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Newborns' preference for face-relevant stimuli: Effects of contrast polarity

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Abstract

There is currently no agreement as to how specific or general are the mechanisms underlying newborns' face preferences. We address this issue by manipulating the contrast polarity of schematic and naturalistic face-related images, and assessing the preferences of newborns. We find that for both schematic and naturalistic face images the contrast polarity is important. Newborns did not show a preference for an upright face-related image unless it was composed of darker areas around the eyes and mouth. This result is consistent with either sensitivity to the shadowed areas of a face with overhead (natural) illumination, and/or to the detection of eye contact.

Most researchers agree that in their natural environment human newborns preferentially orient toward faces (1, 2). However, controversy remains as to whether this preference is based on one or more non-specific biases in the newborn's visual system that happen to maximally respond to faces, or whether the underlying mechanisms are stimulus-specific (1, 3). This issue is important to debates in several fields, including developmental psychology and cognitive neuroscience. For example, in adult cognitive neuroscience some have argued that cortical regions are dedicated for face processing, while others have proposed that these regions are activated by a level of perceptual expertise most commonly achieved with faces (4).

A number of authors have hypothesized that face processing in newborns is relatively well developed and does not differ significantly from that seen in adults (for review, see ref. 5). Evidence in support of this view includes experiments with naturalistic stimuli showing a preference for attractive faces (6, 7). Johnson and Morton (8, 9) argued that newborns' responses to faces are not due to adult-like processing, but rather are subserved by a primitive and sub-cortical mechanism they termed “Conspec”. Conspec was initially defined as being a mechanism that “...contains structural information concerning the visual characteristics possessed by conspecifics” (ref. 9, p. 85), but has become more generally used to refer to “infant’s disposition to direct their attention and sense of belonging to other human beings.”[§] While Morton and Johnson argued that the general configuration that composes a face may be important, they did not consider that there was sufficient evidence at the time to commit to a specific underlying representation. Nevertheless, their empirical observation from the early experiments with newborns, and evidence from other species, indicated that a stimulus with three high-contrast blobs corresponding to the

[§] See http://www.psybox.com/web_dictionary/dictionaryWebindex.htm approximate location of the eyes and mouth (a stimulus that they referred to as "Config") might be sufficient.

Another view of the mechanisms underlying face preferences in newborns is that the preference is the result of one or more non-specific biases, including a bias to look at the greater number of elements or features in the upper visual field (10). This so-called "top-heavy" bias has been used to account for several experiments using schematic face-like patterns, although it has been less successful in accounting for the full range of results obtained with naturalistic face stimuli (11). It is important to note about the "top-heavy" bias account that the arrangement of elements or features is dependent upon the shape and size of a high-contrast border surrounding them (12). Preference for top-heavy configurations has not been observed without this border (13) showing that the bias is more specific than just for elements in the upper visual field. The hypothesised bias appears to be sensitive to a greater number of elements of features in the upper portion of a surface or object within a high-contrast boundary.

When considering the different viewpoints advanced to account for newborns visual preferences, it is useful to distinguish between *functional* accounts, and the exact *mechanisms* that fulfil these functions. Both the "top-heavy" bias and the "Config" representations are assumed to have the same function: the detection of faces in the natural environment of the newborn. The debate between these opposing views cannot be resolved by comparing the stimuli with varying attractiveness to newborns, because there are no independent criteria to decide whether a certain stimulus forms a better face than another. Relying on our adult intuitions may be misleading when we assess newborns' visual biases. Whether or not a visual mechanism acts as a face-preference bias depends not on a goodness-of-fit function to an ideal face template, but on its efficiency in drawing infants' attention to faces in a natural environment. If a bias toward "top-heavy" stimuli successfully selects faces in the species-typical environment of a human newborn without generating too many false alarms, then it is as domain-relevant as a preference for stimuli matching the Config representation, and they share a common function.

The functional approach to newborns visual preferences can also be extended to allow us to draw further predictions about the representations that underlie certain functions. We have predicted that newborns' bias toward face-like stimuli would be influenced by the contrast-polarity of those stimuli. This prediction follows from two related functions that one could ascribe to newborns' face preferences.

