No more top-heavy bias: Infants and adults prefer upright faces but not top-heavy geometric or face-like patterns

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A non-specific “top-heavy” configuration bias has been proposed to explain neonatal face preference (F. Simion, E. Valenza, V. Macchi Cassia, C. Turati, & C. Umiltà, 2002). Using an eye tracker (Tobi T60), we investigated whether the top-heavy bias is still present in 3- to 5.5-month-old infants and in adults as a comparison group. Each infant and adult viewed three classes of stimuli: simple geometric patterns, face-like figures, and photographs of faces. Using area of interest analyses on fixation duration, we computed a top-heavy bias index (a number between −1 and 1) for each individual. Our results showed that the indices for the geometric and face-like patterns were about zero in infants, indicating no consistent bias for the “top-heavy” configuration. In adults, the indices for the geometric and face-like patterns were also close to zero except for the T-shaped figure and the ones that had higher rating on facedness. Moreover, the indices for photographs of faces were positive in both infants and adults, indicating significant preferences for upright natural faces over inverted ones. Taken together, we found no evidence for the top-heavy configuration bias in both infants and adults. The absence of top-heavy bias plus a clear preference for photographed upright faces in infants seem to suggest an early cognitive specialization toward face representation.

Keywords: eye tracking, face processing, non-specific bias, top-heavy configuration, looking preferences


Introduction

Whether newborn infants perceive a rather stable world that is not a “blooming buzzing confusion” as William James (1890) has conjectured may still be debatable (Dobkins, 2009; Mehler & Dupoux, 1994; Spector & Maurer, 2009). Yet, it is widely accepted that neonates’ vision is very limited at birth and their visual functions develop substantially during the first year of life and continue to improve over several years to reach adult level (Atkinson, 1984; Teller, 1997). Despite their poor vision at birth, newborn infants show preferences toward faces or face-like stimuli within days or even hours after birth. This includes studies showing neonates’ preference for face-like patterns (Goren, Sarty, & Wu, 1975), their mother’s face over a female stranger’s face (Bushnell, Sai, & Mullin, 1989; Field, Cohen, Garcia, & Greenberg, 1984; Pascalis, de Schonen, Morton, Deruelle, & Rabre-Grenet, 1995; Walton, Bower, & Bower, 1992), or even attractive faces over unattractive ones as rated by adults (Slater et al., 1998). The observation that newborns exhibit visual preferences for faces or face-like figures has been regarded as a rock-solid proof for a domain-specific innate bias toward this class of stimuli (de Schonen & Mathivet, 1989; Johnson & Morton, 1991). While the idea of domain-specific bias seems straightforward and widely accepted, a different hypothesis, more general and simple, has caught broad attention recently. Simion, Valenza, Macchi Cassia, Turati, and Umiltà (2002) demonstrated that newborns exhibited looking preference for up-down asymmetrical non-face patterns with more elements in the upper part (i.e., top-heavy configuration). Because faces are up-down asymmetrical (two eyes in the upper and one mouth in the lower part), some researchers proclaimed that neonatal face preference actually reflects a non-specific perceptual bias for up-down asymmetry (i.e., a top-heavy bias) rather than an innate bias for face-specific representation (Macchi Cassia, Turati, & Simion, 2004; Simion, Macchi Cassia, Turati, & Valenza, 2001; Turati, 2004; Turati, Simion, Milani, & Umiltà, 2002).

Indeed, the non-specific perceptual bias hypothesis is truly original; one may ask if the top-heavy bias is present at birth, would it stay through infancy or is it a short-lived phenomenon only present at birth? A few studies have explored whether the “top-heavy” configuration bias is still present at 3 or 4 months of age, but the evidence is inconclusive (Chien & Hsu, 2010b; Chien, Hsu, & Su, 2010; Islam, Lobue, & DeLoache, 2010; Quinn, Tanaka, Lee, Pascalis, & Slater, 2010; Turati, Valenza, Leo, & Simion, 2005). Using an eye tracker, Turati et al. (2005) found that 3-month-old infants did not show a consistent preference for top-heavy geometric patterns (Experiment 2). Thus, the authors concluded that “at 3 months of age, the general mechanism responsible for infants’ visual preference for top-heavy patterns is still present, but weaker, and thus, is activated only when the up-down asymmetry is highly salient.” On the other hand, using a modified forced-choice familiarization/novelty procedure (Chien, Palmer, & Teller, 2003), Chien et al. (2010) tested the
basic discriminability between “top-heavy” and “bottom-heavy” geometric patterns in 2- to 4.5-month-old infants. Each infant was tested with three types of top-heavy and bottom-heavy geometric figures and received both familiarized-to-top-heavy and familiarized-to-bottom-heavy conditions. The results showed significant novelty preferences of equal strength in both familiarization conditions across age and figure types, suggesting a reliable discriminability between top-heavy and bottom-heavy configurations and no intrinsic bias toward either configuration at this age.

The present study

Chien et al. (2010) found that the top-heavy bias observed at birth is no longer present at 2.5 months of age; however, the evidence is indirect and the results only apply to the (non-face) geometric figures. Therefore, the present study used an eye tracking apparatus (Tobii T60) to directly measure if there is spontaneous preference for the “top-heavy” configuration embedded in various types of figures for infants aged between 3 and 5 months and for adults as a comparison group. To be able to compare our results with the main findings in the literature, we adopted three classes of digitized stimuli including the “top-heavy” and “bottom-heavy” geometric figures used by Simion et al. (2002), schematic face-like figures used by Turati et al. (2002), and photographs of faces used by Macchi Cassia et al. (2004). Each infant and adult participant must view all three classes of stimuli (ten pairs), presented in pairs with one being top-heavy and the other bottom-heavy.1 Both the infant and the adult experiments were conducted with a remote eye tracking system that allowed for the recording of eye gaze, fixation, and direction by virtue of an infrared camera and commercially available software that automatically detected the eye position in relation to the stimulus display on the monitor.

