Visual Search without Instructions: An Eye-Tracking Study with Toddlers

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Introduction

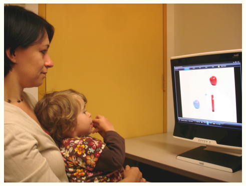
Classic studies of visual attention have distinguished between 'feature search' tasks, in which a target item is uniquely defined among distractors by a single feature, (e.g., a red apple appears among a set of green apples) and 'conjunction search' tasks, in which the target is uniquely defined only by a *conjunction* of features (e.g., that same red apple appears amid a field of green apples and red pears). A core result of such studies is that, while the time needed to find the target grows in an approximately linear fashion with increasing distractor set size in conjunction search, increased set-size has little or no effect on response time (RT) in feature search tasks. In single feature search, then, unlike in conjunction search, the target is said to 'pop-out'. (Treisman & Gelade, 1980).

What is the developmental course of visual search? Several studies have demonstrated pop-out in young infants (Rovee-Collier, Hankins, & Bhatt, 1992; Atkinson & Braddick, 1992: Adler & Orprecio, 2006) and contrasted the two types of search in older children (Thompson & Massaro, 1989; Sireteanu & Rieth, 1992). However, very little is known about the visual search behavior of children between these two age groups (1-3 year-olds).

Using minimal initial verbal cuing, extensive non-verbal training, and a touch-screen response mechanism, Gerhardstein & Rovee-Collier (2002) demonstrated that search times in 1-3-year-olds showed the same pattern in RT's during feature and conjunction search as had been found in adults. The current study extends these results in two ways.

1) We used an **eye-tracker** to measure looking behavior, providing fine-grained measures of search behavior (time-to-first-fixation, fixation duration, fixation count). Response time was measured by the time to first fixation on the target.
2) We provided **no instructions**, even during training. Instead, we gave toddlers minimal non-verbal feedback on the identity of the target item, making the task more naturalistic and more easily extensible to pre- and non-verbal (e.g. certain clinical) populations.

Methods



Participants: 30 healthy toddlers between 14 and 36 months of age (mean: 26.5 months, SD: 6.0 months). None of the children had colorblindness in their family.

Materials: We used a Tobii T60 eye tracking system to display stimuli to participants and to monitor and record eye-movements during search.

Stimuli: Stimuli presented on the display screen consisted of a target (a red apple), 'color' distractors (blue apples), and 'shape' distractors (red, elongated, rectangular apples).

Measures: *Time-to-first-fixation* on the target was our main dependent variable. This measure was used as a naturalistic analog to traditional response-time indicators (e.g. button pressing) to determine whether pop-out occurred in the single-feature trials. *Fixation length* was also measured in the target and distractors, indicating relative allocation of visual attention during search.

Procedure: Children sat approximately 40 cm from the eye-tracking display, usually on the lap of a caregiver or experimenter. Caregivers were instructed to keep their eyes closed during testing.
First, a 5-point calibration was run, immediately followed by a block of four familiarization trials.
In familiarization trials, the three object types – the red, target apple, a blue, 'color distractor' apple, and an elongated, red, 'shape distractor' apple - were shown simultaneously on the screen in different configurations.
In each of the test trials that followed, the target appeared among color distractors (blue apples) and /or shape distractors (red, elongated rectangular apples) (see Figure 1). Participants saw one or two mixed blocks of single-feature trials (distractors: either color *or* shape; number: 4 or 8) and feature conjunction trials (equal number of color *and* shape distractors; number: 4, 8, or 12). Trial length was 4 seconds. At the end of each trial, the target rotated in place for 2 seconds accompanied by a clapping sound (providing minimal feedback concerning its identity as the target). The entire block of trials lasted 3 minutes. Between trials, a target item zoomed in from the top part of the screen, again accompanied by sound effects, and then stood at a central fixation point for 2 seconds.

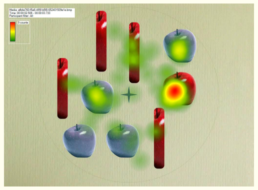


Figure 1. 'Heat map' showing typical fixation density for a feature conjunction trial.

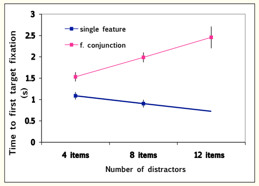


Figure 2. Effect of set size on time-to-first-fixation in single feature and feature conjunction search.

Results

Familiarization trials: We found no significant differences in either time to first fixation (TFF) or fixation length (FL) among the three items (all p's > 0.158.)

Search trials: We replicated the characteristic RT pattern found in adult studies: the number of distractors did not affect time-to-target in single-feature trials, but in feature-conjunction trials time-to-target linearly increased with the number of distractors (see Figure 2).

In general, toddlers spent longer fixating upon the target during search than upon the average distractor (average target FL: 937ms; average distractor FL: 627 ms. t (278) = 7.417, p < 0.001). Overall, time to first fixation was also lower for the target than for the average distractor (average target TFF: 1.443ms; average distractor TFF: 1.680ms. t(277) = 3.319, p < . 001.) See Figures 3 and 4.

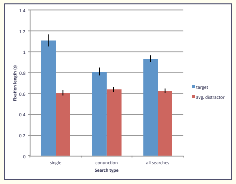


Figure 3. Average fixation length for target and distractors in single feature search, conjunction search, and averaged across all searches.

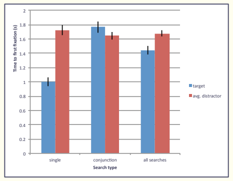


Figure 4. Average time to first fixation for target and distractors in single feature search, conjunction search, and averaged across all searches.

Unsuccessful search trials: The percent of trials where either the target and/or the distractors did not get any looks are as follows:

% of trials	single, 4	single, 8	conj., 4	conj., 8	conj., 12
only target, no distractors	1	3	7	1	0
only distractors, no target	4	9	25	44	65
missed both	2	3	16	11	8

Discussion

We studied 1-3-year-old toddlers' looking behavior in a classic visual search paradigm, but using **time-to-first-fixation as a measure of response time** (rather than more traditional measures such as button-pressing) and **without any verbal instructions**. We gave minimal non-verbal feedback - the target started spinning at the end of each trial and 'zoomed' into the center of the screen between trials - which seemed to provide a sufficient reward to induce search behavior in toddlers.

How do we know that toddlers were searching for the target?

Our data shows that toddlers were treating the target differently from the distractors. Fixation length was, overall, significantly higher for the target than for the average distractor. Furthermore, in the pop-out, single feature displays, the target was fixated significantly more quickly than average distractors.

What are the advantages of a no-instruction paradigm?

There is considerable variability in the verbal abilities of young toddlers. By using a no-instruction paradigm, we can eliminate some of the variance that is due to differences in comprehension skills. Another advantage of our paradigm is that it can be easily used to study very young atypical populations that are partially or totally non-verbal (e.g. toddlers with Autism Spectrum Disorder, Down Syndrome).

References

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