If the mechanisms that bias newborns' orientation to stimuli has been selected to find faces in a natural environment under natural (top-down) illumination (i.e., the function is face detection), it should also be sensitive to the light-shadow pattern generated on faces by such conditions. In particular, the eye and mouth regions are recessed on a face and therefore appear to be darker than other parts of the face that are directly illuminated. By chance, or perhaps necessity, all previous studies of newborns' face preference used darker blobs on white background as schematic face stimuli. If the newborns' visual biases evolved to help them locate faces in a natural environment, infants should show no preference for face-like patterns where the elements within the face are lighter than the background, because those elements would indicate protrusions rather than recesses for their visual system. In contrast, theories that explain newborns' face preference in terms of non-face specific underlying mechanisms that bias towards larger number of enumerable features in the upper half of a surface should predict the same, or even stronger, preference for light elements on a dark background, because these elements may appear to be closer to the observer in relation to a background surface.

A more extended function that one can ascribe to newborns' preferential orientation to certain stimuli is that it reflects a bias towards potential communicative partners, in particular to an upright face in which the eyes are directed toward the observer (11, 14). Evidence that motivates this view includes findings that newborns preferentially orient towards faces with open, as opposed to closed, eyes (15), and faces with direct gaze, as opposed to faces with averted gaze (11, 16). If newborns' preference is directed to eye-contact stimuli, it must be sensitive to the contrast polarity of the elements, because human gaze-perception is known to depend on direction of contrast (17). In particular, perceived gaze seems to be defined for a human observer on the basis of a darker spot (the iris/pupil) within a lighter background (the sclera), as it is demonstrated by the Bogart illusion (18). If this is the case, a stimulus that does not include darker blobs on lighter ground could not be identified as an eye-contact stimulus even if it otherwise resembles the structure of a face, because gaze would not be defined in this stimulus. This predicts that if newborns were seeking eye-contact stimuli, they would not be attracted by face-like configurations of white elements on a black background.

The first of the present studies tested the prediction that the well-established preference for upright schematic face-like configurations would disappear if they were composed of light elements on a dark background. Accounts such as the top-heavy bias should predict that the preference for face-like (or top-heavy) pattern would be preserved, or possibly become stronger, with contrast-reversed stimuli. The second study addressed the question whether the contrast polarity sensitivity of newborns' preference is extended to real faces and across different lighting conditions.

Methods

Full-term newborns were selected to participate in the study from the maternity ward of the Pediatric Clinic of the University of Padua and of the Pediatric Unit of the Hospital of Monfalcone. All of them met the screening criteria of normal delivery, birth weight between 2596 and 3960 g, and an Apgar score of at least 8 at 5 minutes. Their postnatal age was between 13 and 168 hours. Parents were informed about the procedure and gave their consent to their child's participation. One hundred and five newborns participated in the experiments (see Fig. 1 for the exact number of participants in each study). A further 44 newborns were excluded from the analysis because of failing to complete the test (12 newborns), strong side bias (20 newborns), or technical errors (12 newborns).

The stimuli were presented on two adjacent 21" computer monitors at 30 cm distance from the newborn. Black cardboard covered the area around monitors in order to prevent other visual stimuli to get the infants' attention. In between the monitors, a flickering red LED (subtending 2° from 30 cm viewing distance) was employed to attract the infants' attention. The LED blinked at a 300 ms on/off cycle. Above that, a video camera recorded the participants' eye-movement to monitor their looking behaviour on-line, and to allow off-line coding of their fixations.

The newborn sat on an experimenter’s lap in front of the two monitors. The experimenter holding the infant was not aware of the hypotheses under test. Each trial began with flickering the LED in the centre. As soon as the infant fixated the light, another experimenter, who monitored the infant's eye through the video camera, started the sequence of the trial by pressing a key on the computer keyboard. This automatically turned off the LED and the two stimuli appeared simultaneously on each monitor. The stimuli remained on as long as the infant fixated one of them.

When the infant shifted his/her gaze away from the display for more than 10 seconds, the stimuli were removed and the centre light turned on. This procedure, called infant-control preferential looking technique, has been previously used in many studies (2, 11). All the newborns were presented with two trials, in which the position of the stimuli was reversed. The initial side of the two stimuli (left or right) was counterbalanced across subjects. Videotapes of the baby's eye movements throughout the trial were subsequently analysed by two coders, who were unaware of the stimuli presented. The coders recorded, separately for each stimulus and each trial, the number of orienting responses and the total fixation time. Inter-rater reliability was calculated for 10% of the participants with high inter-coder reliability (Cohen's Kappa = .85 for the duration of fixation and .98 for the number of orientations).

