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Face Recognition in 4- to 7-Year-Olds: Processing of Configural, Featural, and Paraphernalia Information

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We tested 4- to 7-year-old children's face recognition by manipulating the faces' configural and featural information and the presence of superfluous paraphernalia. Results indicated that even with only a single 5-s exposure to the target face, most children could use configural and feature cues to make identity judgments. Repeated exposure and experimenter feedback enabled other children to do so as well. Even after attaining proficiency at identifying the target face, however, children's recognition was impaired when a superfluous hat was added to the face. Thus, although young children can process featural and configural face information, their memories are highly susceptible to disruption from superfluous paraphernalia. © 2001 Academic Press

Key Words: face recognition; child development; configural information; featural information; paraphernalia.

The ability to recognize faces is a remarkable human feat. By adulthood, we differentiate and remember hundreds of faces of friends, colleagues, and public figures. Our ability to recognize faces is also little affected by the passage of time. Participants in Bahrick, Bahrick, and Wittlinger's (1975) study recognized former high school classmates from yearbook photographs with 90% accuracy as long as 35 years after graduation and independently of class size. How adults achieve such a high level of proficiency and the specific information used in face recognition are issues that have received extensive research over the past several decades (for a review, see Bruce & Young, 1998).

One important distinction made in the literature is between the "featural" and "configural" information contained within a face (Carey & Diamond, 1977). Featural information refers to face elements that can be referred to in relative isolation such as the size and shape of the eyes, nose, and mouth. In contrast, configural information refers to the spatial layout of these elements within the face. These sources of information are not independent of each other. Specifically, fea-

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tural changes necessitate a change in configuration, whereas changes to configuration may also involve a concomitant change in the features themselves (Tanaka & Sengco, 1997). Nevertheless, the basic distinction between them remains useful and is made throughout this article (for a discussion of this issue, see Rhodes, Brake, & Atkinson, 1993).

Although processing of both featural and configural information is undoubtedly involved in face recognition during adulthood, configural information appears to be particularly important. A number of studies with adults have indicated an extreme sensitivity to the configural properties of faces (e.g., Bruce, Doyle, Dench, & Burton, 1991; Rhodes et al., 1993). The disruption of configural processing has also been cited as the primary cause of decrements in processing of facial identity and expression when a face and/or its features are inverted (e.g., the face inversion effect: Freire, Lee, & Symons, 2000; Yin, 1969; the Thatcher illusion: Thompson, 1980). Configuration also affects adult perception of the aesthetics of faces (Searcy & Bartlett, 1996) and even that of geometric shapes sharing the same visual space with a face (the face–shape illusion: Lee & Freire, 1999).

Research related to infant processing of geometrical patterns in general, and to processing of facial configurations in particular, is also extensive (for reviews, see Dodwell, Humphrey, & Muir, 1987; Flin & Dziurawiec, 1989; Johnson & Morton, 1991). The literature concerning this topic suggests that whether infants process patterns according to their constituent elements or their configuration depends on the complexity of the visual pattern and the age of the infants. For example, a simple angle processed as two separate lines by 6-week-olds is processed as an integrated unit by 14-week-olds (Cohen, 1998). With regard to processing of facial configuration, infants by 2 months of age are able to discriminate among a schematic face arranged naturally, one in which the features are symmetric but scrambled, and one in which the features are scrambled asymmetrically (Maurer & Barrera, 1981). A growing body of research also indicates that 4- to 10-month-olds process different information from both geometrical patterns and faces with each cerebral hemisphere. Specifically, the left hemisphere appears to process local featural information, whereas the right hemisphere processes configural aspects of both patterns and faces (Deruelle & de Schonen, 1998; de Schonen, Deruelle, Mancini, & Pascalis, 1993).

Despite evidence of configural processing of faces during infancy and adulthood, the development of this ability during early childhood remains unclear. One reason for this lack of knowledge is a sheer paucity of research (Chung & Thomson, 1995). Most developmental research on face processing beyond infancy has included children 6 years of age or older, with only a handful of published studies including preschoolers (e.g., Campbell, Walker, & Baron-Cohen, 1995; Ellis, 1990; Flin, 1985; Johnston & Ellis, 1995; Sophian & Stigler, 1981). Furthermore, few studies have specifically examined young children's ability to process a face's configural or featural information.

Limited research notwithstanding, there exists a long-standing debate concerning whether young children are deficient in processing configural information of unfamiliar faces when compared to adolescents and adults. For example, 7-year-olds and a majority of 10-year-olds categorize upright schematic faces analytically rather than on the basis of configuration, the opposite of what is observed for adults (Schwarzer, 2000). A second line of evidence in support of a deficiency in configural processing during early childhood is provided by paraphernalia studies (e.g., Carey & Diamond, 1977; Diamond & Carey, 1977). In such studies, children are asked to recognize a previously seen face that has been modified by the addition or removal of an item such as a hat or glasses. Young children experience great difficulty with this task, but after about 10 years of age it does not cause much of a problem. For example, when asked to choose between a target originally seen wearing a hat but now hatless and a distractor with a hat, young children often incorrectly identify the latter as the target face. This paraphernalia effect has been interpreted as suggesting that young children rely on isolated featural cues to determine the identity of an unfamiliar face (Carey & Diamond, 1977).

That children categorize schematic faces according to their featural similarity might not have any bearing on the issue of what information is used to recognize faces in an everyday context. Similarly, because paraphernalia by definition are "add-on" elements to the face, the paraphernalia effect described above alone is not sufficient to confirm that young children rely primarily on isolated facial features for face recognition and are deficient in processing configural information (Baenninger, 1994; Flin, 1985). To test this notion, one must examine directly whether young children have difficulty in recognizing faces on the basis of configuration. Studies by Baenninger (1994); Carey and Diamond (1994); and Tanaka, Kay, Grimmell, Stansfield, and Szechter (1998) are perhaps the only ones to take this direct approach.

