Article

How Infants Learn From a World of Faces: Implications for Racial Biases and Mask-Wearing

Policy Insights from the Behavioral and Brain Sciences
2022, Vol. 9(1) 65–72

DOI: 10.1177/23727322211068007
journals.sagepub.com/home/bbs
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Abstract

Faces are special to infants from birth, and experiences with faces in infancy are critical to developing brain circuits that support face processing skills through adulthood. Infants learn to extract rich information from faces, including recognizing people, tracking their gaze and expressions, and lip-reading. As infants learn to interact with the people around them, their responses to and understanding of these communicative facial cues become more connected to their social understanding and reflect their developmental context. Infants' face perception is particularly responsive to experience, with some degree of plasticity present through middle childhood. Opportunities to interact with people from diverse racial backgrounds in infancy may help prevent perceptual and social biases toward different groups. Variations in experience with faces beyond face race and gender, such as the use of face coverings, may impact how and what infants learn from faces.

Keywords

face perception, early experience, development, communication, plasticity

Tweet

Faces matter to infants: they are ready to learn to recognize and interact with people around them with gaze, lip-reading, and expression. What infants learn from faces in diverse contexts may offer a chance to curtail some racial biases. How infants learn from masked faces is a puzzle.

Key Points

1. Young infants look more toward faces from birth, and they often see more close views of faces than older infants or adults.
2. Visual experiences with faces in early infancy enable face processing to proceed along a typical path, including the emergence of face-specific areas of the brain.
3. Infants derive rich dynamic information from faces (e.g., gaze direction and "lip-reading"), and understand these communicative cues with increasing sophistication through later infancy.
4. In the first year, infants start learning to differentiate the faces of other people and to recognize those they know across changes in viewpoint or expression.
5. Infants experience a relative loss in the ability to individuate the faces of people from racial groups unfamiliar to them; this loss can be prevented or reversed by intervention and carries implications for the emergence of implicit racial biases.
6. Much remains to be learned about how infants learn from faces in different contexts, such as in environments where face masks are commonly worn.

From the first face that a newborn infant sees, sighted infants are immersed in a world of faces. As the necessity of wearing face masks during the COVID-19 pandemic has been highlighted, people's faces reveal a wealth of information. From looking at someone's face, an adult observer may guess the person's identity, gender presentation, racial and ethnic background, and age; from the face's direction of gaze and expressive facial movements, form inferences about the person's current affect focus of attention, or "lip-read" the person's articulatory facial movements (Bruce & Young, 1986). Infants learn from the faces of the people around them from birth, and their face processing skills become increasingly attuned to their social environment (Pascalis et al., 2020; Quinn et al., 2018). This emerging ability to extract rich information from faces further supports their learning about social categories (Quinn et al.,

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2020), social and affective communication (Geangu et al., 2016; Hernik & Broesch, 2019; Pauen et al., 2015; Senju & Csibra, 2008), and spoken language (Lewkowicz & Hansen-Tift, 2012), thereby yielding cascading effects beyond the domain of face perception alone.

The current review highlights the special place of faces in the world of young infants, how infants learn to recognize and "read" the faces of other people, and how early experiences with faces can drive the emergence of biases in face perception—such as the "other-race" effect. Implications for the emergence of racial biases and for how infants learn from mask-wearing faces are briefly discussed.

Faces are Special for Young Infants and Young Infants' Face Experiences are Special

Young infants learn about faces from dense, canonical, close, and relatively blurry views of just a few individuals, a "face diet" that differs from the faces that older infants and adults typically see. Faces encountered in infants' early visual environment tend to present themselves in close, "canonical" views that, in adults, facilitate processing: upright, in front view, with both eyes visible (Jayaraman et al., 2015; Sugden et al., 2014; Sugden & Moulson, 2017). In addition, most of the views of faces that infants see in their first months tend to belong to the same 1–3 individual(s), typically their caregiver(s), often an adult woman of their own race (Fausey et al., 2016; Jayaraman et al., 2015; Sugden et al., 2014; Sugden & Moulson, 2018)—as detailed later, this skewed experience has implications for the development of gender and race face processing biases. Young infants additionally perceive faces through a visual system that has a lower acuity than older infants' or adults' (e.g., Dobkins et al., 1999). Thus, while closer views partly compensate for lower acuity, infants' face views would probably look blurry to adults. These unique characteristics of the young infant "face diet" may facilitate face perception development, offering potential insights for training more human-like face perception algorithms (Jayaraman et al., 2017; Vogelsang et al., 2018).

