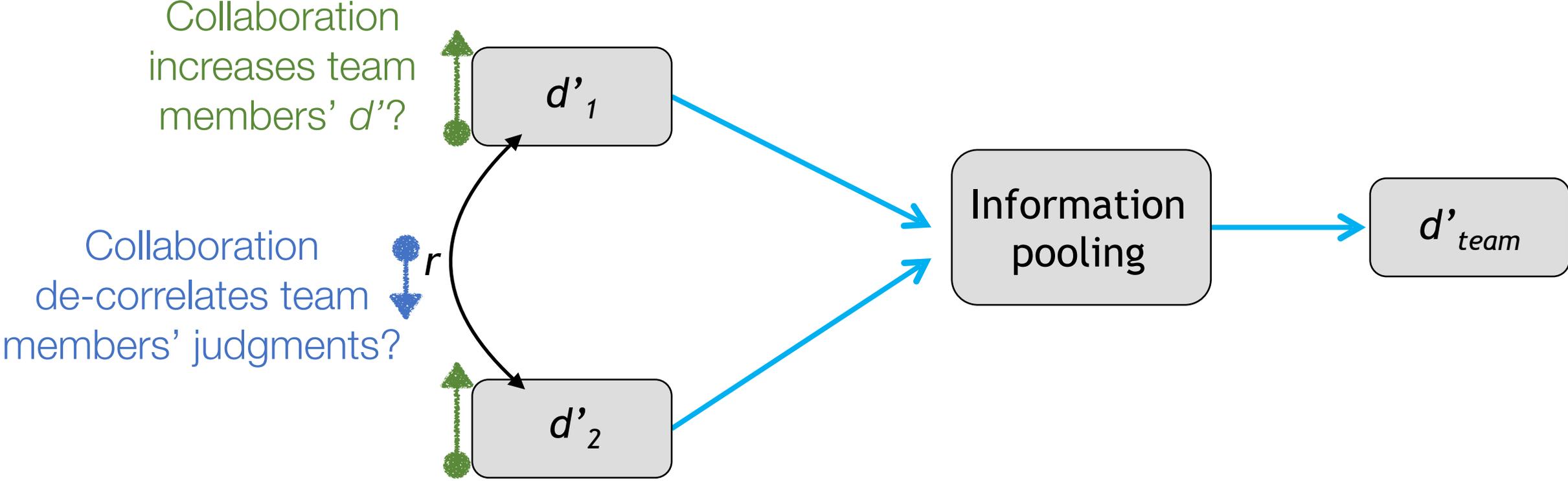


Teams outperform statistical expectations in a collaborative visual search.

Collaboration increases team members'  $d'$ ?



Teams outperform statistical expectations in a collaborative visual search.



# How well does a person collaborate with a computerized aid?