We used the same free-viewing paradigm for both infants and adults. The infant experiment (Experiment 1) aimed to assess whether the top-heavy configuration bias was still present in 3- to 5.5-month-old infants. We chose this age range because a major transition from subcortical to cortical visual pathway takes place at this period of time, marking the starting point where cortical specialization for faces begins to emerge (Halit, de Haan, & Johnson, 2003; Tzourio-Mazoyer et al., 2002). Our predictions are given as follows: If the top-heavy bias is still present and determines infant’s spontaneous looking preference, we expect to obtain reliable and consistent looking preference individually for all the top-heavy configurations across the three classes of stimuli. On the other hand, if the top-heavy configuration bias is no longer present, infant’s looking preference may be specifically triggered by the resemblance of real faces; there shall be no consistent looking preference across all the top-heavy figures except for the ones that are upright photographs of faces. The adult experiment (Experiment 2) was intended to assess if there is any reliable spontaneous preference for the same set of stimuli; the purpose of testing adults is to obtain an end point for comparison as adults’ performance can be regarded as the mature state of human visual behavior. The reason why we did not use reaction time measurement as in typical adult experiments was that we wanted to make the adult experiment as close to the infant experiment as possible. We consider that testing the infants and adults in exactly the same way would guarantee a better and fair comparison between the two groups.

Methods

Experiment 1: Infant eye tracking study

Participants

Sixteen healthy, full-term infants aged between 3 and 5.5 months (8 males, mean age = 137 days) were recruited from the Taichung Metropolitan areas. Informed parent consent was obtained before the experiment. Infants were tested only if they were in an alert state after their parents had given their informed consent. All infants were born within ±14 days of their due dates and had no history of blindness or health problems reported by their parents. Twelve out of 16 infants passed the criterion of completing at least two blocks of the whole experiment. Four infants who did not complete the experiment were excluded from the final data set because of unsuccessful five-point eye-gaze calibration (n = 2) or due to sleepiness/fussiness (n = 2).

Stimuli

As shown in Figure 1, the stimuli included digitized “top-heavy” and “bottom-heavy” geometric patterns (A1–A3: T-shape, H-shape, and L-shape) used in Simion et al. (2002), schematic face-like figures (B1–B4) used in Turati et al. (2002), the Italian woman’s photographed face in Macchi Cassia et al. (2004); C1, C2), and a photographed face of a Taiwanese celebrity (C3: Miss Chi-Ling Lin). Miss Chi-Ling Lin’s upright face photograph was modified with Ulead PhotolImpact 10.0 software and an upside-down version of the same face was generated. All stimuli were shown in black and white and were presented against a black background. The overall contours and the length-to-width aspect ratios for the three types of stimuli were quite different; however, we managed to make the sizes of the three types of stimuli as equal as possible. As a result, the width and height of the white frames for the geometric figures (A1–A3) were 11.5 cm and 12.5 cm, the widest and longest measures for the face-like figures (B1–B4) were 11 cm and 18 cm, the widest and longest measures for the Italian woman’s face (C1 and C2) were 12.5 cm and 18 cm, the widest and longest measures for the face-like figures (B1–B4) were 11 cm and 18 cm, the widest and longest measures for the Italian woman’s face (C1 and C2) were 12.5 cm and...
20 cm, and the widest and longest measures for the Taiwanese woman’s face (C3) were 12 cm and 17.5 cm. Infant and adult participants viewed the same three sets of black-and-white stimuli.

**Apparatus and data recording**

An on-screen remote eye tracking system (Tobii T60) and a professional visualization software (Tobii Studio) manufactured by Tobii were used together to record the eye movements and perform the gaze analysis for the infant and adult observers. The Tobii T60 model was integrated (an infrared camera was embedded at the lower part of the monitor) into a 17" TFT monitor (resolution: 1280 × 1024 pixels), which detects the positions of the pupils and the corneal reflection of the infrared light-emitting diodes (LEDs) in both eyes (binocular tracking). Because these signals changed in relation to the observer’s gaze direction, with a data sampling rate of 60 Hz, the x–y coordinates corresponding to the observer’s fixation point during stimulus presentation could be recorded real time. This model is ideal for infants because there is no visible or moving “tracking devices” that might affect the subject and it allows for relatively large freedom of head movement (about 44 × 22 × 30 cm) for an observer to behave naturally in front of the computer screen. The eye tracking data have high accuracy (0.5 degree), excellent head movement compensation, drift compensation (<0.3 degree), and good tolerance to varying light conditions. In addition, a separate built-in web camera also recorded the observer’s full face view during the stimuli presentation.

**Procedures**

Each infant was held by their parents seated at a distance of about 60 cm from the Tobii T60 monitor display. The session began with an infant-friendly calibration procedure with the Tobii Studio. In the beginning of the calibration, the parents were asked to close their eyes to prevent from being mistaken as the subject’s eyes. Once the infant’s eyes were detected by the infrared camera (shown as two moving dots on the interface dialogue box), the five-location (center, top left, top right, bottom left, and bottom right) calibration procedure began. To attract the infant’s gaze toward the predetermined locations, the Tobii Studio software employed an animated cartoon with a musical soundtrack as the fixation point (i.e., several types of animated cartoons and soundtracks can be selected from the default menu). Once the five-point calibration was completed with sufficient quality (within the default range of spatial precision), the eye tracker system was able to determine the precise direction of the infant’s gaze during the experimental session. Each infant participant viewed (free viewing) a total of 20 test pairs (see Figure 1, for example) presented in three blocks in a pseudorandom sequence (geometric figures: 3 types of pairs × 2 location switches; face-like figures: 4 types of pairs × 2 location switches; photographed faces: 3 types of pairs × 2 location switches).

