

Research Article

OVERT AND COVERT RECOGNITION OF FACES IN CHILDREN AND ADULTS

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Abstract—There has been considerable recent interest in covert face-recognition effects. In Experiment 1, we adapted a paradigm, previously shown to produce covert recognition effects, to test 5-year-old children. Classmates' photographs served as the familiar faces. Children showed effects of familiarity on face matching similar to the effects normal adults and prosopagnosics had previously shown for famous faces. In Experiment 2, we investigated whether brief familiarization with the photographs used in Experiment 1 would suffice to produce the effects, in children and adults. It did not, even though the exposure did lead to above-chance overt recognition. Taken together with previous studies, the data suggest that covert recognition may be doubly dissociable from overt recognition. Finding a double dissociation would place constraints on models of face recognition.

Recently, there has been considerable interest in the finding that people may show effects of prior experience with stimuli or actions, even in the absence of conscious recollection of those stimuli or actions. A dramatic example of this phenomenon occurs in the task of face recognition. Brain-damaged people who have difficulty recognizing faces, or even are completely unable to recognize faces, have been shown to exhibit differential physiological reactions to familiar and unfamiliar faces (Bauer, 1984, Tranel & Damasio, 1985, 1988), as well as preserved performance on several behavioral tasks involving faces (de Haan, Young, & Newcombe, 1987, Greve & Bauer, 1990, Young, Hellawell, & de Haan, 1988).

Covert recognition in the presence of severely impaired overt recognition has been interpreted in several ways. Bauer (1984) suggested that there are two face-processing systems, only one of which is damaged in prosopagnosics. Tranel and Damasio (1985, 1988) proposed that a single face-processing system is detached from access to conscious awareness in prosopagnosics, but continues to influence performance on covert tasks. Burton, Young, Bruce, Johnston, and Ellis (1991) proposed that there is a single system and that at least some prosopagnosics may suffer from attenuated connection strengths between face-processing units and person identification nodes. Farah, O'Reilly, and Vecera (1993) argued that a single face-processing system, after sustaining lesions leading to prosopagnosia, contains degraded representations sufficient to support performance on covert but not on overt tasks.

Covert and overt recognition effects have also been studied in the context of the problem of infantile amnesia, where it has also been found that covert recognition may occur in the absence of overt recognition (Newcombe & Fox, 1994), using

galvanic skin response as an index of covert recognition. Because it would be desirable to have behavioral as well as physiological measures of covert recognition in children, the first study reported here was done to develop such a measure, based on the face-matching paradigm of Young, Hay, McWeeney, Flude, and Ellis (1985). The second study in this article, conducted to examine the effect of different degrees of familiarity on face matching, found unexpected relations between performance on matching and performance on overt recognition, these relations appear to constrain possible models of face recognition.

Young et al. (1985) asked subjects to decide whether two photographs showed the same person or different people. The faces were either of famous people (i.e., public figures) or of unknown people. On some trials, the external parts of the faces (cheeks, forehead, hair) were hidden, on other trials, the internal parts (eyes, nose, lips) were hidden. For matches based on internal parts, familiarity led to faster reaction times, for matches based on external parts, familiarity did not affect reaction time. This same interaction was shown by a prosopagnosic patient (de Haan et al., 1987), suggesting that it is a covert recognition effect.

The task Young et al. employed involved presenting photographs tachistoscopically, with reaction time used as the dependent variable. Because young children find it difficult to sit still in a tachistoscopic apparatus, have very variable reaction times, and commit many errors on the face-matching task, we modified the procedure to involve free viewing of the pairs of faces, with errors used as the dependent variable. We also used classmates' faces rather than famous faces as the familiar faces, both because finding a set of famous faces known to young children is difficult and because we wanted to use the paradigm eventually to evaluate children's memories for their personal history. Thus, the aim of Experiment 1 was simply to determine whether using the modified procedure with young children, we would obtain the interaction Young et al. did.

EXPERIMENT 1

Method

Subjects were 26 children, 10 girls and 16 boys, whose average age at testing was 5 years and 4 months, with a range from 4 years and 7 months to 6 years and 4 months. The children attended four different preschools.

Subjects were photographed in their preschool classrooms, against a uniform blue background. They were asked to take off hats or other paraphernalia, and to smile a little. No one wore glasses. The pictures were taken at two different angles: facing front and turned slightly to the right. Two pictures were needed

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of a person so that "same" pairs would not be identical. In that case, as Young et al. (1985) have shown, subjects make a judgment on the basis of particular characteristics of a picture, instead of looking at the face.

