

Pupil Size Reveals Template Construction and Target Detection in RSVP Search

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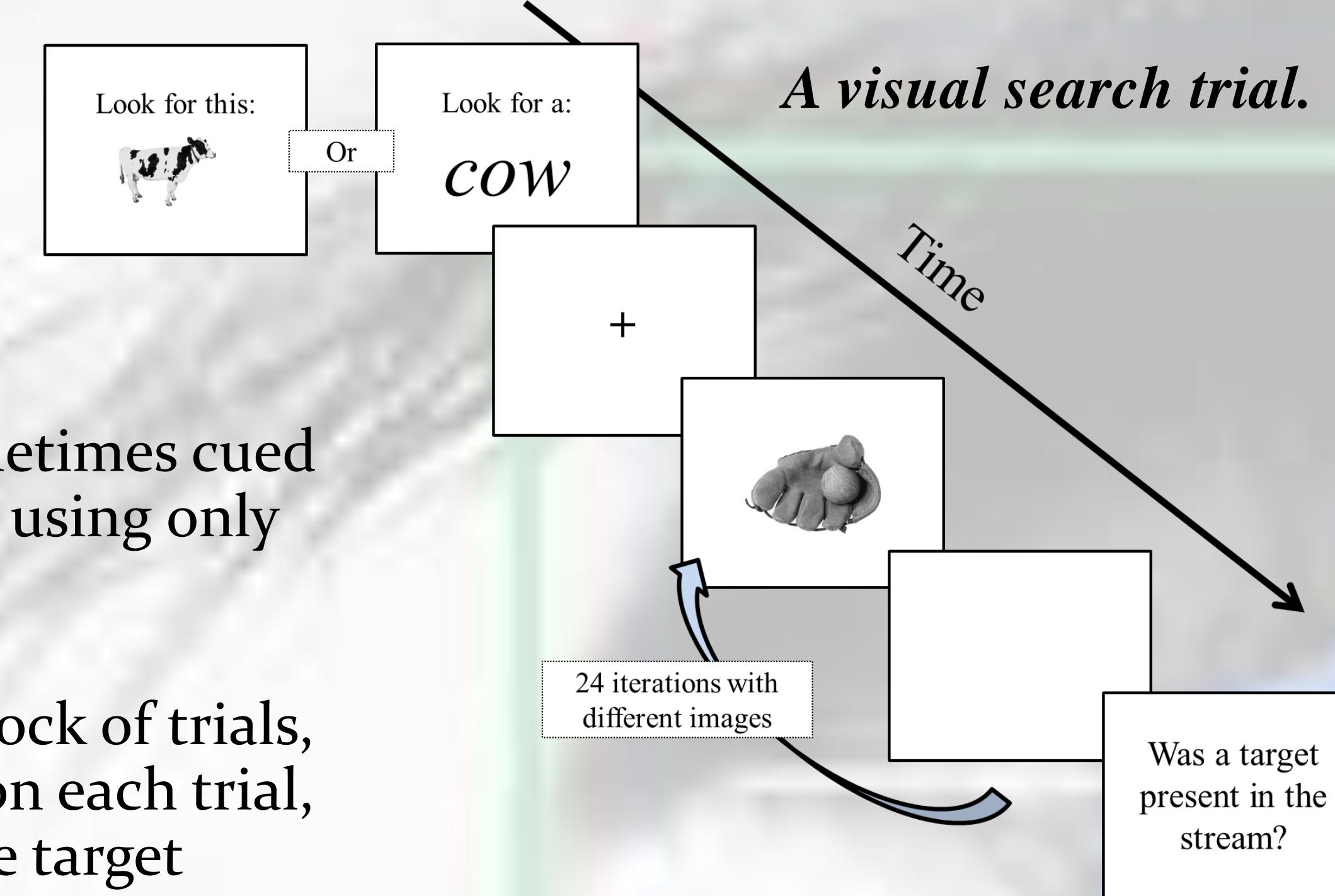
- - - IMPRECISE TARGET TEMPLATES - - -

- In laboratory search, people typically search for single, unambiguous targets.
- But real-life search rarely affords such precision.
- People often look for multiple targets (e.g., shopping for groceries), using imprecise templates (e.g., “find beer” versus “find Guinness”).
- With imprecise targets, observers construct representations by compiling features from long-term memory.