Each experimental trial began with the presentation of an attractive picture as a central fixation (i.e., colorful flower), which was used to direct the infant’s gaze toward the computer screen. As soon as the infant looked at the central fixation picture for 1 s, the central fixation disappeared and the first pair of stimuli appeared on the computer screen for 20 s (initiated by the experimenter). Afterward, the central fixation picture reappeared in the middle of the screen and the trial loop started again. The trials within each block were presented in a random order.

**Eye tracking data analysis**

The Tobii Studio software allowed us to process the raw data directly from the eye tracker system. We adopted the
area of interest (AOI) analysis to assess whether the top-heavy configuration was preferred over the bottom-heavy configuration across all three classes of figures. The strength of AOI analysis was that it accumulates the total fixation time and number of fixation gazes when an infant’s gaze fell within the boundary of a predefined AOI. Thus, in each of the test pairs, we enclosed the left and right figures separately as two AOIs of equal size. This allows us to directly compare the total looking time on the top-heavy versus the bottom-heavy configuration in a test pair. The size of AOIs was 11.5 cm × 12.5 cm for all the geometric figures (A1–A3), face-like figures (B1–B4), and for the photographed faces (C1–C3).

Based on the AOI analysis, the total looking time and total fixation counts within each AOI were computed as the two main dependent variables for each trial. Each infant participant has to complete 20 trials of 20 s each (10 pairs of stimuli * 2 location switches). To maintain the validity of the eye tracking measures, infant’s data must meet one of the following two data inclusion criteria. First, the total looking time for a given test pair in a given trial must be equal or greater than 2 s accumulated within both AOIs. Second, the total number of eye gazes must be equal or greater than 6 counts accumulated within both AOIs. A trial in which the total looking time was less than 2 s and the total fixation counts were less than 6 would be discarded from the final data set.

**Experiment 2: Adult eye tracking study**

**Participants**

A total of 22 adult observers (7 males, 15 females, mean age = 27.7 years) participated in the eye tracking study. The majority of the subjects were undergraduate and graduate students from China Medical University who received cash payment or course credit for introductory psychology class. Informed consent was obtained before the experiment. All observers had normal or corrected-to-normal vision. The observers were naive to the purpose of the experiment and were tested individually in a quiet, dimly lit room. All 22 participants completed the standard calibration procedure and the subsequent experimental sessions successfully, thus, their data were included in the final data set.

**Stimuli and apparatus**

The stimuli were the same as shown in Figure 1 and the apparatus was the same as in the infant experiment.

**Procedures**

The adult procedure closely resembled the infant procedure except for two: First, the adult participant began with a standard 9-point calibration procedure (without the animated cartoons and musical soundtracks) and seated by themselves at a distance of about 60 cm from the Tobii Eye Tracker T60 monitor. Second, the central fixation picture (the same flower pattern as in the infant study) appeared for a fixed duration of 2 s and followed by the presentation of the first stimulus pair automatically. Again, each adult viewed (free viewing) a total of 20 test pairs presented in three blocks of pseudorandom sequence (geometric figures: 3 types of pairs × 2 location switches; face-like figures: 4 types of pairs × 2 location switches; photographed faces: 3 types of pairs × 2 location switches), and the trials within each block were presented in a random order.

**Eye tracking data analysis**

The adult eye tracking data analysis adopted the same AOIs as in the infant experiment, and the main dependent variables were total looking time and number of fixation counts within each AOI. For each trial, all the adults looked at the stimuli more than 3 s and their number of fixation counts exceeded the infant criteria as well. Thus, none of the adult data were excluded from the final data set.

**Facedness rating study**

In order to get a sense about the degree to which the test stimuli resemble a face to an adult’s eye, we conducted a separate facedness rating study about 1 month after the eye tracking study was completed. As our primary interest was to test whether it is the “top-heaviness” or the “facedness” that drives infant’s spontaneous preference, thus, we used a subjective ranking procedure to assess the degree of facedness for the three classes of stimuli, in which nine top-heavy and one bottom-heavy figures were included. The top-heavy ones were A1-L (i.e., the denotation A1-L means the left stimulus of A1 pair shown in Figure 1), A2-L, A3-L, B1-L, B2-L, B3-L, C1-L, C2-R, and C3-L, and the bottom-heavy one was B3-R. Each to-be-rated figure was printed out on high-quality paper and was resized to fit on an 8.9 cm by 12.7 cm picture card. Each picture card was then laminated for protection. Fourteen adult subjects (5 males, 9 females) participated in the rating study, and the majority did not participate in the eye tracking study. They were asked to rate the facedness by sorting the ten laminated picture cards in the order of facedness to his or her own judgment. The subjects were asked to place the picture cards that looked most like a face on the top and the ones that looked least like a face on the bottom. The first card on top would be scored as 1 point; the second card would be 2 points; and the last card would be 10 points (or 9 points if there is a tie). The card that gets the smallest score would be rated most like a face and vice versa. There was no time limit for the subject to complete this rating task. Most of them finished the rating within 5 min. The individual subjects’ rating results and the group medians are illustrated in Table 1. Overall, the C3-L (the upright face
of Ms. Chin-Ling Lin) was rated most like a face, followed by C1-L (the upright Italian woman’s face), B1-L (paddle face), B3-R (paddle face shifted downward), C2-R, B2-L, B3-L, A2-L (T-shape), and A1-L (T-shape), while A3-L (T-shape) was rated least like a face. The overall coherence of the ranking was high among the subject, for example, 14 out of 14 subjects ranked C3-L as the number one while 12 out of 14 subjects ranked the A3-L as the last one.

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* Me = the group median. We used the medians, instead of means, as the index of the central tendency because these data are ordinal scale in nature.

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Table 1. The results of subjective facedness rating for ten stimuli.

