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Distinctiveness, typicality, and recollective experience in face recognition: A principal components analysis

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In this study, participants rated previously unseen faces on six dimensions: familiarity, distinctiveness, attractiveness, memorability, typicality, and resemblance to a familiar person. The faces were then presented again in a recognition test in which participants assigned their positive recognition decisions to either remember (R), know (K), or guess categories. On all dimensions except typicality, faces that were categorized as R responses were associated with significantly higher ratings than were faces categorized as K responses. Study ratings for R and K responses were then subjected to a principal components analysis. The factor loadings suggested that R responses were influenced primarily by the distinctiveness of faces, but K responses were influenced by moderate ratings on all six dimensions. These findings indicate that the structural features of a face influence the subjective experience of recognition.

Studies of face recognition often require participants to rate a set of faces on structural dimensions such as distinctiveness, memorability, and attractiveness. When the faces are later presented in a test of recognition memory, the study ratings typically predict the likelihood that the faces will be recognized. For example, Vokey and Read (1988) found that faces rated as highly memorable are more likely to be recognized than faces rated as less memorable. Other studies have shown effects of distinctiveness, with faces rated as distinctive being recognized more accurately than faces rated as typical (Cohen & Carr, 1975; Light, Kayra-Stewart, & Hollander, 1979; Newell, Chiroro, & Valentine, 1999). Rated attractiveness has also been found to influence face recognition (Shepherd & Ellis, 1973), though it has been argued that this effect is mediated by other factors, such as distinctiveness or typicality (Light, Hollander, & Kayra-Stewart, 1981; Sarno & Alley, 1997; Vokey & Read, 1992). These and other findings indicate that the structural features of a face determine the likelihood of its subsequent recognition. The aim of the present study was to investigate how the structural features of a face determine the subjective experience of recognition.

It has been well documented that the recognition of familiar faces can be associated with two distinct states of awareness (Young, Hay, & Ellis, 1985). On some occasions, we may recognize a face and recollect details of the person, such as name, occupation, and where we previously saw the person. On other occasions, a face may feel familiar but we are unable to identify the person or recollect a previous encounter with them. This second state of awareness is often the result of a breakdown in the face recognition process, which leaves us temporarily unable to identify a person we know well (Young et al., 1985). However, this state of awareness also occurs when we see people we have previously encountered only briefly and about whom we know little. The different states of awareness observed in face recognition also illustrate a more general distinction between recollection and familiarity that has been widely observed in studies of recognition memory (see Yonelinas, 2002, for a review).

One method of investigating the dual nature of recognition memory is the *remember–know procedure*, which allows positive recognition decisions to be divided into those based on recollection and those based on familiarity (Gardiner, 1988; Tulving, 1985). In this procedure, participants are instructed to categorize their positive recognition decisions as either remember (R) or know (K) responses. They are asked to make an R response if they can bring to mind some aspect of an item's study presentation, such as a thought or feeling they experienced at the time, or a K response if the item feels familiar but they cannot consciously recollect its earlier presentation. More recent studies have also included a guess (G) response option,

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which has been found to eliminate guesses from the R and K categories (Gardiner, Java, & Richardson-Klavehn, 1996). The inclusion of a G option also removes the numerical constraints on K responses that are sometimes found when overall recognition scores are high (Gardiner & Richardson-Klavehn, 2000).

Several recent studies have investigated R and K responses in face recognition and found reliable effects of a number of variables. For example, Parkin, Gardiner, and Rosser (1995) investigated the effects of divided attention and repetition on face recognition. In Experiment 1, they found that R but not K responses were reduced by divided attention at study. In Experiment 2, they showed that spaced repetition increased R responses and reduced K responses, but massed repetition increased K and reduced R responses. These findings are consistent with those previously observed in the recognition of words (Gardiner & Parkin, 1990; Parkin & Russo, 1993). More recently, Mäntylä (1997) showed that rating the distinctiveness of faces at encoding increased R responses, and sorting faces into categories increased K responses. The increase in R responses following a distinctive encoding condition is consistent with previous findings that R responses are increased by factors that enhance the distinctiveness of to-be-remembered items (Rajaram, 1996).

