When in infancy does the 'fear bias' develop?

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Abstract

Much research has focused on how infants respond to emotional facial expressions. One of the key findings in this area of research is that by 7 months of age, but not younger, infants show a bias in processing fearful faces, even when compared to other negative and novel facial expressions. A recent study by Heck and colleagues (2016) challenges this idea by showing that 5-month-old infants looked longer at fearful faces than at happy and at neutral faces when dynamic displays (videos) are used. Given that previous work failed to find enhanced attention to fearful faces in 5-month-old infants using static displays (photographs), this was taken as evidence that biased attention to fear can be observed earlier when dynamic information is presented. However, we computed an analysis which indicates that overall amount of motion displayed in the videos in Heck et al.'s study is confounded with emotion such that the greatest amount of motion is evident in the fearful face videos and may have driven infants' looking patterns. We discuss these findings and their limitations in the context of other research using dynamic emotion stimuli. While these findings do not rule out the possibility that 5-month-olds are sensitive to fear, we stress the need to control for physical differences such as motion before any conclusions regarding the emergence of the fear bias in infancy can be drawn and in order to improve research practice in the field.

When in infancy does the 'fear bias' develop?

Emotional facial expressions play an important role for human social interactions. How the sensitivity to process facial emotion develops during infancy has been intensively studied. One of the key findings in this area of research is that by around 7 months of age, but not younger, infants show a bias in processing fearful faces (see Leppänen & Nelson, 2012, for review). Indeed, there is converging evidence using various methods, including looking time, event-related brain potentials (ERPs), and heart rate to support the notion that 7-month-old infants show an attentional bias to fearful faces (e.g., Leppänen & Nelson, 2009; Peltola, Hietanen, Forssman, & Leppänen, 2013). This enhanced attention to fear seen in infants does not simply reflect a heightened sensitivity to any negative or novel facial expression as it is not seen in response to angry faces (Krol, Monakhov, Lai, Ebstein, & Grossmann, 2015) or an unfamiliar facial expression (Peltola, Leppanen, Palokangas, & Hietanen, 2008). Critically, with respect to its developmental emergence, there are studies that compare 7-month-old infants to infants at younger ages (5 months) and find that it is not until 7 months that infants show increased attention to fearful faces (Jessen & Grossmann, 2016; Peltola, Leppänen, Mäki, & Hietanen, 2009).

A recent study by Heck and colleagues (2016) challenges the idea that the fear bias only develops during the second half of the first year. In this study, the authors used videos of emotional displays (fearful, happy, and neutral) from a previously published stimulus set validated with adults (van der Schalk, Hawk, Fischer, & Doosje, 2011). Specifically, Heck et al. (2016) show that when using dynamic facial expressions, 5-month-old infants looked longer at fearful faces than at happy or neutral faces. Given that previous work failed to find enhanced attention to fearful faces in 5-month-old infants using static displays (photographs) (e.g., Peltola et al., 2009), this was taken as evidence that biased attention to fear emerges earlier than previously thought but is only elicited when dynamic information is presented.

We agree with Heck and colleagues (2016) that the use of dynamic stimulus material is an important step in increasing the ecological validity of emotional stimuli. Dynamic information has been shown to impact emotion processing, both in adults (e.g., Carretié et al., 2009; Kilts, Egan, Gideon, Ely, & Hoffman, 2003), but also in the perception of emotional body information in infants (Missana, Atkinson, & Grossmann, 2015; Missana, Rajhans, Atkinson, & Grossmann, 2014). Extending existing work by investigating emotion perception from dynamic faces in infancy is thus an important endeavor.

However, while using videos may represent a more ecologically valid method to examine infants' sensitivity to emotions, it also introduces methodological difficulties in controlling for dynamic stimulus properties. In particular, the overall amount of motion may confound differences between emotional expressions. In the study by Heck et al. (2016), emotional videos showed a face moving from a neutral expression to either a happy or a fearful expression, whereas in the neutral videos, the facial expression remained the same throughout the video. It is thus possible that the dynamic facial expression videos presented in this study vary systematically with respect to their overall amount of motion. While systematic differences in motion content do not rule out the possibility that 5-month-olds are sensitive to fear, they do present a major confound that needs to be considered.

To investigate this possibility, we obtained the stimulus material used by Heck and colleagues (2016) from the Amsterdam Dynamic Facial Expression Set (ADFES, van der Schalk et al., 2011). We carried out an analysis of the amount of motion contained in the videos used by Heck and colleagues based on an established algorithm (e.g., Jessen & Kotz, 2011; Pichon, de Gelder, & Grèzes, 2008, 2009). This algorithm takes individual frames of the video and converts them to gray-scale images in order to calculate mean change in luminance per pixel from one frame to the next. To account for random noise, only pixel exceeding a difference in luminance of 10 (on a scale from 0 to 255) are included in the analysis and averaged. This estimation is run for all consecutive pairs of frames over the entire duration of the video, and the overall average per video is computed from these values. The results of this analysis are shown in Figure 1 and 2. As shown in Figure 1, the amount of motion systematically varied between the three emotion conditions used in the study. Specifically, the greatest amount of motion is seen in the fearful faces, followed by the happy faces. Neutral faces contain the least amount of motion. With the exception of one actress, this was also the case when only the second half of the videos was considered, which reflects the time-window used by Heck and colleagues (2016) for their analysis (see Figure 1). Given that 5-month-old infants looked longest at fearful face videos and these are the face videos, which also contain the most amount of motion, this appears to be a major confound. We therefore caution against the conclusions drawn by Heck et al. (2016) regarding the emergence of biased attention to fear.

