Objects of interest can be selected serially and processed in parallel during visual search

Gregory J. Christie, Richard D. Wright, John J. McDonald
Simon Fraser University, Burnaby, British Columbia, Canada
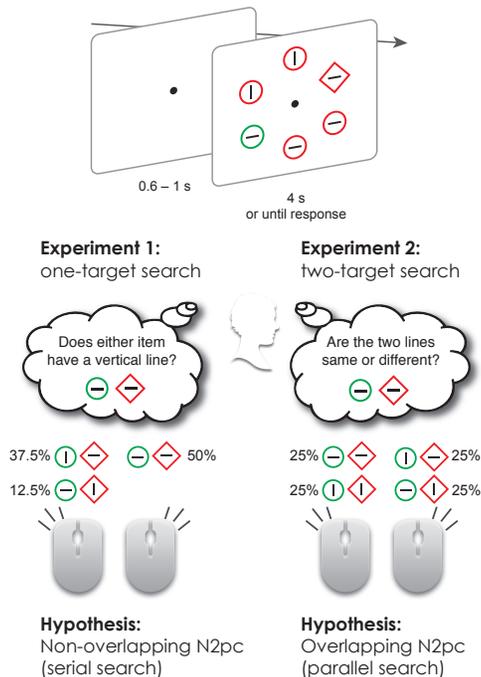
gchristi@sfu.ca
sfu.ca/~gchristi/
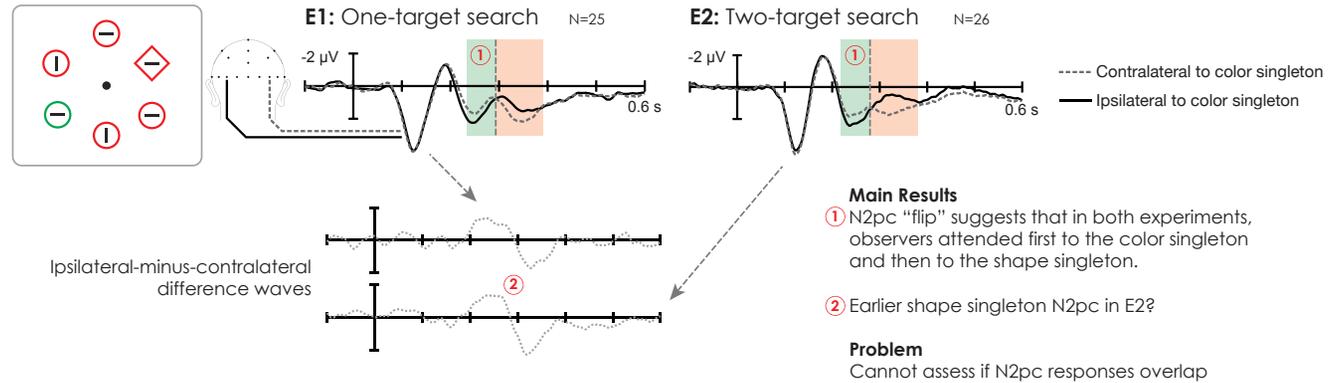
SFU

Parallel and serial visual search

A long-standing debate has centered on whether attention can be deployed simultaneously to many spatial locations, or is restricted to a single spatial location. Several studies have investigated this question using two-singleton visual search tasks. The locus of attentional selection was tracked from one singleton to the other using the N2pc component of the time-locked ERP. Some studies have shown discrete, non-overlapping N2pc responses, which suggests that attention selects items serially (1,2). Other studies have shown overlapping N2pc responses, which suggests parallel search (3).

