Vision Research 102 (2014) 1–10

Contents lists available at ScienceDirect

Vision Research

journal homepage: www.elsevier.com/locate/visres

Both children and adults scan faces of own and other races differently

Chao Hu [a,b], Qiandong Wang [a], Genyue Fu [a,c,*], Paul C. Quinn [d], Kang Lee [a,b,*]

[a] Department of Psychology, Zhejiang Normal University, Jinhua, China
[b] Applied Psychology & Human Development Department, University of Toronto, Toronto, Canada
[c] Hangzhou Teachers College for Infant Children, Zhejiang Normal University, Hangzhou, Zhejiang, China
[d] Department of Psychology, University of Delaware, Newark, DE, United States

ARTICLE INFO

Article history:
Received 3 October 2013
Received in revised form 27 May 2014
Available online 11 June 2014

Keywords:
Face processing
Children
Race
Experience

ABSTRACT

Extensive behavioral and neural evidence suggests that processing of own-race faces differs from that of other-race faces in both adults and infants. However, little research has examined whether and how children scan faces of own and other races differently for face recognition. In this eye-tracking study, Chinese children aged from 4 to 7 years and Chinese adults were asked to remember Chinese and Caucasian faces. None of the participants had any direct contact with foreign individuals. Multi-method analyses of eye-tracking data revealed that regardless of age group, proportional fixation duration on the eyes of Chinese faces was significantly lower than that on the eyes of Caucasian faces, whereas proportional fixation duration on the nose and mouth of Chinese faces was significantly higher than that on the nose and mouth of Caucasian faces. In addition, the amplitude of saccades on Chinese faces was significantly lower than that on Caucasian faces, potentially reflecting finer-grained processing for own-race faces. Moreover, adults' fixation duration/saccade numbers on the whole faces, proportional fixation percentage on the nose, proportional number of saccades between AOIs, and accuracy in recognizing faces were higher than those of children. These results together demonstrate that an abundance of visual experience with own-race faces and a lack of it with other-race faces may result in differential facial scanning in both children and adults. Furthermore, the increased experience of processing faces may result in a more holistic and advanced scanning strategy in Chinese adults.

1. Introduction

Processing of faces based on differential experience has attracted the interest of many researchers in psychology since the early 1900s (Feingold, 1914). One well established example is the differential processing of faces of own and other races (for a review, see Anzures et al., 2013). This phenomenon, which is commonly referred to as the Other-Race Effect (ORE), has been repeatedly demonstrated in studies with infants (Anzures, Ge, Wang, Itakura, & Lee, 2010; Ferguson, Kulkofsky, Cashon, & Casasola, 2009; Kelly et al., 2007; Kelly et al., 2009), children (Anzures et al., 2014), and adults (Caharel et al., 2011; Golby, Gabrieli, Chiao, & Eberhardt, 2001; Tanaka & Pierce, 2009). Recent evidence suggests that the behavioral Other-Race Effect also has a neural equivalent, or Neural Other-Race Effect (NORE) in infancy (Balas & Nelson, 2010), childhood (Ding et al., 2012), and adulthood (Golby et al., 2001; Hugenberg, Young, Bernstein, & Sacco, 2010; Meissner & Brigham, 2001; Natu, Raboy, & O'Toole, 2011; Sporer, 2001).

In spite of the growing behavioral and neural evidence, little is known about whether and how individuals scan faces of own and other races to extract information for face recognition. Faces form one of the most complex and information rich classes of stimuli in our visual environment. They contain a multitude of information such as identity, race, gender, age, and attractiveness as well as gaze and emotion (Lee, Anzures, Quinn, Pascalis, & Slater, 2011). For the task of face recognition, one must scan the face and actively search for identity relevant information to ensure accuracy. Given the existing evidence about the ORE and NORE, one can assume that our active visual scanning of faces of own and other races may also differ due to our differential experience with processing the two types of faces, as demonstrated in a previous eye-tracking study in which Chinese adults scanned Chinese and Caucasian faces with different strategies (Fu, Hu, Wang, Quinn, & Lee, 2012). In Fu et al. (2012), Chinese adults scanned own-race Chinese faces with a focus around the nasal region, whereas they scanned Caucasian faces with a focus on the eyes.

* Corresponding authors. Address: Department of Psychology, Zhejiang Normal University, Jinhua, China (G. Fu). Address: Applied Psychology & Human Development Department, University of Toronto, Toronto, Canada (K. Lee).
E-mail addresses: fugy@zjnu.cn (G. Fu), kang.lee@utoronto.ca (K. Lee).

http://dx.doi.org/10.1016/j.visres.2014.05.010
0042-6989/

Eye-tracking is the ideal methodology for studying scanning patterns during the processing of faces from own and other races. It records observers' fixations on various parts of the face in real time with high temporal and spatial resolution (Frank, Vul, & Johnson, 2009). Several recent studies have used eye-tracking to examine how individuals visually scan faces of own and other races. Some researchers have reported that even in infancy, the scanning strategies of Caucasian and Chinese infants vary for processing faces of different races (Gaither, Pauker, & Johnson, 2012; Liu et al., 2011; Wheeler et al., 2011; Xiao, Xiao, Quinn, Anzures, & Lee, 2013). For example, Wheeler et al. (2011) found that with age, Caucasian infants from 6 to 10 months increased their visual attention to the eye region of own-race faces but their fixations on the mouths of these faces decreased, consistent with an upper region processing bias (Quinn & Tanaka, 2009; Simion, Valenza, Macchi Cassia, Turati, & Umiltà, 2002); during the same time frame, visual attention to the eyes of other-race African faces did not change. In contrast, Liu et al. (2011) found that when viewing own-race Chinese and other-race Caucasian faces, Chinese infants' fixation duration on the Chinese nose had no significant change from 4 to 9 months of age, whereas their fixation duration on the Caucasian nose decreased significantly with age. It seems that Caucasian and Chinese infants have differential scanning patterns for faces of own and other races. Moreover, the development trajectory of scanning strategy for own-race faces seems to be different from that for other-race faces.

