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Developmental Changes in Face Processing: Results from Multidimensional Scaling

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Multidimensional scaling procedures were used to investigate developmental changes in the ability to process previously unfamiliar faces. Eighty male subjects, aged 7, 9, 12, or adult, rated the similarity of pairs of faces. The faces were presented to subjects in either the upright or the inverted orientation. Multidimensional scaling analyses suggest that subjects of all ages use similar information in judging the similarity of faces. However, for upright faces, individual subjects under age 10 seem to use fewer features at a time. The results argue against a qualitative shift in face processing at age 10, and suggest that the improvement in face recognition ability noted at this age is due at least in part to an increased ability to consider more features simultaneously.

It has been claimed there is a developmental change in the manner in which previously unfamiliar faces are encoded, occurring at approximately age 10. Diamond and Carey (1977) report that children under age 10 frequently misidentify photographs of previously unfamiliar faces, basing their judgments on misleading paraphernalia cues (e.g., earrings, hats), while older children and adults are able to ignore these misleading cues in favor of more veridical information. However, when presented with photographs of familiar classmates, children under age 10 successfully identify the faces, ignoring the misleading cues. This suggests that the developmental change in face recognition ability at age 10 is specific to previously unfamiliar faces. Further evidence for a developmental change is that inversion of stimuli results in comparable decrements in the recognition of faces and houses for children under age 10, while inversion differentially impairs the recognition of faces for older children (Carey & Diamond, 1977), as it does for adults (Yin, 1969).

The younger subjects were all students in the Reeths-Puffer school system: Reeths-Puffer Junior High School and Central Elementary School, Muskegon, MI. We thank the administrators and the second-, fourth-, and seventh-grade students and teachers for their cooperation. We are grateful to Lance Rips for his suggestions regarding experimental design and for comments on the manuscript. Send requests for reprints to Susan Levine, Wyler Children's Hospital, Department of Pediatrics, 5841 S. Maryland Avenue, Chicago, IL 60637.

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Based on the "misleading cues" study, Carey (1978; Carey & Diamond, 1977) suggests that children under age 10 recognize unfamiliar faces on the basis of relatively piecemeal, isolated features (e.g., mole, bushy eyebrows), while older children and adults recognize these faces on the basis of more configurational information (e.g., the ratio of the "distance from the hairline to the chin" to the "distance from the bridge of the nose to the upper lip"). The results, in fact, show that children under age 10 use, when available, salient face *extrinsic* information when confronted with the task of recognizing unfamiliar faces, in preference to face *intrinsic* information. This reliance on face extrinsic information may reflect the hypothesized shift from piecemeal to configurational encoding of faces, but this is only one interpretation of these data.

The emergence of an inversion effect at age 10 is interpreted as further evidence for the hypothesized developmental change from piecemeal to configurational representation of unfamiliar faces (Carey & Diamond, 1977). While inversion of a face may interfere with the encoding of piecemeal information, Carey (1978) suggests that it is even more likely to interfere with the encoding of configurational information which entails locating and comparing more points on the face. Because of the difficulty of applying configurational encoding to inverted faces, she suggests that older children and adults resort to the same type of encoding for inverted faces as children under age 10 apply to both upright and inverted faces, i.e., encoding in terms of isolated features. While this argument provides a plausible explanation for the emergence of an inversion effect for faces at age 10, Carey's results also are consistent with an alternative hypothesis. In particular, children aged 10 and over may be able to encode *more* information from upright faces than can younger children, in the absence of a qualitative difference in the *type* of information encoded. In contrast, the ability to encode information from inverted faces may improve less dramatically with age because of the inexperience of all age groups with these stimuli (cf. Bever, 1980).

The present study investigates the proposed developmental change in face recognition ability with multidimensional scaling analyses of subjects' similarity judgments of unfamiliar faces. We hypothesized that a developmental change in face processing should be reflected in subjects' similarity judgments of unfamiliar faces. Faces that appear highly similar to adults may look quite dissimilar to children under 10, if the two groups of subjects are processing the faces differently. Multidimensional scaling procedures locate the stimuli (i.e., the faces) in a space of a specified number of dimensions. The scaling techniques assume that the dissimilarity ratings reflect "distance" among the stimuli in the subject's perceptual space. Each dimension may be interpreted as representing a feature along which the stimuli vary (e.g., hair color), presumed to be important in subjects' mental representations.

An analysis by multidimensional scaling can help evaluate two developmental hypotheses: (1) a quantitative shift in the amount of facial information processed by different age groups, and/or (2) a qualitative shift in the type of facial features processed by different age groups. The first hypothesis, that younger children process less facial information than do older children, would be supported if the data from the younger age groups were satisfactorily fit with fewer dimensions than the data from older age groups. It also is possible that individual subjects of one age group may use fewer features than individual subjects of another, but each age group as a whole may draw from the same pool of features. In this case, the data from younger and from older subjects may require the same number of dimensions, and age differences in the number of features used would be apparent in the individual subjects' weights for the derived feature dimensions. The second hypothesis, that younger and older subjects process qualitatively different features, would be supported by the emergence of different types of feature axes in the derived stimulus spaces for different age groups.