We analyzed two dependent variables of newborns' behaviour (number of orientations and total looking time) against the independent variables of face orientation (upright vs. inverted) or direction of illumination (above vs. below) and the between-subject factor of polarity (positive vs. negative) when it was appropriate.

Experiment 1

The stimuli in Experiment 1a were two head-shaped, head-sized, two-dimensional images with three square features inside (Fig. 1). One of the stimuli had the squares in the appropriate locations for eyes and mouth (i.e., an upright face-like configuration), whereas in the other stimulus the position of the squares was vertically reversed, with two squares located below one square (i.e., an inverted face-like configuration). The stimuli were presented in 14.5 x 23 cm size on the two monitors (one stimulus per monitor) at a distance of approximately 30 cm from a central fixation point. Each square blob within the contours measured 2 x 2 cm. At a viewing distance of about 30 cm, the centre of the head-shaped contours was 45° right and left from fixation.

In Experiment 1a the stimuli in the two conditions differed only in contrast polarity: in the positive polarity condition the head-shape was white against a black background and the internal squares were black (i.e. the Config stimulus of ref. 9); in the negative polarity condition the head-shape was black against a white background and the internal squares were white.

A 2x2 (face orientation x polarity) ANOVA on the total looking time in Experiment 1 resulted in no main effects but a significant interaction: $F_{1,31} = 5.231$, $P < .05$. According to post-hoc tests, this interaction was due to the fact that infants spent significantly more time looking at the upright face in the positive polarity condition ($t_{16} = 2.180$, $P < .05$), while no such difference occurred in the negative polarity condition ($t_{16} = -1.008$, n.s.) (see Fig. 1). This pattern of results was also confirmed by non-parametric Wilcoxon tests. While infants in the positive polarity condition looked longer at the upright face ($z = 2.012$, $P <. 05$), they did not do so in the negative polarity condition ($z = 1.068$, n.s.). Similar analyses on the number of orientations towards the two stimuli did not show any significant effect.

Thus, the positive polarity condition of Experiment 1a replicated the findings of earlier studies (2): Newborns in this condition looked longer at the upright than the inverted face configuration. However, no such preference was observed in newborns who saw the same figures in negative face polarity. This indicates that contrast polarity direction did influence newborns' orientation responses, which were not based solely on the number of high contrast bounded elements in the upper and lower parts of the stimuli.

Before drawing firm conclusions from this result, we have to consider other possible causes of the absence of preference in the negative polarity condition. In particular, although the average luminance of the stimuli was lower in the positive than in the negative polarity condition (see Fig. 1), it is possible that the dark objects in the negative polarity condition were less salient for, and drew less attention from, the newborns than did the positive polarity stimuli. This could potentially explain why they failed to show a preference between the stimuli in the negative polarity condition. This account would predict stronger attention and a longer looking time in the positive than in the negative polarity condition. However, our statistical analysis did not reveal such a main effect ($F_{1,31}$ = 2.899, n.s.) in the two-way ANOVA above, allowing us to rule out this account of our findings.

Alternatively, reversing the contrast polarity of the stimuli changed not only the face and its inner elements, but it also enhanced the luminosity of the background. It is possible that the white background behind the black head-outline attracted the babies' attention, and so they failed to explore the inner features of the stimuli, which prevented them from detecting any differences between upright and inverted configurations. Experiment 1b was designed to investigate this possibility. In this experiment the same stimuli were presented as in the negative polarity condition of Experiment 1a with the exception that the stimuli appeared on a mid grey (50 %) background.

The total fixation time in Experiment 1b to the upright vs. inverted face stimuli did not differ significantly (t_{16} = -1.321, n.s.), and nor did the number of orientations toward them (t_{16} = -1.474, n.s.) (see Fig. 1). In fact, comparing these dependent measures to the negative polarity faces across Experiment 1a and 1b did not reveal any significant difference. Changing the white background to grey, thus making the contrast around the face less, and the contrast within the face more, conspicuous, did not bring back the preference for upright over inverted face configuration in inverted polarity.

