Facial representations contain the information concerning expressions: Evidence from priming experiments

著者	KIRITA Takahiro, ENDO Mitsuo
journal or publication title	Tohoku psychologica folia
volume	60
page range	45-60
year	2002-07-01
URL	http://hdl.handle.net/10097/54757

Tohoku Psychologica Folia
2001, **60**, 45 – 60

Facial representations contain the information concerning expressions: Evidence from priming experiments

KIRITA TAKAHIRO (桐田隆博)[1], and ENDO MITSUO (遠藤光男)[2]
(*Iwate Prefectural University*) (*University of the Ryukyus*)

This study explores whether facial representations contain the information concerning facial expression by probing the repetition priming in face recognition of famous persons (Experiment Ⅰ) and personally familiar persons (Experiments Ⅱa and Ⅱb). In two experiments, we investigate the amount of priming by solely varying facial expression of prime and target. Experiment Ⅰ showed that faces of famous persons primed by the same expression were judged as familiar faster than faces primed by different expression, which, in turn, were judged faster than unprimed faces. Experiment Ⅱa, in which the targets were college staffs, indicated that differential effects of expression could be observed even in unprimed conditions. Furthermore, Experiment Ⅱb showed that graded priming effect, found in Experiment Ⅰ, was held for the case of personally familiar faces with pictorial cues other than expression strictly controlled. These results are inconsistent with Bruce and Young's (1986) view that the face recognition units should not be sensitive to any facial expression. On the contrary, they suggest that the information concerning facial expression should be contained in face recognition units.

Key words: Face recognition; Representations; Facial expression, Repetition priming

Introduction

One of your friends might always be smiling each time you meet. Or you may have a supervisor who always wears a frown. When you see a familiar face, does the facial expression affect your fluency in recognizing that face? The purpose of this study was to examine what influence facial expression exerts on the recognition of familiar faces.

The possibility that facial expression affects recognition of familiar faces, however, was ruled out in the functional models of face recognition as proposed by Hay and Young (1982) and Bruce and Young (1986). In these models, facial identification involves distinct sequential stages, which proceed independently from the analysis of expression. To be concrete, when a face is seen, view-centered descriptions and more abstract structural codes are generated. The former is used for analysis of expression and the latter is compared with sets of structural codes of familiar faces stored in face recognition units (FRU). Each FRU is assumed to contain expression-independent facial descriptions of a familiar person. If the comparison is successful, the face is determined to be familiar and then, access to the person identity node (PIN) is allowed. The

1. Department of Psychology, Faculty of Social Welfare, Iwate Prefectural University, 152-52 Sugo, Takizawa, Iwate, 020-0193 Japan e-mail: kirita@iwate-pu.ac.jp
2. Department of Psychology, Faculty of Law and Letters, University of the Ryukyus, 1 Senbaru, Nishihara, Okinawa, 903-0213 Japan

semantic information connected to the owner of the face is derived from PINs. Finally, name retrieval is only achieved by way of PINs. According to this sequential model, a familiar person will always be recognized with the same fluency regardless of facial expression, because FRUs are not sensitive to facial expression. However, if we postulate there is a stage in which normalization for expression is conducted, the influence of facial expression on face recognition should be apparent in a certain form (see Valentine & Bruce, 1986).

The assumption that information stored in FRUs should be independent of facial expression can be drawn from the idea that if face recognition were influenced by the temporal changes, for example, in lightning, head angle, and expression, it would not work at all in everyday life (Bruce & Young, 1986). This assumption has been supported by studies in different fields including clinical case studies of brain damaged patients (e.g., Shuttleworth et al., 1982; Young et al., 1993), neurophysiological studies of the monkey brain (e.g., Perrett et al., 1984) and psychological studies of human face recognition (e.g., Young et al., 1986). The results of these extensive studies have brought converging evidence to the view that facial identification is independent of analysis of expression (see Bruce & Young,1986; Young & Bruce,1991). However, it should be noted that the presumption that facial identification proceeds independently from the analysis of expression does not necessarily lead to the notion that the information stored in FRUs should be expression-independent structural codes. For example, it is possible that facial expression is stored in FRUs as transformable information, much as information on hairstyles and deformation due to aging. In this case, it is likely that the representation of a familiar face is not static, but is continuously updated by each face encounter.

Moreover, there may be a few problems in the psychological studies that have addressed the relationship between facial identification and analysis of expression. For one thing, unfamiliar faces or cartoon-like faces were used as stimuli in some studies which have been thought to demonstrate the independence of facial identification from analysis of expression. For example, using various smiling and sad faces of two women, Etcoff (1984) asked her subjects to sort those faces by identity in one session, and by expression in another session. Consequently, she obtained the result that the sorting task with respect to identity was not affected by facial expression. Furthermore, there was no influence of facial identity on the classification of facial expression. Similarly, Lay and Bryden (1979), using line-drawings of expressive faces, demonstrated that the identity matching of faces was not affected by facial expression, and vice versa. What needs to be noted is that stimulus persons used in the study of Etcoff and line-drawings used in the study of Lay and Bryden were both unfamiliar to the subjects, though they were given a chance to see some of these faces prior to the experimental sessions. This means that their results said little, if anything, about the nature of FRUs, because FRUs are the facial representations of familiar persons. Indeed, it has been suggested that there are substantial differences in the information which is used in the recognition of familiar and unfamiliar faces (Ellis et al., 1979; Endo et al., 1984).