Finally, the present study examines whether the hypothesized developmental change in face processing is specific to upright faces. Reliance on isolated features by younger children and on configurational information by older subjects in processing upright faces may result in dissimilar stimulus spaces for the two age groups. If the developmental change is specific to upright faces, age differences observed for upright faces should not be observed when inverted faces are used.

METHODS

Subjects

In order to evaluate the hypothesis of a developmental change occurring at or around age 10, resulting in the pattern of face recognition abilities previously discussed, we chose to test a range of ages. Eighty male subjects were tested, 20 from each of four age groups: 7-year-olds (range: 7,1–8,4; mean: 7,7), 9-year-olds (range: 9,0–9,11; mean: 9,7), 12-year-olds (range: 11,8–12,9; mean: 12,5), and adults (range: 18,0–34,3; mean: 23,6). The children were elementary and junior high school students drawn from a suburban western Michigan school system. The adults were graduate and undergraduate students at the University of Chicago. All subjects were unfamiliar with the students whose faces served as stimuli.

Materials and Apparatus

Stimuli consisted of high-quality glossy black-and-white prints of high school boys, photographed with Tri-X Pan film at ASA 400. The boys were posed full face and wore neutral facial expressions. In order to eliminate extraneous cues such as hair length and clothing, photographs were cropped in oval shapes 5 cm high × 3 cm wide, with vertical distance from eyes to chin standardized. Twelve photographs were used; six additional photographs with a similar range of physical appearance were used as practice stimuli. The face photos fit in the front of a toy house facade that had a horizontal row of nine windows (see Fig. 1).

Procedure

The subjects' task was to judge the similarity of pairs of faces ("how much they look alike"). Subjects, who were tested individually, examined the entire set of faces while the experimenter explained the task. The set of photographs then was removed, and the faces were presented in pairs. The subjects' task was to place the first photograph in the left or right end window (the side of the "anchor window" was alternated on successive trials), and then to place the second photograph relative to the first. Faces that appeared very similar were to be placed close together; faces that appeared very dissimilar were to be placed far from each other. Subjects were familiarized with the task using the practice stimuli.

Throughout the task, subjects were encouraged to use the entire range of categories (windows) available. Further, it was emphasized that although there were no correct or incorrect responses, consistency was important. To demonstrate this, the subject's rationale for responses during the practice trials was discussed and compared (e.g., "So they look quite a bit alike to you, but not as much as the first pair").

Each subject judged all possible pairs of the 12 test photographs. Ten different pseudorandom orders of presentation were used (order was randomized with the constraint that no photograph appear more than twice in succession). Half the subjects (N = 10) in each age group viewed and judged pairs of normally oriented, upright faces (Upright condition),

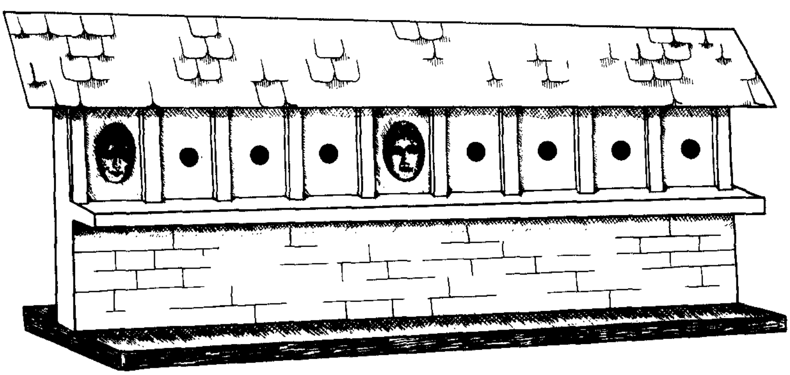

FIG. 1. House facade. Similarity data were collected by asking subjects to place pairs of face photographs in the windows of this toy apartment building. Distance between the faces was taken to reflect the subject's dissimilarity rating for that pair of faces.

and half viewed and judged these same face pairs presented in the inverted orientation (Inverted condition).

Analysis

The positions of the faces in the house facade were converted directly to dissimilarity ratings. The number of windows between each pair of faces was taken to reflect perceived dissimilarity for that pair. Photographs placed adjacent to each other were assigned a dissimilarity rating of 1; photographs separated by one empty window were assigned a rating of 2, etc. This procedure yielded dissimilarity ratings ranging from 1 to 8 for each picture pair, for each subject.

