A mathematical framework for the design and analysis of feature biasing strategies

Vidhya Navalpakkam Laurent Itti

Aim: Given a target and a set of distractors, we wish to find a desirable feature biasing strategy that will render the target most salient and suppress inteference from the distractors. That is, we wish to find how bottom-up features such as color, intensity, orientation can be biased in a top-down manner so as to enable quick detection of the target amidst distractors.

Desirable feature biasing strategy: If a feature is present in the target and absent in the distractor, promoting it can further boost the target's salience. Since it already leads to a pop-out that is optimal performance, biasing is not required. If a feature is present in both the target and the distractor in an equal amount, then biasing the feature cannot yield a performance gain. To investigate this, we designed a SAME type distractor (see figure 2). Whereas, if the feature is present in a less amount in the target as compared to the distractor, then suppressing this feature can boost the target's salience relative to the distractor. To investigate this, we designed a MORE type distractor that contained the target's feature in a greater amount, and another extreme case - a NEW type distractor that contained a new feature absent in the target.

Design and analysis of experiment: To test whether humans use the desirable strategy, we designed search arrays containing the target and all 3 types of distractors and measured the relative number of fixations on each type of distractor (see figure 1 for the list of target and distractors and their difference, and figure 3 for sample search arrays). We tested 7 subjects on 600 trials over a period of 5 days each. Paired t tests over the combined data of all subjects and also for individual subjects supported our hypothesis that humans fixate more on SAME type distractors than MORE (p value = 7.6471e-11) and NEW type distractors (p value = 1.4125e-09), indicating that they used the desirable strategy of suppressing all features as each feature was present in a lesser amount in the target than the distractors.

Conclusion: We have provided a mathematical framework for the analysis and design of experiments to test various feature biasing strategies, to determine a desirable strategy and to test whether humans use that strategy.

Object type	Symbol	Features	Vector of Feature Responses
Target	T	F_T	V_T
SAME	S	$F_S = F_T$	$V_T = V_S$
MORE	M	$F_M = F_T$	$V_M = V_S + V_{more}$
NEW	N	$F_N \supset F_T$	$V_N = V_S + V_{new}$

Figure 1. List of target and distractors: Column one refers to the type of item and column two refers to the symbol by which the item is denoted. Column three denotes the features of the items with respect to the target, and column four denotes the vector of feature responses of the various items with respect to the target.

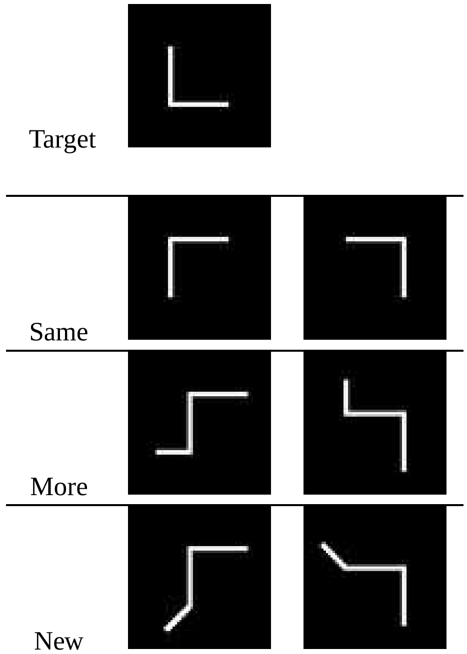

Figure 2. Target and distractor stimuli used in all the experiments.

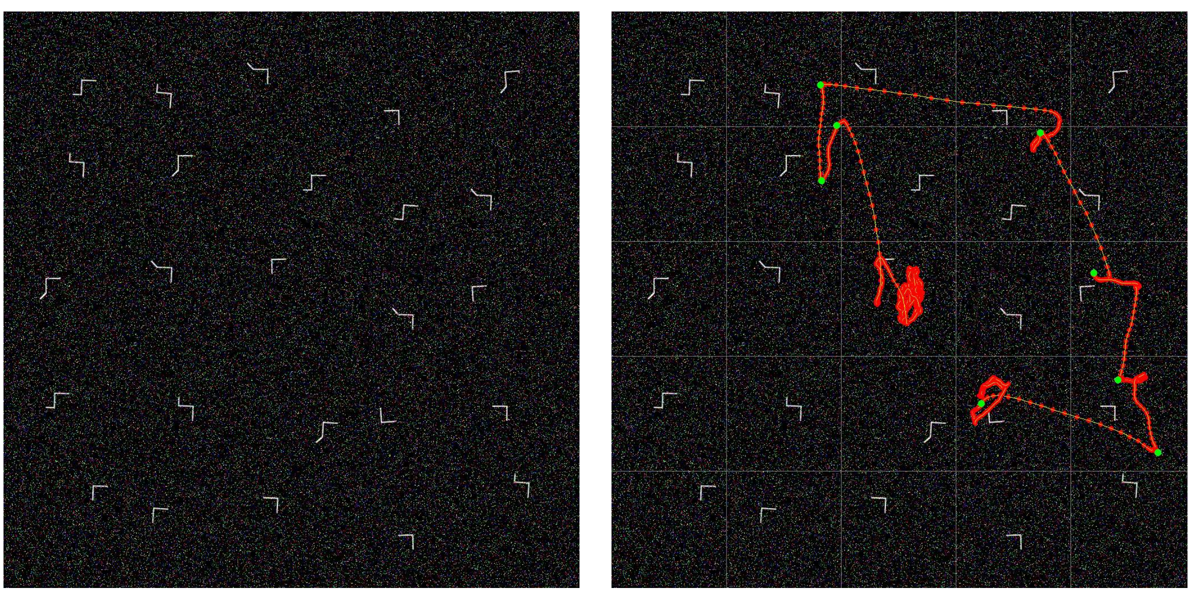

Figure 3. Sample search arrays and eye movement patterns