Familiar faces were those of the classmates of a particular subject, unfamiliar faces were those of children at different preschools. Subjects never saw pictures of themselves. Pairs of photos for "different" trials were selected from children of the same sex and race in the same class. Paired pictures were mounted side by side on a piece of white cardboard measuring 7 in by 3.66 in. Either external or internal parts of the faces were covered with opaque white paper. Trials were grouped into four blocks based on which parts were covered and on familiarity. The order of these four conditions was counterbalanced across subjects. Within each block, half the trials were same pairs and the other half were different pairs. The order of same and different pairs was randomized.

Subjects were tested individually in a quiet room of their preschool. They were told to say "same" if two pictures were of the same child and "different" if two pictures were of different children, and to try not to make mistakes.

The number of trials in each block was 20 for most subjects (80 in all). However, for 7 subjects, the number of trials in the two familiar conditions, external-familiar and internal-familiar, was 16 each, because the sex and race distribution of children in the classes of these 7 subjects constrained pairing. The number of trials in the two unfamiliar conditions, external-unfamiliar and internal-unfamiliar, was 20 for these 7 subjects as for the rest of the subjects.

Twelve practice trials preceded the test trials. First were four practice trials using pairs of whole faces to make sure that subjects understood the instructions. Then came eight trials with one face of a pair having either internal or external parts covered, to make subjects familiar with making judgments on the basis of visible parts. All faces used in practice were unfamiliar. For each subject, it took 15 to 20 min to finish the whole task.

Results

The overall error rate was .25 ($SD = .07$). Two male subjects whose error rates were more than 2 standard deviations above the mean (and thus close to the chance value of .50) were excluded in data analysis. Error rates are shown in Table 1.

A $2 \times 2 \times 2$ within-subjects analysis of variance (ANOVA) was carried out on the error rates to determine the effects of familiarity of the face (familiar vs. unfamiliar), part of the face visible when judging (internal vs. external), and pair (same vs. different). Children performed better at matching in the familiar condition than in the unfamiliar condition, $F(1, 23) = 52.49$, $p < .0001$, in the external condition than in the internal condition, $F(1, 23) = 9.79$, $p < .01$, and with different pairs than with same pairs, $F(1, 23) = 11.99$, $p < .01$.

The crucial interaction of familiarity and parts visible was significant, $F(1, 23) = 9.46$, $p < .01$. Thus, 5-year-old children showed distinctive patterns in matching familiar faces and unfamiliar faces, comparable (although not identical) to the patterns shown by normal adults and by prosopagnosics. As shown at the bottom of Table 1, children made 13% errors with familiar faces, regardless of whether internal or external parts were visible, whereas with unfamiliar faces, they had more difficulties in matching based on internal parts (38% errors) than external parts (27% errors, post hoc Tukey test, $F[1, 23] = 9.61$, $p < .01$). However, unlike the adults studied by Young et al. (1985), children in this study matched familiar faces more correctly than unfamiliar faces with external parts as well as internal parts (post hoc Tukey test, $F[1, 23] = 6.77$, $p < .05$).

The only other significant interaction involved the same/different factor and type of part, $F(1, 23) = 4.70$, $p < .05$. Children made more errors with internal parts than with external parts only when judging same pairs (post hoc Tukey test, $F[1, 23] = 7.40$, $p < .05$). There was no further interaction with familiarity, however.

Discussion

Experiment 1 showed that children as young as 5 years old process faces familiar to them through everyday interaction differently from those they have never seen before. Thus, the effect found in normal adults by Young et al. (1985) and found as a covert recognition effect in a prosopagnosic by de Haan et al. (1987) appears in young children as well, even using a different procedure and dependent variable.