We analyzed these data using multidimensional scaling procedures. An analysis of the ratings yields a stimulus space in which each face is assigned coordinates for a specified number of dimensions. Each orthogonal axis of the plot is taken to represent a unique dimension along which the faces vary, allowing one to infer features that subjects use in processing the faces. The analysis also estimates how much "weight" each subject gives to a particular feature dimension. The weights may be inferred to indicate how salient a subject finds a particular feature dimension, relative to other dimensions.

In order to interpret the dimensions derived from each solution, we collected independent ratings of the face stimuli for a number of characteristics, some of which have been shown to be important in previous studies (Shepherd, Davies, & Ellis, 1981; Hirschberg, Jones, & Haggerty, 1978; Milord, 1978). Five subjects from each age group rated each face for 26 different characteristics: hair color (i.e., light–dark variations visible in black-and-white photographs), length, and texture; location of part in hair; eye slant, shape, color (light–dark) and depth (deep–protruding); face shape and width; eyebrow color (light–dark), bushiness, and slant; width and prominence of nose; width and shape of mouth; thickness of lips; curve of lower lip; smoothness of chin; shape of jawline; cheeks (hollow–puffy); prominence of ears; apparent age; physical attractiveness; and perceived personality (pleasant–unpleasant). Correlation of summed ratings with feature dimensions of an initial exploratory analysis indicated that hair color, hair texture, face width, and eye depth were strongly related to the feature dimensions, and might be considered as possible interpretations. For the final analysis, we therefore collected independent rank-order ratings of these features from six adult subjects who did not participate in the original experiment. In addition, we made physical measurements of face width and distance from the tip of the nose to the upper lip (nose–lip distance). Subsequently, these measurements and ratings were used to interpret the derived dimensions.

The data were analyzed using the Multiscale procedure (Ramsay, 1978). We used Multiscale for descriptive purposes to evaluate (1) the features used by subjects in judging the similarity of faces and (2) the relative salience of each feature for individual subjects. In addition, Multiscale allows hypothesis testing to determine whether two solutions differ significantly from each other (for details, see Ramsay, 1978). While it is possible to assess, for example, whether data for two different subject groups are better fit by two separate solutions than by one joint solution, the χ^2 tests are extremely sensitive to very small differences and often are not useful for judging substantively meaningful differences. We therefore do not consider them here.

A preliminary analysis using the ALSCAL-4 scaling procedure (Takane, Young, & DeLeeuw, 1977; Young & Lewyckyz, 1979) provided a first description of the data and identified those subjects who appeared to respond extremely inconsistently during the test session. Ramsay (1978) recommends that such subjects be removed from the data pool before conducting a Multiscale analysis. We therefore eliminated extreme outliers with SSTRESS ("badness-of-fit" measures) more than two standard deviations above the mean. Eight subjects were eliminated on this basis (*Adults:* 1 Inverted; *12-year-olds:* 1 Upright, 2 Inverted; *9-year-olds:* 2 Upright, 1 Inverted; *7-year-olds:* 1 Upright). Note that approximately the same numbers of older and younger subjects were eliminated.

RESULTS

Scaling results from the Multiscale and ALSCAL procedures are similar, though not identical. We primarily discuss results of the Multiscale analyses; important differences in the results from the two scaling procedures are noted.

The ALSCAL solutions indicated that the data for both upright and inverted faces are best fit in three dimensions: goodness-of-fit improves substantially up to but not beyond three dimensions. The Multiscale analyses verified that at least three dimensions are required.

Upright Faces

For the combined Multiscale solution of all subjects who viewed upright faces, Dimension 1 is related to hair color (darkness). There is an orderly progression along this dimension from faces with light hair to those with dark hair (see Fig. 2). In support of this interpretation, the rank-order correlation of this dimension with independent ratings of hair color is very high ($r = .90$, $p < .001$). Dimension 2 of the Multiscale solution appears to tap face width or fullness (see Fig. 2). Rank-order correlations of this dimension with independent judgments of width and with actual measured face width were also quite high ($r = .72$ and $.74$, respectively, $p < .01$ in each case). Interpretation of Dimension 3 is more problematic. While inspection of the faces along Dimension 3 suggest that it may tap hairstyle, a feature that does not vary continuously across all the faces,

