4636

DYNAMICS of SELECTIVE SPATIAL ATTENTION in a WORKING MEMORY TASK

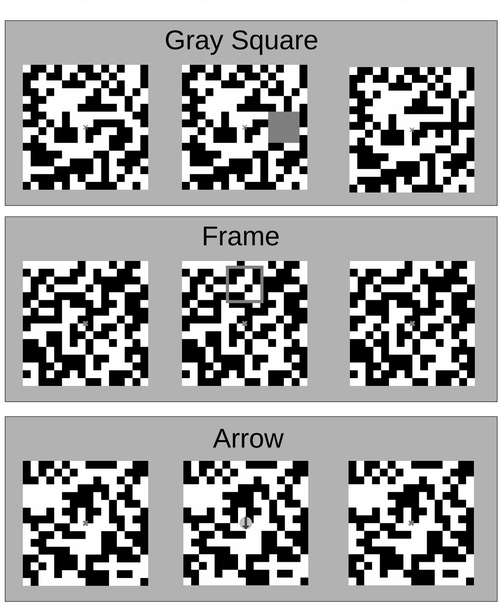
Jonathan D. Victor and Mary M. Conte

Department of Neurology and Neuroscience, Weill Medical College of Cornell University, New York, NY

ABSTRACT

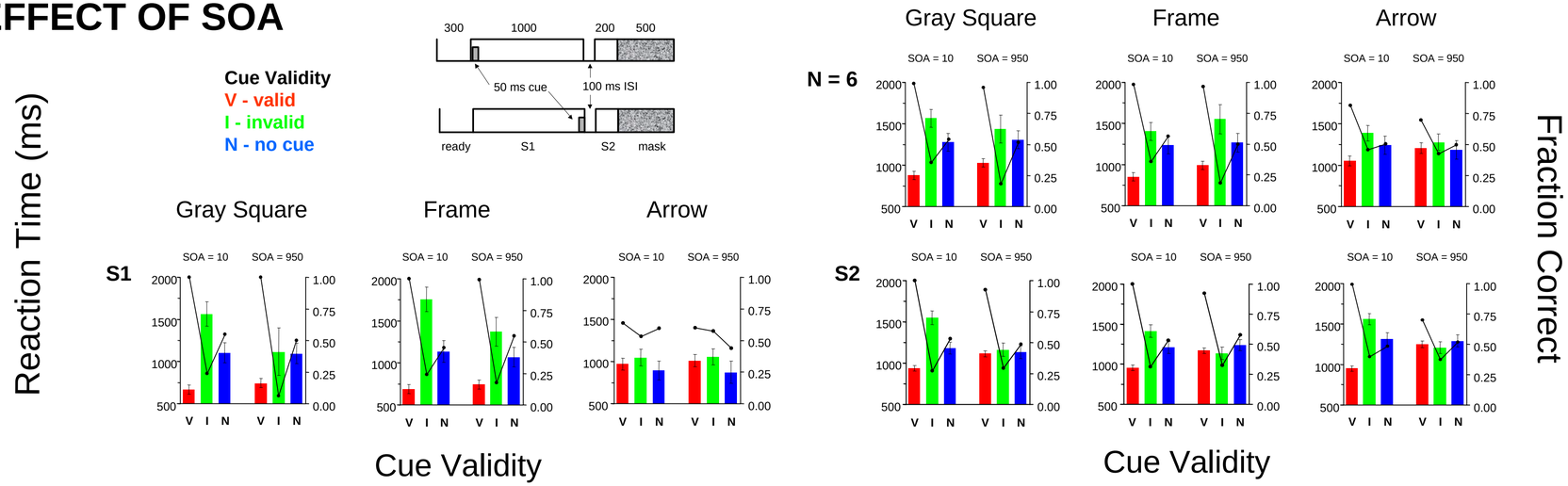
Purpose: Selective visual attention can be directed by explicit cues, such as an arrow at the locus of fixation, and by implicit cues at the target location to be attended. Explicit and implicit cueing is associated with different patterns of brain activation (Corbetta et al., 2000), and thus may act via distinct mechanisms. The time course of a shift from foveal to nonfoveal attention may differ, independent of the processing demands of the cue. The time courses of their effects may also differ due to the different processing demands of the cues themselves.
Methods: We examined these possibilities in a visual working memory task. Subjects were shown a random 16 x 16-element checkerboard (S1) subtending 9 deg. After a blank interval, the display re-appeared (S2), with 8 checks within one of four possible 4 x 4-element target regions (located along the cardinal axes) contrast-reversed. S2 was followed by a mask of smaller checks. Subjects were asked to identify which of the four possible target regions changed from S1 to S2. 80% of trials were cued (55% of these validly) during S1, with an explicit central arrow, or one of two implicit cues: outlining a target region with a frame, or briefly setting its contrast to zero. Cue types were blocked in sessions of 360 trials, and order of sessions was counterbalanced. Within each session, we varied the interval between S1 onset and cue (SOA) and the interval between S1 and S2 (ISI).
Results: Across subjects and experiments, fraction correct was 89% in valid-cue trials, 55% in no-cue trials, and 31% in invalid-cue trials. Performance, measured by reaction time in correct trials, was shortest in valid-cue trials, longer in no-cue trials, and longest in invalid-cue trials. The explicit cue effect on reaction time was reduced when it appeared at the end of S1 (long SOA), compared to when it appeared at the beginning. Implicit cues showed less of a dependence on SOA. Conversely, in explicit-cue blocks, reaction time improved when ISI increased, even when no cue was present.
Conclusions: Cue type (implicit vs. explicit) influences the time course of cueing. Much of this dependence relates to the dynamics of attentional shifts, rather than processing of the cue.