The aim of the present study was to identify the factors that determine whether a recognized face is categorized as "remembered" or "known." In the study phase, participants rated a set of unfamiliar faces on the following dimensions: familiarity, distinctiveness, attractiveness, memorability, typicality, and resemblance to a familiar person. The faces were subsequently presented in a test of recognition memory in which participants made R/K/G decisions to each recognized item. Our focus was on the relation between ratings made at study and states of awareness at retrieval. In order to investigate this relation, we conducted a principal components analysis (PCA) of the study ratings. The central concept in PCA is summarization, where a larger set of variables is represented by a smaller set that best summarizes the larger set. Each summarizing variable is a linear function of a number of the original variables and is given by the factor-loading vector. To produce a unique solution, three statistical constraints are employed—namely, that the derived linear functions are uncorrelated, that any set of n linear functions must include the functions for a smaller set, and that the squared weights defining each linear function must sum to 1. The linear functions produced are called the *principal factors* and typically decline in importance as indexed by the proportion of the variability in the original set that is explained by each factor. Previous research has shown that PCA is a useful technique for investigating the factors that influence face recognition. For example, Vokey and Read (1992) asked participants to provide ratings of typicality, attractiveness, likability, familiarity, and memorability for a set of faces. Using PCA, they found that recognition was predicted by two orthogonal components, which they termed *memorability* and *context-free familiarity*. PCA therefore promises to be a useful tool for identifying the factors that determine the subjective experience of face recognition.

An additional aim of the present study was to provide converging evidence to support the results of experimental investigations of R and K responses. Previous studies have shown that R and K responses are influenced by the characteristics of the to-be-remembered stimuli (see Gardiner & Richardson-Klavehn, 2000, for a review). For example, studies using verbal stimuli have shown that R responses are greater for distinctive items, such as words of low frequency (Gardiner & Java, 1990) or of high imageability (Dewhurst & Conway, 1994). Since faces are easily rated in terms of structural characteristics, they provide an ideal opportunity to test the role of such characteristics in determining the subjective experience of recognition. Stimulus characteristics appear to have less of an effect on K responses. However, this result may reflect the fact that experimental investigations often involve the manipulation of a single variable (such as frequency) that typically exerts an effect only in R responses. The null (or reversed) effects observed in K responses may therefore reflect the dominance of R responses at test. It was hoped that the use of PCA and a wider range of stimulus characteristics would enable us to identify factors that specifically influence K responses.

In many previous studies of face recognition, the ratings and the recognition data were collected from different groups of participants. In the present study, we were interested in how the recognition performance of individual participants was influenced by their subjective ratings of the faces. The rating and recognition data were therefore collected from the same participants.

METHOD

Participants

Eighty undergraduate and postgraduate volunteers from Lancaster University participated in the experiment. They were tested in six groups, and each participant was tested in an individual research cubicle.

Stimuli and Design

A set of 150 monochrome photographs of nonfamous faces was selected from an archive of faces held at Lancaster University. Sixty were of female faces and 90 of male faces. The images were cropped in order to maximize the amount of facial information, and the cropped images were standardized in size (6.5×4 cm) and equated in brightness and contrast using Adobe Photoshop software and an Apple Macintosh G3 computer. The images were divided into two sets of 75 (30 female and 45 male). One set of 75 was presented in the rating task at study. Following a retention interval of 1 h, the same faces were presented again in the recognition test, together with the other 75 faces, which were presented as lures. The two sets of faces were counterbalanced so that they were used as targets and distractors for equal numbers of participants.

Procedure

Prior to the rating phase, the participants received instructions explaining the dimensions on which the faces were to be rated. Each participant was then seated in front of a computer, and the rating phase commenced. First of all, the participants were given a practice trial that consisted of the following series of events: A face appeared in the center of the computer screen. After an interval of

1 sec, a window appeared below the face, containing the prompt *Is this a familiar face?* and a 7-point rating scale, in which a score of 1 indicated *not at all* and a score of 7 indicated *very*. The participants responded by pressing the appropriate number on the keyboard and then responded to the following sequence of further prompts: *Is this a distinctive face?*, *Is this an attractive face?*, *Is this a memorable face?*, *Is this a typical face?*, and finally, *Does this face remind you of someone you know?* The face remained on the screen throughout the duration of the trial. This procedure was then repeated with the 75 critical items. This study phase lasted approximately 30 min.