Another problem is that the double dissociation of facial identification and analysis of expression has not been demonstrated yet with familiar faces. For example, Bruce (1986a) presented a random sequence of familiar and unfamiliar faces to her subjects and asked them to judge whether the face was smiling. The familiarity of faces did not affect the time needed to judge whether the face was smiling. Young et al. (1986) presented two familiar faces or two unfamiliar faces at the same time to the subjects and asked them to judge whether two faces were the same in terms of identity for one session, and in terms of expression for other session. Again, they obtained the result that the familiarity of faces affected the identity judgments, but not judgments of expression. However, these two studies only showed that familiarity of faces did not affect the analysis of expression. It seems necessary to prove that expression does not exert influence on the familiarity judgments or facial identifications to say that the information stored in FRUs should be independent of expression. Unfortunately, neither Bruce (1986b) nor Young et al. (1986) examined whether facial expressions influenced familiarity judgments or the matching of identity.

Accordingly, Endo et al. (1992) were the first to systematically examine the effects of expression on familiarity judgments of faces. In their first experiment, they drew on staff members from their university and took photographs of happy, angry, and neutral faces for each. Their subjects were students at the same university. In addition to these familiar faces, the subjects were also presented with unknown faces bearing different expressions and asked to judge whether they knew the face. Consequently, the effect of expression on familiarity judgments was found only for the target staff members. Compared to happy and angry faces, the faces of staff members were more adroitly recognized as familiar when they bore neutral expressions. There was no effect of expression on the judgments for unfamiliar faces. In their second experiment, they used the happy and neutral expressions of famous persons as familiar targets and repeated the task of familiarity judgment. Here, it was shown that, unlike the case of staff members, famous persons were recognized as familiar faster with happy faces than with neutral expressions. These results deserve special attention in that the effect of expression on the familiarity judgments emerged depending on the class of familiarity. Furthermore, the finding that expression had no effect in the judgments for unfamiliar faces is quite consistent with previous findings such as Etcoff's (1984).

Even if a normalizing process as noted earlier is assumed, the results of Endo et al. (1992) cannot be explained by the notion that FRUs are expression-independent structural codes. This is because if the time needed to normalize the face differs among expressions, the effect of expression should always be observed in the same direction irrespective of familiarity of face. Thus, a normalizing process does not explain the differential effects of expression on recognizing faces for three classes of persons: famous, personally familiar, and unfamiliar persons. Rather, the results are consistent with the view that the facial representation of a known person is formed by superimposing discrete instances, best known as a property of the parallel distributed model proposed by McClelland and Rumelhart (1985).

McClelland and Rumelhart (1985) presented a simulation that, after learning various instances of one category, a distributed recognition module could have sensitivities not only to the learned instances but also to the central tendency of learned instances: the prototype. Indeed, Bruce et al. (1991) demonstrated that subjects came to be sensitive not only to learned faces but also to unseen prototypes of learned faces. Further, Cabeza et al. (1999) suggested that the response to prototype was made based on a mechanism of averaging feature variations across faces when these faces were within the same view. Given this kind of averaging mechanism, the results of Endo et al. (1992) can be explained the following way. That is, when the instance is of a personally familiar person with opportunities to be seen in various kinds of expression, the information concerning facial expression might be attenuated or offset, as a kind of noise, by averaging or superposing exemplars. Thus the prototype of that person would be somewhere close to neutral expression. Otherwise, it is just as probable that the teachers of the university whom they used as familiar targets, showed neutral expressions more frequently than any other expression to their students. On the other hand, in the case of a celebrity who would naturally present a specific expression (i.e., smiling face) more frequently (see Campbell & De Haan, 1998), the expression of the person would not be offset by averaging seen instances. In this case, the prototype of famous person should be greatly influenced by a smiling expression. As a consequence, the recognition of personally familiar persons should be faster for neutral expressions, whereas the recognition of famous persons should be faster with smiling ones.

The view that FRUs are instance-based representations has been supported by studies examining repetition priming in face recognition (Ellis, 1992). Repetition priming refers to the facilitation of recognition of an object by earlier exposure to that object. This recognition gain has been demonstrated in the studies of face recognition (e.g., Bruce, 1986b; Bruce & Valentine, 1985, 86; Ellis et al., 1987) as well as in the studies of object recognition (e.g., Warren & Morton, 1982) and word recognition (e.g., Scarborough et al., 1977).

In face recognition, Ellis et al. (1987) found that repetition priming depended on the degree of visual similarity between prime and target. They obtained maximum effects of priming when the same photograph was used for both prime and target, but recorded a lessened effect when prime and target were similar photographs, with the least effect when dissimilar photographs were used. Furthermore, Brunas et al. (1990; Brunas-Wagstaff et al.,1992) demonstrated that recognizing a portion or part of a familiar face earlier was as effective at priming recognition as seeing the entire face (the part-to-whole completion). The graded similarity effect and the part-to-whole completion found in priming experiments can be easily explained by the instance-based recognition model, though the latter is still consistent with the view that FRUs are abstract descriptions (see Bruce et al., 1994). The view that FRUs are instance-based descriptions is also supported by the analysis of errors in face recognition made in the laboratory (Hay et al., 1991).