- - - CURRENT INVESTIGATION - - -

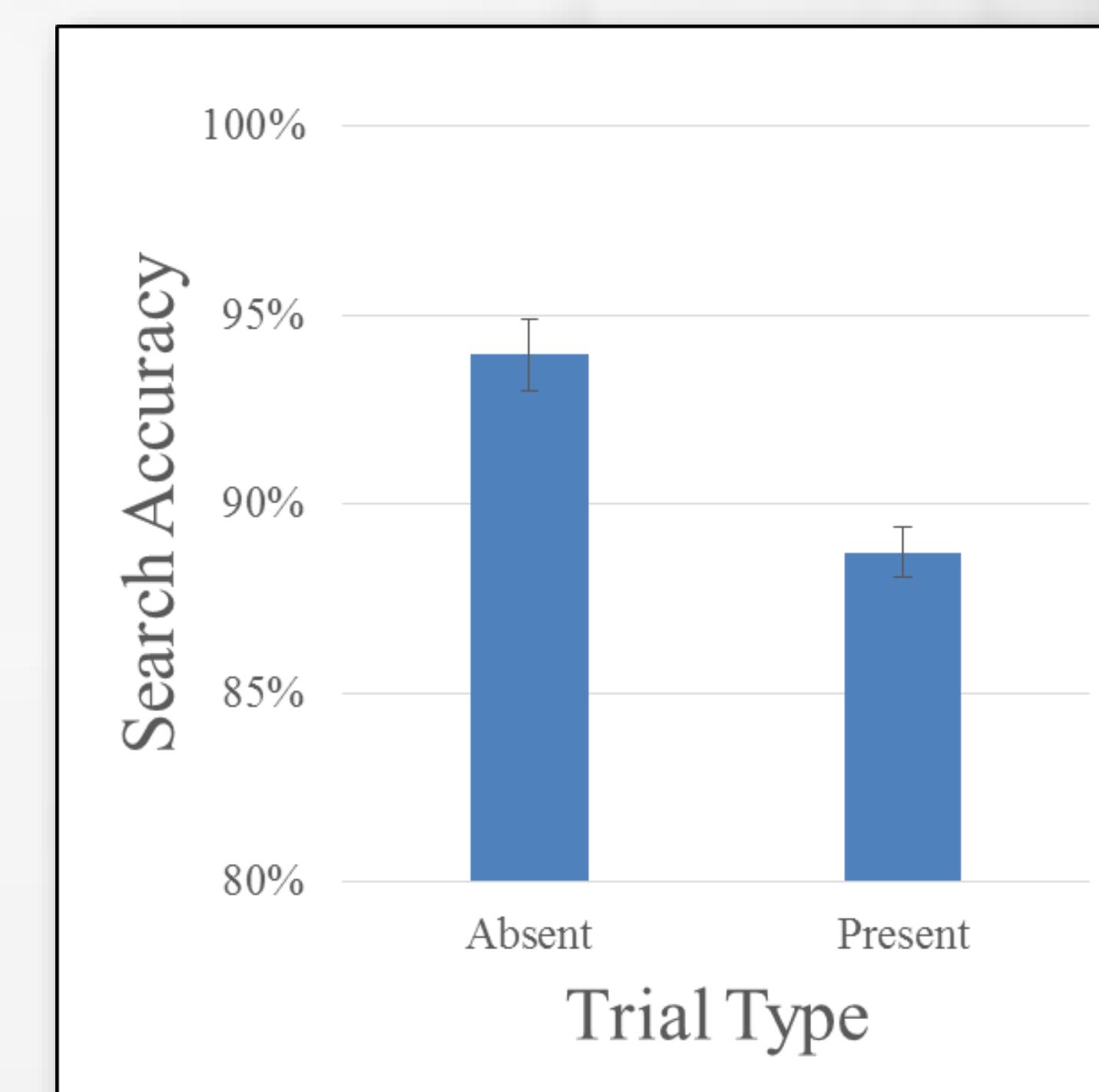
- People searched through streams of 24 rapidly presented (200 msec, followed by a 50 msec blank screen) real-world objects. They indicated target absence or presence after the stream. Images were gray-scaled.
- Load (1 target vs. 3 targets): people sometimes looked for a single target, and on other trials looked for three potential targets (only one target could appear).
- Cue Type (pictures, words): targets were sometimes cued using veridical pictures, and in other blocks, using only word cues (e.g., “find a backpack”).
- Repetition (random vs. blocked): within a block of trials, people sometimes searched for new targets on each trial, and in other blocks, they looked for the same target category(s) on each trial.
- Pupil diameter was recorded by an SR-Systems Eyelink 1000 eyetracker at 500hz. All responses were made using the keyboard. E-Prime software was used.