After an unfilled interval of 1 h, the participants returned for the recognition test. They were told that they would be shown another set of faces, some of which had appeared in the previous phase of the experiment. They were instructed to make an *old/new* decision for each face and to indicate the basis of each positive recognition decision. The participants were then instructed in the use of the R, K, and G response categories. They were asked to make an R response if they recognized the face from the rating phase and were able to recollect some specific detail of its earlier presentation; a K response if they recognized the face because it felt familiar, but they had no specific recollection of its previous presentation; or a G response if they were unsure whether or not the face had appeared in the rating phase.

Each trial began with the presentation of a face in the center of the computer screen, with the prompt *Have you seen this person before?* immediately below it. On-screen instructions invited the participants to press the "1" key if they recognized the face and the "2" key if they did not. The face was then removed, and the participants were asked to describe their memory for the item. For positive recognition decisions, they were asked to press "R" for *remember*, "K" for *know*, or "G" for *guess*. For negative recognition decisions, they were asked to press the space bar to proceed to the next trial. This procedure was repeated until all 150 trials had been completed.

RESULTS

The proportions of times a previously seen face was correctly identified (hits) or falsely recognized (false alarms) were calculated for each participant and were further partitioned into proportions of R, K, and G responses. These proportions are shown in Table 1. The resulting data were analyzed using a 2 × 3 within-subjects ANOVA [type of face (previously seen or novel) × response type (R, K, or G)]. There was a reliable effect of response type [$F(2,158) = 79.17$, $MS_e = 0.01$, $p < .01$, $\eta^2 = 0.50$], which Bonferroni-adjusted tests revealed to result from greater numbers of R than K responses and smaller numbers of G responses. This was qualified by an interaction [$F(2,158) = 233.66$, $MS_e = 0.01$, $p < .01$, $\eta^2 = 0.75$]. Simple main effects analyses revealed different patterns of responses for hits and false alarms. The majority of hits were categorized as R responses [$F(2,158) = 520.81$, $MS_e = 0.01$, $p < .01$, $\eta^2 = 0.87$], whereas false alarms were most likely to be categorized as K responses [$F(2,158) = 46.68$, $MS_e = 0.01$, $p < .01$, $\eta^2 = 0.37$]. These data are consistent with findings from previous studies (see, e.g., Hay, Young, & Ellis, 1991) and confirm the efficiency of the face processing system in recognizing previously unfamiliar faces seen only once. In addition, these data indicate the appropriate use of R, K, and G categories. As expected, previously seen faces were categorized as R responses rather than as K or G responses, and this pattern was reversed when novel faces were incorrectly identified as old. This pattern has frequently been observed with other forms of stimuli, such as words (Gardiner, 1988) and pictures (Dewhurst & Conway, 1994).

Our main interest, however, was in the relationship between the ratings made at encoding and states of awareness at retrieval. In order to investigate this question, we constructed a data file consisting of 12 cells created by crossing response type (R vs. K) and the six rating dimensions (familiarity, distinctiveness, attractiveness, memorability, typicality, and resemblance to a familiar person). Each face was then given a score for each of the 12 categories. These scores represented the mean ratings given by those participants who correctly recognized the item and categorized it as an R (or K) response. Five faces did not yield K responses and were therefore discounted, leaving a total of 145 faces in the analysis. (A number of faces did not produce G responses, so an analysis of G responses was precluded).

Figure 1 shows the mean ratings for the six dimensions as functions of response type (R vs. K). A 2 × 6 (response type × rating dimension) by-items ANOVA showed a significant main effect of response type, whereby faces categorized as R responses were associated with significantly higher ratings overall than were faces categorized as K responses [$F(1,144) = 55.15$, $MS_e = 0.59$, $p < .01$, $\eta^2 = 0.28$]. A significant main effect of rating dimension was also observed [$F(5,720) = 163.30$, $MS_e = 0.77$, $p < .01$, $\eta^2 = 0.53$], plus a significant interaction between response type and rating dimension [$F(5,720) = 8.69$, $MS_e = 0.28$, $p < .01$, $\eta^2 = 0.06$]. Pairwise comparisons showed that R responses were associated with significantly higher ratings than were K responses, for all dimensions except typicality, for which faces categorized as K responses were associated with nonsignificantly higher ratings.