Carey and Diamond (1994) tested 6- and 7-year-olds on a composite face task in which the top and bottom halves of two familiar face images are used to create a new face. The two halves are either aligned or misaligned horizontally, and the task is to name the person who, for example, is depicted in the top half of the image. The aligned condition is actually more difficult for adults than is the misaligned condition, ostensibly because a novel configuration emerges when the two face halves are aligned (Young, Hellawell, & Hay, 1987). Carey and Diamond found that this pattern of results also held for 6- and 7-year-olds. Baenninger (1994) created sets of unfamiliar face stimuli with preserved features but alterations of configuration or with a preserved configuration but different features. Configuration was altered and featural information was preserved by cutting horizontal segments containing the eyes, nose, and mouth and switching their locations. Featural information was altered and configuration was preserved by using white circles to obscure features. Baenninger found that the face recognition of 8-year-olds, 11-year-olds, and adults was more adversely affected by the manipulation of configural information than by that of featural information. Tanaka et al. (1998) tested 6- to 11-year-olds in a task in which the eyes, nose, or mouth from a previously learned face image had to be recognized either in isolation or in the context of the whole face. They reasoned that if children were processing faces in terms of their features, then recognition of face parts should be similar in the two conditions. If the spatial relationships among the parts were also important to children's processing, then parts should be better recognized in the whole face context. Results indicated that features were more readily recognized by children at all ages when presented within the face image, an advantage that has also been reported for adults (Tanaka & Farah, 1993). This advantage held when either Mac-a-Mug images (Experiment 1) or photographs of children (Experiment 2) were used. More important, the advantage in the whole face condition relative to the isolated feature condition did not differ between the ages studied.

The above studies, therefore, provide evidence of configural information processing by children as young as 6 years of age and have advanced our knowledge regarding this issue. Nevertheless, evidence regarding young children's ability to process configural information is still equivocal because of the unnatural aspects of the stimuli or procedures used in these studies. For example, face stimuli in the Carey and Diamond task were clearly comprised of a combination of two face images; they included a prominent line at the junction of top and bottom halves and have irregular shading cues. Baenninger's stimuli included face features that were either dislocated or cut out. Although Tanaka et al. used natural-looking face stimuli in the whole face condition of Experiment 2, recognition of isolated face parts in the comparison task was somewhat unusual and unfamiliar to children. Therefore, it is possible that performance in these tasks reflects not only processing of configural or featural information but also effects of the unnatural aspects of the stimuli or procedure used.

The current study was conducted to address these limitations of previous work and to examine more directly young children's ability to use configural or featural information in face memory. Furthermore, although the studies reviewed above have examined these issues with children 6 years of age or older, none has investigated these abilities with 4- and 5-year-olds. Doing so is important in beginning to bridge the gap in the extant literature of face processing during infancy, on the one hand, and in children 6 years of age or older, on the other. The above studies also share the characteristic that they examined children's recognition of target faces after one viewing. In addition to such recognition, we were interested in examining children's ability to learn about a specific facial configuration or set of features on repeated viewing.

A final objective of the current study was to examine the relationship between configural and featural processing and paraphernalia effects. As discussed above, young children are more adversely affected by the inclusion of paraphernalia items in recognition tasks than are older children. This finding was initially interpreted as reflecting young children's reliance on featural information in face processing (Carey & Diamond, 1977). Subsequent research has cast serious doubt on this view. For example, paraphernalia effects are reduced when the appearances of the target and the distractors are dissimilar relative to when they are similar (Flin, 1985). In addition, young children's performance in a paraphernalia task is significantly improved when paraphernalia do not serve a discriminative function; that is, if the paraphernalia item is present on both the target and the distractors when the identification is made (Baenninger, 1994). These results suggest that children's processing of facial configuration and features and paraphernalia effects are two separate issues. The former concerns whether children are able to process specific types of information from a face, whereas the latter relates to how vulnerable children's representations of faces are to extraneous visual stimuli. Unfortunately, in all previous paraphernalia studies, targets and distractors have been completely different individuals so that they varied simultaneously in configural and featural cues. As such, these studies do not address the possibility that the addition of paraphernalia interferes selectively with processing of either configural or featural information. Furthermore, it is unclear whether children's vulnerability to paraphernalia cues is heightened as a result of seeing the target face only once. The current study begins to address these issues.

In sum, we aimed to provide evidence to address three basic questions. First, can young children recognize a face after a brief exposure, when the face differs from distractors primarily in terms of either configuration or features? Second, can young children *learn* to recognize a face in a short period of time on the basis of configural or featural information? Third, are paraphernalia effects obtained even when the configural or featural information within the target face has been well encoded? To address these issues, we designed a task with three components, each corresponding to one of the three questions of interest. We also used computer graphics to create two sets of stimulus faces. Graphics techniques permitted the manipulation of an original face photograph to create variations on the image that themselves retained photographic quality. Although configural and featural information cannot be fully manipulated independently, the original image was altered such that faces used in Experiment 1 differed *primarily* in configural information, whereas those in Experiment 2 differed *primarily* in featural information (Figs. 1 and 2).

EXPERIMENT 1

Method

Participants

A total of 95 4- to 7-year-old children participated. Participants were 24 4-year-olds (11 boys and 13 girls, M = 4 years 8 months, SD = 2 months), 25 5-year-olds (12 boys and 13 girls, M = 5 years 6 months, SD = 3 months), 23 6-year-olds (12 boys and 11 girls, M = 6 years 6 months, SD = 3 months), and 23 7-year-olds (12 boys and 11 girls, M = 7 years 6 months, SD = 3 months). A comparison group of 10 11-year-olds (6 girls and 4 boys) also participated. Children were from four elementary schools in a primarily middle-income neighborhood. They were predominantly, but not exclusively, white.

FIG. 1. Face stimuli used in Experiment 1. The top four images were used in the recognition and learning phases of the task. The bottom four were used in the paraphernalia tasks.

FIG. 2. Face stimuli used in Experiment 2. The top four images were used in the recognition and learning phases of the task. The bottom four were used in the paraphernalia tasks.

Materials

Stimuli were photograph-quality face images, each a modification of the same original image. The original was a gray-scale video capture of the frontal view of a white adult male face. The model posed with a neutral facial expression and was pictured from the shoulders up. This image was altered with a computer graphics program. Eyes were moved slightly up, down, in, or out relative to the original image, and the mouth was moved up or down. Vertical movement of eyes and mouth was 3 pixels either up or down from the original image; horizontal movement of the eyes was 2 pixels for each eye, either closer together or farther apart than the original image. A total of 8 face images were created in this way, consisting of all permutations of the 4 new eye positions and 2 new mouth positions. Each image was 11.3 cm wide and 8.5 cm high. Of the 8 images, 4 were randomly selected for use in Experiment 1. Face stimuli were comprised of these 4 face images and of images depicting these same faces with an added hat (Fig. 1). Prior to experimentation, one of the 4 faces was randomly selected to be the target, with the remaining faces serving as distractors. High-quality laser printouts of 2 × 2 arrays depicting target and distractors, minus the hat, in each of 24 possible permutations were printed. A similar set of arrays in which the pictures with the hat were used was also printed (*uniform* arrays). A final set of arrays consisted of the target with the hat, one randomly selected distractor with the hat, and the final two distractors minus the hat (*mixed* arrays). These printouts; additional printouts of line drawings of a house, a car, and a rabbit; a blank sheet; and a printout of the target alone minus paraphernalia were placed in individual transparent plastic sheet protectors. Sheets were placed in a three-ring binder in the following order: house, car, rabbit, blank sheet, target alone (no hat), 24 arrays of target and distractors (no hat), 2 uniform arrays, and 2 mixed arrays. Order of placement of uniform and mixed arrays was counterbalanced.