Another possible objection to our contrast polarity result is that the low luminance content of the negative polarity images might have prevented the newborns from detecting, or exploring, the details of these stimuli. Fortunately, one of the hypotheses that predicted the contrast polarity sensitivity of newborns' preferences for face-like patterns also generates predictions for the conditions that would make the preference re-emerge within a dark head-outline. Specifically, if the function of newborns' orientation bias is to establish eye contact, and human eyes are identified as dark spots within lighter areas (19), placing dark "irises" within the white squares in the negative polarity images should bring the preference for upright images back. In Experiment 1c, we changed the stimuli in Experiment 1b slightly by inserting small black squares into the white ones (see Fig. 1). The size of the black squares was 1 x 1cm.

A t-test on the total looking time in Experiment 1c yielded a significant effect of face orientation ($t_{11} = 2.212$, $P < .05$), indicating longer looking time at the upright than at the inverted pattern. Because of the significantly skewed distribution of looking times (skewness = 1.665, $z = 2.613$), we repeated this analysis on logarithmically transformed data, which resulted in a stronger effect ($t_{11} = 2.484$, $P < .03$). The number of orientations toward the two stimuli also differed significantly ($t_{11} = 2.634$, $P < .05$), because the newborns looked more times at the upright (17.3) than at the inverted (12.1) configuration.

We also compared the dependent measurements between Experiments 1c and 1b to check whether inserting the black squares into the white ones made any difference. A 2x2 (face orientation x experiment) ANOVA on the looking times revealed a significant interaction ($F_{1,27} = 7.391$, $P < .01$). An even stronger interaction was found in a similar ANOVA on the number of orientations towards the stimuli ($F_{1,27} = 11.463$, $P < .002$).

These results confirmed that the lack of preference for the upright configuration in the negative polarity condition of Experiments 1a and 1b was not simply caused by lack of scanning of lower luminance surfaces. In fact, the stimuli in Experiment 1c had lower average luminance than those in Experiment 1b. Despite this, newborns showed a clear preference for the upright configuration, which therefore was due to the small black elements that now appeared on the white background.

The results of Experiment 1 contradict the prediction drawn from the account that explains newborns' face preference only by a non-specific bias towards "top-heavy" stimuli (3). Although all conditions in Experiment 1 contrasted an "upright" and an "inverted" configuration, the newborns displayed selective preference only in two of these contrasts. Neither the luminance of the background nor the luminance of the bordered surface determined whether infants would show a bias toward one of he stimuli. One factor that is common in the two "upright" patterns that preferentially attracted newborns' attention is the presence of dark elements on light background within a face-like configuration.

Experiment 2

Experiment 2 was designed to test whether the contrast polarity sensitivity of newborns' visual preferences applies not only to schematic but to real faces as well, where contrast relations change in a more continuous fashion. These experiments were based on the previous finding of a preference for an upright face in realistic face images (20). Stimuli in Experiment 2 measured 17 cm wide and 25.5 cm tall.

In the positive polarity condition of Experiment 2a, infants were presented with two high-quality black-and-white photographs of a woman's face digitally modified to create an upright and an inverted version of it (Fig. 1). The two stimuli were identical except for the inner region of the face, which was preserved in its canonical orientation in the upright face, but was rotated by 180° in the inverted face. This is the same manipulation that was applied in previous studies with schematic and real faces (20). The model was photographed in a frontal pose with a neutral expression. In the negative polarity condition, we used the same two pictures, but this time with the contrast polarity reversed, while keeping the background black (Fig. 1). The positive and negative polarity stimuli did not differ in average luminance.

A 2x2 (face orientation x polarity) ANOVA on the total looking time in Experiment 2a resulted in a significant main effect of face orientation ($F_{1,29} = 16.609$, $P < .001$), a significant interaction ($F_{1,29} = 6.455$, $P < .02$), and no main effect of polarity ($F_{1,29} = 0.720$, n.s.). To analyze the interaction, we compared looking times to the two face orientations within the two conditions. In the positive polarity condition, the newborns looked much longer at the upright than at the inverted face ($t_{15} = 4.887$, $P < .001$), while no such significant difference was found in the negative polarity condition ($t_{14} = 1.039$, n.s.) (see Fig. 1). This pattern of result was confirmed by non-parametric tests. In the positive polarity condition, 15 of 16 infants looked longer at the upright than inverted faces ($P < .001$ by sign-test) and a Wilcoxon-test also showed significantly longer looking at the upright face ($z = 3.361$, $P < .001$). In contrast, only 9 of 15 newborns looked longer at the upright face in the negative polarity condition ($P > .5$ by sign test), and a rank test yielded no significant result either (Wilcoxon $z = 0.966$, n.s.). Similar tests on the number of orientations resulted in no significant difference.

