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Development of facial identification: How do young children process internal and external features?

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Abstract

To identify or recognize human faces accurately, one needs to attend to internal facial information (i.e., eyes, nose, mouth, cheeks, and chin) while disregarding inappropriate external cues (i.e., hairstyles). Young children's tendency to attend to external rather than internal information is believed to explain their inferior performance in facial processing compared with that of adults. This article focused on experimental studies regarding developmental differences in attending to and using internal and external information for facial identification. First, experimental studies from the 1970s to the 2010s were reviewed. Second, methodological problems of earlier studies, such as a lack of total facial configurations, were discussed and recent studies using new methodologies were introduced. Finally, we presented a progressive approach to clarifying the developmental changes that occur in facial processing.

Key words: young children, facial identification, perceptual development

Since Yin (1969) reported an "inversion effect", which showed that facial images, unlike other object images, were processed configurally or holistically, developmental research has mainly focused on children's inability to process faces configurally (e.g., Baenninge, 1994; Flin, 1985; Mondloch, Dobson, Parsons, & Maurer, 2004; Mondloch, Grand, & Maurer, 2002). For example, Mondloch et al. (2002) showed that preschoolers were insensitive to spatial relations among facial features such as space between eyes, and space between nose and mouth (i.e., configural information), despite their sensitivity to the information about individual facial features (e.g., shape of eyes, nose, mouth) and about contour. This type of research tended to limit the region of the face to the area of internal parts (i.e., eyes, nose, mouth, cheeks and chin) for controlling or excluding the influence of external part (i.e., hairstyle including contour). Another branch of research has been concerned with children's preferences for internal or external information when identifying and recognizing faces. Accurate identification and recognition are based on the reliable and stable cues of internal features, but not the unreliable and changeable cues of external features such as hairstyle. Therefore, appropriate use of internal information is a critical factor in explaining the developmental differences in facial processing. In this article, we reviewed facial identification and recognition studies regarding developmental differences in attending to and using internal and external information and presented a progressive approach to clarifying the developmental changes that occur in facial processing.

Children's tendency to attend to external information

The work of Diamond and Carey (1977) is considered the earliest experimental study to focus on young children's tendency to attend to external information. In this study, the authors showed that

facial recognition and identification by young children were based more on matching isolated features such as a hairstyle than on identifying internal facial features. In a series of experiments, 6- to 16-year-olds were asked to identify the same person as a target from two alternatives in which one was identical to the target and the other was a distractor. When the identical stimulus had a different hairstyle and the distractor had the same hairstyle as the target, the recognition accuracy for 6- and 8-year-olds was extremely low compared with that for children aged over 10. The results of simple matching tasks, in which a target and two alternatives were displayed simultaneously, also showed a similar tendency to that shown in the identification tasks: that is, the inferior performance of young children could not be attributed to their immature memory. The experimental study by Diamond & Carey (1977) was probably the first to show young children's strong reliance on external clues, though they did not use the terms "internal" and "external" information.

The next line of thought was to investigate the developmental shift from external to internal advantage or preference when recognizing faces (Campbell et al., 1999; Campbell & Tuck, 1995; Campbell, Walker, & Baron-Cohen, 1995; Ellis, Shepherd, & Davies, 1979; Young, Hay, McWeeny, Flude, & Ellis, 1985). Studies that focused on the difference between processing of familiar and unfamiliar faces (Ellis et al., 1979) examined the tendency of adults to use internal or external facial cues when recognizing familiar faces (i.e., those of famous people) and unfamiliar faces. As a result, adults showed an internal processing advantage in recognizing familiar faces, whereas there was no difference between internal and external processing of unfamiliar faces. We consider that the study by Ellis et al. (1979) was the first to discriminate internal with external information in a face, though they used the terms "inner features" and "outer features". However, developmental studies also examined children's tendency to attend to internal or external information (Campbell et al., 1995; Campbell, et al., 1999). Campbell et al. (1999) used naming tests of famous people (i.e., familiar people) such as movie stars and politicians when presenting internal information, external information, or whole face. Consequently, all participants could recognize whole face most correctly but children aged under 11 years showed an external advantage. Campbell et al. (1995) asked children aged 3–11 years to state whether some facial photos represented those of their schoolmates (i.e., familiar faces) or those of children from another school when presenting three types of images (i.e., internal, external, or whole face). The results showed that judgments of external parts were more accurate those of internal parts for younger children, but the 9- to 11-year age group showed the reverse pattern. These studies suggested that the tendency for adults to recognize familiar faces better from their internal rather than from their external parts is a developmental shift from external to internal advantage that occurs in later childhood.

