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Similarities and differences in the perceptual structure of facial expressions of children and adults

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ABSTRACT

We explored the perceptual structure of facial expressions of six basic emotions, varying systematically in intensity, in adults and children aged 7 and 14 years. Multidimensional scaling suggested that three- or four-dimensional structures were optimal for all groups. Two groups of adults demonstrated nearly identical structure, which had dimensions representing pleasure, potency, arousal, and intensity, despite the fact that one group was tested with a child-friendly "odd-man-out" paradigm and the other group was tested with a conventional similarity-rating paradigm. When tested with the odd-man-out paradigm, the 7-year-olds showed systematic structure, which differed from that of adults in both the meaning of some dimensions and the proximities among some of the expression categories. When tested with similarity judgments, the 14-year-olds showed an adult-like pattern on all measures except that their similarity judgments were more influenced by physical differences than were those of adults. We conclude that an adult-like representation of facial expressions develops slowly during childhood.

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Introduction

Human adults perceive facial expressions categorically (Calder, Young, Perrett, Etcoff, & Rowland, 1996; Etcoff & Magee, 1992; Young et al., 1997). Nevertheless, they also perceive a relationship among different facial expressions. For example, most people would agree that a happy face is more similar to a surprised face than to a sad face. The relationship among facial expressions has been modeled with a

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small number of underlying dimensions. Using ratings on pleasantness–unpleasantness and on attention–rejection, Schlosberg (1952) mapped facial expressions into a two-dimensional space. Expressions formed a circular arrangement along the two predefined dimensions. Later studies used multidimensional scaling (MDS) (Shepard, 1962) to map the perceptual structure of facial expressions without predefining the dimensions (Abelson & Sermat, 1962; Bimler & Kirkland, 1997, 2001; Nummenmaa, 1990; Russell & Bullock, 1985, 1986; Shah & Lewis, 2003). MDS is a statistical procedure that represents similarities between objects as spatial proximities in a multidimensional space. MDS can detect hidden structure underlying complex constructs that are not obvious in the raw similarity judgments (Kruskal & Wish, 1978). To minimize the influence of language, no verbal labels were used and MDS was based on similarity judgments about facial expressions (e.g., Abelson & Sermat, 1962; Russell & Bullock, 1985, 1986) or reaction times to discriminate among them (e.g., Shah & Lewis, 2003). The MDS solutions suggest that adults represent facial expressions in a circular arrangement with two underlying dimensions: pleasure and arousal (Alvarado, 1996; Bimler & Kirkland, 1997, 2001; Russell & Bullock, 1985, 1986; Shah & Lewis, 2003). These results fit well with a broader model that the structure of affective states can be represented by a circular pattern in a two-dimensional space with pleasantness and arousal as the underlying dimensions, that is, the circumplex model of affect (Russell, 1980). Besides facial expression, this model is also supported by studies with emotion words (Russell, 1980), emotional experiences (reviewed by Remington, Fabrigar, & Visser, 2000), emotional voices (Green & Cliff, 1975), and emotion-eliciting music (Bigand, Vieillard, Madurell, Marozeau, & Dacquet, 2005).

Developmental studies reveal that young children show a perceptual structure of facial expressions similar to that of adults. Russell and Bullock (1985) used a sorting method to collect similarity judgments among intense facial expressions from preschoolers and mapped the underlying perceptual structure using MDS. The structure was similar to that of adults and can be characterized by a circular arrangement along the two dimensions of pleasure and arousal, although within the structure the expressions form fewer clusters. With a smaller stimulus set (10 stimuli instead of 20), Russell and Bullock (1986) again found the same two-dimensional structures in children as young as 2 years as are seen in adults. These findings are somewhat surprising because other studies suggest that it takes a remarkably long time for children to acquire adult levels of sensitivity to facial expressions (reviewed by Herba & Phillips, 2004). For example, children's accuracy in recognizing facial expressions from still photographs does not reach adult levels until early adolescence for some facial expressions (e.g., fear and disgust: Durand, Gallay, Seigneuric, Robichon, & Baudouin, 2007; sadness: Gao & Maurer, 2009; Kolb, Wilson, & Taylor, 1992). Studies using brain-imaging techniques also reveal a prolonged developmental course; even 14- and 15-year-olds' event-related potentials for the six basic emotional expressions differ from those of adults (Batty & Taylor, 2006), and in 11-year-olds the amygdala activation revealed by functional magnetic resonance imaging (fMRI) is stronger for neutral faces than for fearful ones, the opposite pattern of that shown by adults (Thomas et al., 2001; but see Guyer et al., 2008). Because 2-year-olds do not yet know the verbal labels for the six basic expressions, the early-emerging structure is not an artifact of language structure. Instead, the early structure seen at 2 years of age may seem similar to that of adults but may reflect a less differentiated concept of emotion or reflect children's perception of physical differences among the facial images rather than their perception of the emotions conveyed by the facial expressions (Russell & Bullock, 1986).

In the current study, we extended these findings by mapping children's and adults' perceptual structure of facial expressions using facial expressions of the six basic emotions with systematically controlled physical intensity. The reason to control the physical intensity of facial expressions is twofold. First, differences in physical intensity provide an objective measure of the physical difference between facial images and, thus, can facilitate an assessment of whether children's perceptual structure is based purely on physical difference. Second, whereas most previous studies mapped only the perceptual structure of intense facial expressions, by using facial expressions at varying intensity levels, we are able to investigate how intensity is represented in the perceptual structure of facial expressions.

The intensity of a facial expression is determined by the amount of muscle displacement away from a neutral state (Hess, Blairy, & Kleck, 1997). For example, the intensity of a happy expression can be characterized by the degree of displacement of the zygomaticus major and orbicularis oculi muscles

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