However, few studies to date have addressed the impact of expression on the recognition of familiar faces, with the exception of the study of Endo et al. (1992). Although quite a few researchers have suggested that FRUs are instance-based description, no one has clearly demonstrated that the information concerning facial expression is contained in FRUs. We think it is important to reconfirm the effect of expression on the recognition of familiar faces in considering the nature of FRUs. For this reason, we decided to examine the nature of FRUs by comparing the amount of priming with different facial expressions. The reasons we used priming paradigm derive from the following: For one thing, repetition priming has been observed in the domain of face recognition but not in other domains such as expression judgments or sex judgments (Ellis et al., 1990). Thus, the facilitating effect of priming has been thought to emerge from the structural change in the face recognition route: the prime lowers the threshold of FRUs (Bruce & Valentine, 1985) or the prime strengthens the connection between feature units and FRUs (Bruce et al., 1994; Ellis et al., 1997) and/or between FRUs and PINs (Burton et al., 1990). In any case, priming should be a valuable probe in examining the nature of FRUs (Bruce et al., 1994). For another, to date, no one has attempted to demonstrate graded priming effect by only varying facial expressions. When Ellis et al. (1987) found a graded similarity effect, they did not describe in what aspects prime and target were similar or dissimilar. We think that if the graded priming effect is demonstrated solely by varying facial expressions, the view that FRUs are instance-based representation and the view that they contain the information concerning facial expression can be confirmed at the same time.

In Experiment I, the faces of famous persons were used as familiar targets, and the expressions in the study and the test phases were varied to examine the effect of expression on priming. Experiments IIa and IIb were nearly identical to Experiment I except that the familiar targets were drawn from members of our college staff whom the subjects met in daily life. These experiments could be regarded as the examination of the graded priming effect by solely varying facial expressions.

Experiment I

In this experiment, the repetition priming paradigm was used and facial expression of familiar targets was varied in the study and the test phases. The familiar faces were selected from famous persons. If FRUs are expression-independent abstract descriptions, then priming would not be impacted by the shift of facial expression from the study phase to the test phase. On the other hand, if information concerning facial expression is contained in FRUs, there would be less priming effect when the expression was changed in the two phases.

Method

Subjects

Twenty-four sophomores of Shokei Women's Junior College participated in this experiment. They were paid 500 yen each for their participation.

Stimuli and apparatus

Forty-six famous persons (30 males and 16 females) were selected as candidates of familiar targets. For each candidate, faces with both smiling and neutral expressions were garnered from magazines with the constraint that head angles and hair styles of the two photographs be as identical as possible. These photographs were transformed into black-and-white slides. Prior to Experiment I, we presented these slides to 25 independent subjects and asked them to rate neutral expressions on three 7-point scales: familiarity (totally unknown: 1, very well known: 7), likeness (very poor likeness: 1, very good likeness: 7), and the expression (utterly neutral: 1, fully smiling: 7). Where we presented smiling faces, the subjects rated these on only two scales: likeness and expression. We adopted the likeness rating following the suggestion that even very famous persons might be judged as unfamiliar when faces drawn from media sources showed little likeliness to that person (Hay et al., 1991, see also Johnston & Barry, 2001). Based on these ratings, we identified 20 male and 10 female famous persons to serve familiar targets. The mean ratings of 30 familiar targets on each scale are given in Table 1. In addition to these 30 familiar targets, 20 famous persons (10 smiling and 10 neutral faces) were gathered from magazines as fillers in the study phase. Further, more faces, 10 famous persons (five smiling and five neutral faces) and 40 unknown persons (20 smiling and 20 neutral faces) were drawn from magazines as fillers for the test phase. The sex ratio and the age range of fillers were roughly matched to those of the familiar targets.

To minimize any pictorial cues other than expression, we cut familiar and unfamiliar faces along the hairlines. Then we used a scanner (EPSON: GT-6000) to digitalize these into files using a 256 gray-scale. Presentations of faces and measurements of reaction times were carried out using a TV-type tachistoscope (IWATSU ISEL: IS-701AB) and a host computer (NEC: PC-9801DS). Subjects, immobilized with a chin rest, observed the stimuli from a distance of 80 cm where stimuli subtended $5.0^\circ \times 3.6^\circ$ in visual angle.

Design and procedures

The combination of smiling and neutral expressions in the study and the test phases made four conditions: two congruent prime conditions where the expressions of the study and the test phases were the same (i.e., neutral-neutral, smile-smile), and two incongruent prime conditions where the expressions in the two phases changed (i.e., neutral-smile, smile-neutral). Besides these four conditions, two unprimed conditions, in which no primes were presented, were established as control conditions (i.e., -neutral, -smile). Thirty familiar targets were divided into six groups with each group assigned to one of the six conditions. The assignment to each condition was rotated around every four subjects.

The task consisted of two distinct phases: a study phase and a test phase. In the study phase, 20 familiar targets and 20 familiar fillers were randomly presented to the subjects. Half of the familiar targets were presented with smiling faces, while the remaining half were presented with neutral expressions. Similarly, half of the familiar fillers were presented with smiling faces while the other half were presented with neutral expressions. Each face was presented for 5 sec during which the subjects were instructed to name the owner. If the name of the owner could not be retrieved, the subject described the occupation of or some information related to the owner. The

Table 1 Mean ratings on familiarity, likeness, and expression scales for famous targets

	Familiarity		Likeness		Expression	
	Neutral	Smile	Neutral	Smile	Neutral	Smile
Rating	6.35	–	5.16	5.57	2.08	5.59
SD	0.25	–	0.47	0.75	0.41	0.79

inter-trail interval was 2 sec.