Recent studies have maintained that previous observations of a shift in reliance from external to internal facial features can be attributed to experience with familiar faces rather than to age-related changes in facial processing (Ge et al., 2008; Megreya & Bindemann, 2009; Wilson, Blades, & Pascalis, 2007). Earlier studies (e.g., Campbell et al., 1999) used photographs of celebrities as the stimuli of familiar faces. However, while adults have known these celebrities for many years, children knew little about them even if they were able to say their names. Thus, such stimuli could be processed as highly familiar faces by adults but only as slightly familiar faces by children, and this could lead to children's reliance on external features. Recent studies used the facial stimuli of the children's teachers or classmates, which were more familiar to the children than the faces of celebrities. Wilson et al. (2007) asked children aged 5–11 years to choose their own teacher from two alternatives (i.e., a target and a distractor) when presenting three types of images (i.e., internal, external, or whole face). The results showed that the youngest age group (5- to 6-year-olds) recognized their teachers' faces better from internal features than from external features. Ge et al. (2008) also showed that 4-year-olds show internal advantage in a task of naming their own classmates. This study, which reported on the internal preference of preschool children, concluded that children generally process familiar faces based on internal features and unfamiliar faces from external features. It also suggested that even young children process familiar or

unfamiliar faces in the same manner as that of adults.

Total configuration of internal and external features

Many studies have examined the use of internal and external information; however, several studies (Ge et al., 2008; Knowles & Hay, 2014; Meinhardt-Injac, Persike, & Meinhardt, 2014; Nachson, Moscovitch, & Umilta, 1995; Sugimura, 2013) have highlighted a methodological problem of such experiments: the lack of total facial configurations or the lack of interaction between internal and external features. In most previous studies, internal parts were cut out from a whole face and presented in the absence of external parts, and vice versa, to control the effect of the other parts on facial processing. For example, Ge et al. (2008) used stimuli such as "inner face only" (i.e., cutting out the internal area, including eyebrows, eyes, nose, mouth, cheeks, and chin) and "outer face only" (i.e., what remained of the face after excluding the inner face—contour, hair, forehead, and ears). In their study, they commented on the limitation of their own methodology, pointing out that it ignored the influence of outer faces when processing inner faces. From a practical point of view, investigations using the facial stimuli of either external or internal parts do not reflect real-life facial processing because people do not see internal face and external hairstyle separately (Sugimura, 2013). As noted by Meinhardt-Injac et al. (2014), little developmental research has focused on the perceptual integration of external and internal features into holistic face representations, even though there is strong evidence that external features play a critical role in children's facial perception (e.g., Diamond & Carey, 1977). The results of previous experiments using isolated stimuli that excluded the influence of the external area may have overestimated children's ability to identify or recognize faces. For example, the study by Gilchrist and McKone (2003), in which internal faces were cut out from the whole face, revealed that the pattern of sensitivity of a second-order relation in 7-year-olds was similar to that in adults. However, in Baudouin, Gallay, Durand, & Robichon (2010), 7-year-olds did not show adult-like sensitivity of a second-order relation. Therefore, unless investigations take into account the interaction between internal and external areas, it is difficult to clarify the developmental differences in facial processing in reality.

More recently, several studies (Knowles & Hay, 2014; Meinhardt-Injac, et al., 2014; Sugimura, 2013) have developed identification or recognition tasks in which the effect of external information when processing internal features of a face can be assessed. Sugimura (2013) examined the differences between 5- to 6-year-olds and adults in terms of reliance on internal features (i.e., eyes, nose, mouth, and cheeks) or external features (i.e., hairstyle) when making same or different decisions for two facial images positioned side by side. Four different types of stimuli were presented: two incongruent stimuli, in which the two images showed either the same internal face (i.e., same person) with different hairstyles or two different internal faces (i.e., different people) with the same hairstyle, and two congruent stimuli, in which the two images showed either the same face and hairstyle or two different faces and hairstyles. The participants were asked to decide whether the two facial images were those of an identical person or different people. As a result, 5- to 6-year-olds were more likely to base their responses on external hairstyles for the incongruent stimuli even when they were instructed to attend to internal features. In contrast, adults' responses were entirely based on the cue of internal features. Meinhardt-Injac et al. (2014) also examined the difference in responses between 8- to 10- year-olds and adults using incongruent and congruent stimuli in sequential same–different matching tasks. In the task, participants were asked to match faces based on either internal or external features. The children's performance was generally higher when attending to external features rather than internal features. In particular, their performance in internal matching of incongruent stimuli was extremely poor. However, adults tended to perform better when attending to internal features. These results indicate that external features are much more relevant in facial processing by children.

