APPENDIX

Simulations were conducted to determine whether the observed error in localizing the target centroid or the distractor centroid could be achieved by sampling a subset of the individual locations, and making an informed guess about the centroid position. The most important assumption of this model is that estimates of individual item positions are noisy, and that this noise can be estimated from participants performance on individual item tests. In each experiment, participants were required to localize a single missing target or distractor on some trials. The distribution of errors was well approximated by a normal distribution, and the model assumes that each individual item position was represented with independent, normally distributed noise of this magnitude and standard deviation.

Simulation Methods

For a particular participant, individual estimates have an average error (meanErr), and a standard deviation of errors (stdErr). The accuracy of guessing the mean by pooling different numbers of individual estimates was simulated as follows.

1. A random set of 8 xy-coordinates were generated (4 targets and 4 distractors). These coordinates are referred to here as actualX and actualY. The actualCentroidX and actualCentroidY values were calculated by taking the mean of the actualX and actualY values, respectively.

2. Noisy estimates of these individual locations were generated as follows (modeling the participants' internal representations of the individual items).

errAngle = rand(0,359)

errMagnitude = meanErr + randn * (stdErr)

predictedX = actualX + magnitude*cos(angle/180*pi)

predictedY = actualY + magnitude*sin(angle/180*pi)

Where errAngle is a random integer between 0 and 359, corresponding to the direction in which the error occurs relative to the actual xy position, errMagnitude is the size of the error (normally distributed with an average of meanErr and a standard deviation of stdErr), predictedX is the predicted x position, and predictedY is the predicted y position.

3. Predicted centroid locations were generated by averaging 1, 2, 3, or 4 of these noisy local estimates.

predictedCentroidX=average(predictedX1,predictedX2...)

predictedCentroidY=average(predictedY1,predictedY2...)

4. The error in these centroid estimates was calculated

errX = predictedCentroidX-actualCentroidX

errY = predictedCentroidY-actualCentroidY

predErrMagnitude = sqrt(errX*errX + errY*errY)

Where errX is the error in the X position, errY is the error in the Y position, and predErrMagnitude corresponds to the magnitude of the prediction error.

Simulation Results

Figure A1 shows the simulation results for each experiment. The y-axis shows the predicted error in degrees, and the x-axis shows the number of individual positions sampled to predict the centroid position. For reference, the dashed lines show actual error in centroid localization averaged across participants. Each panel shows two prediction functions: circles show predictions calculated from noisy estimates centered around actual item positions, as described above, whereas triangles show predictions calculated from noisy estimates centered around completely random locations. This latter curve was generated to demonstrate that it is not possible to localize the centroid as accurately as participants did just by randomly guessing. The top panels show the results of the model simulation for target items. As the number of individual targets sampled increases, error in predicting the centroid decreases. However, only when sampling all 4 targets does predicted performance reach the actual performance level observed in each experiment. This suggests that information from all 4 targets is required to estimate the centroid as accurately as participants actually did, given the noise observed in estimates of the individual locations. The results were qualitatively identical for target simulations and distractor simulations.

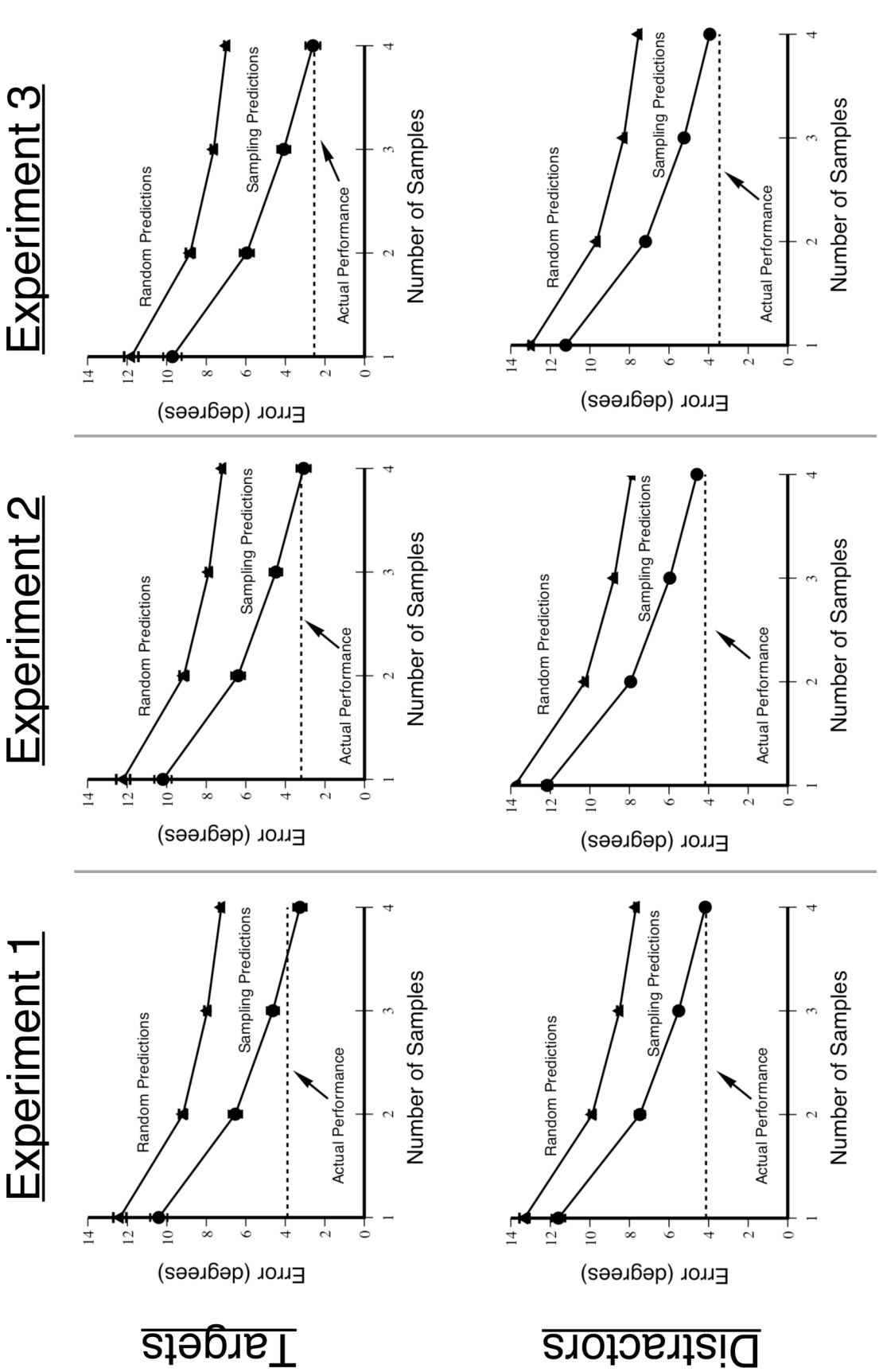

Figure A1. Predicted centroid localization error in each Experiment. The y-axis shows the predicted error in degrees, and the x-axis shows the number of individual positions sampled to predict the centroid position. Error bars are presented where greater than the data symbols and represent 1 s.e.m. For reference, the dashed lines shows actual performance averaged across participants. Circles show predictions based on noisy samples of individual items (sampling predictions). Only when sampling all 4 items does predicted performance reach the actual performance level (dashed line) for each simulation shown. Triangles show predictions based on noisy samples centered around random locations (random predictions), which never reach the actual performance level. This suggests that information from all 4 targets is required to estimate the centroid as accurately as observed. The results were similar for target and distractor simulations.