

ATTENTIONAL CONTRIBUTIONS TO VISUAL PROCESSING OF SYMMETRY

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INTRODUCTION

Previously (SFN, 2002) we showed that processing of vertical-axis mirror symmetry (V) is not consistent with either a pure parallel or serial model, and is more efficient along the vertical midline than off-axis. Here we extend the analysis to horizontal (H) symmetry, to determine the generality and basis of these observations.

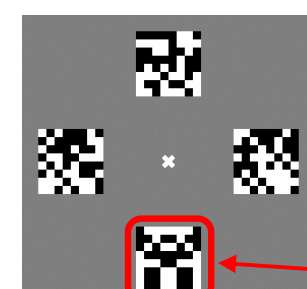
Each stimulus consisted of four 8x8 arrays of black and white checks. Three of the arrays (distractors) were colored at random; in the fourth array (the target), bilateral symmetry was introduced. We measured fraction correct (FC) and reaction time in a 4-AFC search task. Trained observers (N = 7) viewed these stimuli in single-symmetry blocks (V or H), and in randomly mixed blocks (V and H). The four arrays were positioned 4 deg from fixation along the cardinal axes, and presented for durations of either 100 or 400 ms. In single-symmetry blocks, an RSVP mode (SFN, 2002) was also employed (100 ms per stimulus, 50 ms ISIs).

In many respects, V and H symmetry results were similar: FC in RSVP was higher than FC for simultaneous presentation at 100 ms, but not as high as FC for simultaneous presentation at 400 ms. In RSVP modes, FC was highest when the target was presented first. A masking effect was seen at 200 ms followed by recovery of sensitivity at 300 and 400 ms. Errors were not temporally random. When wrong, subjects usually selected the distractor immediately preceding or following the target. However, the spatial error patterns were distinctive. For V-only blocks, FC was highest along the vertical midline of the display. For H-only blocks, FC was highest along the horizontal midline. In mixed blocks, the error pattern was intermediate.

We conclude that stimulus expectation guides the focal attention scanning strategy employed when processing bilateral symmetry. In particular, stimulus expectation enhances processing of vertical symmetry on the vertical midline, and horizontal symmetry on the horizontal midline.

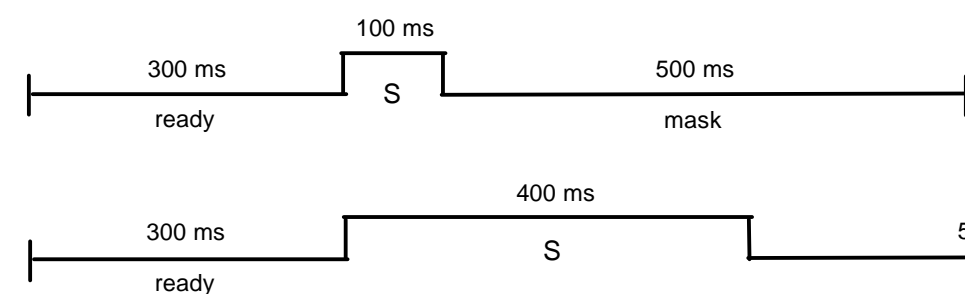
STIMULI & METHODS

Simultaneous – Parafoveal (100 ms and 400 ms)