- - - BEHAVIORAL RESULTS - - -

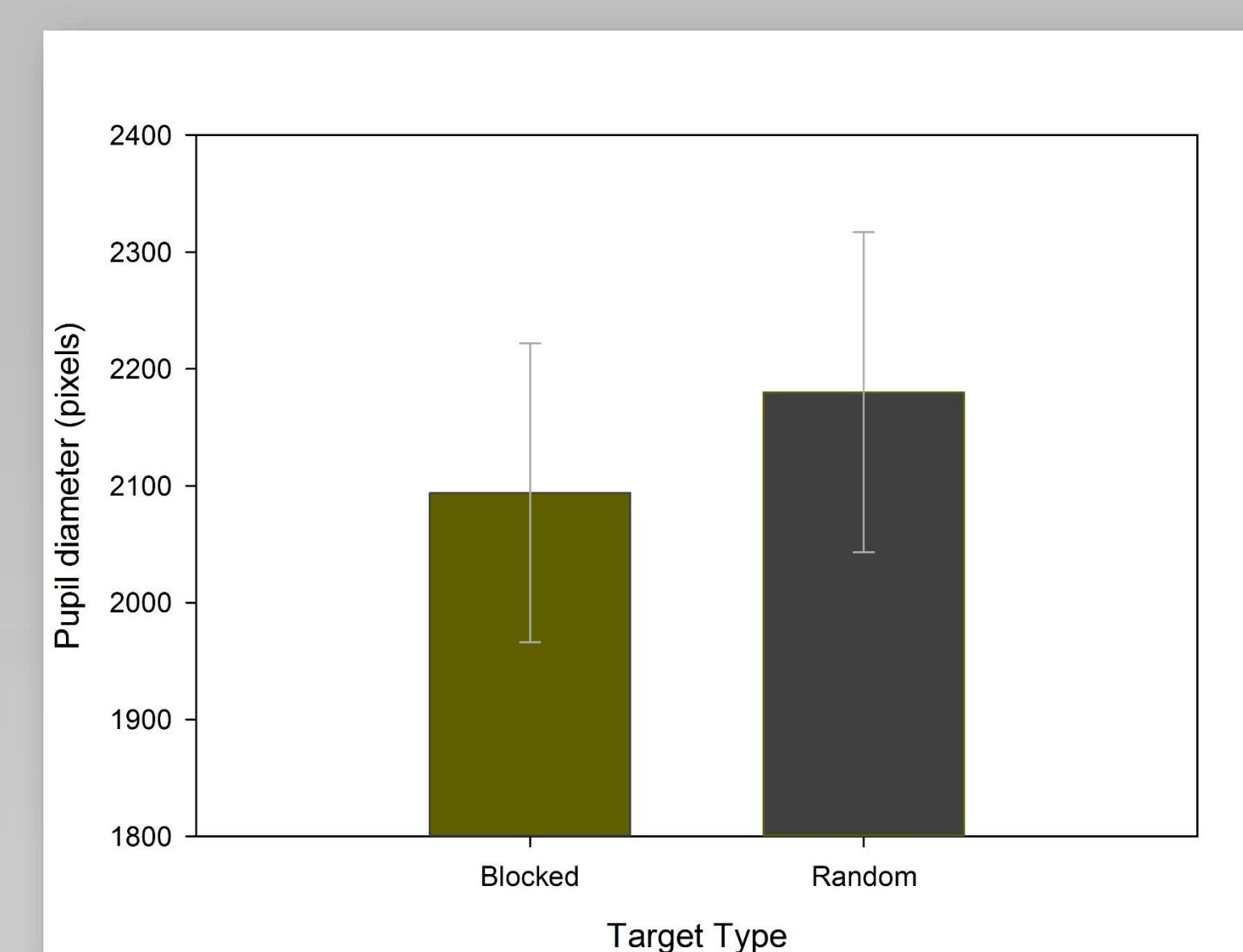