Approximately three minutes after the study phase finished came the test phase. In the test phase, in addition to 20 familiar targets seen in the study phase, 10 unseen familiar targets, 10 new familiar fillers, and 40 unfamiliar fillers were randomly presented. In each trial, the fixation point was presented for 0.5 sec on the center of the display, and then the stimulus face was presented for two seconds. The subjects were asked to decide whether the face was familiar, and to respond by pressing one of two response keys as quickly as possible while trying to avoid errors. The inter-trial interval was two seconds. The counterbalance of response keys was taken among the subjects. Using another set of faces, 14 trials were carried out for practice before the experimental session.

Results and discussion

All subjects were familiar with all the targets presented in the study phase. Since the focus here was on priming, we did not analyze responses to unfamiliar persons. The mean reaction times needed to correctly judge familiar targets as familiar and mean percentages of errors for familiar targets in each condition of the experiment are shown in Table 2. A one-way repeated measures ANOVA was performed on the reaction times. It revealed a significant main effect of experimental conditions, $F(5,115) = 13.16, p<0.001$. Planned comparisons (multiple *t*-test) showed the following. First, faces primed by the same expression (congruent prime conditions) were judged as familiar faster than faces primed by different expressions (incongruent prime conditions), $t(115) = 3.87, p<0.01$, which, in turn, were judged faster than unprimed faces (no prime conditions), $t(115) = 4.43, p<0.01$. However, there was no significant difference in reaction times between smiling and neutral faces in no prime conditions, $t(115) = 1.00$, $p>0.1$. Likewise, no significant difference in reaction times was found between the two congruent prime conditions, $t(115) = 0.87$, $p>0.1$, nor between the two incongruent prime conditions, $t(115) = 0.10, p>0.1$.

A one-way repeated measures ANOVA was performed on the arcsine transformed percentages of errors, which revealed the main effect of experimental conditions to be significant, $F(5,115) = 5.96, p<0.001$. Planned comparisons (multiple *t*-test) showed that the subjects made more errors in the no prime conditions than in the incongruent prime conditions, $t(115) = 3.66, p<0.01$. However, there was no significant difference in error rates between congruent and incongruent prime conditions, $t(115) = 1.40$, $p>0.1$. Furthermore, no significant difference was found in error rates between two congruent prime conditions, $t(115) = 0.62$, $p>0.1$, between two incongruent prime conditions, $t(115) = 1.37, p>0.1$, nor between two no prime conditions, $t(115) = 0.15, p>0.1$.

Taken together, the results indicate that primed targets are recognized more quickly and accurately than unprimed targets. Moreover, the greatest priming is observed when the prime and target bear the same expression, and moderate priming is observed when the expression of the prime and target is changed. These results can be regarded as replication of the graded priming effect (Ellis et al., 1987) by solely varying the expression.

Unlike the results of Endo et al. (1992), we found no differences between unprimed smiling and unprimed neutral faces. This result is rather consistent with the view that FRUs are the expression-independent abstract descriptions. However, if FRUs are abstract codes, then the priming should be constant irrespective of any changes in expression between prime and target. However, this experiment found priming to be a function of congruency of expression between prime and target. Thus, to explain the graded priming effects, we have to think that the equal fluency of recognition observed in two unprimed conditions arise not because FRU is insensitive to facial expression, but because it has equal sensitivities to both smiling and neutral expressions of a famous person.

It should be noted, however, that while the same photograph was used as prime and target in congruent prime conditions, different photographs were used in the incongruent prime conditions. Thus, if pictorial codes were also involved in the priming effect (Bruce & Valentine, 1985; Roberts & Bruce, 1989; Warren & Morton, 1982), we cannot entirely deny the possibility that the moderate priming found in incongruent prime conditions was due to different pictorial codes, although we made every possible effort to eliminate such pictorial cues. We will consider this possibility again in Experiment Ⅱb.

Table 2 Mean correct reaction times and mean error rates to famous targets in each of the priming conditions in Experiment Ⅰ

	Congruent prime conditions		Incongruent prime conditions		No prime conditions	
	Neutral-Neutral	Smile-Smile	Neutral-Smile	Smile-Neutral	-Neutral	-Smile
RT	678	658	726	723	784	807
Error rate	3.3	1.7	8.3	3.3	14.2	13.3
Overall RT	668		725		795	
Overall error rate	2.5		5.8		13.8	

Note: Reaction times in msec and error rates in %.

Experiment Ⅱa

The results of Experiment Ⅰ showed that the faces with smiling and neutral expressions of a famous person were recognized with the same efficiency. Endo et al. (1992) reported that personally familiar persons were recognized faster when they bore neutral expressions than when they were smiling. In this experiment, we used staff members of our junior college as familiar targets and repeated the priming experiment. Since the members of college staff whom students regularly saw were limited to 12 persons, we only barely fulfilled the requirements for two congruent prime conditions and two unprimed conditions. Incongruent prime condition where the expression of the prime and target are be changed will be examined in Experiment Ⅱb.

Method

Subjects

Sixteen sophomores of Shokei Women's Junior College participated in this experiment. They were paid 500 yen each for their participation.

Stimuli and apparatus

Twelve staff members of Shōkei Women's Junior College (five males, seven females) were selected as familiar targets. Photographs of smiling and neutral faces were taken for each target with strictly controls on expression, head angle, and lightning. In addition to these 24 target photographs, we used six faces of famous persons (three smiling and three neutral faces) as fillers for the study phase. For the test phase, 12 faces of famous persons (six smiling and six neutral faces) and 24 faces of unfamiliar persons (12 smiling and 12 neutral faces) were used as fillers. The sex ratio and the age range of fillers were roughly matched to those of the familiar targets. As in Experiment I, all these photographs, after cut along the hairlines, were digitized into files with 256-gray scale. Stimulus examples of personally familiar targets are shown in Fig. 1. The apparatus were also the same as in Experiment I.