Procedure

Children were tested individually. Settings varied slightly depending on arrangements at each school but typically involved working at a table and chairs in a quiet area of the library or a similar setup just outside the child's classroom. The experimenter introduced himself and engaged the child in a short conversation to reduce anxiety and facilitate cooperation. The task was then introduced as a "challenge" in which the child was to identify pictures of the experimenter's friend, Bob, from among pictures of Bob and his three brothers, whom people had a difficult time telling apart. Providing the target with a name circumvents the potential ambiguity in asking the child to identify the "same person" or "same face" seen previously, which could be interpreted as "Who looks most like the person you saw before?" or "Who is disguised like the person you saw before?" (e.g., Baenninger, 1994; Carey & Diamond, 1977). With binder held upright and at a distance of approximately 30 cm so that the child looked straight ahead to see the pages, the child was told a short story about Bob and was shown sketches of his home, car, and pet rabbit. The child was then told that Bob would be shown next and to look carefully so that he could be identified in other pictures in which his brothers also appeared. The three experimental phases followed:

Phase 1: Recognition trials. The page was flipped to reveal the image of Bob, which was shown for 5 s. This page was then turned to reveal a blank page. Although research by Ellis and Flin (1990) suggests that inspection and delay intervals are of minimal importance to the face recognition of children at the ages examined here, a period of 5 s for each was chosen because it is common for this type of research (e.g., Baenninger, 1994; Flin, 1985). The blank page was flipped to reveal the first array of Bob and distractors without hats, and the child was asked to point to Bob. There was no time limit for a response. If the child seemed reluctant to point to an image, then a comment that it was okay to guess typically sufficed to produce an answer. There was no feedback for this first trial. Another recognition trial followed; the page was flipped to the second array, and the instruction to point to Bob was repeated.

Phase 2: Learning trials. After the second selection in the recognition phase, the correct target was indicated to the child and examination of the target (and distractors) was allowed for an additional 5 s. This feedback procedure continued until a criterion of 3 correct choices within any sequence of 4 trials (including recognition trials) was reached or until all 24 arrays of target and distractors without hats were viewed without reaching criterion. Although on the surface this seems like an easy task, there is evidence to suggest otherwise. Campbell et al. (1995), using a paradigm wherein familiarity judgments were made of part face and whole face photographs, found that children younger than 7 years of age were more accurate in identifying classmates from photographs of their hair and outer facial region than from photographs containing the eyes, nose, and mouth. They also found that 8-year-olds showed no clear advantage for either region and that by about 9 or 10 years of age, an advantage for the internal photographs was observed, corresponding to the advantage reported for adults (Ellis, Shepherd, & Davies, 1979). The criterion had a 12/256 (.05) probability of occurring by chance. Correct choices from the arrays were greeted with experimenter enthusiasm in order to sustain the motivation and interest of the child. Incorrect choices led to reassurances that the child was doing fine, that the task was very tricky, and that the child would start identifying Bob accurately very soon. If criterion was reached, then paraphernalia trials ensued.

Phase 3: Paraphernalia trials. The experimenter expressed the opinion that the child was too smart and obviously was finding the task too easy, so that a trickier task was required. The child was told that now maybe Bob or some of his brothers would be wearing a hat that would make it more difficult to tell them apart. The child was also informed that he or she would no longer be told when answers were correct or incorrect, which would also make choosing Bob more difficult. Two uniform trials (target and distractors all wear a hat) and two mixed trials (target and one distractor wear a hat, two other distractors do not) were completed, with the order counterbalanced.

After completing the task, the child was thanked, provided with reassurances that he or she had done a great job, and given a choice of stickers as a prize. Four different orders of the 24 learning arrays were used, each for approximately equal numbers of children at each age.

Results

Descriptive data of the overall performance of children in all task components of Experiment 1 are shown in Table 1. The table shows the percentages of children at each age scoring 0, 1, and 2 in recognition and paraphernalia trials (chance percentages of scoring 0, 1, and 2 are 56.25%, 37.50%, and 6.25% respectively). Table 1 also shows the mean numbers of trials to criterion for the learning trials. Preliminary analyses indicated no sex differences in performance on any task component, and so data for boys and girls were combined. Children in the 11-year-old comparison group made a total of 5 errors across all task components. Their results are not discussed further.

Recognition Trials

Chi-square analysis revealed that the distribution of children achieving scores of 0, 1, and 2 did not differ with age, $\chi^2(6, N = 95) = 8.86$, *ns*. Therefore, a second chi-square analysis was completed to examine whether the overall distribution of children differed from chance and was significant, $\chi^2(2, N = 95) = 35.91$, $p < .01$. Specifically, fewer children scored 0 than would be expected by chance, whereas more scored 1 or 2, suggesting that children encoded some configural information from the target face (Table 1).

TABLE 1
Experiment 1 (Percentages)

	Age (years)				
	4	5	6	7	11
Recognition					
0 correct	41.7	40.0	43.5	21.7	0.0
1 correct	50.0	36.0	26.1	60.9	30.0
2 correct	8.3	24.0	30.4	17.4	70.0
Learning					
Mean and standard deviation	10.6 (5.3)	10.7 (7.0)	8.9 (6.7)	6.5 (5.6)	1.1 (0.3)
Uniform					
0 correct	60.0	40.0	50.0	30.0	0.0
1 correct	40.0	50.0	30.0	50.0	0.0
2 correct	0.0	10.0	20.0	20.0	100.0
Mixed					
0 correct	75.0	70.0	55.0	30.0	0.0
1 correct	25.0	15.0	40.0	60.0	10.0
2 correct	0.0	15.0	5.0	10.0	90.0

Learning Trials

A total of 15 children completed the learning trials but were unable to reach criterion. There was no age difference in the likelihood of reaching the criterion, $\chi^2(3, N = 95) = .10$, *ns*. Because of concern for floor effects, these 15 children were excluded from analyses of the learning component. Performance of the remaining 80 children was analyzed in terms of the number of trials to reach a criterion of 3 correct identifications within any 4-trial sequence. Correct identifications on recognition trials were considered in ascertaining when criterion had been reached. However, because these first 2 trials were analyzed separately, they were subtracted from the number of trials completed in determining a trials to criterion score. The possible number of trials to criterion, therefore, ranged from 1 (first 3 trials correct) to 22 (reaching criterion on final learning trial). A one-way analysis of variance (ANOVA) of trials to criterion did not reveal a significant effect of age, $F(3, 76) = 1.98$, *ns*. There was, however, a significant linear trend in the trials to criterion data for the age factor, $F(1, 76) = 5.12$, $p < .05$.