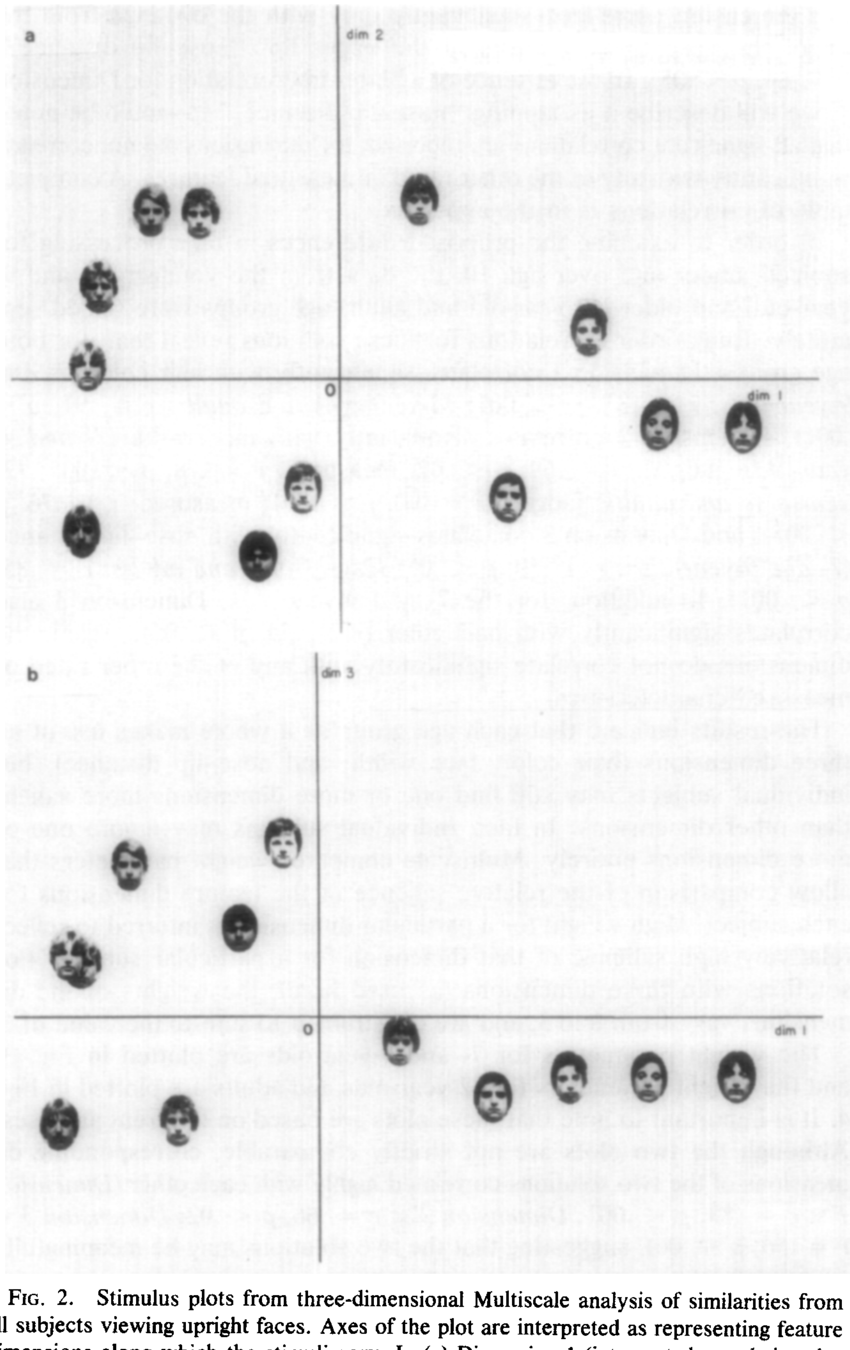

FIG. 2. Stimulus plots from three-dimensional Multiscale analysis of similarities from all subjects viewing upright faces. Axes of the plot are interpreted as representing feature dimensions along which the stimuli vary. In (a) Dimension 1 (interpreted as a hair color dimension) is plotted against Dimension 2 (interpreted as a face width dimension). In (b) Dimension 1 (hair color) is plotted against Dimension 3 (interpreted as nose–lip distance).

this dimension correlated significantly only with the distance from the tip of the nose to the bottom of the upper lip ("nose–lip distance"; $r = .64, p < .05$). In the absence of a better interpretation for Dimension 3, we will describe it as tapping "nose–lip distance." It should be noted that all significant correlations are reported; the dimensions did not correlate significantly with any of the other rated or measured features. A complete table of correlations is in the appendix.

In order to examine the proposed differences in face processing for subjects under and over age 10, the data from the younger (7- and 9-year-old) and older (12-year-old and adult) age groups were scaled separately. Rank-order correlations for these solutions reveal that, for both age groups, Dimension 1 correlates significantly with hair color (*7- and 9-year-olds:* $r = .83, p < .001$; *12-year-olds and adults*: $r = .91, p < .001$), Dimension 2 correlates significantly with face width (*7- and 9-year-olds:* judged: $r = .69, p < .02$; measured: $r = .78, p < .005$; *12-year-olds and adults:* judged: $r = .90, p < .001$; measured: $r = .76, p < .005$); and Dimension 3 correlates significantly with nose–lip distance (*7- and 9-year-olds:* $r = .59, p < .05$; *12-year-olds and adults:* $r = .85, p < .001$). In addition, for the 7- and 9-year-olds, Dimension 3 also correlates significantly with hair color ($r = .59, p < .05$). Again, the dimensions do not correlate significantly with any of the other rated or measured characteristics.