Design and procedures

Two congruent priming conditions and two no prime conditions were set. In congruent prime conditions, the familiar targets were always primed by the same expression (i.e., neutral-neutral, smile-smile). In no prime conditions, the familiar targets appeared with smiling or neutral faces for the first time in the test phase (i.e., -neutral, -smile). Twelve familiar targets were divided into four groups and each group was assigned to one of four conditions. Rotation of the assignment to each condition was carried out for every four subjects.

As in Experiment I, the task consisted of the study and the test phases. In the study phase, photographs of six of 12 staff members and six famous fillers were randomly presented to the subjects. Half the staff members were presented smiling, and the remaining half appeared with neutral expressions. Likewise, half the famous fillers were presented with smiling expressions, and the remaining half were presented with neutral expressions. Each face was presented for five seconds during which the subjects were required to name its owner. They were also instructed to describe the owner in terms of occupation or related information if the name could not be retrieved. The inter-trial interval was two seconds.

Approximately three minutes after ending the study phase, the test phase was begun. In the test phase, 12 familiar targets (six smiling and six neutral faces), 12 famous fillers (six smiling and six neutral faces), and 24 unfamiliar fillers (12 smiling and 12 neutral faces) were presented. In each trial, a fixation point was presented for 0.5 seconds on the center of the display, followed by a face for two seconds. The subjects were instructed to judge whether the face was familiar and to respond by pressing one of two response keys as quickly and as accurately as possible. The order of presentation was randomized and the inter-trial interval was two seconds. Using another set of faces, the subjects were submitted to 10 practice trials before the experimental session.

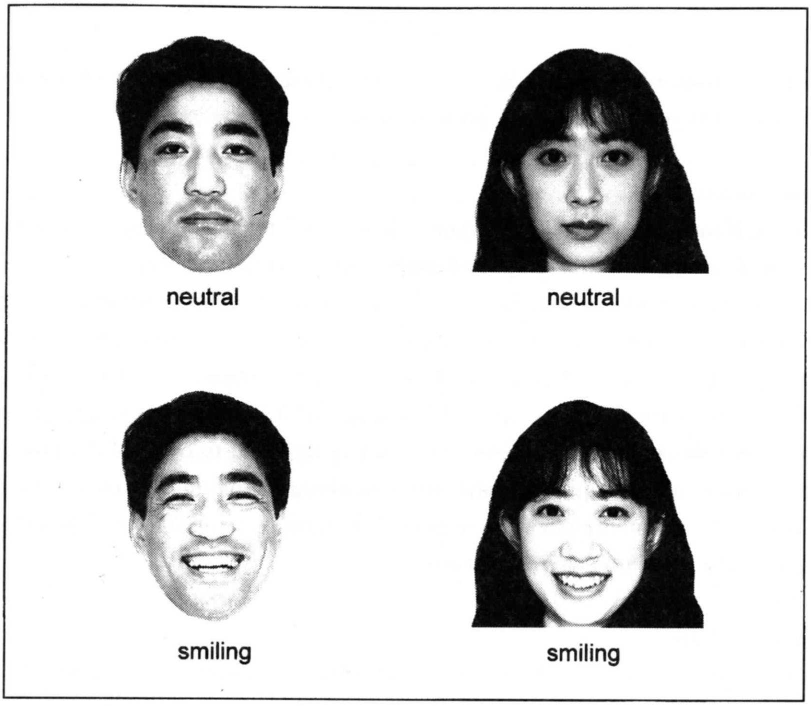

Fig. 1. Examples of personally familiar faces (college staffs) used in Experiments IIa and IIb.

Results and discussion

Mean correct reaction times and error rates for familiar targets in each condition were calculated for each subject. The overall means for each condition are given in Table 3. A one-way repeated measures ANOVA was performed on the reaction times. It yielded significant main effect of experimental conditions, $F(3,45) = 15.96$, $p<0.001$. Planned comparisons (multiple t-test) showed that familiar targets were recognized faster in congruent prime conditions than in no prime conditions, $t(45) = 6.46$, $p<0.01$. Furthermore, there was a significant difference in the reaction times between two no prime conditions, $t(45) = 2.06$, $p<0.05$. In no prime conditions, staff members were recognized faster with neutral faces than with smiling ones. However, there was no significant difference in reaction times between two congruent prime conditions, $t(45) = 0.82$, $p>0.1$.

A one-way repeated measures ANOVA was performed on the arcsine transformed percentages of errors, which revealed the main effect of experimental conditions to be significant, $F(3,45) = 5.00$, $p<0.01$. Planned comparisons (multiple t-test) showed that the subjects made more errors in no prime conditions than in congruent prime conditions, $t(45) = 3.83$, $p<0.05$. However, there was no significant difference in error rates between two congruent prime conditions, $t(45) = 0.39$, $p>0.1$, nor between two no prime conditions, $t(45) = 0.39$, $p>0.1$.

These results show that as in Experiment I, staff members were recognized more quickly and accurately under primed conditions than under unprimed conditions. The most remarkable result of Experiment Ⅱa is that, unlike famous persons, staff members were recognized as familiar faster with neutral expressions than with smiles, exactly the same result that Endo et al. (1992) had obtained. This result is not consistent with the view that FRUs are expression-independent abstract codes. Rather, the results of Experiment Ⅱa support the view that FRUs are sensitive to information on facial expression.