The relationship between the ratings made at encoding and response type at retrieval was then investigated using a by-items PCA, results of which are presented in Table 2. The validity of the factor structure was confirmed by employing a variety of different factor extraction techniques, including maximum likelihood and unweighted least squares. In addition, the influence of different rotation methods was also explored. All of these methods produced similar structures, including a method that allowed the factors to correlate. In this case, the resulting factor correlations were small, ranging from −.006 to .191, indicating that the resulting factors are best conceived of as being orthogonal. As a result, only the results from the PCA are presented.

Four factors were identified, accounting for 79% of the variance. The first accounted for 30% of the variance and

Table 1
Proportions of *Yes* Responses Made to Previously Seen and Novel Faces, Classified Further as Remember (R), Know (K), and Guess (G) Responses

		Relative Proportions		
Type of Face	*Yes* Responses	R	K	G
Previously seen	.94	.77	.20	.03
Novel	.19	.14	.60	.26

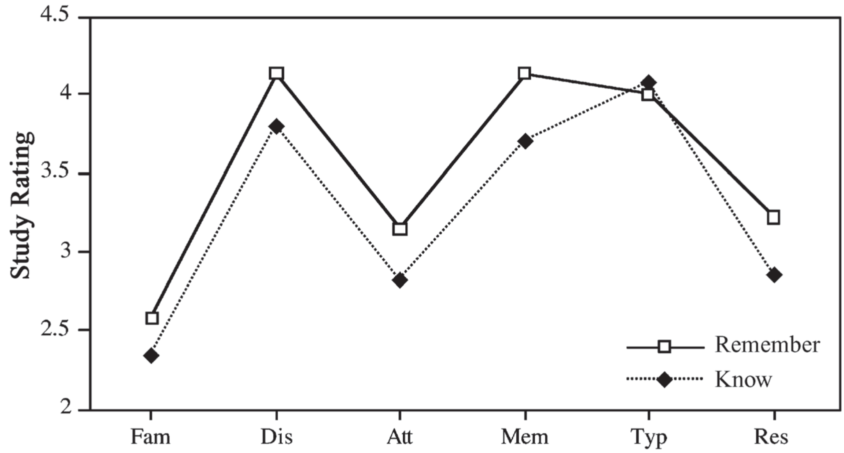

Figure 1. Mean study ratings (out of 7) for familiarity (Fam), distinctiveness (Dis), attractiveness (Att), memorability (Mem), typicality (Typ), and resemblance to a familiar person (Res) as functions of response type (remember vs. know).

included three significant loadings on R responses: positive loadings of distinctiveness and memorability, and a negative loading of typicality. The second accounted for 24% and showed moderate to high positive loadings of all six factors on K responses. The third accounted for 16% of the variance and showed significant positive loadings of familiarity and resemblance on R responses. Finally, the fourth factor accounted for 9% and showed positive loadings of attractiveness on both R and K responses. We labeled the factors *R distinctiveness*, *K responses*, *R familiarity*, and *attractiveness*. The correlation matrix is presented in Table 3.

DISCUSSION

The main finding from the present study was that the structural features of a face influenced the manner in which it was recognized. A PCA yielded four orthogonal factors, two of which showed significant loadings on R responses. The first (R distinctiveness) showed positive loadings of distinctiveness and memorability and a negative loading of typicality. This pattern suggests that the more distinctive, memorable, and atypical a face is, the more likely it is to be recognized and categorized as an R response. This is consistent with findings from previous studies that faces rated as distinctive are more easily recognized than faces rated as typical (see, e.g., Cohen & Carr, 1975; Light et al., 1979; Newell et al., 1999). The observed effect of distinctiveness is also consistent with previous findings that R responses are greater for distinctive stimuli. For example, participants make more R responses to pictures than to words (Dewhurst & Conway, 1994) and to low-frequency than to high-frequency words (Gardiner & Java, 1990).

Table 2
Rotated Component Matrix (Rotation Converged in Five Iterations)

Dimension	Component: Factor 1: R Distinctiveness	Factor 2: K Responses	Factor 3: R Familiarity	Factor 4: Attractiveness
RFam	−.08	.01	.90	.06
RDis	.95	.04	−.06	−.08
RAtt	.04	−.08	.26	.91
RMem	.93	.06	.02	.05
RTyp	−.88	−.04	.19	.06
RRes	−.03	−.02	.91	.17
KFam	−.28	.74	.23	.07
KDis	.28	.81	−.21	.06
KAtt	−.22	.46	−.03	.77
KMem	.22	.81	−.26	.14
KTyp	−.68	.41	−.02	.09
KRes	−.24	.75	.20	.05

Note—Rating dimensions were associated with either remember (R) or know (K) responses; for abbreviations, see Figure 1 caption. The extraction method was principal components analysis, and the rotation method was varimax with Kaiser normalization.