The results indicate that each age group as a whole makes use of all three dimensions (hair color, face width, and nose–lip distance), but individual subjects may still find one or more dimensions more salient than other dimensions. In fact, individual subjects may ignore one or more dimensions entirely. Multiscale computes weight parameters that allow comparison of the relative salience of the feature dimensions for each subject. High weight for a particular dimension is inferred to reflect relatively high salience of that dimension for a particular subject. For solutions with three dimensions (as used here), the weights of the dimensions vary from 0 to 3, and are constrained to sum to the value of 3.

The weight parameters for 7- and 9-year-olds are plotted in Fig. 3, and the weight parameters for 12-year-olds and adults are plotted in Fig. 4. It is important to note that these plots are based on different analyses. Although the two plots are not strictly comparable, corresponding dimensions of the two solutions correlated highly with each other (*Dimension 1*'s: $r = .83, p < .001$; *Dimension 2*'s: $r = .66, p < .02$; *Dimension 3*'s: $r = .56, p < .06$), suggesting that the two solutions may be meaningfully compared.

In Figs. 3 and 4, weight values for Dimension 1 ("hair color") are plotted against weight values for Dimension 2 ("face width"). Each symbol represents an individual subject. Subjects who weight "hair color" very heavily are represented by points near the extreme right end of the

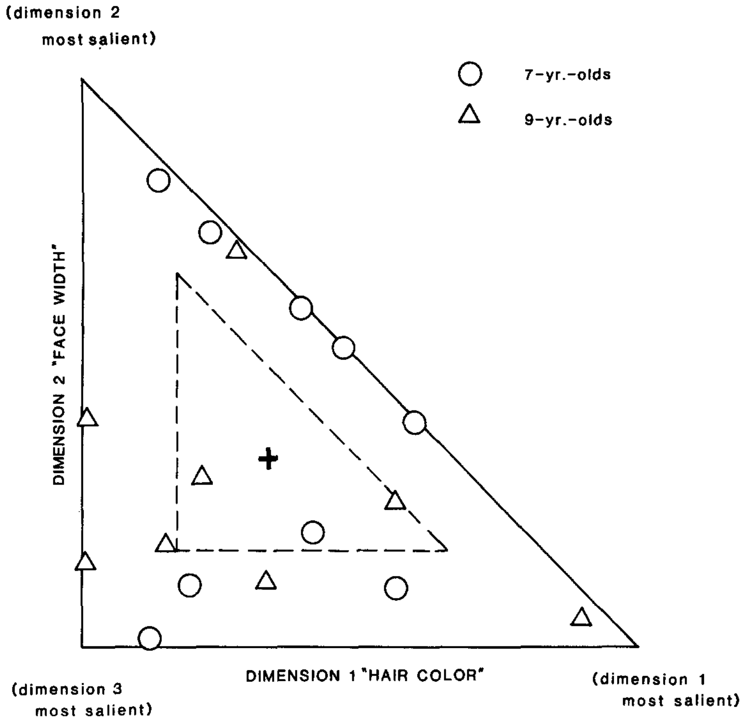

FIG. 3. Weight parameters from three-dimensional Multiscale analysis of similarities from 7- and 9-year-olds viewing upright faces. The symbols represent individual subjects; axes are the value of the weight parameter for Dimension 1 ("hair color") and the value of the weight parameter for Dimension 2 ("face width"). Subjects who weight Dimension 3 ("nose–lip distance") heavily fall in the lower left-hand corner. Cross at center marks equal weights for all three dimensions.

horizontal axis; those who weight "face width" heavily fall near the top of the vertical axis. Since the weights are constrained to sum to 3, those subjects who weight Dimension 3 ("nose–lip distance") very heavily necessarily have low weights for Dimensions 1 and 2 and hence are represented by points near the lower left-hand corner. Comparison of the plots in Figs. 3 and 4 reveals an interesting contrast between subjects under age 10 and those over age 10. Younger subjects (Fig. 3) tend to fall near the periphery of their plot, outside the dashed line indicating a weight of $\frac{1}{2}$ or lower for at least one dimension. This suggests that they tend to ignore at least one dimension, giving it less than $\frac{1}{6}$ the total weight. Older subjects (Fig. 4), in contrast, tend to fall near the center of their plot, inside the dashed line, indicating that they tend to take all three dimensions into account (weighting them more or less equally). Thus, the difference between older and younger subjects appears to be

