WORKING TITLE

Evidence for systematicity in children's curiosity-driven visual exploration

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Author note

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Abstract

Method

Participants. Within each age group, half of the participants were randomly assigned to the *silent* condition, and half to the *label* condition. All participants were from monolingual English-speaking backgrounds. Participants were recruited from a database of caregivers who had expressed an interest in participating in developmental research. Parents were reimbursed £10 for travel expenses and children received a storybook for participating.

Infant participants were 40 typically-developing 12-month-olds (23 girls). Unpaired *t*-tests revealed no between-condition differences in age (silent: M_{age} = 12;14, SD_{age} = 19.50 days, range = 11;10 – 13;24; label: M_{age} = 12;13, SD_{age} = 14.24 days, range = 11;17 – 13;18; $t(34.78) = -0.064$, $p = .95$, 95% CI[-11.31, 10.61], $d = 0.020$) or in productive vocabulary (silent: M_{vocab} = 5.35 words, SD_{vocab} = 6.71, range = 0 - 24; label: M_{vocab} = 6.70 words, SD_{vocab} = 8.55, range = 0 - 31; $t(35.97) = 0.56$, $p = .58$, 95% CI[-3.58, 6.28], $d = 0.18$). Data from two additional participants were excluded from further analysis due to fussiness (defined as crying or refusal to remain on the caregiver's lap).

Toddler participants were 40 typically-developing 28-month-olds (21 girls). Again, unpaired *t*-tests revealed no between-condition differences in age (silent: M_{age} = 28;18, SD = 40.06 days, range = 26;08 – 31;20; label: M_{age} = 28;15, range = 26;23 – 30;16; $t(34.47) = -0.27$, $p = .78$, 95% CI[-27.56, 20.96], $d = 0.087$) or in productive vocabulary (silent: M_{vocab} = 451.66 words, SD_{vocab} = 169.37, range = 12 - 668; label: M_{vocab} = 414.75, SD_{vocab} = 176.79, range = 89 - 665; $t(37.93) = -0.67$, $p = .50$, 95% CI[-147.74, 73.92], $d = 0.21$). Data from 11 additional participants were excluded from further analyses due to low eyetracker sample rate (33% or less; 7), bilingualism (1), equipment error (1), poor calibration (1) and experimenter error (1).

Stimuli

Visual stimuli are depicted in Figure 1 and consisted of five exemplars from a novel shape category. Two novel crescent shapes were created in Microsoft Powerpoint and morphed using Fantamorph software to create a category in which each exemplar differed from the next to the same extent along a five-point continuum. Specifically, on one extreme the exemplar was red, tall and narrow, and on the other extreme the exemplar was blue, short and wide. The three interim exemplars varied from maroon to purple and were successively shorter and wider than the red exemplar.

Audio stimuli consisted of the sentence *Look! A tife!* recorded by a female native British English speaker and edited for clarity using Audacity software.

Attention-getting stimuli consisted of a 5 s animation of a cartoon object or animal jiggling, rotating or looming, accompanied by a child-friendly novel sound.

All stimuli are available for download: OSF HERE.

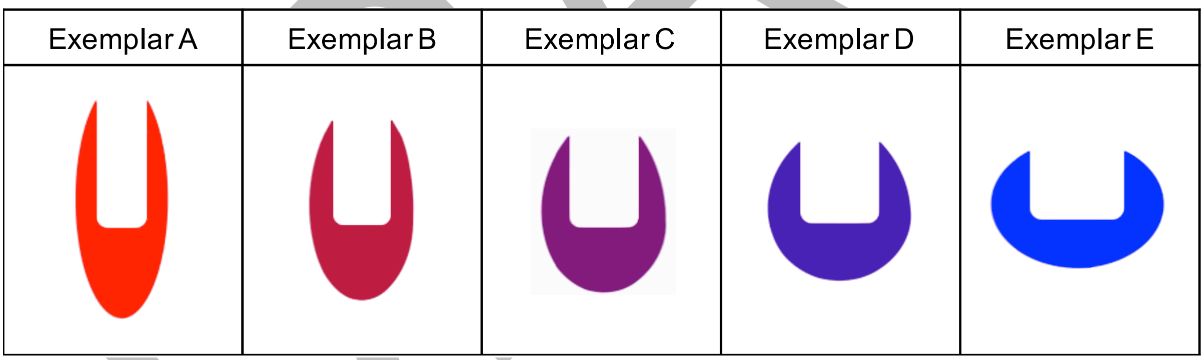

Fig. 1. Category exemplars serving as visual training and test stimuli.