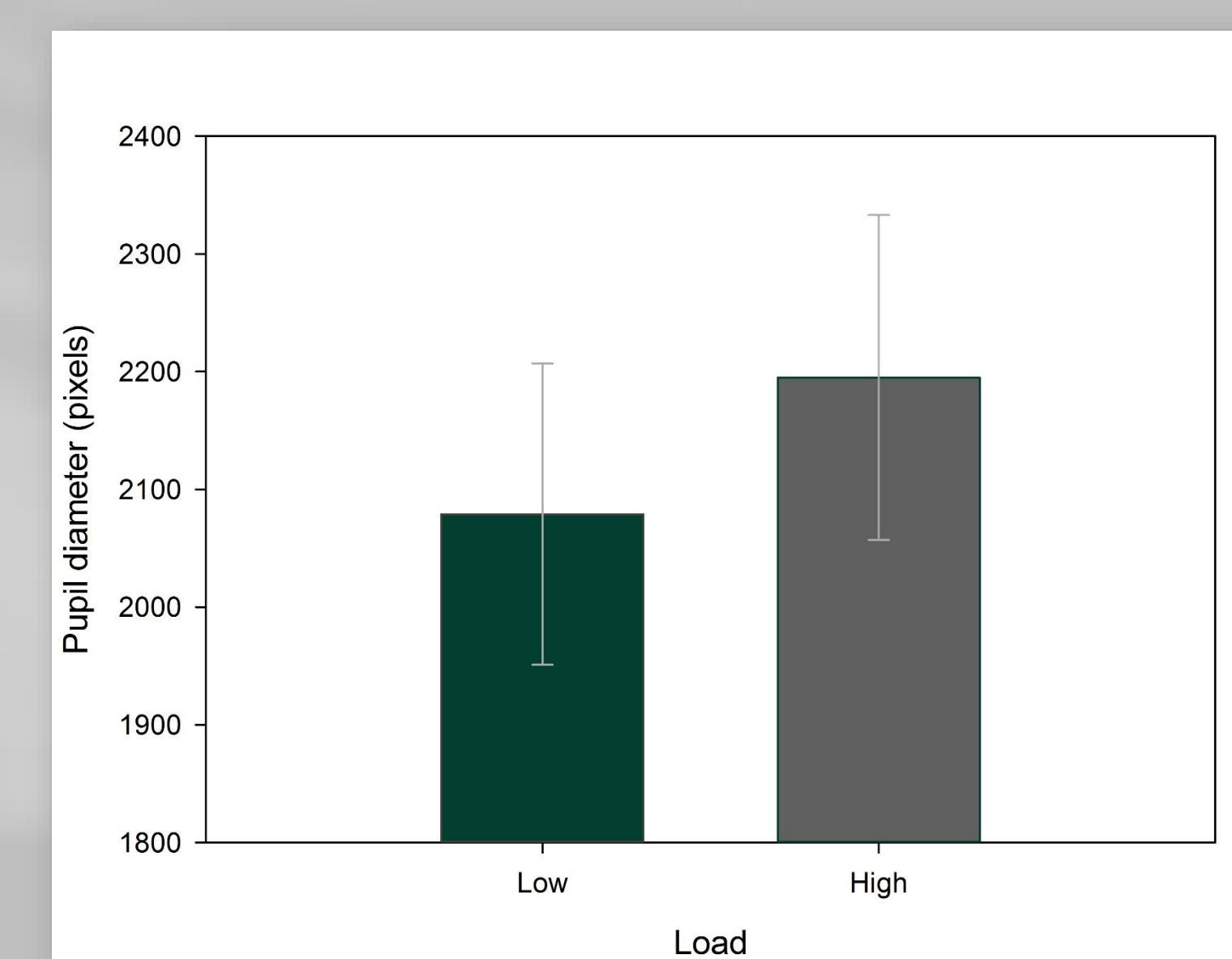


