A TECHNIQUE FOR MEASURING SINGLE-ITEM IDENTIFICATION EFFICIENCIES

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Vision Sciences Society, 2007
Poster #355

Thresholds and corresponding efficiencies (ideal/human thresholds) in identification tasks are typically measured by combining data across all items to be identified and computing a single threshold. However, this kind of analysis ignores the efficiency with which human observers use information when identifying *individual* items.

We developed a simple technique for measuring single-item efficiencies in identification tasks. For a given task (e.g., object recognition), we use a staircase procedure to initially measure a psychometric function for the entire set of *j* items ('calibration'). We then use this information to generate a fixed set of *k* stimulus levels that span the threshold range. We present all *j* items for *n* trials at each of the *k* stimulus levels, randomly intermixed. The same stimulus levels are used for all items to eliminate stimulus level as a possible cue for item identity. We then fit indvidual-item psychometric functions and compute corresponding thresholds for each stimulus by conditionalizing the analysis according to item identity (Fig 1). Individual item efficiencies are then computed by the comparing ideal/human thresholds for each item (Figs. 2 & 3).

In our experiments, we used a set of six 3D rendered objects. The images were shown in high contrast Gaussian white noise. Percent correct performance was measured at 6 fixed contrast levels over a 2 log unit range (20 trials per contrast level per item).

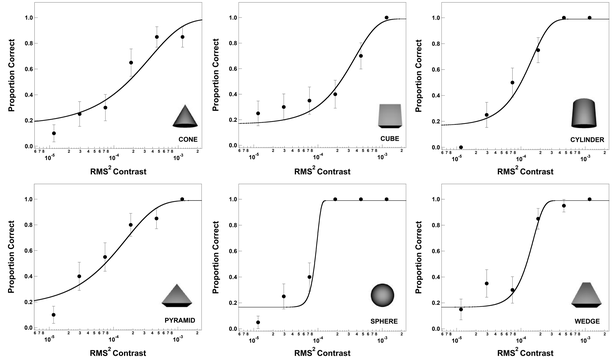

Figure 1: Example 3D Object Identification Psychometric Functions (Obs. AE)

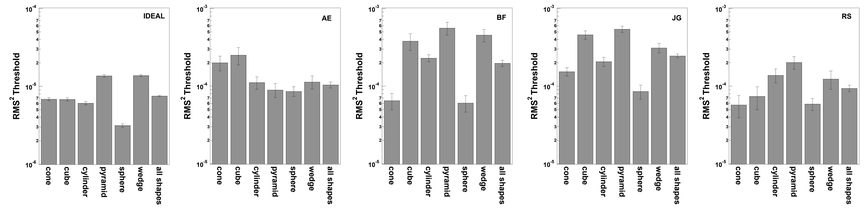

Figure 2: Identification Thresholds

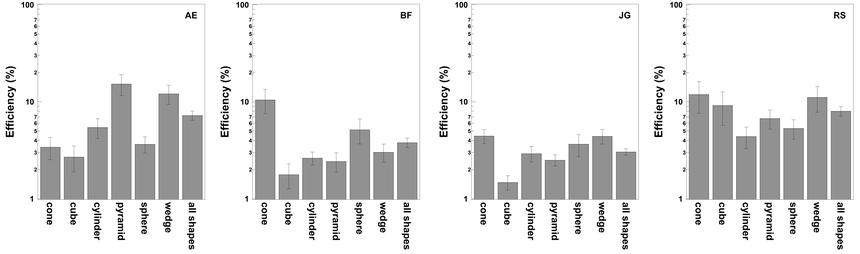

Figure 3: Identification Efficiencies

Response Bias?

If observers were biased to choose a particular item more frequently, this would serve to erroneously increase efficiency for that item. We found a moderate correlation between response frequency and efficiency for some of the observers, indicating the presence of response biases (Fig. 4).

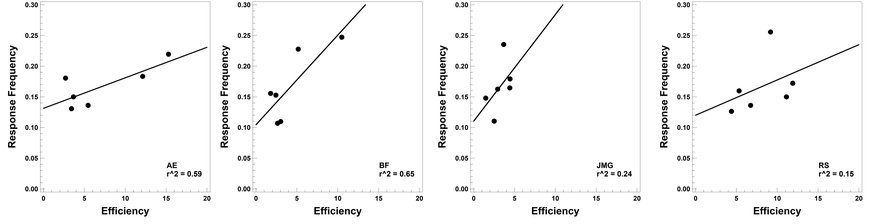

Figure 4: Response frequency vs. efficiency scatterplots / correlations.

d' Psychometric Functions.

We computed d' vs. rms contrast psychometric functions to remove the effects of response bias from our threshold estimation procedure. This was carried out at each contrast level for each item by computing the proportion of hits (correct identifications) and false alarms (incorrectly naming an item when one of the other *j-1* items appeared) and computing d' in the usual fashion (this makes some model assumptions that we are currently exploring). We then computed bias-corrected thresholds and efficiencies.

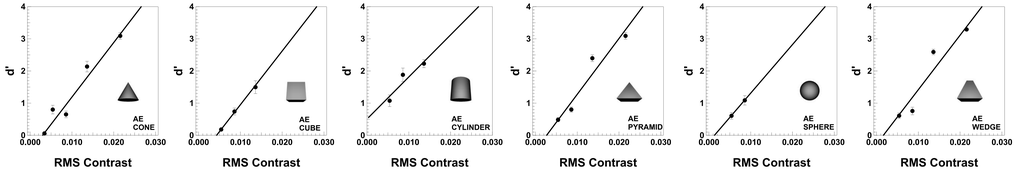

Figure 5: d' psychometric functions for observer AE (missing data points correspond to negative or infinite d' values).

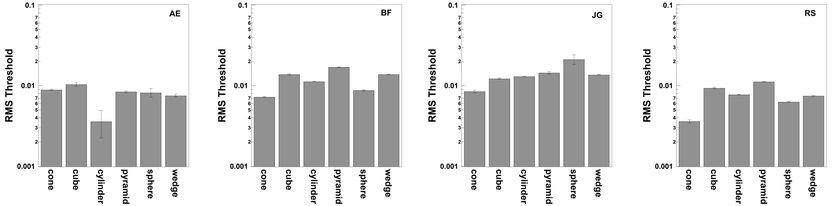

Figure 6: d' Identification Thresholds (d' = 1)

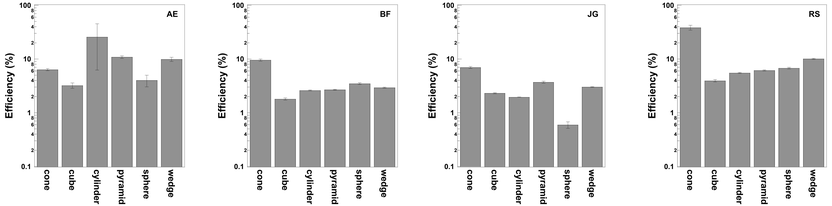

Figure 7: Bias-Corrected Identification Efficiencies

Conclusions.

Efficiency varied greatly across items in an object recognition task. We are currently applying this technique to other stimulus sets, such as letters of various fonts (e.g., bookman vs. *kunstler*). We are also exploring how varying context (e.g., set membership, set size) affects identification efficiency for individual items.