Design

Figure 1 depicts an example presentation order. In both conditions participants saw five prime-test trial pairs. On prime trials, participants saw a single category exemplar on presented centrally on a white background. On the immediately successive test trial, participants saw the remaining four category exemplars presented in 2 × 2 formation. Pair order was Latin square counterbalanced, resulting in ten presentation orders. In the label condition only, visual stimuli were accompanied by the audio stimulus, on both prime and test trials. For child participants, each prime and test trial was immediately preceded by one of five attention-getting stimuli, each of which was shown twice with order randomised across test orders.

Procedure

Children

Before the experiment caregivers were asked to complete a UK adaptation of the Macarthur-Bates Communicative Development Inventory (REF) either via online questionnaire or on the day of the study. Before the experimental session began, caregivers and children were taken to a child-friendly waiting room where the experimenter explained the procedure and obtained informed consent. When the child was comfortable with the experimenter and his/her surroundings, the experimenter took the caregiver and their child to a quiet, dimly-lit eye-tracking room.

During the eye tracking session, children were seated on their caregiver's lap 50 – 70 cm in front of a 1920 × 1080 computer screen. Caregivers either faced forwards and were asked to shut their eyes for the duration of the experiment, or perpendicular to the screen. All parents were requested not to interact with their child or speak during the experiment unless they wished to halt the study. Underneath the screen a Tobii X20 eyetracker recorded the child's gaze position at 17 ms intervals. The apparatus was situated in a separate area divided from the main room with black curtains, with no extraneous visual stimuli. The experimenter controlled stimulus presentation from a computer located outside the curtain.

Before stimulus presentation began, the eyetracker was calibrated using five-point calibration. A small cartoon bird appeared in each corner of the screen and centrally, accompanied by a jingling sound. When children fixated the stimulus the experimenter recorded the child's gaze location using a keypress. Calibration quality was checked online; recalibration was not necessary for any child.

The five prime/test trial pairs were presented immediately following calibration in silence or accompanied by the labelling phrase according to condition. Each prime and test trial was presented for 10 s.

Data cleaning and coding. Gaze co-ordinates were calculated automatically in Tobii Studio (v. 3.2) by averaging the gaze location of both eyes. Timestamps for which the eyetracker failed to detect an eye were excluded (infants: X; toddlers: X).

Our primary variable of interest was the between-exemplar distances children traversed during visual exploration of the test stimuli after the two extreme primes[1] (i.e., A and E; see Fig. X). We defined four AOIs as equally-sized square areas (DIMENSIONS) centred on and closely bounding the test exemplars. Non-AOI looks were discarded, resulting in a final dataset of X samples for infants and X for toddlers. Successive gaze samples to the same AOI were treated as an individual look. For each look we coded the distance of that look from the exemplar previously explored. For the first look to any exemplar, distance was coded as distance from the prime. For example, after prime A, if the first look was to exemplar B, that look was assigned a distance of 1. Similarly, if after prime A the first look was to exemplar D, that look was assigned a distance of 3. Distances for subsequent looks were coded in a similar way, based on the distance from the previous exemplar(?). Finally,

[1] We made this decision because of the probability of traversing a given distance on the first look as well as tractability of the dataset. After prime A, children's first look on the test trial could be to exemplar B, C, D or E, resulting in distances of 1, 2, 3 or 4. In contrast, after prime B, first looks could be to exemplar A, C, D or E, resulting in distances of 1, 1, 2 or 3. Thus, to ensure an equal chance of first looks of each distance, we focus here on data from test trials following the two exemplars from the extreme of the continuum. The remaining test trials were not analysed, however data are available for download from OSF LINK. In statistical analyses of subsequent exploratory sequences, we normalise distances before submission to statistical models.

looks of less than three successive gaze samples were re-coded as part of the preceding look. The final dataset for analysis consisted of two exploratory sequences per child.