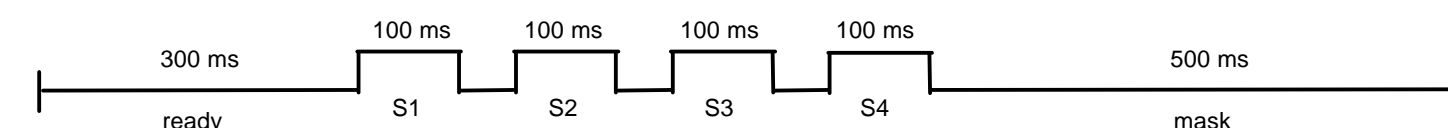
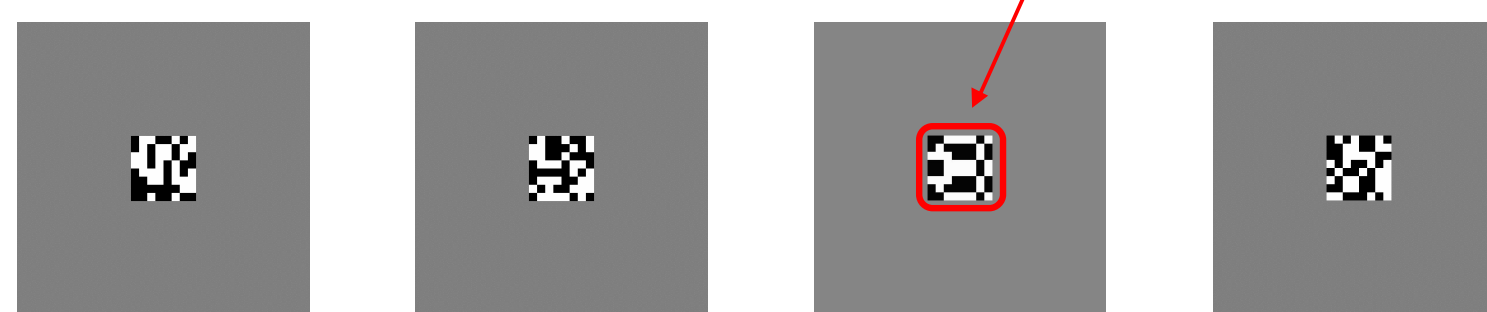
TASK: Which one of the four arrays is different?

- check size: 20 min
- test distance: 103 cm
- mean luminance: 47 cd/m²
- 8x8 arrays; contrast = 1.0
- Cambridge Research VSG2 system
- 7 trained observers; corrected to 20/20 VA
- 4-AFC; 1 - 6 hrs of practice with feedback