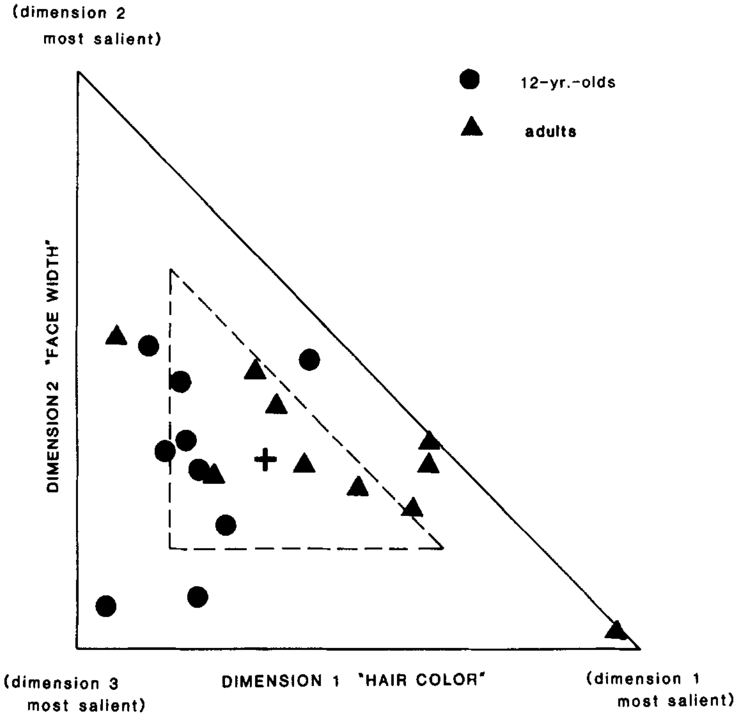

FIG. 4. Weight parameters from three-dimensional Multiscale analysis of similarities from 12-year-olds and adults viewing upright faces. Symbols represent individual subjects; axes as in Fig. 3.

in the number of dimensions considered by an individual subject rather than in the set of dimensions used by the two groups of subjects.

Inverted Faces

The Multiscale analysis of the data from all subjects viewing inverted faces revealed a dimension related to hair color (r = .91, p < .001), and a dimension concerned with face width (judged, r = .76, p < .01; measured, r = .66, p < .02); these results are similar to the solution for upright faces. The last dimension did not correlate significantly with any judged or measured features (the largest correlation was .49, p > .10). Recall that Dimension 3 in the upright solution for all subjects correlated with nose–lip distance. The ALSCAL analysis of subjects' ratings for inverted faces revealed dimensions with the same interpretation as for Multiscale, except that the third dimension correlated with both nose–lip distance (r = .64, p < .03) and hairstyle (r = .57, p < .05).

The inverted faces data for younger and for older subjects also were analyzed separately using Multiscale. Dimension 1 taps hair color for both age groups (*7- and 9-year-olds:* r = .88, p < .001; *12-year-olds and* *adults:* $r = .87$, $p < .001$) and a second dimension taps face width for both age groups (*7- and 9-year-olds:* judged: $r = .85, p < .001$; measured: $r = .58$, $p < .05$; *12-year-olds and adults:* judged: $r = .85$, $p < .001$; measured: $r = .74$, $p < .001$).[1] The third dimension differed for the two age groups. For the 7- and 9-year-olds it is correlated highly with both hair texture ($r = .61$, $p < .05$) and nose–lip distance ($r = .56$, $p < .06$), but for the 12-year-olds and adults, it correlated only with hair texture ($r = .56$, $p < .06$).

Despite different interpretations, the feature dimensions of the stimulus plots for younger subjects again correlated highly and exclusively with corresponding dimensions of the plot for the older subjects (Dimension *1*'s: $r = .89$, $p < .001$; Dimension *2*'s: $r = .69$, $p < .02$; Dimension *3*'s: $r = .73$, $p < .01$). This suggests that the feature dimensions of the two solutions order the stimuli in similar fashion, and that the relative weights of subjects over and under age 10 for these (separately derived) dimensions may again be meaningfully compared. Comparison of subject weight plots in Figs. 5 and 6 does not reveal the age difference seen for upright faces (compare Figs. 3 and 4). In contrast to the finding for upright faces, older and younger subjects are similarly distributed at the center and periphery of the inverted faces weight plots.

DISCUSSION

The results of the present study lend support to the hypothesis of a developmental change in face processing at age 10. In agreement with Carey and Diamond (1977), we find a change only with upright faces. However, in contrast to Carey and Diamond's (1977) hypothesis of a qualitative change from piecemeal to configurational representation of faces, our findings suggest that the developmental change may be quantitative in nature.

The features inferred from the similarity judgments are remarkably consistent across age groups and conditions of stimulus presentation (upright versus inverted). At least one feature dimension in all solutions is concerned with hair. This finding appears to be quite robust and widely valid: numerous scaling studies with adult subjects report hair color, texture, and length as salient features guiding similarity judgments of faces (Christie, 1979, cited in Shepherd et al., 1981; Davies, Shepherd

[1] For the inverted faces, Dimension 3 was correlated with face width, and Dimension 2 with nose–lip distance and/or hairstyle. Multiscale assigns dimensions to the stimulus space such that Dimension 1 has the largest variation among its coordinates, Dimension 2, the next largest, etc. (Ramsay, 1978). Since this ordering is meaningful, we maintained the numbers, but plotted the results in Figs. 5 and 6 so that comparable dimensions (that is, dimensions with the same interpretation) would appear in the same position in all figures.

