Red to green or *fast* to s l o w :

Infants' use of equally salient static (color) versus dynamic (rotation speed) features in object identification

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Introduction

Here we compared 6-month-old infants' visual working memory (VWM) for a static feature (color) and a dynamic feature (rotation speed).

Infants' use of dynamic versus static properties has been contrasted in category formation (Rakison & Poulin-Dubois, 2002), object completion (Kellman & Spelke, 1983) and object individuation (Wilcox & Schweinle, 2003).

Indeed, the "...tendency to attend to moving things over static ones" (e.g. Rakison, 2004) feeds a conventional wisdom that dynamic features - in search, memory, identification - trump static ones.

But between-feature comparisons are only fair if manipulations to these feature dimensions are equally *salient* (Kaldy, Blaser & Leslie, 2006; Kaldy & Blaser, 2009).

Comparing apples and oranges

Between-feature comparisons are notoriously difficult.

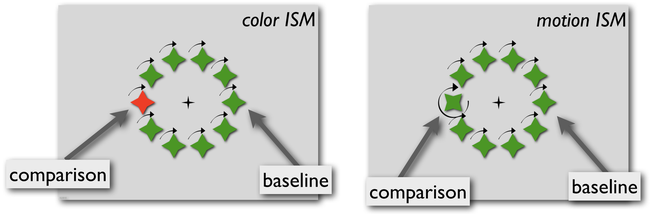
For instance, if infants are surprised when a briefly occluded, rotating star is revealed with a faster rotation, but not when it is revealed with a different color, can we conclude that infants better remember dynamic features than static ones? What speed change should be used? What color change?

We developed an Interdimensional Salience Mapping (ISM) method to calibrate stimuli beforehand, to determine manipulations to appearance (along different feature dimensions) that are of equal 'size'.

Participants' reactions to these differences can then be fairly compared in object cognition, e.g. our VWM tests.

Step 1: Interdimensional Salience Mapping

Goal: Determine a rotational speed difference that is equally salient to the difference between green and red.

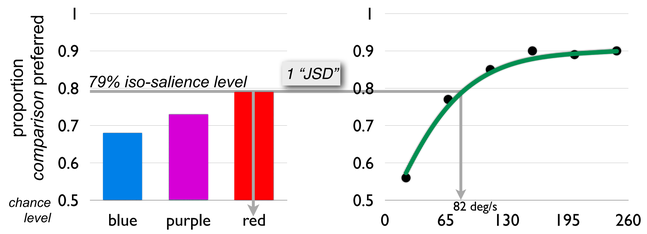


A *comparison* is pit against the *baseline* in a competition for 'first looks'.

The baseline and comparison were embedded in a context of baseline objects, engaging the bottom-up, 'feature-contrast' mechanisms that support pop-out and visual search. However, this was designed not to be a search task.

The baseline and comparison objects always appeared at the 3 o'clock and 9 o'clock locations (randomly) in the context ring. As well, the first three, and every 5th thereafter, trial was a location cue trial where two attention-grabbing objects appeared at these critical two locations.

The bigger the perceptual difference between the comparison and baseline, the more salient it becomes and the more likely to win the first look.



We chose a color and motion comparison that had equally salient differences - each a single *Just Salient Difference* - from (their common) baseline.

For 6-month-olds, the salience of the difference between 22.5 deg/s and 82 deg/s rotation speed is the same as the difference between green and red.

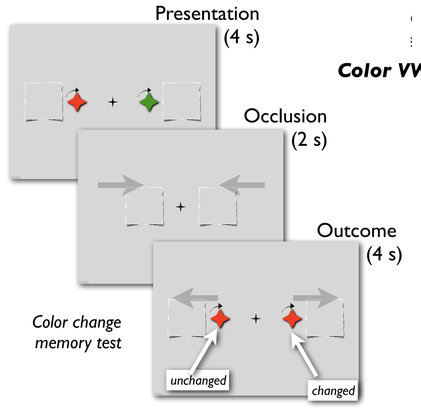
Participants
Color calibration: 8 healthy, full-term 6-month-olds (age: 149 – 213 days, mean: 184 ± 20 days).
Motion calibration: 8 healthy, full-term 6-month-olds (age: 154 – 197 days, mean: 170 ± 17 days).
Stimuli & procedure
Each block consisted of 20 test trials, interspersed with 7 location cue trials. In test trials, a baseline object (always a green, slowly rotating (22.5 deg/s) star) was pit against either one of three color comparisons (a blue, red, or purple star, rotating identically to the baseline) or one of five motion comparisons (a star rotating at 68, 113, 158, 203, or 248 deg/s, identically colored to the baseline). ISM was used to find a speed difference that was equally salient to a particular color difference.

The *Just Salient Difference*

We introduce the Just Salient Difference in order to quantify the salience of the perceptual difference between stimuli. It is nominally the difference at which an object is preferred (say, 75% of the time) vs. a competitor. While analogous, the JSD is different from the JND. The JND is best understood as limited by sensory and perceptual mechanisms. The JSD though is appropriate for differences that are supra-threshold - certainly multiple JND's under idealized conditions - where the the limiting factor is not perceptual, but attentional. Clearly, both our red, 22.5 deg/s rotating star and green, 82 deg/s star are many JND's away from our 22.5 deg/s green baseline, but they are both one JSD.

Step 2: Visual Working Memory Test

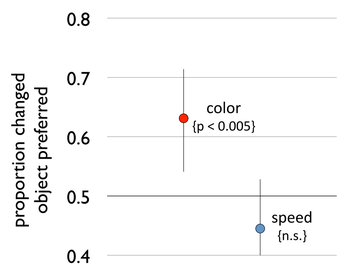
Will infants more readily note a change made to the color or rotation speed of a briefly occluded object?



Outcome could be green/green as well. The presentation phase for for motion trials contained fast/slow stimuli with outcomes of fast/fast or slow/slow. Importantly, the final outcome was always two identical objects.

For VWM tests, we used a speed change (22.5 vs. 82 deg/s) that was *equally salient* to the color change (green vs. red).

We measured whether the changed or unchanged object was 'preferred' (fixated first).



Binomial tests were conducted to test whether performance (proportion correct; defined by preferential looking to the changed object) was significantly different from chance.

6-month-olds more readily note a color change than an equally salient change in rotation speed.

Participants
Color memory: 12 healthy, full-term 6-month-olds (154–204 days, mean: 188 ± 21 days)
Motion memory: 16 healthy, full-term 6-month-olds (150–218 days, mean: 178 ± 18 days).
Stimuli & procedure
Familiarization trials: a pair of baseline objects, a pair of comparison objects, or a mixed baseline and comparison pair presented to the left and right of fixation for 4 seconds. An example test trial is shown above (color only).

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Conclusions

We showed here that it is possible to compare VWM for a static and a dynamic feature of an object.

Our results showed that infants reliably noted when a briefly occluded object changed color, but not when it changed rotation speed.

Crucially, this was a fair test, as the 'size' of these to-be-detected changes were calibrated by the ISM procedure of Step 1 to be equally salient.

Taken together, this shows that it is possible to fairly compare static and dynamic features, and that a static feature may trump a dynamic one.

We also introduced here the notion of a *Just Salient Difference* (JSD): the minimal featural change that produces a reliable preference (as measured by, e.g., allocation of attention or gaze) for an object vs. its context.

Our main finding is consistent with our Ecological Principles hypothesis: features that are more diagnostic of object identity are better remembered.

References

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A **Tobii T120** eye tracker measured eye movements. Caregivers were recruited from a commercially available database of the Greater Boston area. None of our infant participants had first-degree relatives with colorblindness.