Results

The eye tracking results for infants (Experiment 1) and for adults (Experiment 2) are presented side by side in this section. Basically, the results are analyzed by two separate measures: total looking time\(^4\) and top-heavy bias index. The group results of total looking time analysis within the AOIs will be described separately for the geometric figures, the face-like patterns, and the photographed faces across age groups. The looking time analyses give us a sense as to how interesting the three classes of the stimuli are to infants and adults and whether they show a preference for top-heavy configuration within the class of stimuli. To reveal whether there is a consistent preference for the top-heavy configuration across the three classes of the stimuli, we computed an index of top-heavy bias (a number between \(-1\) and \(1\)) for each test pair and conducted a scatter plot analysis for individual infants and adults. This is described in the last subsection. The index analysis gives us a normalized sense of the strength of top-heavy preference for any particular pair and, thus, allows for direct comparisons among the three classes of stimuli.

Total looking time analysis for the geometric figures

Figure 2 illustrates the main results for infants and adults. Each bar represents the group average of 40-s total presentation for the A1, A2, and A3 test pairs (the
top-heavy configuration is on the left for 20 s plus the top-heavy on the right for 20 s). To investigate whether the top-heavy configuration was preferred over the bottom-heavy configuration for all three types of geometric figures in infants and adults, we conducted a 3-way mixed ANOVA. The between-subject factor was age group (infants vs. adults), while the within-subject factors were configuration (top-heavy vs. bottom-heavy) and stimulus type (A1, A2, A3). There was a main effect of age group, \( F(1, 29) = 73.09, p < 0.001, \eta^2_p = 0.716 \), showing that the mean looking time of the adults (\( M = 16.11 \text{ s}, SE = 0.60 \text{ s} \)) was significantly higher than the infants (\( M = 6.49 \text{ s}, SE = 0.94 \text{ s} \)) across configurations and stimulus types. The main effect of stimulus type was not significant, indicating that the mean looking times for A1 (\( M = 11.35 \text{ s}, SE = 0.58 \text{ s} \)), A2 (\( M = 10.99 \text{ s}, SE = 0.67 \text{ s} \)), and A3 (\( M = 10.53 \text{ s}, SE = 0.58 \text{ s} \)) pairs across configurations and age were quite similar.

With regard to the most crucial factor of “configuration,” the main effect was not significant, indicating that the mean looking times for A1 (\( M = 11.35 \text{ s}, SE = 0.58 \text{ s} \)), A2 (\( M = 10.99 \text{ s}, SE = 0.67 \text{ s} \)), and A3 (\( M = 10.53 \text{ s}, SE = 0.58 \text{ s} \)) pairs across configurations and age were quite similar.

To summarize, we found that adults had a longer looking time for the geometric pairs than infants in general. In addition, infants did not show any reliable preference for the top-heavy or the bottom-heavy configuration for any of the three pairs. Adults showed longer looking time for the top-heavy configuration across the three pairs, but only the T-shape figure (A1) reached significance and the other two pairs did not. The observation that a preference for the upright T-shape was present in adults and absent in infants was interesting. This might be due to adults’ familiarity for T-shape as it looked like the English letter T. We will further address this finding in the Discussion section.

Figure 3 illustrates the main results of B1–B4 pairs for infants and adults. The format is the same as Figure 2. For B1, B2, and B3 pairs, we conducted a 3-way mixed ANOVA in which the between-subject factor was age group and the within-subject factors were configuration and stimulus type (B1, B2, B3). Note that B4 pair was not included in the ANOVA because the two stimuli were both top-heavy. Planned \( t \)-tests were conducted for B4 pair instead. For the ANOVA results, there was a significant main effect of age group, \( F(1, 26) = 81.09, p < 0.001, \eta^2_p = 0.757 \), in which the mean looking time of the adults (\( M = 15.82 \text{ s}, SE = 0.55 \text{ s} \)) was significantly longer than the infants (\( M = 5.81 \text{ s}, SE = 0.96 \text{ s} \)) across configurations and stimulus type. The main effect of stimulus type was not significant, showing that the mean looking times for B1 (\( M = 11.44 \text{ s}, SE = 0.69 \text{ s} \)), B2 (\( M = 10.98 \text{ s}, SE = 0.69 \text{ s} \)), and B3 (\( M = 10.02 \text{ s}, SE = 0.62 \text{ s} \)) pairs across configuration and age were similar.
As for the factor of “configuration,” the main effect was not significant either, meaning that there was no difference between the top-heavy ($M = 10.90 \, s$, $SE = 0.53 \, s$) and the bottom-heavy configurations ($M = 10.73 \, s$, $SE = 0.77 \, s$) across age and stimulus types. However, the configuration * age group 2-way interaction was significant, $F(1, 26) = 4.46$, $p = 0.044$, $\eta^2_p = 0.147$. Like the geometric patterns, adults looked slightly longer at the top-heavy configurations ($M = 16.68 \, s$, $SE = 0.53 \, s$) than the bottom-heavy ones ($M = 14.96 \, s$, $SE = 0.77 \, s$); while infants showed the opposite, their looking time for the top-heavy configurations ($M = 5.12 \, s$, $SE = 0.92 \, s$) was slightly shorter than the bottom-heavy ones ($M = 6.51 \, s$, $SE = 1.35 \, s$). Moreover, the stimulus type * configuration * age group 3-way interaction was significant, $F(2, 52) = 4.34$, $p = 0.018$, $\eta^2_p = 0.143$, indicating that the effect of the 2-way interaction above was dependent on the stimulus type. Pairwise comparisons for the three pairs were further conducted. For adults, the B1 pair showed significant longer looking time for the top-heavy configuration ($M = 19.13 \, s$, $SE = 1.32 \, s$) than for the bottom-heavy one ($M = 13.52 \, s$, $SE = 1.09 \, s$), $t(20) = 3.269$, $p = 0.004$; the B2 pair also showed a longer looking time for the top-heavy configuration ($M = 17.27 \, s$, $SE = 1.02 \, s$) than for the bottom-heavy one ($M = 14.77 \, s$, $SE = 1.02 \, s$), $t(21) = 2.363$, $p = 0.028$. For infants, only the B3 pair revealed a longer looking time for the top-heavy configuration ($M = 5.03 \, s$, $SE = 1.08 \, s$) than for the bottom-heavy one ($M = 3.00 \, s$, $SE = 0.49 \, s$), $t(10) = 2.303$, $p = 0.042$.