- Search performance was worse under load ($p < .001$; $\eta_p^2 = .62$), worse with imprecise templates ($p < .001$; $\eta_p^2 = .54$), and worse when templates had to be updated on each trial ($p < .001$; $\eta_p^2 = .67$).
- People also committed more misses than false alarms ($p < .001$; $\eta_p^2 = .41$).
- Having to update one’s template exacerbated the difficulty of looking for several targets (Load x Repetition: $p < .01$; $\eta_p^2 = .22$) and of having imprecise templates (Cue Type x Repetition: $p < .001$; $\eta_p^2 = .37$).



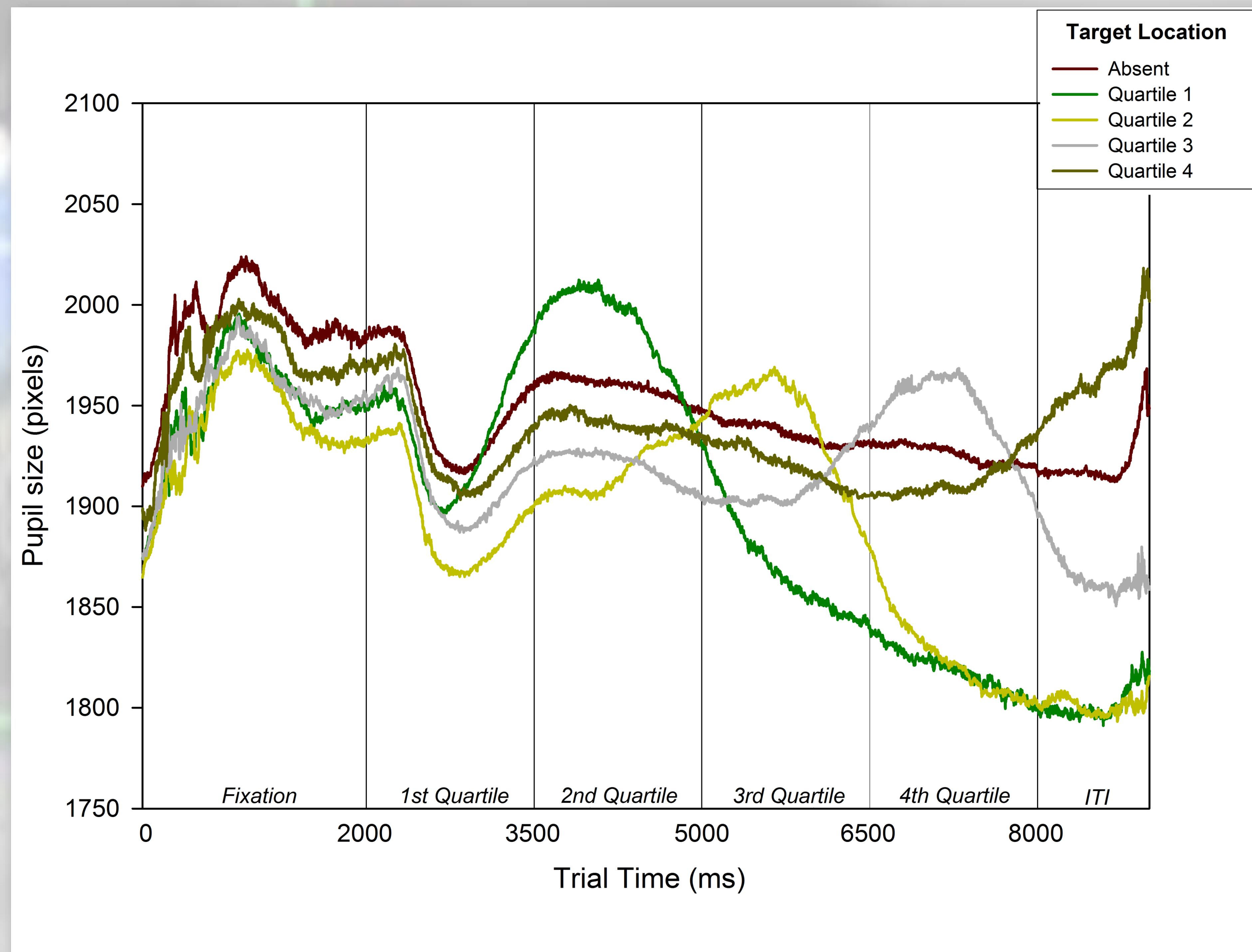
- - - PUPILS: SETTING UP THE TEMPLATE - - -

- Reflexive (tonic) pupillary changes occur independently of task-related (phasic) changes; phasic changes reflect increases in mental effort (Steinhauer et al., 2004; see Papesh & Goldinger, 2012 for a review).
- Pupillary data was analyzed (on correct trials only) from participants’ left eyes, and missing data were filled in using linear interpolation.
- Average peak diameter (in pixels) was analyzed during the fixation cross, during which time participants maintained the search target(s) in working memory. Average diameter was analyzed during presentation of the search stream.



- Peak pupil diameter was larger when participants held three targets in memory, relative to when they held a single target in mind ($p < .05$; $\eta_p^2 = .40$).
- Dilation was also greater when target categories changed from trial to trial, relative to when they remained constant throughout a block of trials ($p < .05$; $\eta_p^2 = .36$).

- - - PUPILS: IDENTIFYING THE TARGET - - -



- During the search stream, we found parallel main effects of Load and Cue Type, consistent with prior results showing that pupils dilate more in difficult visual search (Porter et al., 2007).
- Each RSVP trial was segmented into five interest periods: four quartiles of RSVP search (each 1500 msec in duration) and the 1000 msec post-search delay period (prior to the response prompt).
- We found that pupils were sensitive to the onset of the search target (see Privatera et al., 2010). There were main effects of target location at each interest period (all $p < .05$; $\eta_p^2 > .19$).
- Although participants were not required to issue a behavioral response upon target detection, their pupils peaked during the interest period following the onset of the search target. When no target appeared, “vigilance” was manifested as consistently dilated pupils throughout the trial.
- These results are the first to show that pupils respond to the difficulty of setting up (and maintaining) target representations in VWM.