More specifically, it is known that infants show a preference (increased attention) for moving over static stimuli (Volkmann & Dobson, 1976) as well as for biological motion over non-biological motion (Fox & McDaniel, 1982; Simion, Regolin, & Bulf, 2008). It is therefore plausible that infants show greater attention to a facial stimulus containing greater amount of motion compared to one containing less motion, irrespective of the emotional expression displayed by the face.

Here it is important to mention that Heck et al. (2016) also tested 3.5-month-old infants and did not find any evidence that infants at this younger age distinguished between the dynamic facial expressions. The finding that 3.5-month-old infants did not show the same effect as 5-month-old infants could be used to argue that the motion confound, which we identified above, is unlikely to account for the effect of the dynamic fearful faces because then it should also be seen in the 3.5-month-old infants. However, based on the means reported in this study, the 3.5-month-old infants appear to generally look less at the facial expressions than the 5-month-old infants (marginally significant) and may thus fail to show any statistically significant differences between conditions (looking to fearful faces is nominally higher also in the 3.5-month-old infants, see Figure 2 of Heck et al. [2016]). Furthermore, while already young infants show a high sensitivity in processing local visual motion, the processing of global visual information develops only later in infancy (Hou, Gilmore, Pettet, & Norcia, 2009). For instance, it is not until 5 months of age (Booth, Bertenthal, & Pinto, 2002) that infants reliably show sensitivity to global motion during visual processing, which might be needed to detect motion differences in the dynamic face displays. In addition, 5-month-old infants, but not 3-month-old infants, show a sensitivity to the movement of inner facial features (Johnson, Dziurawiec, Bartrip, & Morton, 1992). Thus, there might be reasons why 3.5-month-old infants failed to show sensitivity to the amount of motion of the inner facial features displayed in the dynamic facial expressions.

Another important point to consider is infants' looking behavior during the first half of the video, which was not the main focus of the analysis by Heck et al. (2016). While Heck and colleagues (2016) did not find any differences in looking time, the videos clearly differed in motion content (see Figure 1). Crucially, during this time period, the face video was presented in isolation, that is, without the checkerboard as a competing stimulus but no differences between emotions were obtained. This is in contrast to previous studies with older infants, which report differences in looking time to different emotions when the faces were presented without a distractor (Hunnius, de Wit, Vrins, & von Hofsten, 2011; Jessen, Altvater-Mackensen, & Grossmann, 2016). This discrepancy with prior work, that is, the absence of any emotion effect in Heck et al.'s (2016) study for the looking time measurement when the face was presented in isolation, further challenges Heck et al.'s conclusion that 5-month-old infants are able to discriminate between facial emotions.

Another line of research to consider is work on the early development of emotion perception using emotional body expressions (Missana et al., 2015; Missana & Grossmann, 2015). While previous studies on face processing typically used static displays, studies investigating emotional body expressions often use video material. Recent studies on emotional body perception in infancy may provide important clues about the potential impact of using dynamic emotional stimuli. For example, Missana and colleagues (2015) presented 4- and 8-month-old infants with dynamic point-light-displays of happy and fearful body expressions and measured ERPs. This study shows that 8-month-old infants, but not 4-month-old infants, distinguished between happy and fearful body expressions. Therefore, in contrast to the present findings by Heck and colleagues (2016), Missana et al. (2015) did not find an earlier onset of emotion discrimination when dynamic information was used. Instead, the findings from using dynamic emotional body expressions is in line with previous work using static fearful and happy facial expressions (Peltola et al., 2013; Peltola et al., 2009), suggesting that infants' ability to discriminate these emotions from facial and body cues undergoes similar development between the first and second half of the first year of life. Critically, Missana and colleagues (2015) obtained these findings controlling for overall amount of motion contained in the dynamic emotion displays used. In addition, this study revealed differences between processing fear and happiness only when point-light-displays were presented in an upright orientation but not when presented upside-down. This provides further evidence that motion cannot account for the differences seen at 8 months of age, because the same motion content was present in the inverted stimuli.

Further evidence for the similarity in processing emotions from faces and bodies comes from another recent ERP study in which Missana and colleagues (2014) used static fearful and happy body expressions and found that 8-month-old infants discriminate between happy and fearful bodies, showing similar neural signatures as in previous ERP work using happy and fearful facial expressions. Indeed, most recently, Rajhans et al. (2016) showed that 8-month-old infants match body and face when processing fear and happiness. Therefore, the existing evidence from multiple studies, including dynamic stimuli, stands in contrast to Heck et al.'s (2016) and suggests that detecting fear from body and facial expressions undergoes development later than argued by Heck et al. (2016).