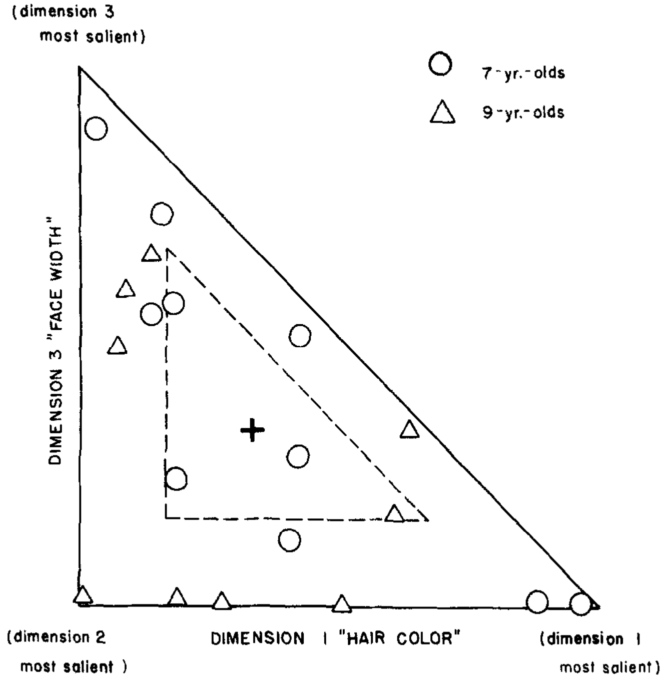

FIG. 5. Weight parameters for the three-dimensional Multiscale analysis of similarities from 7- and 9-year-olds viewing inverted faces. Symbols represent individual subjects.

& Ellis, 1979; Hirschberg et al., 1978). In the present study, hair color is the variable most highly correlated with Dimension 1 of every solution. In some cases, hair texture is also correlated with one of the dimensions. Due to the manner in which the photographs were cropped, hair length is not a distinguishing variable in the present stimulus set.

The second feature dimension in all solutions, face width (actually, a length-to-width ratio, since eye-to-mouth length was standardized), is also consistent with findings of other investigators (Christie, 1979, cited in Shepherd et al., 1981; Davies et al., 1979; Hirschberg et al., 1978). The third dimension, nose–lip distance, although consistent across subjects viewing upright faces in the present study, to our knowledge has not been reported previously.

Of course, these dimensions do not account for all of the information encoded from faces. The nature of the task, the analysis technique, and the range of variability within the stimulus set necessarily limit the number and kinds of dimensions that can emerge. Thus, subtler, less easily measured features and complex configurational information involving ratios of distances may not be detected; similarly, inferred personality characteristics such as honesty, intelligence, or likability were not investigated (cf. Blaney & Winograd, 1978; Bower & Karlin, 1974; Milord,

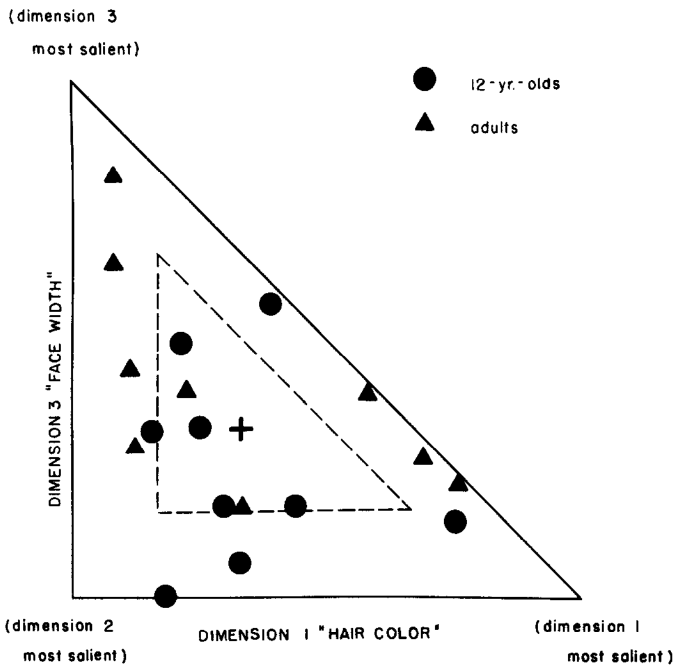

FIG. 6. Weight parameters for three-dimensional Multiscale analysis of similarities from 12-year-olds and adults viewing inverted faces. Symbols represent individual subjects.