STIMULI and METHODS

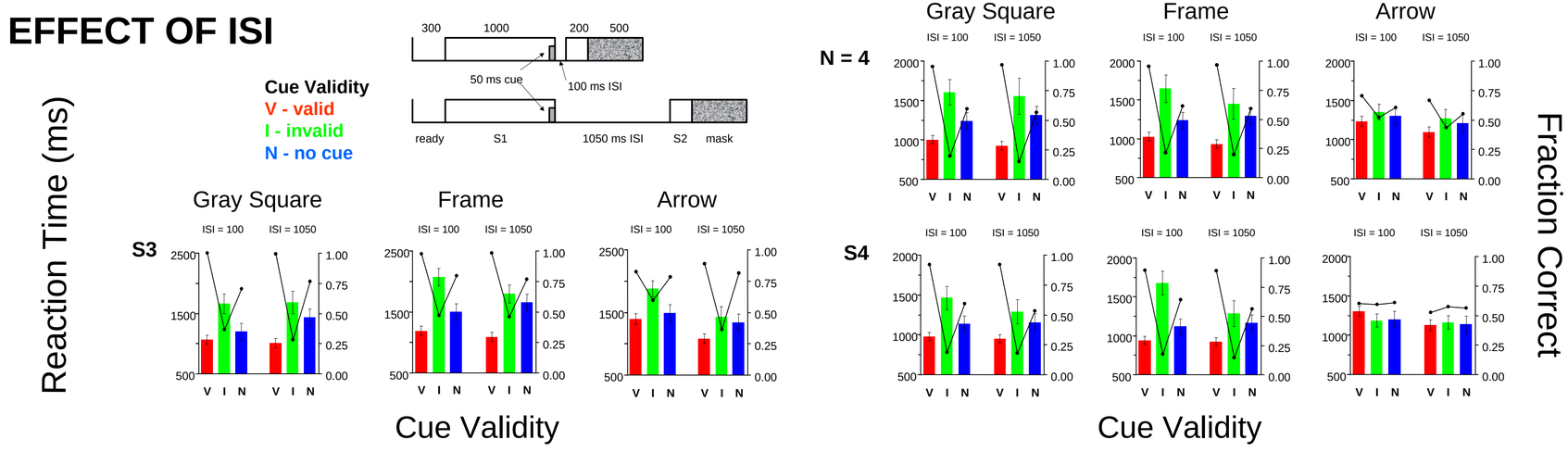


- 6 subjects (5 naïve) in SOA experiment, 4 subjects continued in ISI experiment
- 6 to 8 hours of practice with feedback
- 720 trials per condition, 5-AFC
  - 11% catch trials; other trials equally divided among 4 alternative targets
  - 80% cued trails; 55% of these were validly cued
  - no feedback

EFFECT OF SOA



EFFECT OF ISI



RESULTS

- In all subjects, valid cues decreased reaction time and increased fraction correct; invalid cues increased reaction time and decreased fraction correct.
- The two implicit cues (gray square and frame) led to nearly identical attentional effects.
- The attentional effect of the explicit cue (centrally-placed arrow) was weaker.
- Short and long SOAs led to similar cueing effects, across cue types and subjects.
- For the two implicit cues, attentional effects did not depend on ISI.
- For the explicit cue, reaction times were shorter at the long ISI. In addition, the cueing effect was greater.

CONCLUSIONS

- Spatial cueing effects are readily demonstrated in a visual working memory task, and are comparable in magnitude to cueing effects in simple detection tasks.
- Implicit spatial cueing is rapid, and appears to be independent of the nature of the cue.
- Explicit spatial cueing to a peripheral location requires a measurable interval to achieve full strength.
  - Some of this ISI-dependence may reflect the time to process the explicit cue.
  - Results in the absence of a cue indicate that the time required to shift spatial attention is greater when the fixation point is being monitored for a cue than when the cues appear in the periphery.

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