Paraphernalia Trials

The 80 children that reached criterion in the learning phase completed paraphernalia trials. Preliminary analyses revealed that the order in which paraphernalia trials were completed had no bearing on performance. Ensuing analyses, therefore, were collapsed across order of task completion.

Chi-square analysis indicated that the distribution of children into groups scoring 0, 1, and 2 differed for uniform and mixed trials, $\chi^2(4, N = 80) = 12.17$, $p < .05$. Examination of Table 1 reveals that fewer children scored 0 in uniform trials than in mixed trials but that more scored 1 or 2, indicating that uniform trials were the easier of the two types. The distribution of children in the three groups did not differ with age for uniform trials, $\chi^2(6, N = 80) = 7.92$, *ns*. A second chi-square analysis, therefore, was completed to examine whether the overall distribution in uniform trials differed from chance and was significant, $\chi^2(2, N = 80) = 7.33$, $p < .05$. As in recognition trials, fewer children scored 0 than would be expected by chance, but more scored 1 or 2, indicating that paraphernalia trials in which the hat did not discriminate the target and the distractors were completed at above chance rates.

The distribution of children in the groups scoring 0, 1, or 2 in mixed trials differed with age, $\chi^2(6, N = 80) = 14.17$, $p < .05$. Additional chi-square analyses, therefore, were completed separately for children at each age. Chi-square analysis could not be completed on the distribution of 4-year-olds on mixed trials because none was correct on both trials. However, as seen in Table 1, more 4-year-olds were in the 0 correct group than expected and fewer were in the 2 correct group than expected, suggesting that performance was below chance. The distribution of 5-year-olds approached being different from chance, $\chi^2(2, N = 20) = 5.82$, $p = .06$. As indicated in the table, although more 5-year-olds than expected by chance scored 2 on these trials, more than expected also scored 0 and fewer than expected answered only 1 correctly. The distribution of 6-year-olds on mixed trials was at chance, $\chi^2(2, N = 20) = 0.09$, *ns*. The distribution of 7-year-olds approached difference from chance, $\chi^2(2, N = 20) = 5.60$, $p = .06$. Few 7-year-olds answered both trials incorrectly, and more answered correctly in one or both trials. The overall pattern of performance on mixed trials is one beginning with below chance performance, reaching chance performance by 6 years of age, and then improving to near above chance performance by 7 years of age.

Discussion

Results of recognition trials provide the first *direct* evidence of above chance level configural encoding in face recognition by 4- and 5-year-olds, an ability previously demonstrated for children 6 years of age or older (e.g., Tanaka et al., 1998). Configural information from an unfamiliar face, therefore, can function as an effective cue to identity for 4- to 7-year-olds, even after a single 5-s exposure to the target image. Remarkably, this is the case when the configurations of target and distractors differed only in terms of a small number of pixels in the eye and mouth regions.

It should be noted that recognition of briefly seen faces in the present experiment did not improve with increasing age of children, and the recognition rate was rather low overall. Developmental studies have generally indicated increasing proficiency in face recognition tasks until 14 years of age, at which time performance is comparable to that of adults (e.g., Carey, Diamond, & Woods, 1980; Chance, Turner, & Goldstein, 1982; Goldstein & Chance, 1980; for a review, see Chung & Thomson, 1995). One point worth making is that recognition rates in traditional studies are typically 70% to 80% for 6-year-olds, the youngest group usually sampled. By comparison, the highest mean score on recognition trials of the current experiment was by 7-year-olds, who made just less than 1 correct identification in 2 trials. This discrepancy is attributable to the fact that target and distractor faces in traditional studies are completely different individuals; they differ saliently in both featural and configural information as well as in peripheral cues such as hairstyle and shape of ears. In contrast, differences between face images in Experiment 1 were restricted primarily to subtle variations of the internal facial configuration. We also note that the 11-year-olds showed near perfect recognition of the target face, indicating that the difficulty level of our recognition task was not so extreme as to be beyond the competence of children in general. This finding also suggests that the ability to process facial configuration on the basis of a single brief view may undergo rapid improvement between 7 and 11 years of age. The precise timing of this advancement is beyond the scope of this article and awaits future research.

Furthermore, the above chance performance of our 4- to 7-year-olds suggests that they already had the basic capacity to process facial configural information. This suggestion is confirmed by results of the learning task. The vast majority of children were able to reach criterion within 24 learning trials. These trials were important in that previous developmental work has not investigated recognition of faces on repeated exposure. Our results suggest that 4- to 7-year-olds can learn about a specific facial configuration over a short period of time.

In addition, by setting a criterion for learning such that successful and comparable encoding can be inferred, subsequent effects of paraphernalia cannot be attributed to poor encoding of the target face during the brief initial inspection phase. Although there were no age differences in uniform trials, these trials overall were completed at a level better than chance. This result is consistent with the finding that young children can complete paraphernalia tasks well when paraphernalia items do not serve to differentiate the target and the distractors (Baenninger, 1994). Recognition in uniform trials was also superior to that in mixed trials. Here, only the target and one distractor were wearing a hat, whereas two other distractors remained without a hat. The two latter distractors, therefore, were highly similar in appearance to the target face in its original guise. This procedure resembled that used by Carey and Diamond (1977) in which the target was mismatched in terms of the presence or absence of paraphernalia between the inspection and test phases. The finding of detrimental effects on recognition of misleading paraphernalia cues, therefore, replicates a previously reported effect (Carey & Diamond, 1977; Diamond & Carey, 1977). What is interesting about our results is twofold. First, although paraphernalia effects were initially interpreted as indicative of a lack of configural processing, we have shown that they are still produced when configural information is clearly encoded and retrieved. Second, our results indicate that although recognition and learning of the target configuration were comparable at all ages, younger children were subsequently more susceptible to effects of mismatches in paraphernalia than were older children.

In sum, Experiment 1 clearly indicates that 4- to 7-year-olds can encode configural information with a very brief exposure to an unfamiliar face and can learn about such information with repeated exposure to the face. Results also suggest that when paraphernalia do not serve to differentiate a target from distractors, children can use configural information in judging identity. When paraphernalia cues are misleading, as in mixed trials, children are prone to making misidentifications. Experiment 2 addressed whether these same findings hold when a target face shares a similar configuration with distractors but differs from them in featural information.