Another point we must note here is that the difference found in reaction times between unprimed smiling and unprimed neutral faces disappeared when they were primed by the same expression. Could this be assimilated into the nature of distributed recognition model in which the most recent instance should retain the most influence on the representation? We will discuss this problem later.

Table 3 Mean correct reaction times and mean error rates to personally familiar targets in each of the priming conditions in Experiment Ⅱa

	Congruent prime conditions		No prime conditions	
	Neutral-Neutral	Smile-Smile	-Neutral	-Smile
RT	573	596	682	739
Error rate	2.1	4.2	16.7	18.7
Overall RT	584		711	
Overall error rate	3.2		17.7	

Note: Reaction times in msec and error rates in %.

Experiment Ⅱb

In Experiment Ⅰ, where factors other than expression could not have been strictly controlled, medium priming effect was found when the expression of prime and target was changed. Thus, if it is assumed that the pictorial codes were also involved in priming effect, the results of Experiment Ⅰ could be still consistent with the view that FRUs are the expression-independent codes. Using the same personally familiar targets as in Experiment Ⅱa, here we compared the amount of priming between the congruent and incongruent prime conditions. By taking photographs of personally familiar persons, we could strictly limit pictorial cues other than facial expression.

Method

Subjects

Eighteen sophomores of Shokei Women's Junior College participated in this experiment. They were paid 500 yen each for their participation.

Stimuli and apparatus

As in Experiment IIa, 12 staff members of the college were the familiar targets. In this experiment, another type of tachistoscope (IWATSU ISEL: IS-701D) and a host computer (Apple: Quadra 800) were used to present the stimuli and to measure responses.

Design and procedures

We set the three conditions in this experiment. In congruent prime condition, the neutral faces were primed by the same faces (i.e., neutral-neutral). In incongruent prime condition, the neutral expressions were primed by smiling faces (i.e., smile-neutral). In no prime condition, there was no prime, thus, neutral faces were first shown in the test phase (i.e., -neutral). Twelve staff members were divided into three groups and each group was assigned to one of three conditions. Rotation of the assignment to each condition was carried out for every six subjects.

As in Experiments I and IIa, the task consisted of the study and the test phases. In the study phase, eight of 12 staff members and eight famous fillers were randomly presented to the subjects. Half of the staff members were presented smiling, and the remaining half appeared with neutral expressions. Likewise, half of the famous fillers were presented with smiling faces, and the remaining half were presented with neutral faces. Each face was presented for 5 sec during which the subjects were required to name its owner. They were also instructed to describe the owner in terms of occupation or related information if the name could not be retrieved. The inter-trial interval was 2 sec.

Approximately three minutes after the study phase finished began the test phase. In the test phase, 12 familiar targets, 12 famous fillers, and 24 unfamiliar fillers were presented with neutral expression. In each trial, fixation point was presented for 0.5sec on the center of the display, followed by presentation of a face for 2 sec. The subjects were instructed to judge whether the face was familiar or not, responding by pressing one of two keys as quickly and as accurately as possible. The order of presentation was randomized and the inter-trial interval was 2 sec. Using another set of faces, the subjects were submitted to 10 practice trials before the experimental session.

Results and discussion

Mean correct reaction times and error rates for familiar targets in each condition were calculated for each subject. The overall means for each condition are given in Table 4. A one-way repeated measures ANOVA was performed on the reaction times. It revealed that the main effect of experimental conditions was significant, $F(2,34) = 15.00$, $p<0.001$. Planned comparisons (multiple t-test) showed that familiar targets were recognized faster in incongruent prime condition than in no prime condition, $t(34) = 4.47$, $p<0.01$. However, there was no significant difference in the reaction times between congruent and incongruent prime conditions, $t(34) = 0.51$, $p>0.1$.

A one-way repeated measures ANOVA was performed on the arcsine transformed percentages of errors, which proved the main effect of experimental conditions to be significant, $F(2,34) = 5.70$, $p<0.001$. Planned comparisons (multiple t-test) revealed that while the subjects made fewer errors in congruent prime condition than in incongruent prime condition, $t(34) = 2.05$, $p<0.05$, there was no significant difference in error rates between incongruent and no primed conditions, $t(34) = 1.58$, $p>0.1$.

Unlike Experiment I, the results of Experiment IIb showed no difference in reaction times between congruent and incongruent prime conditions. However, the subjects made more errors in the incongruent condition than in the congruent condition, which indicates the speed-accuracy trade-off. Taken together, recognition efficiency may fall in the order: congruent prime condition > incongruent prime condition > no prime condition. Thus it can be concluded that the graded priming is still present when the factors other than expression are strictly controlled.

Table 4 Mean correct reaction times and mean error rates to personally familiar targets in each of the priming conditions in Experiment IIb

	Congruent prime condition	Incongruent prime condition	No prime condition
	Neutral-Neutral	Smile-Neutral	-Neutral
RT	581	593	697
Error rate	5.6	15.3	25.0

Note: Reaction times in msec and error rates in %.

General discussion

The series of experiments show a number of important aspects of repetition priming and recognition of familiar faces. First, the results of Experiment I indicate that smiling faces and faces with neutral expressions of famous persons are recognized with equal fluency (unprimed conditions). This result is not consistent with the Endo et al.'s (1992) finding that famous persons are recognized faster with smiling faces than with neutral expressions. On the other hand, the results of Experiment IIa show that when it comes to personally familiar persons (staff members), neutral faces are recognized faster than smiling ones, which is consistent with the findings of Endo et al.