RSVP - Central

arrays are presented sequentially at one fixed location



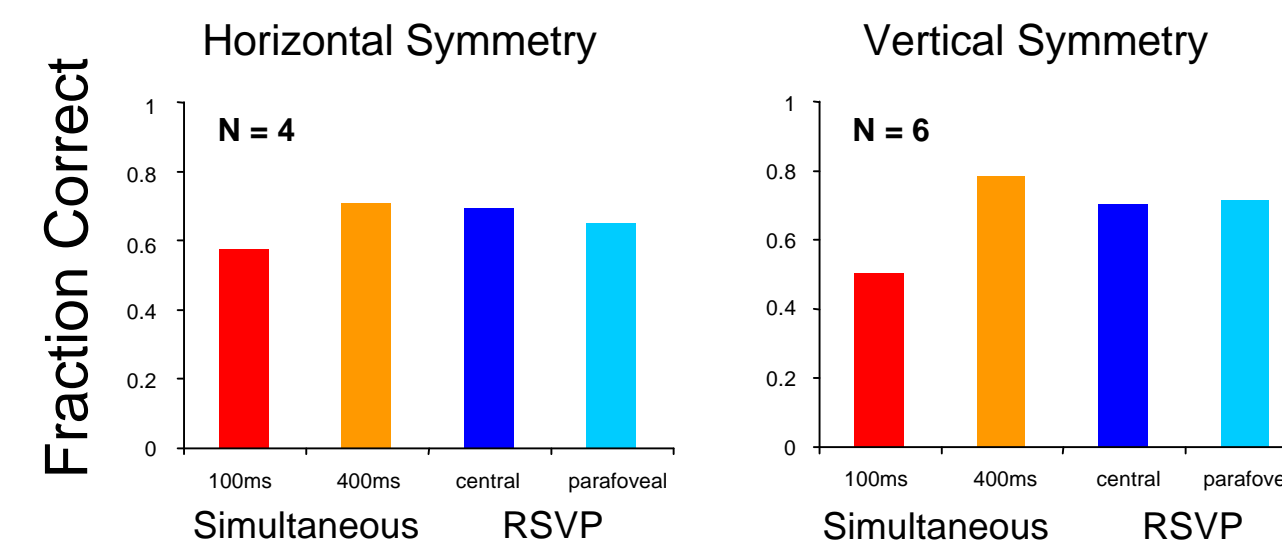
RSVP - Parafoveal

arrays are presented sequentially and randomly at four fixed locations



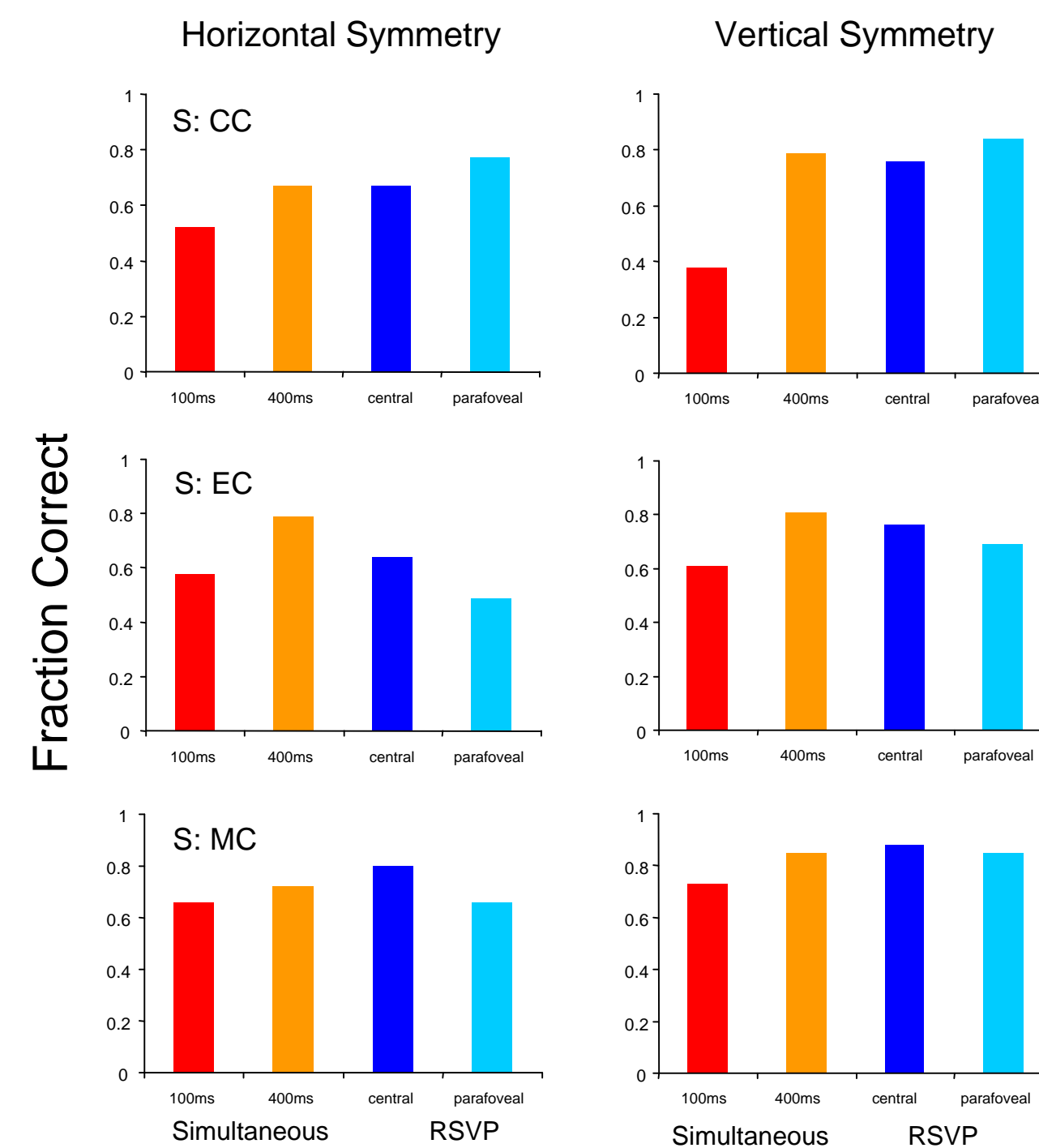
RESULTS

1. Not Parallel, Not Serial



Comparison Across Presentation Modes. Pooled fraction correct data for single-symmetry blocks (horizontal or vertical) are shown above for each of the four presentation modes. Fraction correct in the 100 ms Simultaneous condition is *less* than for the two RSVP conditions (100 ms per stimulus array). This suggests that processing is not purely parallel. However, fraction correct in the 400 ms Simultaneous condition is *greater* than for the RSVP conditions, suggesting that processing can be more efficient when the arrays are visible simultaneously. This indicates that processing is not purely serial.