EXPERIMENT 2

Experiment 2 duplicated Experiment 1 with a different stimulus set. Rather than varying primarily in terms of configural information, faces now differed primarily in featural information.

Method

Participants

A total of 99 4- to 7-year-old children participated. None had taken part in Experiment 1. Participants were 22 4-year-olds (10 boys and 12 girls, $M = 4$ years 7 months, $SD = 3$ months), 25 5-year-olds (13 boys and 12 girls, $M = 5$

years 6 months, *SD* = 3 months), 27 6-year-olds (12 boys and 15 girls, *M* = 6 years 7 months, *SD* = 3 months), and 25 7-year-olds (13 boys and 12 girls, *M* = 7 years 7 months, *SD* = 4 months). In addition, 10 11-year-olds (5 boys and 5 girls) participated as a comparison group. Children were from three elementary schools in a predominantly middle-income neighborhood. Most, but not all, children were white.

Materials

The stimulus set was analogous to that in Experiment 1 except that face images now shared a similar configuration but differed in features. The target face image from Experiment 1 was retained as a template. Three new face images were created with a computer graphics program by pasting the eyes, nose, and mouth of images of three different white adult males over the corresponding features of the original target face, thereby maintaining a similar configuration (Fig. 2). Prior to feature replacement, eyes from the additional images were resized such that the diameter of the iris was equivalent to that of the original image. Similarly, the widths of the nose and mouth were equalized prior to feature replacement. Features were then replaced so that the location of the irises remained constant, nostrils were at the same height, and the line at the boundary of the upper and lower lips appeared in the same location.

Procedure

The procedure was identical to that in Experiment 1.

Results

Descriptive data of the overall performance of children in Experiment 2 are shown in Table 2. Preliminary analyses indicated no sex differences in any component, and so data for boys and girls were combined. The 11-year-old group made a total of 3 errors across all task components. Their results are not discussed further.

Recognition Trials

The distribution of children achieving scores of 0, 1, and 2 differed with age, $\chi^2(6, N = 99) = 29.95$, $p < .01$. Additional analyses, therefore, were completed to examine whether the distribution of scores differed from chance for each age. The distribution of 4-year-olds was different from chance, $\chi^2(2, N = 22) = 6.32$, $p < .05$. Although the number of 4-year-olds in the 0 correct group was as expected, fewer than expected scored 1 and more than expected scored 2, suggesting that performance was above chance. The distribution of 5-year-olds was not different from chance, $\chi^2(2, N = 25) = 4.23$, *ns*. Distributions of 6- and 7-year-olds differed from chance, $\chi^2(2, N = 27) = 95.83$, $p < .01$, and $\chi^2(2, N = 25) = 143.32$, $p < .01$, respectively. For both ages, fewer children than expected were in the 0 correct group, and many more were in the 2 correct group, indicating above chance performance.

TABLE 2
Experiment 2 (Percentages)

	Age (years)				
	4	5	6	7	11
Recognition					
0 correct	59.1	36.0	29.6	12.0	0.0
1 correct	22.7	56.0	18.5	24.0	20.0
2 correct	18.2	8.0	51.9	64.0	80.0
Learning					
Mean and standard deviation	7.3 (6.1)	5.8 (5.0)	3.0 (2.8)	1.9 (1.6)	1.1 (0.3)
Uniform					
0 correct	11.1	13.6	16.0	0.0	0.0
1 correct	44.4	50.0	36.0	36.0	0.0
2 correct	44.4	36.4	48.0	64.0	100.0
Mixed					
0 correct	11.1	36.4	40.0	16.0	0.0
1 correct	50.0	31.8	20.0	16.0	0.0
2 correct	38.9	31.8	40.0	68.0	100.0

Learning Trials

A total of 9 children completed the learning trials but were unable to reach criterion. As in Experiment 1, there was no significant age difference in the likelihood of reaching criterion, $\chi^2(3, N = 99) = 0.50$, *ns*. The 9 children who did not reach criterion were excluded from analyses of the learning component. Levene's test for homogeneity of variance was significant, and so a log-linear transformation was completed on the trials to criterion data for the 90 remaining children. A one-way ANOVA of the transformed data revealed a significant age effect, $F(3, 86) = 12.45$, $p < .01$. Post hoc (LSD) tests indicated that 4- and 5-year-olds took significantly more trials to reach criterion than did 6- and 7-year-olds. There was no difference between the 4- and 5-year-olds or between the 6- and 7-year-olds.

Paraphernalia Trials

The 90 children who reached criterion in the learning phase completed paraphernalia trials. Preliminary analyses indicated that the order in which paraphernalia trials were completed had no bearing on performance, and so remaining analyses were collapsed across order of task completion.

The distribution of children into groups scoring 0, 1, and 2 differed for uniform and mixed trials, $\chi^2(4, N = 90) = 25.98$, $p < .01$. Examination of Table 2 reveals that although approximately the same number of children scored 2 in each task, fewer children scored 0 in uniform trials than in mixed trials and correspondingly many more scored 1. This result suggests that, as in Experiment 1, uniform trials were easier for children than were mixed trials. The distribution of children in groups with 0, 1, and 2 trials correct did not differ with age for uniform trials, $\chi^2(6, N = 90) = 6.45$, *ns*. A second chi-square analysis indicated that the overall distribution of children in uniform trials differed from chance, $\chi^2(2, N = 80) = 296.34$, $p < .01$. Fewer children scored 0 in uniform trials than would be expected by chance, whereas many more than expected answered both trials correctly. Thus, as in Experiment 1, paraphernalia trials in which the target and all distractors wore a hat were answered at an above chance level.

The distribution of children achieving the three scores in mixed trials differed with age, $\chi^2(6, N = 90) = 14.29$, $p < .05$. As shown in Table 2, for each age, many fewer children scored 0 than would be expected by chance, and many more scored 2 than would be expected by chance. Chi-square analyses confirmed that the distributions of children at all ages differed from chance, 4-year-olds: $\chi^2(2, N = 18) = 37.95$, $p < .01$; 5-year-olds: $\chi^2(2, N = 22) = 24.75$, $p < .01$; 6-year-olds: $\chi^2(2, N = 25) = 48.78$, $p < .01$; and 7-year-olds: $\chi^2(2, N = 25) = 162.80$, $p < .01$. Together, these results suggest that the misleading paraphernalia cues had some, but limited, impact on children's identification of the face stimuli differing mainly in featural information.

