

Iso-salient color and luminance information in infant visual working memory

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Summary

What type of visual information can infants use to identify physical objects? Are certain features easier to use than others? How can we compare differences along two separate featural dimensions? In the present series of experiments, we studied visual working memory in young (6.5-month-old) infants using computer-generated stimuli. We contrasted two perceptual features: **color** and **luminance**.

First, a **preferential looking study** was conducted to determine the luminance difference that is equally salient to a predetermined color difference. This step represents a novel application of a well-established method to approach the elusive concept of **salience**.

Calibrating iso-salient stimuli is essential for sound comparison across different featural dimensions.

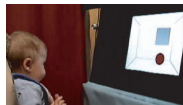
The second step consisted of the **memory test** for the **iso-salient** color vs. luminance pair. Our results show that infants at this age are **capable of identifying objects from memory by color, but not by luminance**, where, crucially, the perceptual differences along those dimensions were equal-salient.

Why salience?

Studies of infants' use of different features in object cognition (Wilcox, 1999; Káldy & Leslie, 2003) faced difficult choices: for example, what kind of color change can be compared to a particular shape change? Differences in **visual salience (bottom-up priority value)** of objects constrained the interpretation of these earlier findings. Here we show a novel method to eliminate this problem and **create stimulus pairs where the featural differences are equally salient**.

General method

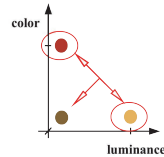
Infants sat on their parent's lap and watched a computer-animated movie on a 17" LCD screen. Viewing distance was approx. 60 cm.



Step 1. Calibrating iso-salience

Using a preferential looking paradigm, we designed two stimulus pairs with **equally salient differences**:

- a brown-red (isoluminant) color pair and
- a brown-yellow (isochromatic) luminance pair.



Method

In each trial, infants saw two disks on a uniform brown background: a standard red disk (isoluminant to the background) and a lighter brown comparison disk (randomly chosen from 5 predetermined luminance levels).



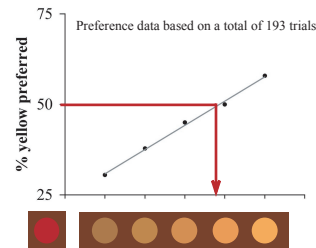
Stimuli were presented for 2 seconds, and were followed by a central fixation cross (2 s). A sound cue signalled the beginning of each trial. First looks (left/right) were coded by an experienced observer who was blind to the experimental stimuli. A maximum number of 35 trials were run. The average number of trials completed by infants was 21.4 trials.

Subjects

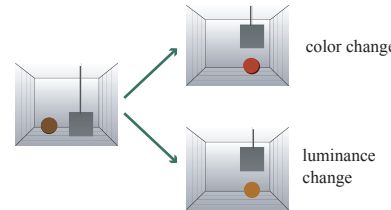
9 full-term infants (5 females) participated in the study (age range: 6 months, 0 days - 6 months 30 days, mean age: 6 months 14 days).

Results

Preference ratios for the different luminance level disks (against the red standard) are shown below. From this psychometric function, the luminance value of the iso-salient (50% preferred) item can be determined.



Step 2. Comparing visual working memory for color and for luminance



We tested visual working memory for color and luminance with the violation-of-expectation method using the calibrated object pairs.

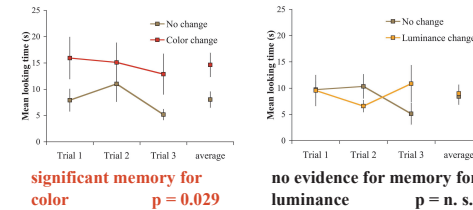
Method

Subjects were first familiarized to a pair of objects that differed in either color (brown vs. red) or luminance (brown vs. yellow). 4 familiarization trials (with alternating objects) were run. The familiarization trials were followed by 3 test trials: infants were shown one of the two objects in the fam. pair, which then disappeared behind a screen. After a 2 sec delay, either this same object, or the other object from the pair was revealed. Looking times were measured by two independent observers who were blind to conditions.

Subjects

40 full-term infants (17 females) participated in the study (age range: 6 months, 0 days - 6 months 30 days, mean age: 6 months 11 days), 10 in each condition.

Results



significant memory for color
 $p = 0.029$

no evidence for memory for luminance
 $p = n.s.$

Control experiment

An additional study was conducted to crosscheck the iso-salience of the red-brown, yellow-brown and red-yellow pairs on the new grey background with seven 6.5-month-old infants (5 females, mean: 194.0 $\pm$ 9.5 days, 26.0 completed trials/subject). No significant preferences were found, that is, all three of the objects remained iso-salient to one another on the grey background.

	#trials	brown	red	yellow	chi square(1)	P
brown/red	63	44.4%	55.6%	-	0.778	0.378, n.s.
brown/yellow	61	57.4%	-	42.6%	1.328	0.249, n.s.
red/yellow	58	-	48.3%	51.7%	0.069	0.792, n.s.

Visual salience is a crucial yet often neglected factor in infancy studies. Here we showed that this factor can be experimentally controlled using psychophysical methods.

Our results showed that (1) young infants can identify objects based on color, (2) color and luminance information are processed differently in infants' visual working memory.

We speculate that infants' better memory for color is adaptive, since the color of an object is a more reliable identifier than its luminance. Results of psychophysical studies with adults match our results (Sachtler & Zaidi, 1992; Wichmann et al., 2002).

While local changes in *luminance* are not good indicators of object boundaries...



local changes in *color* usually correspond to object boundaries.



References

- Káldy, Z., & Leslie, A. M. (2003). Identification of objects in 9-month-old infants: integrating 'what' and 'where' information. *Developmental Science*, 6, 360-373.
- Sachtler, W. L., & Zaidi, Q. (1992). Chromatic and luminance signals in visual memory. *J Opt Soc Am A*, 9, 877-94.
- Wichmann, F. A., Sharpe, L. T., & Gegenfurtner, K. R. (2002). The contributions of color to recognition memory for natural scenes. *J Exp Psychol Learn Mem Cogn.*, 28, 509-20.
- Wilcox, T. A. (1999). Object individuation: infants' use of shape, size, pattern, and color. *Cognition*, 72, 125-166.