Second, the results of Experiment I also show that faces of famous persons are recognized faster when they are primed by the same expression than when primed by different expressions. Furthermore, the results of Experiment IIb indicate that this tendency holds for cases of personally familiar persons with the pictorial cues other than facial expression being strictly controlled. Thus, these results can be regarded as the graded priming effect of solely varying facial expression. As far as the reaction times for Experiment IIb, however, use of the same photograph advantage in priming is less obvious indicating that the pictorial cues might be also involved in repetition priming.

In order to explain these results consistently as well as to preserve the notion of FRUs, we have to consider FRUs are instance-based representations rather than abstract ones. Then how does the instance-based FRU model explain why personally familiar persons are recognized faster with neutral expressions than with smiling ones? As noted earlier, the subjects may well have opportunities to see various expressions of staff members, which results in removal of expressive components from the prototypes. Otherwise, Japanese teachers seldom smile as they lecture. Consequently, the result that smiling and neutral faces of famous persons were recognized with equal fluency could be explained by assuming that smiling and neutral exemplars of a famous person have same influence on the creation of FRUs. In fact, mean ratings of likeness for famous persons was even higher on smiling faces than on neutral ones, $t(29) = 2.20$, $p < 0.05$. So, it may be possible that when the famous persons are familiar targets, smiling faces will be occasionally recognized faster than neutral faces, as Endo et al.(1992) reported, depending on the selection of famous persons.

More recently, we obtained the results of experiments indicating that the nature of FRUs change according to experiences. In that experiment, smiling and neutral faces were drawn from both staff members of the college and famous persons as familiar targets. Smiling and neutral faces of unknown persons were also used as distractors to conduct the task. The first- and second-year students of the college participated in the experiment of familiarity decision task. With first-year students the effect of expression on the familiarity decisions was not found for any class of familiarity. There was no difference in reaction times between smiling and neutral faces whether the owners of faces were staff members, famous persons, or unknown persons. On the other hand, in the second-year students, the effect of expression was found to affect only judgments for personally familiar persons. Again, staff members were recognized faster with neutral faces than with smiling ones. These results suggest that the daily life interaction of students and teachers change the FRUs for teachers. Recall that in the experiments reported here, all subjects were in their second year of junior college.

It should be worthy of note, however, that our results do not deny the view that the facial identification and the analysis of expression are independent of each other. They suggest that facial expression retained in FRUs is a changeable, constantly updated information similar to hairstyles or aging information. That FRUs have sensitivities to facial expression is one thing, but the independence of recognition of faces from analysis of expression is another.

There remains one thing to be considered: the greater priming observed in smiling faces. In experiment IIa, whereas there was significant difference in reaction times between two unprimed conditions, the difference was no more significant when the targets had been primed by same faces. To be precise, the difference in reaction times between unprimed neutral and primed neutral conditions was 109 msec, and the difference between in reaction times unprimed smiling and primed smiling conditions was about 143 msec. Could this slight difference be assimilated into the nature of distributed recognition model in which the most recent instance should retain the most influence on the representation? Alternatively, could this mean that the priming of smiling faces was actually larger than that of neutral faces by 34 msec?

Aside from the nature of distributed recognition model, there are two other plausible possibilities. For one, it is probable that there might be a floor effect in the primed neutral condition in Experiment IIa. In fact, compared with the results of Experiment I, overall mean reaction times in Experiment IIa were shortened by about 100 msec. For another, it is also possible that the priming is actually greater when the prime and target bear smiling expressions than when they both have neutral expressions, since the same tendency was found in the results of Experiment I. While the difference in reaction times between unprimed neutral and congruent prime neutral conditions was 106 msec, the difference in reaction times between unprimed smiling and congruent prime smiling conditions was 149 msec. Again, the priming with smiling faces was greater than that of neutral faces by 43 msec. This might imply that, in repetition priming, there should be slight but consistent differences between smiling and neutral faces. Unfortunately, in both Experiments I and IIa, the experiment design did not allow us to directly examine these differences. As such, this problem must be reserved for future study.

Acknowledgements

The experiments were carried out while first author worked at Shokei Women's Junior College. This research was partly supported by the Grant-in-Aid for Scientific Research (No.08710062) from the Ministry of Education, Science, and Culture of Japan. We would like to thank IWATSU ISEC for lending us the tachistoscope used in Experiments I and IIa.

References

Bruce, V. (1986a). Influences of familiarity on the processing of faces. *Perception*, **15**, 387-397.

Bruce, V. (1986b). Recognizing familiar faces. In H. D. Ellis, M. A. Jeeves, F. Newcombe, & A. Young (Eds.), *Aspects of face processing* (pp.107-117). Dordrecht: Martinus Nijhoff.

Bruce, V., Burton, A. M., Carson, D., Hanna, F., & Mason, O. (1994). Repetition priming of face recognition. In C. Umiltà & M. Moscovitch (Eds.), *Attention and performance XV* (pp.179-210). Cambridge, MA: MIT Press.

Bruce, V., Doyle, T., Dench, N., & Burton, M. (1991). Remembering facial configurations. *Cognition*, **38**, 109-144.

Bruce, V., & Valentine, T. (1985). Identity priming in the recognition of familiar faces. *British Journal of Psychology*, **76**, 363-383.