Experiment 2 was designed to explore the kind and degree of familiarity sufficient to produce the effect. Experiments to date have used faces that are familiar through repeated exposure, whether from viewing on film and in magazines, as with famous faces, or during extended natural interaction, as in our experi-

Table 1 Mean error rate in each condition of Experiment 1

Type of pair	Internal part		External part	
	Familiar faces	Unfamiliar faces	Familiar faces	Unfamiliar faces
Same	20 (.20)	50 (.20)	18 (.16)	31 (.17)
Different	06 (.09)	27 (.17)	07 (.10)	23 (.24)
Overall	13 (.17)	38 (.22)	13 (.14)	27 (.21)

Note. Standard deviations are in parentheses.

ment However, many investigators of other topics in face recognition have used experimentally familiarized faces. Such brief exposure is sufficient to support standard recognition judgments, other findings sometimes vary depending on the degree of familiarity with the stimuli or the class of stimuli (Bauer & Verfaellie, 1988, Diamond & Carey, 1977, 1986, Levine, 1985). Given these data, we wished to ascertain whether children (or adults) would show familiarity effects in face matching with faces they had seen briefly during an experimental session. An additional aim was to determine how familiarity effects (if found) are related to overt judgments of recognition.

EXPERIMENT 2

Method

Twenty-four children, 10 girls and 14 boys, from a preschool participated. An additional 5 children, 2 girls and 3 boys, were excluded in data analysis because they gave all "same" or all "different" responses during at least one block of trials. The average age of subjects included in data analysis was 5 years and 4 months, with a range from 4 years and 7 months to 6 years. Additionally, 24 college students from summer session classes were tested.

All face pictures were selected from the pool of pictures used in Experiment 1, sex, race, and the overall similarity of children in pictures were matched across the familiar and the unfamiliar conditions. In the familiarization session and recognition test, only the whole faces were used, half the faces (10 faces) were of girls and the other half were of boys.

During the familiarization session, 20 face pictures were shown, one at a time, with a short story about the person told as each face was being examined. For example, while showing a boy's face, the experimenter said, "This is Charlie. He helped

his dad plant last Sunday. His mom said, 'Good boy!' Do you like to help your dad, too?" The stories were randomly paired with the faces for each subject. Subjects were told that after the session they would be asked whether they had seen the faces before, to make sure that they paid attention to the faces.

A recognition test was administered immediately after the familiarization session. In the test, the faces were shown one at a time together with 20 foil faces, 10 of girls and 10 of boys. Subjects were asked to say "yes" if they had previously seen a face and to say "no" if not.

The matching task followed immediately after the recognition test. With the exception that the faces in the familiar condition were the faces subjects had seen in the familiarization session, rather than faces of classmates, the matching task procedure was the same as in Experiment 1.

Results

Recognition test

The children's overall error rate (false alarms to foils plus incorrect rejections of faces shown) was 40 ($SD = .09$), and the adults' error rate was 16 ($SD = .09$). All subjects' error rates were within a range of 2 standard deviations around their group's mean, except for 1 adult, whose rate was 35. Children said "yes" correctly more often than they gave false alarms (48 vs 27), $t(23) = 5.48$, $p < .0001$. The same was true for adults (78 vs 10), $t(23) = 18.97$, $p < .001$. Thus, when a recognition test follows a familiarization session without delay, children as well as adults show above-chance explicit recognition of faces they saw even briefly. However, the children made significantly more errors than adults, $t(46) = 8.93$, $p < .001$. The age difference was due to differences in both correct "yes" responses and false alarms, $t_s(46) = 5.86$ and 3.38 , respectively, both $p < .01$.

Matching task

The overall error rate for children was 33 ($SD = .06$) and for adults was 16 ($SD = .05$). One child's error rate was more than

1. Adults were told that the stories were made up for children and that to keep the procedure comparable, the stories were to be read to them, too. However, adult subjects were not asked to answer any questions about the stories.

Table 2 Mean error rate in each condition of Experiment 2

Type of pair	Internal part		External part	
	Familiar faces	Unfamiliar faces	Familiar faces	Unfamiliar faces
	Children ($n = 23$)			
Same	44 (24)	47 (24)	20 (18)	26 (19)
Different	33 (21)	34 (20)	28 (17)	26 (19)
Overall	38 (23)	41 (23)	24 (17)	26 (19)
	Adults ($n = 24$)			
Same	19 (17)	22 (16)	10 (9)	09 (10)
Different	22 (14)	21 (17)	10 (14)	11 (11)
Overall	20 (13)	22 (11)	10 (10)	10 (06)

Note. Standard deviations are in parentheses.

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2 standard deviations above the mean, and her data were excluded from subsequent analysis. Error rates in each condition are shown in Table 2.

Matching data were analyzed using a split-plot ANOVA with four factors, each with two levels: age (children vs. adults), familiarity (familiar vs. unfamiliar), facial part (internal vs. external), and pair type (same vs. different). The first factor, age, was a between-subjects factor, and the rest were within-subjects factors.