Young infants' brains process faces differently than other visual input. By at least 4–6-months, faces preferentially engage right occipitotemporal areas of the brain (e.g., de Heering & Rossion, 2015; Deen et al., 2017; Guy et al., 2016), and this functional specificity will strengthen in later development. Newborns also look longer to upright face-like patterns than to other visual patterns (Johnson et al., 2015; Macchi Cassia et al., 2004), as do newborn macaques and chicks (Rosa-Salva et al., 2010; Sugita, 2008), and perhaps human fetuses by 33–36 weeks of gestational age (Reid et al., 2017). This behavior is thought to involve subcortical mechanisms (Johnson et al., 2015), though face-like patterns also preferentially engage occipital and perhaps frontal cortices from birth (Buiatti et al., 2019). Functionally, newborns' orienting toward faces and face-like stimuli is thought to contribute to ensuring a rich exposure to canonical views of faces (i.e., upright, both eyes visible, etc.) in early infancy, perhaps in conjunction with caregiver behavior (e.g., Jayaraman et al., 2017).

Early experience with faces provides critical input to the development of cortical regions that will support face processing throughout life. If this input is missing, such as in individuals who were deprived of patterned visual input in early infancy due to congenital cataracts, face processing develops atypically with some deficits persisting through adulthood (Maurer et al., 2005). Infant macaques deprived of exposure to faces from birth lack robust cortical functional specificity for faces, and either lose or never develop a behavioral preference to look toward faces—instead, they exhibit cortical selectivity and behavioral preference for hands (Arcaro et al., 2017). While specific mechanisms remain disputed (Livingstone et al., 2019; Powell et al., 2018), early experiences with faces in infancy are clearly critical in enabling the emergence of typically developing face-specific areas in the brain.

What Infants Learn from Faces

In the first year of life, infants become increasingly adept at recognizing familiar faces or distinguishing the faces of unfamiliar individuals. Newborns show signs of recognizing their mother's face as little as 4 days after birth (Bushnell et al., 1989). Less is known about the typical age by which infants recognize their father's, siblings', or other caregivers' faces, although there is exploratory evidence for the recognition of siblings' faces by 12 months (Damon et al., 2021). Infants also distinguish between unfamiliar faces—an ability that becomes increasingly robust in the first year (Bayet & Nelson, 2020). At birth, newborns can recognize newly learned faces across slight viewpoint variations (Turati et al., 2008), or newly learned partially occluded faces (Gava et al., 2008). By 7–12 months, as infants' have accumulated more experience with faces under varying viewing conditions (Gliga & Dehaene-Lambertz, 2007), recognition of newly learned, unfamiliar faces becomes robust to larger variations in viewpoint (such as front to profile) or expression (such as smiling to frowning) (Kobayashi et al., 2011, 2014; Rose et al., 2002). These face recognition abilities will continue to develop well into childhood and adolescence (Bayet & Nelson, 2020).

During the first two years of life, infants exhibit an emerging sensitivity to the dynamic, communicative information that faces convey, such as gaze (Senju & Johnson, 2009), visual speech ("lip-reading"; e.g., Lewkowicz, 2003), and expressive facial movements (e.g., Bayet & Nelson, 2019; Leppänen & Nelson, 2009; Ruba & Repacholi, 2019), and leverage them to learn about objects and people. For example, newborns look longer to faces with direct gaze (Farroni et al., 2002); by 4 months, infants will follow a