Experiment 2a essentially replicated the findings of Experiment 1a. While there was no significant preference for either stimulus in the negative polarity condition, we found a strong bias in looking time towards the upright face in the positive polarity condition. However, we also found a main effect of face orientation, suggesting that the newborns tended to prefer the upright face in both conditions. This can be explained by the non-significant bias towards the upright faces in the negative polarity condition, a trend not observed in Experiment 1. This is not surprising, if infants tend to prefer stimuli that contain darker spots on lighter background in their upper part, as the "eye-contact hypothesis" suggests. Note that the polarity-inverted sclera on the negative image represent precisely such elements, as they appear to form "pseudo-pupils" on lighter backgrounds. Whether or not this illusion made newborns look slightly longer at the upright than the inverted configuration in the negative polarity condition, the interaction between face orientation and polarity confirmed that their bias toward the upright configuration was much stronger in the positive polarity condition, where the larger dark elements appeared on a light background, making them more easily detectable by newborns' eyes. Note also that the absence of main effect of contrast polarity makes it unlikely that differential effects in the two conditions was attributable to generally higher attention to the positive polarity images.

The sensitivity to larger dark elements in face-like patterns may be a by-product of the newborns' visual system, but it may also reflect the fact that this preference is tuned to the particular distribution of dark and light patches characteristic of a face illuminated from above. Specifically, when the light comes from above, it creates large dark areas in the sockets around the eyes, while other directions of illumination tend to generate patterns containing higher spatial frequencies. Experiment 2b tested directly whether newborns could discriminate between, and are biased towards one of, two faces, which are illuminated either from above or from below.

We presented newborns with the same female face photographed with two different directions of illumination: from above and from below (Fig. 1). The average luminance of the two stimuli was the same, while the distribution of the darker and lighter patches was markedly different. The face showed a neutral expression.

The direction of illumination had a strong effect on newborns preference: They looked longer ($t_{11} = 4.076$, $P < .01$) and more times ($t_{11} = 2.620$, $P < .05$) at the top-lit face than at the bottom-lit face. Non-parametric Wilcoxon-tests also confirmed these results, showing that the newborns tended to prefer the face illuminated from above both in terms of looking times ($z = 2.667$, $P < .01$) and in terms of number of orientations ($z = 2.323$, $P < .05$).

Experiment 2 demonstrated that the sensitivity to contrast polarity in newborns' preferences is not restricted to schematic face-like stimuli, but is also present in their orientation towards photographic images. We have also shown that preference for a face stimulus depends not only on the contrast polarity, but also on the shading pattern created by lighting conditions. It is reasonable to assume that these two aspects of the orientation bias reflect the functioning of a single mechanism, which favours face-like configurations in which the elements in the upper parts are darker than their background.

Discussion

These experiments demonstrate that the contrast polarity of schematic and realistic face stimuli influences the degree of preference shown by newborns for an upright face configuration. The pattern of data that we have obtained over the experiments make it unlikely that our results can be explained by differences in the overall luminance of our stimuli (see figure 1 and experiment 1c), or by differences in general within-object luminance. The latter possibility predicts that newborns will generally look longer at stimuli in which the figure or object has greater luminance. By this account, preferences for an upright configuration are only shown with pairs of stimuli that have a relatively high intra-object luminance. However, in both Experiments 1a and 2a there was no significant difference in the overall looking time to positive and negative contrast stimuli. Further, in Experiment 1c newborns showed a preference between stimuli with less intra-object luminance than in Experiment 1b in which no preference was shown. Finally, a preference was also observed in Experiment 2b in which luminance was generally lower than in all of the other experiments. The absence of statistical effects of contrast polarity on looking times indicated that the contrast polarity exerted its impact by modulating the perceptual preference of newborns, rather than facilitating or reducing their overall attention.

Most hypotheses about the nature of newborn preferences for face-like patterns that utilise non-specific biases would predict either no effect of contrast polarity, or a stronger preference for the negative contrast polarity. Conversely, a mechanism that is sensitive to the unique form of a human face under natural lighting conditions (daylight, or overhead illumination) may be sensitive to the darker shadowed areas around the eyes and mouth. Similarly, a mechanism that attempts to identify eye contact within the context of an upright face will also be biased towards stimuli that potentially contain appropriate contrast polarity. Our results are consistent with the view that the mechanism(s) underlying newborn preference for upright configurations requires the contrast polarity characteristic of faces and/or eyes in which one or more dark areas are surrounded by a lighter surface.