Only two main effects were found significant: age and type of facial parts shown. Adults made fewer matching errors than children, $F(1, 45) = 153.2, p < 0.001$, and fewer matching errors were made in the external-parts condition than in the internal-parts condition, $F(1, 45) = 80.96, p < 0.001$. No significant effects were found for familiarity or the interaction of age and other factors.

The fact that both children and adults show the same matching patterns to experimentally familiarized faces and to faces never seen before suggests that familiarity established through interaction on a daily basis results in different face representations than those acquired through brief exposure during an experiment. To compare the two kinds of familiarity directly, an ANOVA was carried out on the data from children in the familiarity conditions in Experiments 1 and 2. The most important question was whether the interaction of type of familiarity and type of facial parts was significant, and it was, $F(1, 45) = 13.12, p < 0.01$. That is, knowing the children in the photographs, as opposed to having seen their pictures briefly, facilitated matching based on internal parts more than matching based on external parts.

Relations between matching and recognition

It is possible that, despite the overall results of the experiment, matching of internal face parts was facilitated by brief exposure, but only for the subset of briefly familiarized faces that were correctly recognized. However, an ANOVA on the data from Experiment 2, using the between-subjects factor of age and the within-subjects factors of internal versus external face parts and recognized versus not-recognized faces showed no effect of recognition on matching, nor any interaction of recognition and type of facial parts. The means were, in fact, nearly identical for matching of external and internal face parts of recognized and unrecognized faces.

Although the same patterns of matching were found for both recognized and unrecognized faces, other questions about the relation between matching and overt recognition can be asked as well. In particular, it is of interest whether the two tasks were stochastically independent. It appears that they were, based on several approaches to the problem. First, probabilities for correct matching conditionalized on recognition performance and

for correct recognition conditionalized on matching performance were virtually identical. Second, for individual faces, with data summed across subjects, there was no relation, as assessed by chi-square tests, between recognition and matching.²

Discussion

The results of Experiment 2 show that familiarity with faces established through brief exposure during an experiment does not suffice to produce effects on matching, in children or adults. Nevertheless, overt recognition for both groups was above chance. In addition, the present data showed stochastic independence between recognition and matching. Given the finding by de Haan et al. (1987) that a prosopagnosic subject showed effects of familiarity on matching but not on overt recognition, it seems possible that overt and covert recognition can be doubly dissociated.

This pattern of effects, if further substantiated in experiments using exactly comparable procedures, would require re-assessment of models of face recognition. Although double dissociation and stochastic independence are commonly taken to support two-system models, we believe that the data do not compel them. A two-system model would still need to answer significant questions to provide a satisfactory, comprehensive account of data on face recognition; single-system models could, with suitable modifications, account for the data. In this section, we briefly consider what the existing proposals regarding face recognition architecture would need to do to account for a double dissociation.

We begin from the idea that any model would need to postulate that the face-recognition system (or systems) encodes different kinds of facial information, in order to explain the fact that the effect of familiarity on facilitating matching of internal parts apparently emerges over time, as well as to explain other effects reported in the literature, such as differential effects of attention (Reintz, Morrissey, & Demb, 1994). One proposal regarding different kinds of facial information is Carey's (1992) distinction between interactive coding and second-order relational coding. It might be that interactive coding occurs rapidly and with little obligatory attention, but second-order relational coding emerges more slowly, makes more attentional demands, and is more relevant for internal parts of faces (Reintz et al., 1994).

In the case of a two-system model, as proposed by Bauer (1984), the need to differentiate types of face information leads to the question of how to apportion the informational types to the systems. However, if the system linked to conscious awareness and used in overt recognition encodes one kind of information and the system not linked to conscious awareness encodes another, certain difficulties arise in accounting for face recognition data, whereas if both systems contain both kinds of encoding, other difficulties arise. A successful two-system model will need to deal in a detailed way with a variety of problems in face recognition, not just dissociation, to be successful.

Tranel and Damasio (1985, 1988) proposed that a single sys-

2 Overall performance on the recognition and matching tasks was correlated for children, $r(22) = .49, p < .01$, but not for adults, $r(23) = -.10$. The correlation for children is likely to reflect general effects of motivation and maturity, more than specific processing commonalities of the two tasks, given the stochastic independence analyses.

tem of face encoding is sometimes detached from access to consciousness. A potential way for this model to deal with the present data is by proposing that the information supporting the covert recognition effect builds more slowly over exposure to faces than does information sufficient to support above-chance overt recognition, with all information stored in a single representational system. The challenge for this model is to explain why some portions of a representation (or types of information within it) might lose access to consciousness, but not others.

