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PROCESSING OF IMAGE SYMMETRY IN AN RSVP TASK

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INTRODUCTION

Bilateral symmetry is visually salient and facilitates image segmentation. Previous modeling of perceptual performance suggests that, in contrast to processing of local statistics, processing of symmetry does not proceed in parallel over wide regions. Here we examine spatial and temporal factors that influence symmetry processing.

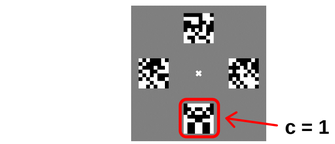
Each stimulus consisted of four 8x8 arrays of black and white checks. Three of the arrays (distractors) were colored at random; in the fourth array (the target); bilateral symmetry was introduced in a graded fashion. Trained observers (N = 6) viewed these stimuli in three modes. **(1)** SIM-P*ARAFOVEAL*: simultaneous presentation of the four arrays, positioned 4 deg from fixation along the cardinal axes, for durations of either 100 or 400 ms. **(2)** RSVP-C*ENTRAL*: sequential presentation of the four arrays, centered at fixation, 100 ms duration, 50 ms ISI. **(3)** RSVP-P*ARAFOVEAL*: sequential presentation of the four arrays with the RSVP-C time course, but at the four locations trained in SIM-P, in random order. In all modes, a 500 ms mask followed the final stimulus. In each trial, the observer was to indicate with a button press the location of the target in the array **(1)**, or the position of the target in the temporal sequence **(2, 3)**.

Counter to the prediction of a parallel model, fraction correct in RSVP-C and RSVP-P presentations was higher than for simultaneous presentation (SIM-P) at the same exposure duration. However, counter to the prediction of a serial model, performance in SIM-P mode was better than in either RSVP mode for stimuli with approximate symmetry, when the exposure duration in SIM-P mode equaled the total presentation time in RSVP mode.

We conclude that processing of bilateral symmetry is constrained by attentional scanning, and is neither purely parallel nor serial.

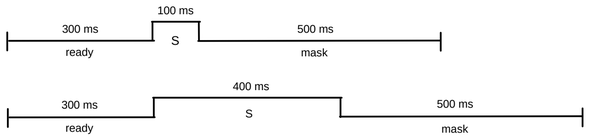
TASK: Which one of the four arrays is different?

Simultaneous - Parafoveal

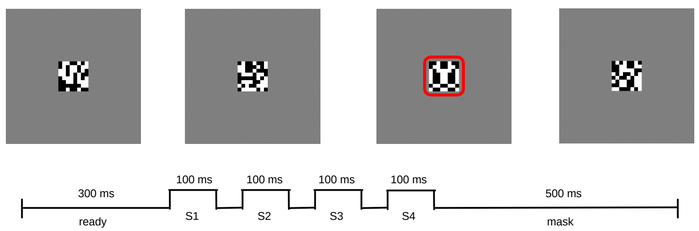


METHODS

- 8 x 8 arrays; check size: 20 min
- test distance: 102.6 cm
- mean luminance: 47 cd/m^2
- Cambridge Research VSG2/3 system
- 6 trained observers; corrected to 20/20 VA
- 4AFC; 1 - 6 hours of practice with feedback
- 144 - 176 trials per data point per subject



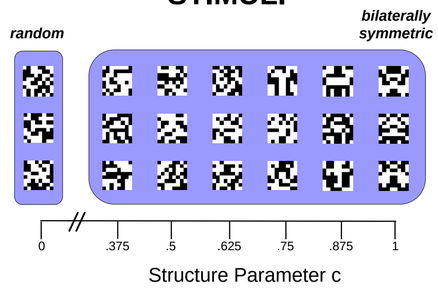
RSVP - Central



RSVP - Parafoveal

Supported by EY7977 (MC, JV) and NS36699 (KP)

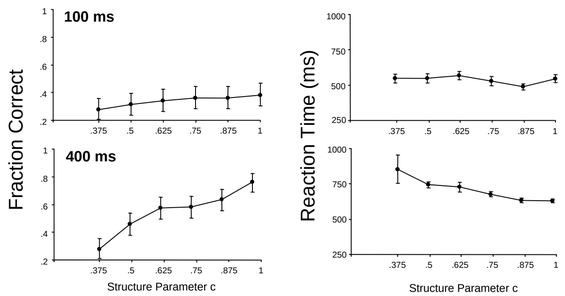
STIMULI



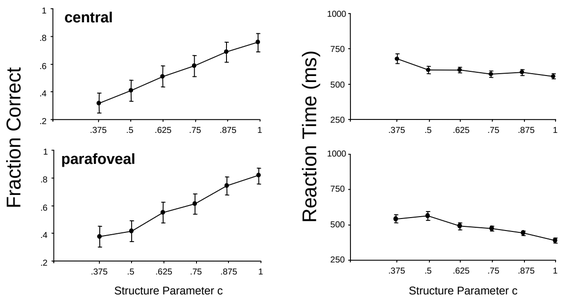
Each trial contained four arrays: three distractors that were spatially random, and one target with a particular value of the structure parameter c (above). An array with c = 1 corresponds to perfect bilateral symmetry; an array with a lower value of c has partial (degraded) symmetry.