The B4 pair denotes an interesting comparison. Both figures are top-heavy, but one is more like a face (B4-L, the paddle face) than the other (B4-R). Infants’ mean fixation lengths for B4-L ($M = 5.92 \, s$, $SE = 2.07 \, s$) and for B4-R ($M = 5.10 \, s$, $SE = 1.94 \, s$) were not statistically different. As for adults, they looked slightly longer at the paddle face figure ($M = 18.13 \, s$, $SE = 1.20 \, s$) than the top-heavy one ($M = 14.60 \, s$, $SE = 1.12 \, s$), and the difference was marginally significant, $t(21) = 1.914$, $p = 0.069$.

To summarize, in general, adults looked much longer at the face-like patterns than infants did. Infants did not show any reliable preferences consistently for the top-heavy or the bottom-heavy configuration across the four pairs of face-like patterns. Rather, infants selectively showed a preference toward the top-heavy configuration only for the B3 pair in terms of fixation duration. The preference observed in the B3 pair was not present in the counterpart of the adults’ data. On the other hand, adults showed significant looking preferences for the upright face-like figures of the B1 and B2 pairs and a marginal preference for B4 pair (i.e., B4-L). Therefore, it appeared that adults showed somewhat consistent preferences for the upright face-like patterns, and this preference was unlikely driven by top-heaviness as both figures in the B4 pair were top-heavy. We will further address these findings in the Discussion section.

**Total looking time analysis for the photographed faces**

Figure 4 illustrates the main results of C1–C3 pairs for infants and adults. For C1 and C3 pairs, we conducted a 3-way mixed ANOVA in which the between-subject factor was age group and the within-subject factors were configuration and stimulus type (C1, C3). Note that C2 pair was not included in the ANOVA because the two stimuli were both top-heavy (i.e., like the B4 pair). Planned $t$-tests were conducted for C2 pair instead. For the ANOVA results, there was a significant main effect of age group, $F(1, 30) = 62.58$, $p < 0.001$, $\eta^2_p = 0.676$, in which the mean looking time of the adults ($M = 16.90 \, s$, $SE = 0.66 \, s$) was significantly longer than the infants ($M = 7.57 \, s$, $SE = 0.98 \, s$) across configurations and stimulus type. The main effect of stimulus type was not significant, showing that the mean looking times for C1
Most importantly, the main effect of configuration was highly significant, $F(1, 30) = 32.00, p < 0.001, \eta^2_g = 0.516$, meaning that both infants and adults looked longer at the upright faces ($M = 16.62$ s, $SE = 1.10$ s) than the inverted ones ($M = 7.84$ s, $SE = 0.82$ s) across stimulus types. What was even more interesting is that neither the 2-way configuration * age group interaction nor the 3-way stimulus type * configuration * age group interaction was significant. This suggested that the magnitude of configuration effect in infants and adults was about equal and that it did not differ for the Italian woman’s face (C1) or the Taiwanese woman’s face (C3).

The C2 pair is the photographed face counterpart of the B4 pair. This also denotes an interesting comparison in which both figures have a top-heavy configuration, but only one resembles a face (C2-L, the upright face) and the other (C2-R, the unnatural face) does not. Infants’ mean looking times for the upright Italian woman’s face ($M = 9.78$ s, $SE = 1.48$ s) and for the unnatural face ($M = 7.19$ s, $SE = 1.49$ s) were not different statistically. However, adults looked significantly longer at the upright face ($M = 19.57$ s, $SE = 1.54$ s) than the unnatural face ($M = 14.31$ s, $SE = 1.56$ s), $t(21) = 2.169, p = 0.042$.

To summarize, in terms of the overall looking time, the photographed face stimuli (C1–C3) appeared to better attract infants’ attention than the geometric figures (A1–A3) and the face-like patterns (B1–B4). In addition, infants show reliable and consistent preferences for the upright Italian woman’s face (C1-L) and Taiwanese woman’s face (C3-L) when paired with their inverted counterparts (C1-R, C3-R). For the C2 pair, however, infants seemed to show equal preferences for the top-heavy upright face and the top-heavy unnatural face. As for adults, they showed highly consistent preferences for all the upright faces when paired with their inverted or unnatural counterparts (C1-L, C2-L, C3-L). More interestingly, adults’ looking behavior revealed an even stronger preference for the upright Taiwanese woman’s face over its inverted version than that for the upright Italian woman’s face over its inverted version, $t(21) = 2.281, p = 0.033$.

**Top-heavy bias index analysis: Scatter plots across figure types for infants and adults**

To reveal whether a consistent looking preference for the top-heavy configuration across figure types exists for any individual participants, we computed an index of top-heavy bias for each figure and conducted a scatter plot analysis for individual infants and adults. For any particular pair of test stimuli, the index is computed as follows:

$$\text{Index} = \frac{\text{looking time for top-heavy configuration}}{\text{Total looking for the test pair}} - \frac{\text{looking time for bottom-heavy configuration}}{\text{Total looking for the test pair}}$$

Therefore, the value of the index will be a number that ranged between $-1$ and 1. A positive value indicates a preference for the top-heavy configuration; a negative value indicates a preference for the bottom-heavy configuration; a value close to zero indicates no preference for either. These indices allow us to directly assess whether there is correlated preference for all top-heavy configurations across figure types in each individual participant. The scatter plot results for the eight stimulus pairs are depicted in Figure 5 for infants and Figure 6 for adults, in which B4 and C2 pairs were excluded from the analysis because the two test pairs have only top-heavy configurations on both sides.