Comparison of Experiments 1 and 2

Exploratory analyses were carried out to compare performance in the various phases of Experiments 1 and 2 for each age group. Prior to these analyses, however, we wished to test for a possible interaction between age and experiment. To this end, we carried out a log-linear analysis for the recognition score measure and the two paraphernalia scores, in each case comparing the fully saturated model to a model omitting the interaction of age and experiment. For the recognition score measure, the difference between the two models was significant, $\chi^2(6, N = 194) = 14.53$, $p < .05$. Additional analyses revealed significant differences between experiments for the recognition phase only among 7-year-olds, 4-year-olds: $\chi^2(2, N = 46) = 3.86$, *ns*; 5-year-olds: $\chi^2(2, N = 50) = 3.14$, *ns*; 6-year-olds: $\chi^2(2, N = 50) = 2.34$, *ns*; 7-year-olds: $\chi^2(2, N = 48) = 10.84$, $p < .01$. An examination of Tables 1 and 2 reveals that although a comparable number of 7-year-olds scored 0 in the recognition phase of either experiment, many more children at this age scored only 1 in Experiment 1 compared to Experiment 2, and many more children got both trials right in Experiment 2 compared to Experiment 1. This result suggests that for 7-year-olds recognition after a single exposure to the target was easier when distractors differed from the target primarily in terms of features than when they differed primarily in configuration.

For the learning phase, Levene's test for homogeneity of variance was significant for criterion scores in Experiments 1 and 2, and so a log-linear transformation was applied. A two-way between-subjects ANOVA (Age $\times$ Experiment) of transformed scores revealed that the target in Experiment 2 was learned faster than that in Experiment 1, $F(1, 162) = 38.57$, $p < .01$. There was also a main effect of age, $F(3, 162) = 11.35$, $p < .01$. The interaction of experiment and age was not significant.

For uniform scores, a comparison of the fully saturated model to a model omitting the interaction of age and experiment (already tested above) was not significant, $\chi^2(6, N = 170) = 5.16$, *ns*. There was a difference between experiments in these scores when ages were combined, $\chi^2(2, N = 170) = 37.28$, $p < .01$. Specifically, although approximately the same number of children scored 1 in the uniform trials of either experiment, four times as many scored 0 in Experiment 1 than in Experiment 2 and correspondingly four times as many in Experiment 2 got both trials correct relative to Experiment 1, indicating higher performance in uniform trials for Experiment 2. In contrast to uniform scores, the fully saturated model and that omitting the interaction of age and experiment was significant for mixed scores, $\chi^2(6, N = 170) = 16.16$, $p < .05$. Additional analyses revealed significant differences between experiments for mixed trials among all ages but 5-year-olds, 4-year-olds: $\chi^2(2, N = 38) = 18.03$, $p < .01$; 5-year-olds: $\chi^2(2, N = 42) = 4.75$, *ns*; 6-year-olds: $\chi^2(2, N = 45) = 7.64$, $p < .05$; 7-year-olds: $\chi^2(2, N = 45) = 15.88$, $p < .01$. As indicated in comparing Tables 1 and 2, at each of 4 , 6 , and 7 years of age, performance in Experiment 2 mixed trials was superior to that in Experiment 1. Figure 3 further illustrates differences in performance on recognition and paraphernalia trials between Experiments 1 and 2. It shows the percentage of children tested at each age, and for each component, who completed at least 1 of the 2 trials successfully.

Discussion

As in Experiment 1, young children were able to recognize the target at above chance rates from a single brief exposure, this time when it differed from distractors primarily in featural cues. Although the conclusion that children can use features to recognize a face is not new, we have shown it to be the case with stimuli that do not confound processing of features with identification based on the presence or absence of paraphernalia or with processing of configural information. Recognition rates were generally higher than those in Experiment 1. The 7-year-old group had a mean of 1.52 correct, corresponding to 76%, in the range that has been found for this age group in traditional developmental studies of face recognition (e.g., Diamond & Carey, 1977; Goldstein & Chance, 1980). Although age effects favoring older children were found, even 4-year-olds recognized the target at an above chance rate in Experiment 2. We have no ready explanation for the relatively poor performance of 5-year-olds in this component of the task.

Results of learning trials were similar to those in the recognition phase, with older children outperforming younger children. Despite the age differences, the vast majority of children at all ages were able to reach the criterion for learning, indicating that featural information can be readily used in identifying a face. Moreover, our results suggest that it may be easier for 4- to 7-years-olds to learn about a face's features than about its configuration. This notion is consistent with other research if the definition of featural information is broadened to include features in the face periphery. Campbell et al. (1995) found that children recognized classmates better from images of their hair and outer face region (ears and jawline) than from images of their internal facial region.