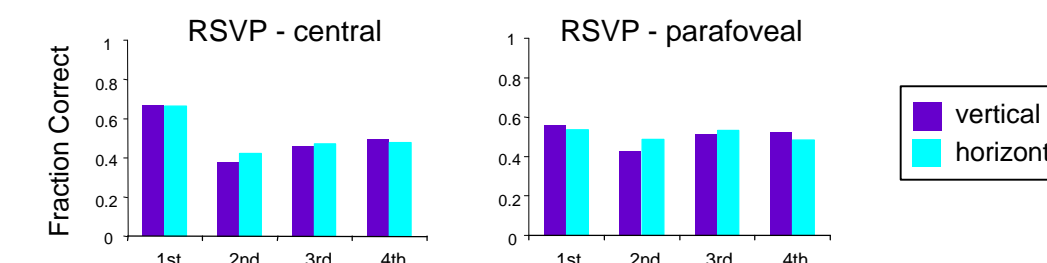
Results from the three subjects who participated in both experiments are shown below.



There are individual differences between subjects, but within each subject, the performance pattern is similar for horizontal and vertical symmetry. The advantage of 400 ms Simultaneous presentation over both RSVP modes (subject EC) suggests a scanning 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.

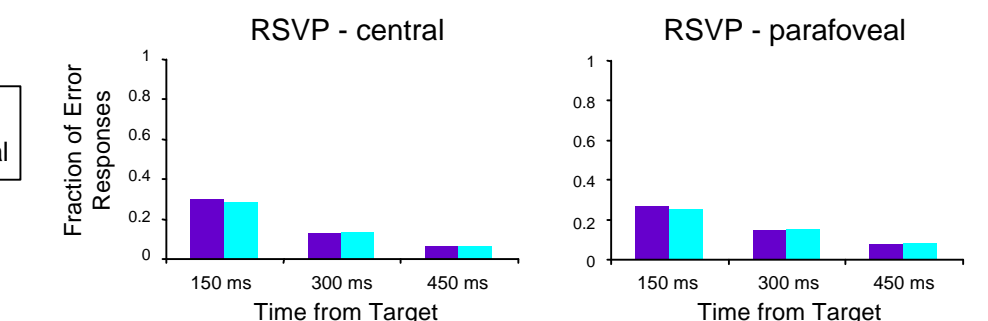
RSVP Presentation Modes

2. When is the Target Detected?



For both sequential presentation modes, fraction correct was highest in the 1st interval and lowest in the 2nd interval, suggesting that masking is occurring at 150 - 250 ms followed by recovery by the 3rd interval. Some masking is present even when stimuli are presented in separate locations (RSVP-parafoveal).