Several developmental studies (Sugimura, 2006a, 2006b) showed a similar tendency of children's responses in discriminating the gender of faces; that is, they often responded inaccurately because of

attending to the external cue of hairstyle. For example, Sugimura (2006a) examined how accurately young children and adults discriminate the gender of faces with a variety of hairstyles. The results showed that young children were likely to discriminate using the external cue of hairstyle, in particular for faces with a hairstyle typical of the opposite gender (e.g., a male with long hair). In contrast, the responses of adults were accurate and based on information from internal facial features, not from external hairstyles.

Why do young children depend on external information?

Why are facial identifications by children likely to depend on external information even though internal and external features are interrelated? One possibility is that children misinterpret the demands of a task. As noted by Sugimura (2013), young children's reliance on external hairstyles may have been due to misunderstanding the instructions of a matching task: they might have interpreted "the same person" as being "the same-haired person". However, children's responses based on external clues remained constant even when the children were encouraged to attend to internal features and not be distracted by external cues (Sugimura, 2013, Experiment 2). A study by Meinhardt-Injac et al. (2014) revealed that 8- to 10- year-old children also tend to rely on external hairstyle even when asked to respond based on internal features. Sugimura (2006b) also reported similar results for gender-discrimination tasks: young children depended on external hairstyles even when they were asked to make a judgment based on internal features. Therefore, children's inability to attend to internal features was not due to their misunderstanding the demands of the task.

Another possibility is that children may not have regulated their attention based on the instructions, even though they had understood them correctly. In other words, children may not have directed their attention to internal areas and focused instead on the external hairstyle more often than on internal facial features. To clarify this point, Sugimura (2013, Experiment 3) examined which parts young children and adults attended to when matching faces by means of analyzing eye movement data. The results showed that both children and adults spent longer looking at the internal features and gave surprisingly little attention to the external hairstyle, and that children attended to internal features for as long as, or even longer than, the adults. Sugimura (2011) also analyzed eye movements during gender-discrimination tasks. The results showed that children's judgments of gender, unlike those of the adults, were inaccurate and mainly based on the external cue of hairstyle. However, both children and adults mainly studied internal facial features and paid little attention to the external hairstyle. These eye-tracking studies revealed that children showed external advantage when identifying or discriminating faces even though they were able to direct their attention toward the internal area or features of the faces.

Before a discussion about the discrepancy between response tendency and eye-movement data, we would like to refer to several studies using eye movements, to present a brief overview of facial processing. Eye movement has been widely used to examine the nature of facial processing (Chawarska & Shic, 2009; Farzin, Rivera, & Hessl, 2009; Firestone, Turk-Browne, & Ryan, 2007; Kano & Tomonaga, 2010; Liu, Quinn, Wheeler, Xiao, Ge, & Lee, 2010). In particular, the studies that focused on adult participants showed a difference in eye movements between recognizing familiar and unfamiliar faces (Heisz & Shore, 2008; Stacey, Walker, & Underwood, 2005), upright and inverted faces (Hills, Sullivan, & Pake, 2012; Xu & Tanaka, 2013), and face matching and gender discrimination (Armann & Bülthoff, 2009). These studies seemed to indicate that differences in eye movement reflect different means of facial processing. However, other research has maintained that eye movements do not necessarily reflect facial processing. For example, several studies (Anderson, Bothell, & Douglass, 2004; Henderson, Williams, & Falk, 2005; Hsiao & Cottrell, 2008) have shown that eye movements play a functional role in the learning or encoding process but not in the retrieval or recognition process. The same research has shown that eye movements reflect only foveal vision, which is a small part of a visual scene, but also that a high resolution (Armann & Bülthoff, 2009) and holistic processing is related to low spatial frequency

information, which does not require foveal vision (Henderson, et.al., 2005). These studies suggest that only local and analytical aspects of facial processing are reflected in eye-movement behavior.

As previously mentioned, the children's responses tended to be based on external hairstyle even though the children were mainly studying internal facial features. Sugimura (2011, 2013) interpreted this discrepancy under the assumption of a process of disregarding information relating to a peripheral visual field, which does not reflect eye-movement data. To match faces correctly based on internal cues, one needs to succeed in the dual task of processing internal facial features and disregarding the external cue of hairstyle. It is possible that children's reliance on external hairstyle is due to their inability to disregard the information of a peripheral visual field to which they are not attending (i.e., external hairstyles) while they attend to the information of a central visual field (i.e., internal features) (Sugimura, 2013). The same study also pointed out that the process of disregarding irrelevant information affects children's responses considerably more than the process of attending to relevant information.