Simultaneous

S: CC



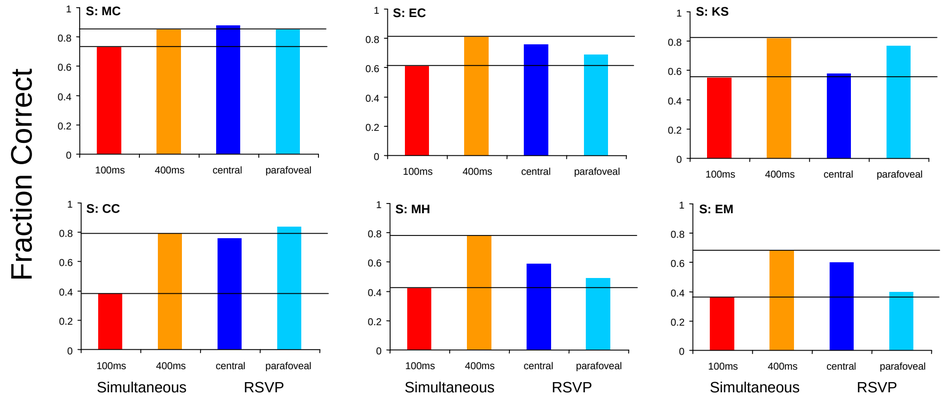
RSVP



For subject CC, fraction correct for perfect symmetry (c = 1) was 0.79 at 400 ms, but near chance at 100 ms in the simultaneous-parafoveal mode. Fraction correct for both RSVP modes was comparable to the fraction correct for the 400 ms simultaneous presentation.

In the three conditions in which fraction correct increased with increasing structure, reaction time correspondingly decreased. Reaction time in the RSVP-parafoveal condition was shorter than in the RSVP-central condition by 97 ms in this subject, and by an average of 206 ms across subjects.

Comparison Across Presentation Modes

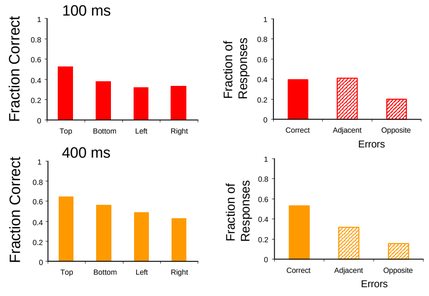


Fraction correct for perfect symmetry (c = 1) is shown above. In all subjects, fraction correct in the 100 ms simultaneous-parafoveal condition (lower horizontal line) is less than for both of the RSVP conditions. This indicates that processing is not purely parallel. In four of six subjects, fraction correct in the 400 ms simultaneous-parafoveal condition (upper horizontal line) is greater than for both of the RSVP conditions. In these subjects, processing is more efficient when targets are visible simultaneously, thus indicating that processing is not purely serial.

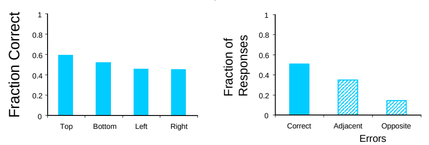
N = 6

Where is the target detected?

Simultaneous - parafoveal



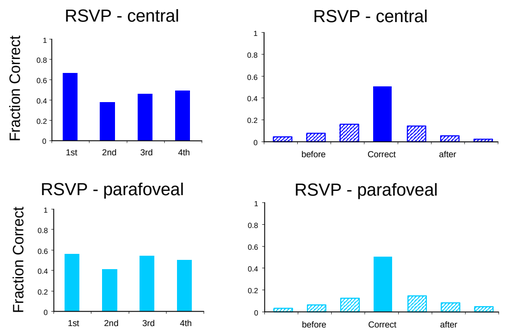
RSVP - parafoveal



In the three parafoveal conditions above, the arrays were spatially separated. Fraction correct was highest for targets in the top position and next highest for targets in the bottom position.

Errors were spatially random (adjacent arrays accounted for twice as many errors as the opposite array), other than a slight bias towards the adjacent target in the RSVP-parafoveal mode.

When is the target detected? ***When are the errors made?***



In the two serial modes (RSVP-central, RSVP-parafoveal), fraction correct was highest when the target is presented first and lowest when the target appears in the second stimulus interval.

Errors were *not* temporally random, with most incorrect choices consisting of selecting a distractor that immediately preceded or followed the target.

Since these phenomena were seen equally for stimuli that overlapped spatially (RSVP-central) and those that did not (RSVP-parafoveal), they implicate attentional mechanisms rather than spatial masking.

SUMMARY & CONCLUSIONS

Processing of bilateral symmetry is not consistent with either a purely parallel or serial model. We suggest that the advantage of simultaneous presentation seen in 4 of 6 observers is that it allows a strategy in which visual selection of a subset of the arrays is followed by focal attention and processing - a parallel mechanism followed by a serial process.

Symmetry detection is best along the vertical axis of symmetry in the display, whether or not arrays are presented simultaneously. In sequential presentations, the first stimulus is processed most efficiently, and errors generally reflect temporal confusion. Together, these findings suggest that symmetry detection utilizes a dynamic visual routine, rather than a static neural computation.