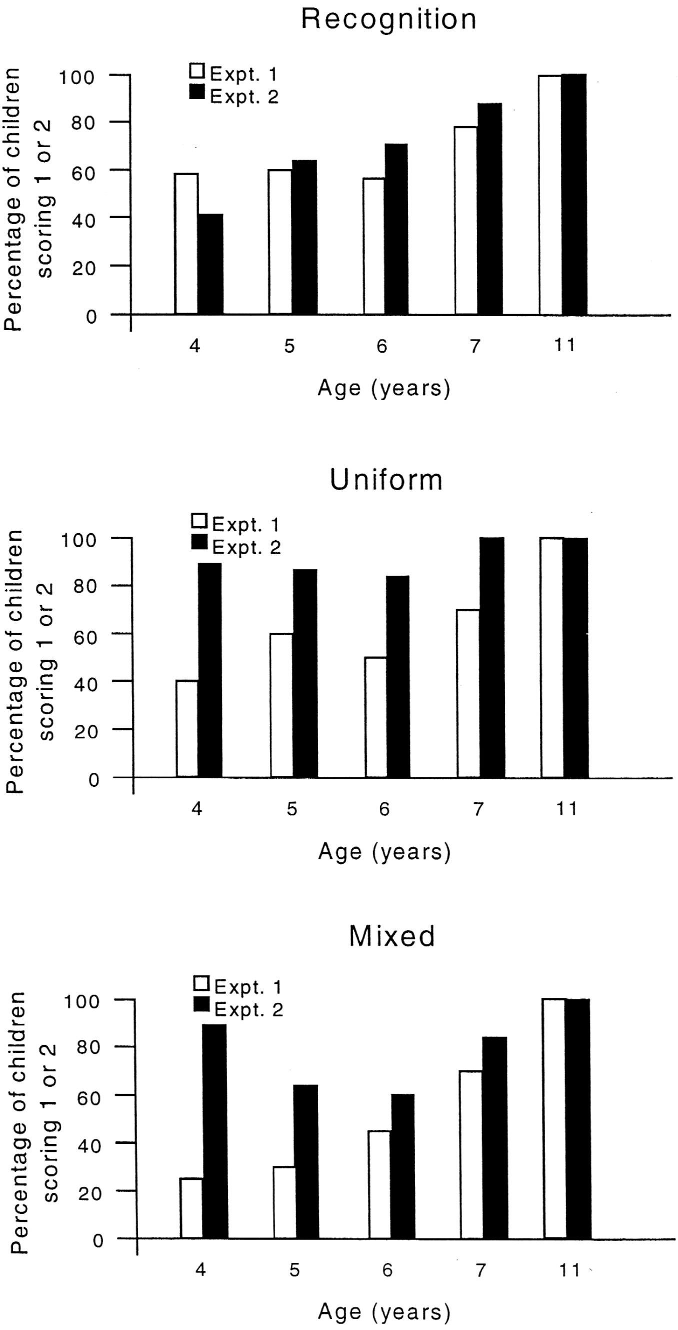

FIG. 3. Percentage of children scoring either 1 or 2 on recognition and paraphernalia trials in Experiments 1 and 2.

The overall pattern of results of paraphernalia trials in Experiment 2 paralleled that found in Experiment 1. Uniform trials were completed with greater accuracy than were mixed trials. Again, there were no age differences for uniform trials but significant age differences in mixed trials, with older children completing more trials correctly. Despite this similarity, results of Experiment 2 differed in that the adverse effects of paraphernalia were much less pronounced than in Experiment 1. Whereas not even 7-year-olds in Experiment 1 recognized the target in mixed trials at a level above chance (although they very nearly did so), children at all ages did this in Experiment 2. One possibility is that children trained in the feedback procedure on faces differing in (internal) featural information were less susceptible to external featural manipulations related to paraphernalia. If this interpretation is correct, then the finding suggests that the particular task condition may have influenced the encoding strategies that children employed. Specifically, configural variation may have led to a more holistic approach to encoding, whereas featural variation may have induced a more analytic approach. Alternatively, addition of a hat may influence perception of facial configuration, especially in the forehead region, more so than it does perception of featural information. This proposal could be examined by repeating the experiment but changing the shirt in the images on paraphernalia trials rather than adding a hat because a shirt would not alter perception of facial information.

Children's performance in all components of the current study was better when face stimuli were differentiated primarily by featural information than when they differed primarily in configuration. This finding suggests that featural information may be better processed by young children and may be less susceptible to interference from extraneous visual cues than is configural information. Alternatively, perhaps the consistency of configuration allowed children to focus more closely on the particular facial features than they would otherwise, in the same way that they performed better when paraphernalia cues were consistent than when they were not. On this account, the consistency of features in Experiment 1 did not similarly function to allow children to focus more closely on configuration or did so to a lesser extent. In any case, caution must be exercised when considering the suggestion that featural information is easier for children to process and less susceptible to interference than is configural information given that only one set of features was used in Experiment 1 and only one configuration was used in Experiment 2. For example, if we had made configural differences among faces sufficiently salient in Experiment 1, then children's performance might improve to levels comparable to those achieved in Experiment 2. On the other hand, our own observations indicated that additional changes to the original configuration began to cause an unnatural appearance in the face images. It is known that extreme manipulations of configuration can lead to a grotesque appearance, adding a confound that we wished to avoid (Searcy & Bartlett, 1996). Nevertheless, definitive conclusions about which type of information is easier to process or is less susceptible to interference requires further systematic investigation.

Several recent findings in the neurophysiological and neurological literature suggest that configural and featural processing involve different neural mechanisms. For example, configural processing has been linked to activity primarily in the right hemisphere, whereas featural processing tends to activate the left hemisphere (e.g., Hillger & Koenig, 1991). Furthermore, prosopagnosic individuals, selectively impaired in face processing as a result of neurological damage, have been found to be deficient in processing configural information but not featural information (e.g., Bliem & Danek, 1999). Finally, early visual deprivation due to congenital cataracts has permanent effects on processing of configural information but does not affect featural processing (Le Grand, Mondloch, Maurer, & Brent, 2001). This dissociation leaves open the possibility that featural information may indeed be easier to process than configural information.

Despite differences between results of the two experiments, we would also like to highlight the many similarities observed. Regardless of whether configural or featural information was available to differentiate faces, children were able to use the information to recognize the target after a single exposure. Children were able to learn about either type of information within a small number of trials and time span. And identification of the target was adversely affected by the subsequent addition of a misleading paraphernalia item, with this effect being more pronounced for the youngest children in our study.

GENERAL DISCUSSION

The current study serves to clarify several findings in the extant literature related to the development of face processing. First, our results provide direct evidence that children as young as 4 years of age can process both configural and featural information from an unfamiliar face and that either type of cue can be used for recognition, even after a single 5-s exposure to a target. Information about features and configuration can also be learned with repeated presentations of a face. Finally, our results are the first to indicate that paraphernalia items cause problems of identification even when configural or featural information is well encoded. Memory for both configural and featural information is negatively affected by the introduction of paraphernalia, although the effect *may* be stronger for configural information. Effects are especially severe in the case when absence (or presence) of paraphernalia is misleading (mixed trials) relative to when paraphernalia does not differentiate the target from the distractors (uniform trials). In general, detrimental effects of paraphernalia were more pronounced among the younger children in our study. Each finding is discussed in detail below.

Regarding recognition, processing of configural and featural properties of faces by young children has sometimes been a matter of inference. When they respond on the basis of misleading paraphernalia cues, children are assumed to have encoded featural rather than configural information. Conversely, when they are no longer susceptible to misleading paraphernalia cues, children are inferred to be encoding configural properties (Carey & Diamond, 1977; Diamond & Carey, 1977). However, as Flin (1985) pointed out, this last inference is problematic. Because previous studies have used faces that vary simultaneously in featural and configural elements, when children's memory is no longer influenced by paraphernalia items, they may still be relying on featural information for face recognition. When the two forms of information have been manipulated independently, stimuli have lacked a natural appearance (e.g., Baenninger, 1994; Carey & Diamond, 1994). In contrast, the current work used stimuli that were intact, face-like, and of photographic quality. Given this fact and the high similarity of target and distractors in both experiments, children's recognition of the target attests to their skill at encoding both configural and featural information from an unfamiliar face.