Aligned with children's difficulty in disregarding external information, a similar phenomenon was observed in infants' perceptions to geometrical figures: the "externality effect" (Bushnell, 1979; Milewski, 1976). This effect refers to infants not being able to discriminate a geometrical internal element enclosed by an external element. For example, Bushnell (1979) showed that 1-month-old infants had difficulty in discriminating a line drawing of a square enclosed within a line drawing of a circle and a triangle enclosed within a circle, whereas 3-month-olds could discriminate these stimuli. However, even 1-month-olds could distinguish these when the saliency of internal figures was manipulated by oscillating or flashing the figures. However, Bushnell (1982) showed that 3-month-old infants who could distinguish their mother from an unfamiliar woman had difficulty in discriminating between them when they had the same external feature of wearing a bathing cap. These results suggest that observation of the externality effect depends on the difference in the complexity level of tasks constructed using a combination of internal and external parts. We assumed that the facial matching or recognition task was a task that induced the externality effect in young children.

Domain-general or domain-specific development?

We have been discussing children's facial processing that is dependent on external information. Here, we would like to refer to the topic of domain-specific or domain-general development. Many studies that have focused on the use of a configural cue (e.g., de Heering, Rossion, & Maurer, 2012; Mondloch, Maurer, & Ahola, 2006; Pellicano, Rhodes, & Peters, 2006; Picozzi, Cassia, Turati, & Vescovo, 2009) have examined which factor contributes more to improvements in facial processing: specific maturity (i.e., expertise derived from experience of seeing a variety of faces), or general cognitive and perceptual development (i.e., attention span or memory). For example, Pellicano et al. (2006) showed that even 4-year-olds, like adults, were sensitive to the configural relations of faces based on an inversion effect. They concluded that development of facial processing, from at least 4 years old, was likely to be attributed to children's immaturity of general cognitive skills. However, research investigating own-age effect (e.g., Cassia, Pisacane, & Gava, 2012) and other-age effect (e.g., Sangrigoli & De Schonen, 2004) has underlined the development of a specific prototype of faces from experience. These standpoints do not necessary contradict each other. Both general cognitive and facial-specific skills are considered critical to the development of facial processing.

Which aspect do researchers emphasize for explaining the phenomenon of external advantage observed in children: general cognitive or facial-specific skills? From the standpoint of eye-movement studies, Sugimura (2011, 2013) ascribed greater importance to general cognitive factors such as development of executive function (EF) to disregard or inhibit irrelevant information. The term "EF" refers to higher-order, self-regulatory cognitive processes that aid in the monitoring and control of thought and action, and these processes include working memory, inhibitory control, attentional flexibility, and planning (e.g., Carlson, 2005; Welsh, Pennington, & Groisser, 1991). Sugimura (2013)

suggested that the process of inhibitory control, which is inhibiting a prepotent response or resisting interference from irrelevant distraction, likely relates to the ability to disregard the irrelevant cue of hairstyle. However, Meinhardt-Injac et al. (2014) stressed that children's difficulties in responding to internal features are not caused by deficits within general attentional capabilities. They examined the difference in the effect of external part in processing a face and a watch representing a non-facial object, which has the same structure as a face (i.e., the watch face as an internal part, and the surrounding parts, including a frame, as an external part). The results showed that the responses of 8- to 10-year-olds were affected by external information when identifying faces. However, there was no such tendency when identifying watches. The interpretation of these results was that children's tendency to be affected by external information is a domain-specific deficit observed only in facial processing.

It is premature to conclude which aspect is more closely related to the development of accurate identification and recognition of internal facial features while ignoring external cues. Further studies are needed to clarify facial processing from the standpoint of interaction or the process by which internal and external information is integrated. First, we need to examine the developmental change of dominance of external information from infants to young adolescents. Recent studies in infants have shown that infants rely on external area when discriminating faces. For example, in the first week of life, infants can recognize their mother's face, but they fail to do so if the external area of contour and hair are masked by a scarf (Pascalis, de Schonen, Morton, Deruelle, & Fabre-Grenet, 1995). Rose, Jankowski, & Feldman (2008) reported that 5-month-olds used only external features to recognize faces, whereas 7- and 9-month-old infants used both internal and external features. However, no studies have yet focused on identification and recognition skills in 1- to 3-year-olds. To solve the domain-general or domain-specific problem, a detailed analysis of the relation between task demands and response tendencies at each stage of all ages must be conducted. Second, evidence from neuroscience studies should be adapted to explain the developmental differences in children's preference for external information. According to Knowles & Hay (2014), the fusiform face area (FFA) has been found to contain intact rather than separate representations of inner and outer features (Andrews, Davies-Thompson, Kingstone, & Young, 2010), and patterns of activation in the FFA have revealed that outer features strongly modulate the processing of inner features (Axelrod & Yovel, 2011). Finally, facial processing models including interaction, or the process by which internal and external information is integrated, must be developed.

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