Another important line of research with respect to the use of dynamic stimulus material comes from the investigation of multisensory emotion processing in infancy (e.g., Flom & Bahrick, 2007; Vaillant-Molina, Bahrick, & Flom, 2013, see Walker-Andrews, 1997, for a review). In this area of research, videos are commonly paired with auditory information, and several studies show that, using multisensory stimuli, sensitivity to differing emotional expressions can already be observed at 5 months of age. For example, Vaillant-Molina et al. (2013) used videos of positive and negative facial expressions along with positive and negative vocal utterances, and provide evidence that at 5 months of age but not younger (3.5 months) infants are able to match happiness/joy compared to anger/frustration. While these findings suggest sensitivity to emotional content at 5 months of age, this early onset can probably be attributed to the multimodality rather than the dynamics of the stimulus material. In fact, when comparable stimuli are used in isolation, that is, only visual or auditory information is provided, sensitivity to emotional content was only observed at 6 months for auditory and at 7 months for visual information (Flom & Bahrick, 2007). Crucially, Flom and Bahrick (2007) used videos in their study and only observed sensitivity to emotions at 7 months of age but not younger, providing further support for the notion that dynamic content alone may not be sufficient to enable emotion discrimination at 5 months of age.

In summary, while we agree that it is important to extend existing work by relying more on ecologically valid emotional stimuli including videos in developmental research with infants, we would also like to emphasize the importance of controlling for potential differences in physical stimulus properties. Controlling for the overall amount of motion contained in experimental video stimuli appears to be one vital measure that can be taken to improve existing methods. Moreover, it is essential to stress that this issue is not only relevant for the work discussed here, but more generally applies to research that relies on methods that are susceptible to motion characteristics such as looking time and ERPs.

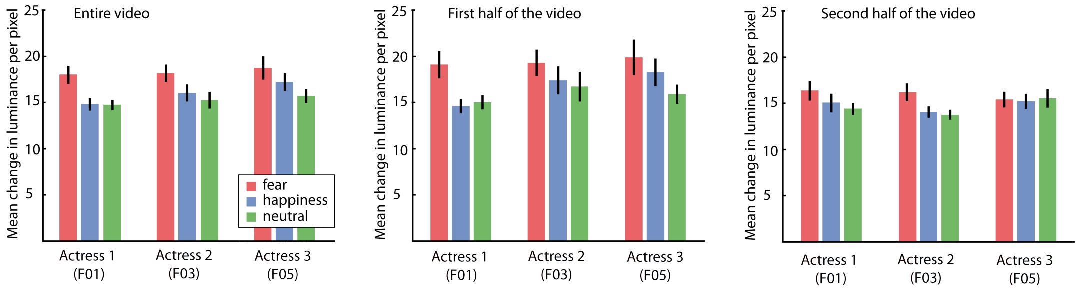

Figure 1. Mean motion content during video. Shown is the mean motion content (± standard error) during each video used in Heck et al. (2016), which includes videos from 3 actresses displaying fearfulness, happiness, and a neutral expression. Since Heck and colleagues (2016) investigated looking time only during the second half of the video, amount of motion is shown separately for the entire duration of the video (left panel), the first half of the video (middle), and the second half of the video (right panel). As can be seen, the motion content is highest for fearful expressions, smaller for happy expressions, and the smallest for neutral expressions, both during the entire video as well as during the first and second half of the video.

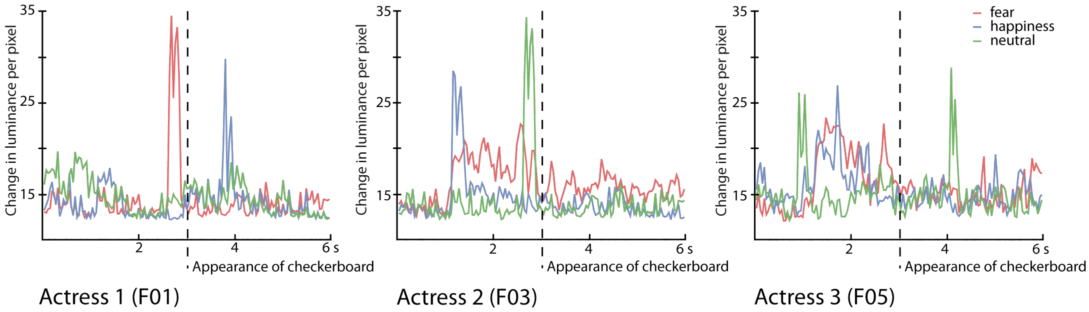

Figure 2. Motion plotted across time for over the entire video. Shown is the motion content (quantified as change in luminance per pixel) over the entire video separately for each actress and video (emotion). The appearance of the checkerboard (dashed line) marks the onset of the second half of the video, which was the main focus of analysis by Heck and colleagues. The spikes correspond to very localized events in the video, such as mouth opening (F01, fearful face, around 2.5 s) or eye blinks (F03, neutral face, around 2.5 s).

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