person's gaze, as a result of visual experience (Peña et al., 2014). By 6–7 months, infants follow a person's gaze shift more if preceded by a communicative cue (Hernik & Broesch, 2019), suggesting an understanding of gaze as communicative. Infants' understanding of gaze further develops in later infancy, along with social cognition (Beier & Spelke, 2012; Gredebäck et al., 2008; Senju & Csibra, 2008); infants' gaze understanding is thought to contribute to other skills such as object learning (e.g., Pauen et al., 2015). By 6–8 months, infants additionally "lip-read" visual speech when processing auditory speech, a process that becomes increasingly attuned to native speech (Lewkowicz & Ghazanfar, 2006). For example, between 8 and 12 months, infants will shift their attention toward the mouth (vs. the eyes) of a talking face, a pattern of attention that is hypothesized to facilitate language learning (Lewkowicz & Hansen-Tift, 2012) and continues into the second year in some cases (e.g., Birulés et al., 2019). Finally, infants demonstrate an emerging sensitivity to facial movements that express affect. Newborns and very young infants look longer to smiles under certain conditions (Bayet et al., 2015; Farroni et al., 2007), and exhibit some perceptual biases for processing canonical "fear" faces by 3–4 months (Bayet et al., 2017; Safar & Moulson, 2020). By 7 months, the infant's brain responds differentially to several facial expressions (Bayet et al., 2021; Jessen & Grossmann, 2015; Nakato et al., 2011; Xie et al., 2018), and these responses vary depending on infants' developmental context (e.g., parenting; de Haan et al., 2004; Taylor-Colls & Pasco Fearon, 2015). At that age, infants allocate more attention to canonical "fear" faces (Leppänen & Nelson, 2009; Pyykkö et al., 2019), a phenomenon that is also modulated by environmental factors (e.g., caregiver sensitivity or psychopathology; Kataja et al., 2020; Rajhans et al., 2015). While what these young infants *understand* about facial expressions remains unclear (Ruba & Repacholi, 2019), older infants and toddlers increasingly seem to derive meaning from facial expressions, for example, expecting someone's smiling toward an object to denote a preference (Phillips et al., 2002; Reschke et al., 2017), or looking to a caregiver's face in unfamiliar situations (Sorce et al., 1985). Infants' visual attention to different facial features such as the eyes, nose, or mouth, reflect which facial features tend to convey more information in the context in which they are raised. For example, sighted infants of blind parents show less differentiated neural responses to gaze shifts than infants of sighted parents by 6–10 months (Vernetti et al., 2018), and different behavioral face scanning patterns by 12–16 months (Senju et al., 2015); similarly, by 7 months, infants' scanning of facial expressions differs by culture (Geangu et al., 2016). Taken together, these findings indicate that infants actively scan faces for dynamic information that over development becomes increasingly embedded into their emerging understanding of social communication.

Perceptual and Social Biases in Face Processing Emerge in Infancy

While newborns process faces from different races or species equally (Pascalis et al., 2002), by 9–12 months of age infants experience a relative loss in the ability to individuate faces of people from social groups (e.g., species, gender, and races) that they have less experience with (Markant & Scott, 2018; Maurer & Werker, 2014; Quinn et al., 2018; Scott & Monesson, 2009; Sugita, 2008; Woo et al., 2020). At 3 months, infants look longer toward faces from familiar social groups. For example, 3-month-olds with racially homogeneous experiences, but not those with multiracial experiences, look longer toward stranger faces of their own race (Bar-Haim et al., 2006; Liu et al., 2015). From 3- to 9-month-olds, infants raised in a primarily monoracial environment will shift to a visual preference toward other-race faces (Fassbender et al., 2016; Liu et al., 2015), and their ability to recognize individual other-race faces declines (Quinn et al., 2018; Sugden & Marquis, 2017). In multiracial environments, such as the capital of Malaysia, infants maintain their ability to recognize individual faces from other-race groups they are familiar with (e.g., female Malay faces, to a Malaysian infant of Chinese descent), but not from other-race groups that they do not have experience with (e.g., White European faces) (Tham et al., 2019). Importantly, race-based relative face processing deficits acquired in infancy are neither inevitable nor irreversible in childhood: perceptual training with other-race faces in infancy prevents the other-race effect (Anzures et al., 2012; Heron-Delaney et al., 2011), and experience with other-race faces in childhood (up to 12 years of age) decreases its strength (McKone et al., 2019).