Bruce, V., & Valentine, T. (1986). Semantic priming of familiar faces. *Quarterly Journal of Experimental Psychology*, **38A**, 125-150.

Bruce, V., & Young, A. (1986). Understanding face recognition. *British Journal of Psychology*, **77**, 305-327.

Brunas, J., Young, A. W., & Ellis, A. W. (1990). Repetition priming from incomplete faces: Evidence for part to whole completion. *British Journal of Psychology*, **81**, 43-56.

Brunas-Wagstaff, J., & Young, A. W., & Ellis, A. W. (1992). Repetition priming follows spontaneous but not prompted recognition of familiar faces. *Quarterly Journal of Experimental Psychology*, **44A**, 423-454.

Burton, A. M., Bruce, V., & Johnston, R. A. (1990). Understanding face recognition with an interactive activation model. *British Journal of Psychology*, **81**, 361-381.

Cabeza, R., Bruce, V., Kato, T., & Oda, M. (1999). The prototype effect in face recognition: Extension and limits. *Memory & Cognition*, **27**, 139-151.

Campbell, R., & De Haan, E. H. F. (1998). Repetition priming for face speech images: Speech-reading primes face identification. *British Journal of Psychology*, **89**, 309-323.

Ellis, A.W. (1992). Cognitive mechanisms of face processing. *Philosophical Transactions of Royal Society of London*, **B335**, 113-119.

Ellis, A. W., Burton, A. M., Young, A., & Flude, B. M. (1997). Repetition priming between parts and wholes: Tests of a computational model of familiar face recognition. *British Journal of Psychology*, **88**, 579-608.

Ellis, A. W., Young, A. W., & Flude, B. M. (1990). Repetition priming and face processing: Priming occurs within the system that responds to the identity of a face. *Quarterly Journal of Experimental Psychology*, **42A**, 495-512.

Ellis, A. W., Young, A. W., Flude, B. M., & Hay, D. C. (1987). Repetition priming of face recognition. *Quarterly Journal of Experimental Psychology*, **39A**, 193-210.

Ellis, H. D., Shepherd, J. W., & Davies, G. M. (1979). Identification of familiar and unfamiliar faces form internal and external features: Some implications for theories of faces recognition. *Perception*, **8**, 431-439.

Endo, M., Takahashi, K., & Maruyama, K. (1984). Effects of observer's attitude on the familiarity of faces: Using the difference in cue value between central and peripheral facial elements as an index of familiarity. *Tohoku Psychologica Folia*, **43**, 23-34.

Endo, N., Endo, M., Kirita, T., & Maruyama, K. (1992). The effects of expression on face recognition. *Tohoku Psychologica Folia*, **52**, 37-44.

Etcoff, N. L. (1984). Selective attention to facial identity and facial emotion. *Neuropsychologia*, **22**, 281-295.

Hay, D. C., & Young, A. W. (1982). The human face. In A. W. Ellis (Ed.) *Normality and pathology in cognitive functions* (pp.173-202). London: Academic Press.

Hay, D. C., Young, A. W., & Ellis, A. W. (1991). Routes through the face recognition system. *Quarterly Journal of Experimental Psychology*, **43A**, 761-791.

Johnston, R. A., & Barry, C. (2001). Best face forward: Similarity effects in repetition priming of face recognition. *Quarterly Journal of Experimental Psychology*, **54A**, 383-396.

Lay, R. G., & Bryden, M. P. (1979). Hemispheric differences in processing emotions and faces. *Brain and Language*, **7**, 127-138.

McClelland, J. L., & Rumelhart, D. E. (1985). Distributed memory and the representation of general and specific information. *Journal of Experimental Psychology: General*, **114**, 159-188.

Perrett, D. I., Smith, P. A. J., Potter, D. D., Mistlin, A. J., Head, A. S., Milner, A. D., & Jeeves, M. A. (1984). Neurones responsive to faces in the temporal cortex: Studies of functional organization, sensitivity to identity and relation to perception. *Human Neurobiology*, **3**, 197-208.

Roberts, T., & Bruce, V. (1989). Repetition priming of face recognition in a serial choice reaction-time task. *British Journal of Psychology*, **89**, 201-211.

Scarborough, D.L., Cortese, C., & Scarborough, H.S. (1977). Frequency and repetition effects in lexical memory. *Journal of Experimental Psychology: Human Perception and Performance*, **3**, 1-17.

Shuttleworth, E. C. Jr, Syring, V., & Allen, N. (1982). Further observations on the nature of prosopagnosia. *Brain & Cognition*, **1**, 307-322.

Valentine, T., & Bruce, V. (1986). The effect of race, inversion and encoding activity upon face recognition. *Acta Psychologica*, **61**, 259-273.

Warren, C., & Morton, J. (1982). The effects of priming on picture recognition. *British Journal of Psychology*, **73**, 117-129.

Young, A. W., & Bruce, V. (1991). Perceptual categories and the computation of "grandmother". *European Journal of Cognitive Psychology*, **3**, 5-49.

Young, A. W., Mcweeny, K. H., Hay, D. C., & Ellis, A. W. (1986). Matching familiar and unfamiliar faces on identity and expression. *Psychological Research*, **48**, 63-68.

Young, A.W., Newcombe, F., De Haan, E. H. F., Small, M., & Hay, D. C. (1993). Face perception after brain injury: Selective impairments affecting identity and expression. *Brain*, **116**, 941-959.

(Received September 4, 2002)
(Accepted October 14, 2002)