Consistent with the infant findings, a study of Chinese adults revealed that their scanning strategies for Caucasian faces and Chinese faces were different, with greater focus on the nose of Chinese faces and the eyes of Caucasian faces (Fu et al., 2012). However, little is known about young children's scanning strategies for faces of own and other races (Kelly et al., 2011). An abundance of research has been carried out to investigate face processing strategies in adults and children, using an array of techniques such as inversion, part-whole, and composite face methodologies (e.g., Brace et al., 2000; Diamond & Carey, 1986; Maurer, Grand, & Mondloch, 2002; Pellicano, Rhodes, & Peters, 2006; Tanaka, Kiefer, & Bukach, 2004; Young & Bion, 1981). Collectively, these studies have demonstrated that both children and adults process faces holistically, although children perform more poorly than adults (e.g., Pellicano & Rhodes, 2003). However, due to limitations of the behavioral paradigms, no detailed differences in processing strategy between children and adults were demonstrated. Furthermore, existing eye-tracking studies have mainly used the area of interest approach to focus on the fixation data and have not utilized the multiple sources of information afforded by eye-tracking technology.

To bridge this gap and obtain a more informed view of the developmental course of differential scanning of faces of own and other races, we conducted an eye-tracking investigation with native Chinese children from 4 to 7 years of age and native Chinese adults. The data during the learning and reviewing of target faces were analyzed. In this study, we took a multi-method approach to analyze the eye-tracking data. First, we used the traditional Area of Interest (AOI) approach. The AOI approach has the advantage of being easy to use and provides a default mode of analysis for most eye-trackers. With this approach, visual fixations on a predefined key area of the face are grouped together to reveal the amount of time that an observer spent on this area when encoding that face (Fig. 1).

The disadvantage of the AOI approach is that it groups fixations on a large area of the face together as if they are the same (e.g., fixations on the pupil, sclera, and eye lid are indiscriminately lumped together as fixations on the eyes). This approach thus fails to reveal potentially important differences in fixations on different parts within an AOI. Also, important fixation effects may sometimes occur at the borders of multiple AOIs, resulting in obscuration of the effects.

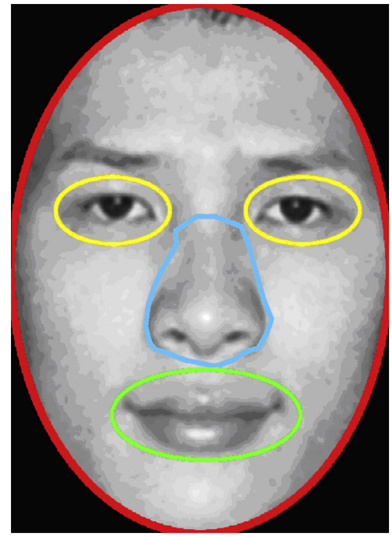

Fig. 1. An example face showing how the AOIs were defined in our study.

To compensate for these shortcomings of the AOI approach, we also took a pixel level data-driven approach. More specifically, we used a novel method that computes statistical fixation maps of eye movements (Caldara & Miellet, 2011). Unlike the above AOI analyses that amalgamate all fixation points that fall into a particular predetermined area of interest and perform statistical tests on the total fixations to the area between conditions, iMap allows for statistical testing of condition differences on any part of a stimulus without the restriction of the AOIs. Also, it allows for statistical testing of condition differences on a scale finer than the AOI analyses. Thus, iMap provides pixel level statistical maps about the fixation distribution differences between own- and other-race face scanning in each age group. This data-driven approach allows for direct comparisons of the differential scanning patterns between own- versus other-race faces across ages. By employing this approach, we aimed to reveal more subtle differences in the scanning patterns of faces of own and other races in children and adults.

We additionally used another novel approach, the scan path analysis, which has yet to be widely used to analyze scanning of faces. The scan path analysis capitalizes on the rich saccade data that are concurrently collected with the fixation data in an eye-tracking experiment, but often left unanalyzed. This analysis assesses specific fixation shifts between major internal face features, such as visual shifting between the eyes, between the eyes and the mouth, or between the eyes and the nose. Further, this analysis measures not only the frequency of saccades between key face areas but also saccade amplitudes. Saccade amplitude has been used to analyze adult eye-movement data since the 1970s (Baloh, Sills, Kumley, & Honrubia, 1975). It measures the length of saccades in degrees of visual angle, or in the distance between two successive fixations, which is determined by the visual angle if the distance from the viewer's eyes to the object is stable, which is the case in our study. Maw and Pomplun (2004) suggest that short saccades indicate fine-grained processing of local information, whereas long saccades often signify low information content or superficial scanning of local visual input.

Based on the existing eye-tracking studies, we hypothesized that both Chinese children and adults' proportional fixation duration on the eyes of Chinese faces would be less than on the eyes of Caucasian faces, and their proportional fixation duration on