One possibility is that these discrepant results are due to different target parameters. Studies supporting serial selection required the detection of a task-defining feature contained in only one of the two singletons (one-target task). By comparison, studies supporting parallel selection required the evaluation of both singletons (two-target task). Here, we confirm that searching for one target promotes serial selection and that searching for two targets promotes concurrent selection.
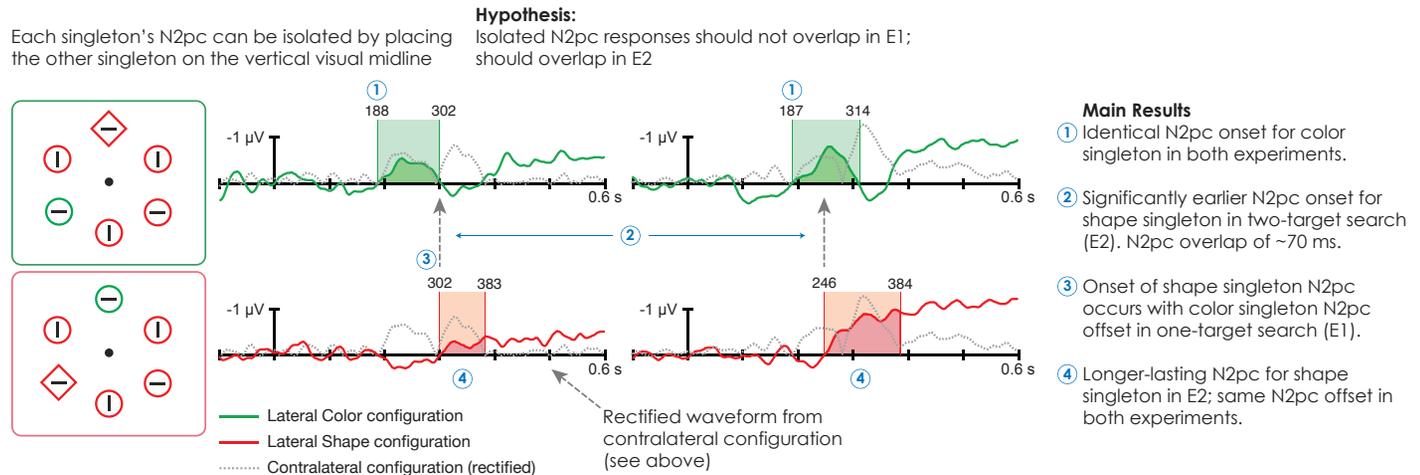
Two-singleton search display[4]

Experiment 1: one-target search
Experiment 2: two-target search

Does either item have a vertical line?

Are the two lines same or different?

37.5% 50%
12.5%

25% 25%
25% 25%

Hypothesis: Non-overlapping N2pc (serial search)

Hypothesis: Overlapping N2pc (parallel search)

N2pc tracks the order of attentional selection

E1: One-target search   N=25
E2: Two-target search   N=26
-2 μV   0.6 s

- - - - Contralateral to color singleton
———— Ipsilateral to color singleton

Ipsilateral-minus-contralateral difference waves

Main Results

① N2pc "flip" suggests that in both experiments, observers attended first to the color singleton and then to the shape singleton.

② Earlier shape singleton N2pc in E2?

Problem
Cannot assess if N2pc responses overlap

Different search strategies in one- and two-target search tasks

Each singleton's N2pc can be isolated by placing the other singleton on the vertical visual midline

Hypothesis:
Isolated N2pc responses should not overlap in E1; should overlap in E2

-1 μV   188 302   0.6 s
-1 μV   187 314   0.6 s
-1 μV   302 383   0.6 s
-1 μV   246 384   0.6 s

———— Lateral Color configuration
———— Lateral Shape configuration
.... Contralateral configuration (rectified)

Rectified waveform from contralateral configuration (see above)

Main Results

① Identical N2pc onset for color singleton in both experiments.

② Significantly earlier N2pc onset for shape singleton in two-target search (E2). N2pc overlap of ~70 ms.

③ Onset of shape singleton N2pc occurs with color singleton N2pc offset in one-target search (E1).

④ Longer-lasting N2pc for shape singleton in E2; same N2pc offset in both experiments.

Conclusions

Purely serial selection has been observed when participants searched for a target located in one of two singletons. On the other hand, partially concurrent selection has been observed when participants compared two target singletons against each other.

Here, we show that the shift from one- to two-target search results in concurrent target processing, as evidenced by partially overlapping N2pc responses.

This finding supports theories that visual attention can serially select items for parallel processing in some search tasks (5).

1. Woodman & Luck (1999), *Nature*
2. Woodman & Luck (2003), *JEP:HPP*
3. Eimer & Grubert (2014), *Curr. Biol.*
4. Theeuwes (1991), *Percept. Psychophys.*
5. Wolfe (2007), *Guided Search 4.0*

INNOVATION.CA

hel human electrophysiology lab

CANADA RESEARCH CHAIRS

NSERC CRSNG