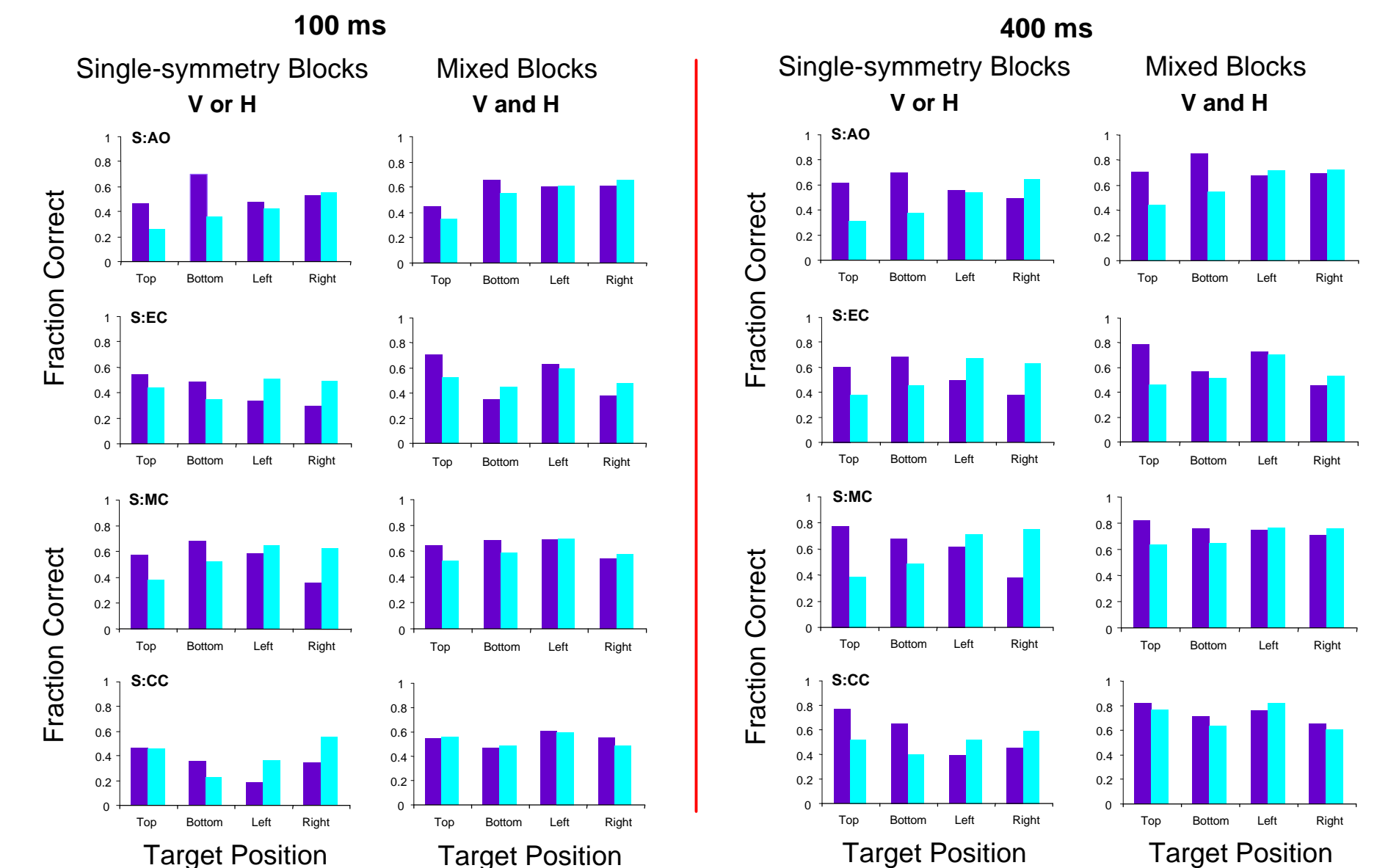
3. When are the Errors Made?



Errors were *not* temporally random. The most frequent error response is the choice of the temporally adjacent distractor (150 ms before or after target).

Simultaneous - Parafoveal Modes

4. Where is the Target Detected?



In the single-symmetry blocks, fraction correct depended strongly on target position. Horizontal symmetry was detected more frequently on the horizontal axis, and vertical symmetry was detected more frequently on the vertical axis. In addition, some subjects detected targets more frequently on the top than bottom, or more frequently on the left than right. Positional biases were larger at 400 ms than at 100 ms. In the mixed blocks, there was almost no dependence of fraction correct on target position for 100 ms presentations, and a modest dependence on target position for 400 ms presentations. These interactions are summarized by the **Symmetry Bias Index** below.

SUMMARY & CONCLUSIONS

• Horizontal and vertical symmetry detection is inconsistent with a purely parallel or serial process (Results 1). Both tasks show similar masking (Results 2) and temporal confusion errors (Results 3) in RSVP presentations.

• Positional biases in symmetry detection interact with the direction of the symmetry axis (Results 4). These biases can be induced by the subject's expectation of the direction of symmetry axis (single-symmetry blocks), and evolve over the processing of the stimulus (400 ms vs 100 ms).

• These findings suggest that symmetry detection utilizes a dynamic visual routine, in which ongoing processing guides attentional strategy, rather than a static neural computation.