Our observations thus suggest that these mechanisms are, in some respects, more face-related than previously supposed. Whether the configuration of elements requires to be those of facial features or not (Config or “top heavy” bias), these elements must occur within a border that defines an overall object or surface, and must be set against a background that is lighter than the elements themselves, consistent with cavities or recessed shadowed areas. It is plausible to assume that evolutionary selection on newborns' visual preferences would have relied on these characteristics of human faces, which in natural lighting conditions are as invariant aspects of them as the geometric arrangements of the elements within faces. Few, if any, naturally occurring objects share the patterns of shadow and reflected light characteristic of faces. Thus, the “positive” and “negative” polarities investigated in this paper are defined relative to the unique structure of faces. From this perspective, artificially generated stimuli such as a banded head-shaped surface with more shadowed indentations in the upper half, may be sufficient to activate preferences in newborns, but are unlikely to be encountered within their natural environment. Note that newborns do not need the ability to extract the direction of illumination from patterned stimuli in order to show such a preference. A mechanism that biases their orientation toward visual patterns that are consistent with being faces illuminated from above would be sufficient to fulfil the function of finding conspecifics in a natural environment.

Alternatively, several characteristics of newborn's visual preferences suggest that they may have been selected for a more specific function than the detection of conspecific faces; the detection of communicative partners. The first piece of evidence that supports this view is that newborns prefer upright to inverted face configurations (1, 2), even though they are likely to see faces in non-canonical orientations. A face in any orientation could be a sign of the presence of a human, but only an upright face indicates a potential communicative partner, because normal human face-to-face communication occurs only in the canonical face orientation. Importantly, caregivers always make sure that their baby's head is aligned with their own head when they initiate an interaction with their offspring (21). Second, human newborns prefer faces with direct gaze to faces with averted gaze (11), even with schematic faces (16). This preference disappears if the faces are inverted (our unpublished data). Third, as the results of the present studies suggest, infants' preferences are restricted to stimuli composed of darker elements on lighter background, the same contrast relation that is utilized in identifying gaze direction in humans (17-19). Taken together, these aspects of newborns' preferences imply that human babies at birth are most attracted to stimuli appropriate for social interaction.

Eye contact is one of the strongest communicative signals in humans, and it is plausible to assume that evolutionary selection has made human newborns sensitive to such a signal. Recognizing this, Baron-Cohen (22, 23) proposed that an innate eye-direction detection module assists infants to evaluate the gaze direction of social partners. Our hypothesis is less ambitious here in that it simply involves sensitivity to, and a bias to attend toward, stimuli that would most likely indicate a face with gaze directed to the viewer. For such a bias, newborns do not need a mechanism to identify the exact gaze direction of a face; it is sufficient if they orient toward visual patterns that are consistent with a human being looking at them. Similar preferences may also be found in the auditory domain: Newborns prefer not only human voices to other sounds (24), and speech to non-speech stimuli (25), but they are also biased toward the specific intonation patterns (i.e., infant-directed speech) that indicates that they are the ones who are addressed by an utterance (26).

We offered two different functional accounts (top-lit faces, or eye-contact stimuli) for the contrast polarity sensitivity of newborns' visual biases. It remains a question for further research, and beyond the scope of the present paper, to decide which of these accounts provides a better explanation for newborns' preferences to face-like stimuli. Both accounts predicted the lack of preference for upright patterns when contrasting images with negative face polarity (Experiments 1a and 2a). Additionally, and beyond this prediction, both accounts generated novel positive predictions for the kind of stimuli that newborns would prefer, and both predictions were confirmed (Experiments 1c and 2b). It is important to note that these accounts are not mutually exclusive. It is possible that the same mechanism that helps infants to find a top-lit face at a distance or in the periphery would also help them to locate and fixate eyes at close proximity. In both cases, the approximate size of the retinal image of darker elements on light background could be similar. Future research will investigate this possibility.

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Figure Legends

Figure 1

Stimuli and looking times in all experiments. Newborns' looking time was measured to each of the pairs of stimuli to reveal their preference. Significant differences are indicated by asterisks (* = $P < .05$, ** = $P < .01$, *** = $P < .001$). The numbers below the columns represent the number of newborns tested in the corresponding condition.