1978; Winograd, 1978). The present study provides no information about the processing of features related to age (cf. Milord, 1978; Davies et al., 1979), sex (cf. Milord, 1978), or race (cf. Hirschberg et al., 1979; Milord, 1978), since these were not varied in the present stimulus set. While it is possible that older and younger children differ in the processing of some of these types of facial information, our findings demonstrate that children under age 10 rely on at least some of the same features used by older children and adults.

Our evidence further suggests that while younger and older children draw from a common set of facial features, they use this information differently for upright faces. Relative weight parameters indicate that subjects under age 10 tend to rely on fewer dimensions than older subjects in making their similarity judgments. The use of more facial features by older subjects provides a possible explanation for the finding of improved recognition of upright faces by children age 10 and older (Carey & Diamond, 1977). This possibility is consistent with Winograd's (1981) suggestion that faces judged for traits such as "honesty" are better remembered than faces judged for physical features such as "size of nose" because the trait judgment results in the encoding of more facial features, rather than different types of facial information. In contrast to our results for upright faces, there is not a striking age difference for the inverted faces. This is consistent with the finding of equivalent levels of recognition of inverted faces by children under and over age 10 (Carey & Diamond, 1977).

In order to assess whether the age difference in processing upright faces is related to the emergence of a "configurational" strategy, as suggested by Carey, it is necessary to clarify what is meant by "configurational." The term has been used differently by various investigators. The Gestalt psychologists' law of good form (Kohler, 1940) embodies one use of configurational: the perception of a complex stimulus as a unitary whole rather than as separate components (Sergent & Bindra, 1981). The present results do not bear on this use of the term configurational.

Carey's (1978) use of the term seems to embrace two aspects of face recognition: (1) the manner in which facial features are integrated in face recognition tasks and (2) the nature of the features themselves. Regarding the former, she suggests that properties of faces are integrated in different ways by "piecemeal" versus "configurational" encoders. Neither the present results nor Carey's own findings provide any evidence on the question of how younger versus older children integrate facial information. In order to test the hypothesis of a shift from piecemeal to configurational processing in this sense, methods such as those used to investigate separable versus integral perceptual properties (e.g., Garner, 1974; Treisman & Gelade, 1977; Treisman, Sykes, & Gelade, 1977) might be applied to the problem of developmental changes in face recognition ability.

Regarding the second aspect of the term "configurational" in face recognition, the nature of the features themselves, Carey and Diamond (1980) suggest that the distinguishing features of faces can be arrayed along a piecemeal to configurational continuum. "Hair color" would be an example of a piecemeal property, as its value can be assigned without reference to other properties of the face, whereas "face width" and "nose–lip distance" would be examples of more configurational properties since they involve spatial relations among several parts of the face. The present findings do bear on this aspect of Carey's hypothesis. Specifically, the results obtained provide evidence for the processing of both piecemeal (hair color) and so-called configurational information (face width, nose–lip distance; these are ratios of distances in the present stimulus set, since eye–chin length was standardized for all faces) by younger as well as by older children.

In sum, the results of the multidimensional scaling analyses applied to subjects' similarity ratings of faces suggest that the developmental change in face recognition ability, previously noted to occur at age 10, may be characterized as a change in the quantity of facial information used, rather than as a qualitative change in the nature of the features.

APPENDIX

Spearman Rank-Order Correlations of Derived Feature Dimensions (*Multiscale* Analyses) with Independently Judged and Measured Stimulus Characteristics

	"Hair color"	Hair texture	Face width (judged)	Face width (measured)	Nose–lip distance	Protruding eyes
			Inverted faces			
All subjects, combined						
Dimension 1	.91**	.53	.15	.00	.30	.60
Dimension 2	.47	.45	.36	.49	.21	.09
Dimension 3	.16	.08	.76**	.66*	.19	.13
12-yr-olds and adults						
Dimension 1	.87**	.22	.24	.07	.44	.60*
Dimension 2	.24	.56	.04	.31	.41	.05
Dimension 3	.11	.03	.85**	.74**	.20	.13
7- and 9-yr-olds						
Dimension 1	.88**	.08	.79	.23	.10	.55
Dimension 2	.36	.61*	.15	.46	.56	.35
Dimension 3	.12	.01	.85**	.58*	.37	.48
			Upright faces			
All subjects, combined						
Dimension 1	.90**	.05	.29	.30	.05	.38
Dimension 2	.29	.27	.72**	.74**	.08	.03
Dimension 3	.20	.01	.25	.11	.64*	.31
12-yr-olds and adults						
Dimension 1	.91**	.00	.14	.18	.08	.43
Dimension 2	.34	.08	.90**	.76**	.38	.43
Dimension 3	.20	.45	.18	.06	.85**	.55
7- and 9-yr-olds						
Dimension 1	.83**	.15	.20	.09	.43	.46
Dimension 2	.14	.39	.69*	.78**	.21	.32
Dimension 3	.59*	.14	.35	.21	.59*	.17

* Denotes significant, $p < .05$.
** Denotes significant, $p < .01$.

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