Burton et al. (1991) proposed a single-system model in which prosopagnosia (of the sort in which covert recognition effects are found) results from a weakening of connections between face recognition units and person identification nodes. The present data suggest the need for this model to specify the kinds of processing that occur in face recognition units at various stages of the learning process, and the ways in which these kinds of encodings are linked to person identification. A serious challenge for the model is to explain why recognition and matching performance appear to be independent, at least at some stage of learning faces, as shown in Experiment 2.

Farah et al. (1993) argued for a single-system model, with dissociation effects in prosopagnosia explained as resulting from lesions weakening face representations enough to lead to very poor overt recognition, but preserved performance on covert tasks. Farah et al. demonstrated that a computational model based on this proposal in fact showed faster encoding of familiar than unfamiliar faces (part of the findings by de Haan et al., 1987) at levels of lesion that impaired overt recognition. However, Farah et al. did not model the interaction explored here. The present data suggest the importance of assessing whether a modified computational model, incorporating different kinds of face recognition information, and distinguishing between internal and external areas of the face, would continue to produce the interaction of part of face with familiarity after random lesions to the database, as well as showing the kind of learning effects seen in the present data.

In summary, these experiments suggest that overt recognition may be possible in the absence of the kind of representation supporting a covert recognition effect. The opposite pattern is known from prior research. Traditionally, data of this kind have been taken to support two-system models. However, in this case, we argue that such a finding would pose significant unresolved issues for all extant proposals regarding the architecture of face recognition.

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REFERENCES

- Bauer R M (1984) Automatic recognition of names and faces in prosopagnosia: A neuropsychological application on the Guilty Knowledge Test. *Neuropsychologia* 22, 457-469.
- Bauer R M & Verfaellie M (1988) Electrodermal discrimination of familiar but not unfamiliar faces in prosopagnosia. *Brain and Cognition* 8, 240-252.
- Burton A M, Young A W, Bruce V, Johnston R A, & Ellis A W (1991) Understanding covert recognition. *Cognition* 39, 129-166.
- Carey S (1992) Becoming a face expert. *Philosophical Transactions of the Royal Society of London Series B Biological Sciences*, 335, 95-103.
- de Haan E H, Young A, & Newcombe F (1987) Face recognition without awareness. *Cognitive Neuropsychology* 4, 385-415.
- Diamond R & Carey S (1977) Developmental changes in the representation of faces. *Journal of Experimental Child Psychology*, 23, 1-22.
- Diamond R & Carey S (1986) Why faces are and are not special: An effect of expertise. *Journal of Experimental Psychology: General* 115, 107-117.
- Farah M J, O'Reilly R C, & Vecera S P (1993) Dissociated overt and covert recognition as an emergent property of a lesioned neural network. *Psychological Review* 100, 571-588.
- Greve K W & Bauer R M (1990) Implicit learning of new faces in prosopagnosia: An application of the mere exposure paradigm. *Neuropsychologia* 28, 135-141.
- Levine, S C (1985) Developmental changes in right-hemisphere involvement in face recognition. In C. Best (Ed.), *Developmental neuropsychology and education: Hemispheric function and collaboration* (pp. 157-191). New York: Academic Press.
- Newcombe N & Fox N (1994) Infantile amnesia: Through a glass darkly. *Child Development* 65, 31-40.
- Reintz M T, Morrissey J, & Demb J (1994) Role of attention in face encoding. *Journal of Experimental Psychology: Learning, Memory and Cognition* 20, 161-168.
- Tranel D & Damasio A R (1985) Knowledge without awareness: An automatic index of facial recognition by prosopagnosics. *Science*, 228, 1453-1454.
- Tranel, D & Damasio A R (1988) Non-conscious face recognition in patients with face agnosia. *Behavioral Brain Research* 30, 235-249.
- Young A W, Hay D C, McWeeny K H, Flude, B M, & Ellis, A W (1985) Matching familiar and unfamiliar faces on internal and external features. *Perception* 14, 737-746.
- Young, A W, Hellawell D & de Haan E H F (1988) Cross-domain semantic priming in normal subjects and a prosopagnosic patient. *Quarterly Journal of Experimental Psychology* 38A, 297-318.

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