Infants' unequal experience with people from different groups carries implications for the developmental origin of racial biases (Lee et al., 2017; Quinn et al., 2018, 2020). For example, by 9 months, infants raised in a racially homogeneous environment categorize faces from different other-race groups as a single category (e.g., Black and Asian together, in a predominantly White environment), despite their perceptual differences (Quinn et al., 2016, 2021). By the end of the first year, infants associate other-race faces with negative valence (Xiao et al., 2017) and with foreign languages (Uttley et al., 2013), and are less likely to follow the gaze of other-race faces (Pickron et al., 2014; Xiao et al., 2018). Implicit racial biases comparable to those observed in adults emerge by 3 years of age (Dunham et al., 2013; Setoh et al., 2019), and are thought to build on perceptual and social biases present in infancy (Lee et al., 2017; Quinn et al., 2018). Indeed, in preschoolers, perceptual training in individuating other-race faces reduces implicit (but not explicit) biases against the trained other-race group (Qian et al., 2019; Xiao et al., 2015). Bilingualism is also associated with lower racial bias in infants in a gaze

following task (Singh et al., 2019); these correlational findings suggest a comparable protective effect of early bilingualism against the development of some social biases.

Implications: Integrated Caretaking and Compensating for Masks

The infancy period is critical to developing lifelong face perception skills (Maurer et al., 2005). In particular, the heightened *plasticity* of face perception in infancy presents opportunities for learning to interact with diverse individuals (Lee et al., 2017), which may prevent the emergence of some implicit racial biases (Qian et al., 2019; Xiao et al., 2015). Conversely, racially homogeneous experiences in infancy contribute to race-based face perception deficits and social biases, unless offset by experiences in early or middle childhood (McKone et al., 2019; Quinn et al., 2018). Practices and policies that promote multiracial interactions, integration, or desegregation at the level of neighborhoods, housing, care arrangements, or schools, to the extent that they influence infants' and young children's experiences with peers' and adults' faces, are thus expected to broaden their face processing abilities through adulthood; more research is needed to document the impact of such policies or practices where they exist (Bar-Haim et al., 2006; Setoh et al., 2019; Tham et al., 2019; Woo et al., 2020).

In addition to race, much remains to be learned about the diversity of "face diets" (Jayaraman et al., 2015) that individual infants experience within and across cultural contexts, and how these variations in experiences, combined with other contextual variations (e.g., Wörmann et al., 2012), influence *what* and *how* infants learn from faces (e.g., Geangu et al., 2016). Consequently, much remains unknown about how the faces that infants see may be leveraged to *enrich* their learning, or how variations in the availability or nature of facial cues (e.g., widespread use of face-masking veils or masks in public spaces) impact it. For example, while the COVID-19 pandemic necessitates the universal wearing of face masks, surprisingly little is known about how infants process cues from mask-wearing faces (Carnevali et al., 2021; in adults, see, e.g., Barrick et al., 2021). Clear masks or face shields have been proposed as an alternative to opaque masks to facilitate infants' access to visual speech and other facial cues. However, in the laboratory, 2-year-olds actually seem *less* able to recognize words spoken through a clear full-face shield compared to either an opaque mask or no mask (Singh et al., 2021). Future research may examine how infants and those who care for them can compensate for masks in other ways, for example, by focusing on other channels of communication (such as the eyes, prosody, auditory speech, or gestures) where masks are worn, or by capitalizing on the learning that occurs where masks are not worn (e.g., at home).

Conclusion

Infants tune in to faces from birth. The faces that infants see and how they see them change with age and provide rich opportunities for learning: from recognizing people to communicating through lip-reading, gaze, or expressions, along with other cues (e.g., hand gestures). Infants' readiness to learn from faces and the plasticity of face processing in infancy open potential opportunities to enhance learning or promote other desirable developmental outcomes, such as the prevention of implicit racial biases. Future research should inform interventions or recommendations that capitalize on infants' readiness to learn from the faces around them.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author thanks American University and the American University College of Art and Sciences for funding.

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