Figure 5 illustrates the distributions of individual infant’s indices of the top-heavy bias. The black circles represent the group means for the eight stimulus pairs. The pink marks are for infants younger than 20 weeks, while the blue marks are for those older than 20 weeks. In terms of the degree of resemblance to a face, the order of
the test pairs from bottom up follows the subjective facedness rating result. The one on the bottom represents the pattern that was rated most like a face (i.e., C3-L: Taiwanese woman’s face), while the one on top represents the pattern that was rated least like a face (i.e., A3-L: □-shape). In terms of top-heavy vs. bottom-heavy configuration, the vertical order of presentation of the eight stimulus pairs shall not matter at all, because in any given pair, the top-heavy configuration is always placed on the right and the bottom-heavy on the left. The main argument is that if infants still exhibit a top-heavy bias at this age, such bias should manifest itself in all three classes of test pairs regardless whether that particular pattern looks like a face or not. Thus, we expect to see that most of the data points shall fall on the positive side regardless of the subjective rating of facedness. On the other hand, if the top-heavy bias is no longer present at this age and infants’ preference is specifically driven by realistic face representation, we expect to find two features in the scatter plot: First, most of the data points shall fall on either side of the zero line (indicating no consistent preference for either configuration) for the geometric and face-like patterns. Second, the data points for the photographed faces shall fall on the positive side (as the top-heavy face is also an upright face), indicating a preference for upright natural faces.

As revealed in Figure 5, the alternative argument that the top-heavy bias is no longer present in infants of this age range was supported. The majority of the data points for the top-heavy and bottom-heavy geometric and face-like patterns fall randomly on either side of the zero line, while the data for the last two photographed face pairs clearly cluster on the positive side. This pattern of result is more evident if we consider the infant group means (i.e., the large black dots) as the measure of central tendency.

Figure 5. The distributions of individual infant’s indices of the top-heavy bias for the eight stimulus pairs. The top-heavy figures are on the right side and the bottom-heavy ones are on the left. The value of each index will be a number between −1 and 1. A positive value indicates a preference for the top-heavy configuration; a negative value indicates a preference for the bottom-heavy configuration; a value close to zero indicates no preference for either. The black circles represent the group means for these eight stimulus pairs. The pink marks represent infants younger than or equal to 20 weeks, while the blue marks represent those older than 20 weeks. In terms of the degree of resemblance to a face, the order of presenting the test pairs from top to bottom follows the subjective facedness rating result. The first figure represents the pattern that is rated least like a face (i.e., the A3-L: □-shape), while the last one represents the pattern that is rated most like a face (i.e., C3-L: Taiwanese woman’s face).

Figure 6. The distributions of individual adult’s indices of the top-heavy bias for eight stimulus pairs. The top-heavy figures are on the right side and the bottom-heavy ones are on the left. The value of each index is a number between −1 and 1. A positive value indicates a preference for the top-heavy configuration; a negative value indicates a preference for the bottom-heavy configuration; a value close to zero indicates no preference for either. The black circles represent the group means for these eight stimulus pairs. Different combinations of color and shape represent individual adult participant. In terms of the degree of resemblance to a face, the order of presenting the test pairs from top downward follows the subjective facedness rating result. The first figure represents the pattern that is rated least like a face (i.e., the A3-L: □-shape), while the last one represents the pattern that is rated most like a face (i.e., C3-L: Taiwanese woman’s face).
The group means from top downward were \(-0.09\) (A3), 0.07 (A1), \(-0.13\) (A2) for the geometric figures, \(-0.18\) (B2), 0.09 (B3), 0.03 (B1) for the face-like figures, and \(0.37\) (C1), 0.42 (C3) for the photographed faces. Among the eight indices, only the last two indices (C1 and C3) were significantly greater than zero, \(t(11) = 4.44, p = 0.001\) for C1, \(t(9) = 3.84, p = 0.004\) for C3, while the remaining six indices were not significant at all.

Figure 6 illustrates the distributions of individual adult’s indices of the top-heavy bias for the same stimuli. The format is the same as Figure 5. The overall pattern of the adults’ data shows much less variability among individuals. For the first three geometric figures, the majority of the data points seem to distribute evenly on both sides of the zero line except for the data points for A1 (T-shape) that shifted more to the positive side. The group mean values for the three pairs were 0.09 (A3), 0.16 (A1), and \(-0.02\) (A2), in which only the index for A1 was significantly greater than zero, \(t(21) = 2.58, p = 0.017\).

For the middle three face-like figures (B3, B2, B1), there is an interesting trend showing rightward deviation from the zero line as the stimulus resembles more and more like a face. The group mean values were \(-0.01\) (B3), 0.08 (B2), and 0.18 (B1), in which the indices of B2 and B1 were significantly greater than zero, \(t(20) = 2.30, p = 0.032\) for B2, \(t(20) = 3.36, p = 0.003\) for B1. For the last two photographed face pairs, the majority of the data points fall on the positive side. The group means for the Italian face (C1) was 0.26, which was significantly greater than zero, \(t(21) = 3.63, p = 0.002\), and 0.38 for the Taiwanese face (C3), which was also highly significant, \(t(21) = 6.39, p < 0.001\). This indicates a clear preference for the upright natural faces over the inverted ones.