Results related to recognition fit well with several other research findings. Pedelty, Levine, and Shevell (1985), using multidimensional scaling techniques, showed that both configural and featural dimensions emerged in a face similarity rating task completed by children 7 to 12 years of age. Furthermore, Johnson and Morton's (1991; see also Morton & Johnson, 1991) seminal theory of infant face processing includes mechanisms for processing both configural and featural information. This proposal is difficult to reconcile with the suggestion that young children are deficient in processing configural aspects of an unfamiliar face. Finally, our results are consistent with findings that children 6 years of age or older use holistic processing in face recognition (e.g., Tanaka et al., 1998). Thus, our findings begin to bridge the age gap in the literature related to children's abilities to use configural and featural information in recognition. Taken together, results of previous research and the present study suggest strongly that both types of information are accessible as cues to recognition during infancy and early childhood. Furthermore, children were generally able to learn to reliably use information about either configuration or features for purposes of identification, even when they did not fare well in the recognition task. Because the learning component of the current task can be conceptualized as involving a shift from recognizing an initially unfamiliar face to recognizing one that is increasingly familiar, our results suggest that both featural and configural information becomes more useful for children as cues to identity as a face becomes familiar.

The influence of paraphernalia items on the face recognition of young children has been a contentious issue in the literature. It has been reported that young children's face recognition is negatively influenced by paraphernalia items (e.g., Carey & Diamond, 1977). Carey and Diamond (1977) suggested that young children may use paraphernalia items as cues to face identity. Flin (1985, Experiment 2) called for the qualification of this conclusion. She found that the paraphernalia effect is stronger when the appearance of targets and distractors is highly similar than when it is dissimilar. Baenninger (1994) further suggested that when paraphernalia do not serve to discriminate between the target and the distractors, they are less disruptive to face recognition for children 6 years of age or older. Our results extend Baenninger's findings by showing that the same general patterns of paraphernalia effects result when a target face and distractors differ primarily either in configural or featural information and when either aspect of the target face is well encoded.

Regardless of the above findings and any qualifications they may entail, it is clear that paraphernalia effects are a very robust phenomenon; all studies concerning them have produced the strong effects originally reported by Carey and Diamond (1977). In considering the existing evidence and our findings, we may be in a position to speculate about why such effects occur. There are two basic paradigms in which paraphernalia effects have been produced. One paradigm involves a target not wearing a paraphernalia item in the inspection phase but doing so in the recognition phase. The second involves a target wearing a paraphernalia item in the inspection phase but not doing so in the recognition phase. In either case, there is a mismatch in the presence or absence of paraphernalia between the inspection and recognition phases.

Paraphernalia effects may occur at different phases of face processing. They can arise during encoding or recognition. The first paradigm mentioned above seems best suited to addressing whether effects occur at recognition because it involves a target not wearing a paraphernalia item in the inspection phase but doing so in the recognition phase. Indeed, previous studies with this design have produced strong paraphernalia effects (Carey & Diamond, 1977; Flin, 1985). That is, children are biased to choose a distractor that does not wear a paraphernalia item rather than the target now wearing a paraphernalia item.

However, these studies are limited because the target is shown only once and for a short duration (typically 5 s). As such, it is unclear whether children have initially encoded the target face properly. It could be that children have a very poor memory of the target face as a result and at test make a relative judgment about the image that bears the greatest overall similarity to that seen previously. Such an interpretation is consistent with early findings from the literature on children's performance in free classification tasks that suggested that young children make classifications on the basis of overall appearance (Kemler, 1983; Smith & Kemler, 1977). Although the current task is not a classification task per se, it can be construed from that perspective; the task in this case is to "classify" the proper stimulus as Bob. More recent evidence indicates that, in fact, the vast majority of children at the ages tested in the current study most frequently make classifications on the basis of a single dimension and that the early findings can be explained as statistical artifact (e.g., Thompson, 1994). The basic finding from early paraphernalia studies can also be explained from this perspective if the dimension that children are using to choose is the presence or absence of paraphernalia. Our results, however, rule out either possibility as the sole explanation of the paraphernalia effect at recognition. In our design, children were shown the target repeatedly and attained a high level of recognition prior to the introduction of paraphernalia. Nonetheless, strong paraphernalia effects were obtained. Clearly, such effects do occur in the recognition phase.

There is also a further question to consider regarding effects of introducing paraphernalia items in the recognition phase, as in the current study. There are at least two explanations for the detrimental effects of paraphernalia. First, the introduction of paraphernalia simply distracts the child from attending to the face, but the representation of configuration and features remains intact (the distractibility hypothesis). Second, the representation of face configural and/or featural information is fragile, so that such information is lost from memory as a result of introducing a paraphernalia item (the fragility hypothesis). Our results suggest that the distractibility hypothesis is partially correct because no order effect was obtained for the mixed and uniform trials. Even when children performed poorly in the mixed trials first, their recognition of the target face improved significantly in the subsequent uniform trials. It is also worth noting that paraphernalia effects are greatly diminished in the case of a familiar target face (Diamond & Carey, 1977). Thus, even though children in the current study were able to recognize the target reliably prior to paraphernalia trials, subsequent errors indicate that the target was never really "familiar" per se. This distinction is consistent with the fragility hypothesis. One way of examining the possible contributions of these two factors is to modify the paradigm used in the current study such that after intervening paraphernalia trials, children are presented again with a face array in which the target and distractors are not wearing paraphernalia. If performance on such trials reverts to pre-paraphernalia rates, then we can infer that the salience of the hat or other item is functioning as a distraction. If recognition is as poor as in the paraphernalia trials, then the fragility hypothesis is supported. Of course, it is also possible that both distractibility and fragility are involved in paraphernalia effects in the recognition phase.

Paraphernalia effects may also occur in the encoding phase. The second paradigm mentioned above seems well suited to clarifying this issue. In this paradigm, the target at inspection is wearing a hat or other item, but in the recognition phase the item is worn by distractors but not by the target. Studies using this paradigm have also produced strong paraphernalia effects, suggesting the involvement of the encoding phase. Two explanations exist regarding why face encoding is also affected by paraphernalia items. First, because the paraphernalia items are so salient, children may mostly encode these items while ignoring the internal featural and configural properties of the face. It follows that whichever distractors are wearing the item in the recognition phase are more likely to be chosen than is the target. Second, it could be that children encode both internal properties of the face and paraphernalia items. Because of young children's general limitations in processing capacity, encoding of configural and featural information is diminished relative to the case when a paraphernalia item is not present. Future studies can modify the existing paradigm to test these possibilities. For example, in addition to the task requiring children to identify the target face originally seen, one may present children with the same target wearing a different hat and ask them to identify the previously seen hat. If the first hypothesis is correct, then children should excel in the hat task but perform poorly in the face task. Alternatively, if the second hypothesis is correct, then they should perform equally poorly in both tasks.

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