### Discussion

Using a free-viewing paradigm across the stimulus classes and an eye tracker, we systematically investigated whether the top-heavy configuration bias is still present for 3- to 5.5-month-old infants and for adults as a comparison group. Each infant and adult viewed “top-heavy” and “bottom-heavy” geometric patterns, face-like patterns, and photographed faces as used in the previous studies. We presented the data in two formats. First, we showed the group averages of the total looking time for the top-heavy versus bottom-heavy configurations by area of interest (AOI) analyses; this gave us a sense of the absolute values for infants’ and adults’ performance. Second, we computed a top-heavy bias index (between \(-1\) and 1) for eight test pairs and for each individual; this gave us a relative sense for the strength of top-heavy bias for each test pair and, thus, allowed for direct comparison across stimulus types within individuals. The results of total looking time showed that there is no consistent preference for either the top-heavy or the bottom-heavy configurations within the geometric and face-like patterns in either infants or adults. The only reliable preference for both infants and adults is for the upright natural faces. Consistent results were confirmed by the top-heavy bias index data. For infants, the values of the geometric and face-like patterns were close to zero, indicating no consistent bias for either the “top-heavy” or the “bottom-heavy” configuration. For adults, the indices for the geometric and face-like patterns were also close to zero except for the T-shape figure and the ones that had higher ratings on facedness scale. Moreover, the indices for photographed upright faces were positive in both infants and adults, indicating a clear preference for upright natural faces over inverted or unnatural ones.

### Comparing the results of Turati et al. (2005)

We will now turn to compare our results with those of Turati et al. (2005), which were obtained by using an eye tracking apparatus (Applied Science Laboratory, ASL) in 3-month-old infants. In their Experiment 1, it was found that 3-month-old infants preferred upright natural faces over inverted unnatural ones. This is compatible with our findings that infants preferred the upright Italian woman’s face (C1-L) and the upright Taiwanese woman’s face (C3-L) over the inverted ones. In their Experiment 2, infants showed a preference for the Τ-shaped figures but not for the T-shaped figures. Thus, they concluded that “at 3 months of age, the general mechanism responsible for infants’ visual preference for top-heavy patterns is still present but weaker and, thus, is activated only when up-down asymmetry is highly salient” (pp. 269–270). The salience is positively correlated with the strength of the top-heaviness, which is in the order of Τ-shape (5 elements) > Τ-shape (4 elements) > T-shape (3 elements) according to Turati et al. (2005). We disagree with this claim as our infants did not show any reliable preference for the top-heavy configuration nor reveal any trend of preference as a function of the strength of top-heaviness. Only adults show a clear preference particularly for the upright T-shape figure. Because the adult participants were undergraduate or graduate students who had learned English as their second language since junior high school, their preference for the T-shape figure is likely due to the T-shape that looked like a familiar English letter “T.” This conjecture can be supported by the absence of preference for the Τ-shape (A3) or the Τ-shape (A2) figures as neither figures looked meaningful.

In their Experiment 3, when an upright natural face (which is also top-heavy) was paired with a top-heavy but scrambled unnatural face (i.e., the C2 pair in our study), they found that infants preferred the upright natural face. They concluded that “the preference for faces at 3 months of age could not be explained, as in newborns, as the result of the asymmetrical distribution of the inner
features within the face. Because the two stimuli were equated with the number of features appearing in the upper and lower portions of the configuration, up-down asymmetry was not the crucial factor in inducing 3-month-olds’ preference for faces” (p. 270). We found slightly different results for the C2 pair. The adults exhibited a looking preference for the upright natural face over the scrambled unnatural face, whereas our infants showed equal preferences for both. To explain this discrepancy, we further divided our infants into two groups: ≤20 weeks and >20 weeks. Interestingly, the older infants (>20 weeks, mean age = 157 days), like the adults, showed a significant looking preference for the upright natural face (M = 10.90 s, SD = 2.28 s) over the scrambled face (M = 6.29 s, SD = 1.07 s), t(5) = 2.80, p = 0.038, whereas the younger infants (<20 weeks, mean age = 118 days) showed equal preferences for the upright natural face (M = 8.65 s, SD = 2.18 s) over the scrambled face (M = 8.09 s, SD = 2.90 s). Although the two stimuli were both top-heavy because the number of features appearing in the upper and lower portions of the configuration was the same, we did not consider the younger infants’ equal preference for the particular C2 pair as sufficient evidence for the existence of the top-heavy bias. Given that there was no consistent preference for the top-heavy configuration in other test pairs, the absence of a preference for the scrambled face attracted infants’ attention because of its novel arrangement of a face.

To sum up, we are inclined to conclude that the intrinsic top-heavy configuration bias is absent at 3 to 5.5 months of age. Nevertheless, at a deeper level, our findings do not fully disagree with the results of Simion et al. (2002) and Turati et al. (2005), as the “top-heavy” configuration bias observed in newborn infants may be an extremely short-lived phenomenon.

No more top-heavy bias in early infancy

Overall, our finding that young infants did not show a reliable looking preference for top-heavy configurations across stimulus types is consistent with some recent studies. For example, using a discrete type of familiarization/novelty procedure, Chien et al. (2010) tested the basic discriminability between “top-heavy” and “bottom-heavy” geometric patterns in 2- to 4.5-month-old infants. Each infant was tested with the three types of top-heavy and bottom-heavy geometric figures (A1–A3) and received both familiarized-to-top-heavy and familiarized-to-bottom-heavy conditions. The results showed significant novelty preferences of equal strength in both familiarization conditions across age and figure types. This suggests that there is no intrinsic bias toward either the top-heavy or the bottom-heavy configuration but a reliable discriminability between the two configurations for infants of this age range.

In terms of the face-like patterns (B1–B4), our adults showed a looking preference for the upright top-heavy paddle faces (i.e., B1-L, B2-L, B4-L) over the inverted ones. In addition, the value of the top-heavy bias index increased as the rating on facedness for paddle face stimuli increased. However, our infants behaved differently from the adults; they did not show any reliable preference for the upright top-heavy paddle faces over the inverted versions at all. This suggests that, for infants between 3 and 5.5 months, the upright paddle face was not perceived as a face, even though it contains a face-like structure (i.e., three darker areas in an upside-down triangular configuration). Our finding agrees with another recent report. Islam et al. (2010) tested slightly older infants (4- to 10-month-old infants) with photographs of artifacts (i.e., light switch, shovel, cheese grater, etc.) in which the configuration of elements in the photographs had a top-heavy and face-like appearance (the main elements were arranged in an upside-down triangular configuration). On each trial, the upright (top-heavy) and the upside-down (bottom-heavy) versions of the same image were presented side by side. Results showed that infants did not prefer the upright face-like images over the same images upside down, suggesting that they did not perceive the pictures as face-like nor did they prefer top-heavy configurations.

Although we did not directly test newborns in the study per se, the top-heavy bias theory has recently been challenged by a recent newborn study on the importance of contrast polarity or both schematic and naturalistic face images. Newborns did not show a preference for an upright face-related image unless it was composed of darker areas around the eyes and mouth (Farroni et al., 2005). Moreover, a recent study on newly hatched chicks (2-day-old domestic chicks) that were visually naive for the arrangement of inner facial features showed spontaneous preference for face-like, schematic stimuli. This preference was maintained when the top-heavy bias was controlled for or when put in direct conflict with facedness, indicating no evidence for the presence of an innate up-down bias in chicks (Rosa-Salva, Regolin, & Vallortigara, 2010).

Early face specialization process

It is the photographed upright faces, over any other kind of stimuli, that our infants showed a clear preference for. This finding supports the notion that when infants are older than 2 months, they are more likely to show preferences for the upright face when the stimulus material is more realistic (Johnson & Morton, 1991). We consider this as evidence for a rather fast learning process that is specifically tuned to upright, natural, or realistic face representation in early infancy. Some recent developmental cognitive neuroscience studies that used positron emission tomography (PET) scans (Tzourio-Mazoyer...
et al., 2002) or measured event-related potentials (ERPs; Halit et al., 2003) suggested that the first signs of cortical specialization for faces may be observed in 2- to 3-month-old infants. Tzourio-Mazoyer et al. (2002) observed that when looking at unknown women’s faces, 2-month-old infants activated a distributed network of cortical areas that largely overlapped with the adult face processing network. Moreover, Halit et al. (2003) even found an ERP component that differentiates human faces from monkey faces in 3-month-old infants. In other words, these studies suggested that infants show some specialization for human faces as young as 3 months of age, although not to the same degree as older infants or adults. In fact, the early face learning process is not only species-specific but also race-specific in processing face–identity information. A growing body of studies showed evidence for own-race advantage (ORA) in as early as 3 or 4 months in Caucasian infants (Hayden, Bhatt, Joseph, & Tanaka, 2007; Kelly et al., 2005; Sangrigoli & de Schonen, 2004b) and in Asian infants (Chien & Hsu, 2010a; Hsu & Chien, 2011; Kelly et al., 2007). This indicates an early influence of race-typical stimuli in the environment (Elman et al., 1996; Johnson, 1993).

## Conclusion

The present study used an eye tracker to investigate whether a top-heavy configuration bias is still present for 3- to 5.5-month-old infants and for adults as a comparison group. In terms of fixation time, the overall results showed no evidence for the existence of a top-heavy configuration bias for geometric and face-like patterns in either infants or adults. The only reliable preference was found for the upright natural faces for both infants and adults. In terms of index analysis, the values of the geometric and the face-like patterns were close to zero in infants, indicating no consistent bias for the “top-heavy” or the “bottom-heavy” configuration. In adults, the indices for the geometric and face-like patterns were also close to zero except for the T-shape figure and the figures that had higher rating scores on facedness. Finally, the indices for photographed upright faces were positive in both infants and adults, indicating a clear preference for upright natural faces over inverted or unnatural ones. Taken together, our findings suggest that the “top-heavy” configuration bias, which may be present in newborns, does not seem to be present at 3 months of age. This indicates a rather fast learning process that is specifically tuned to natural or realistic face representations in early infancy. In conclusion, our findings are consistent with the CONSPEC/CONLERN model\(^1\) on early face preference proposed by Johnson and Morton (1991) as we found that infants at this age only prefer the photographed upright faces, which is a signature of the CONLERN mechanism. In addition, our results are consistent with the experience-expectant view of early face processing. This view considers cortical specialization and specificity for faces as gradually emerging from the interaction between small innate constraints and the critical input provided by the species-typical or race-typical environment (Nelson, 2003).

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## Footnotes

1. The only exceptions were the pairs of B4 and C2 (see Figure 1) in which both figures in the two pairs were top-heavy.
2. During the experimental session, we gave more freedom to the parents that they may open their eyes if they feel uncomfortable to keep their eyes closed throughout the whole experiment. Nevertheless, the parents were instructed to stay relaxed, quiet, and not to interact with their infants.
3. In the pilot study, we tried three different stimulus durations, 10 s, 20 s, and 30 s, on a small set of infants. We found that 30-s presentation was too long for most of the stimuli, while 10-s presentation was fine for the geometric and face-like figures but a little too short for the photographed faces. The key manipulation of this project is that each infant has to view all three classes of stimuli and we wanted the same duration for each test stimulus, thus, 20-s presentation seemed to be the best choice.
4. We also did the analysis on “fixation counts” for all three classes of stimuli, but it was not included in the main text. This is because the overall result was very similar to that of total looking time analysis. We decided to drop it to avoid redundancy and to make the paper more succinct as suggested by the reviewers.
5. Johnson and Morton (1991) argued that human infants were born with some information about the structure of faces. The preferential response to face observed in
newborns is mediated by a rudimentary face-detecting subcortical visuomotor pathway, the “CONSPEC”, whereas later abilities to recognize individual faces and facial expressions of internal features are mediated by cortical visuomotor pathways, the “CONLERN.”

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