Table 3
Correlation Matrix Showing Pearson's *r* and Significance

	RFam	RDis	RAtt	RMem	RTyp	RRes	KFam	KDis	KAtt	KMem	KTyp	KRes
RFam	1	−.164*	.251**	−.093	.234**	.756**	.133	−.119	.064	−.156	.073	.118
RDis		1	−.057	.880**	−.807**	−.105	−.203*	.257*	−.230**	.193*	−.536**	−.193*
RAtt			1	.087	.083	.367**	.068	−.053	.543**	−.004	.026	.038
RMem				1	−.785**	−.018	−.169*	.244**	−.143	.189*	−.424**	−.131
RTyp					1	.226**	.274**	−.226**	.207*	−.177*	.460**	.197*
RRes						1	.140	−.159	.081	−.181*	.049	.116
KFam							1	.348**	.380**	.335**	.373**	.696**
KDis								1	.316**	.877**	.162*	.334**
KAtt									1	.393**	.332**	.469**
KMem										1	.206*	.376**
KTyp											1	.341**
KRes												1

Note—For remember (R) and know (K) dimension abbreviations, see Figure 1 caption. *Correlation is significant at the .05 level (two-tailed). **Correlation is significant at the .02 level (two-tailed).

The second factor observed for R responses (R familiarity) showed positive loadings of familiarity and resemblance to a familiar person. This factor indicates that the preexperimental familiarity of a face (as distinct from the familiarity arising from its study presentation) influences the likelihood of recollection. One possible explanation for this finding is that participants were able to recollect the feelings of familiarity or resemblance they experienced when they saw the face at study and categorized it as an R response on that basis. This is consistent with previous findings that the recollection of thoughts and memories activated at encoding supports R responses (Dewhurst & Hitch, 1999; Java, Gregg, & Gardiner, 1997). This finding, however, contrasts with the finding of Vokey and Read (1992) that typicality loaded equally with familiarity and memorability. Here, we found that typicality and distinctiveness load with memorability for R responses, and not with familiarity (which loads on a separate factor with resemblance and with a moderate loading from attractiveness). These results are consistent with those of Morris and Wickham (2001), who reported that familiarity loads with attractiveness rather than distinctiveness.

The second most powerful factor overall (K responses) showed moderate to high positive loadings of all six rating dimensions on K responses. This is consistent with the view that K responses reflect a generic feeling of familiarity in the absence of specific details, whereas R responses are supported by the recollection of the distinctive attributes of a stimulus. These findings indicate that K responses are less sensitive than R responses to stimulus characteristics. Rajaram (1996) suggested that K responses are influenced more by factors that determine the fluency with which a test item is processed. It is possible that faces given moderate ratings at study are processed fluently because they do not possess any distinctive features that might cue recollection of the learning context. It is perhaps somewhat counterintuitive that both typicality and distinctiveness showed positive loadings, since they are often considered to be opposite ends of a continuum. However, it is possible that a moderate rating on any dimension is sufficient to boost the familiarity of a face on its subsequent presentation, despite its not being sufficient to elicit an R response.

The fourth factor (attractiveness) showed a general effect of attractiveness on R and K responses. The finding that attractiveness did not load significantly with either distinctiveness or typicality conflicts with previous research suggesting that attractive faces are usually typical or average (Langlois & Roggman, 1990; Light et al., 1981). However, Wickham and Morris (2003) found that attractive faces can be either typical or distinctive when distinctiveness ratings are used rather than measures of averageness and that such faces produce a complex nonlinear relationship. The results of the present study are broadly consistent with these findings.

The present findings show that the structural features of a face influence not only the likelihood that it will be recognized but also the subjective experience of recognition. Faces rated as distinctive and memorable are likely to be categorized as R responses. In contrast, the dominant attribute for K responses appears to be the typicality of a face, since typicality was associated with higher ratings than the other attributes and was the only attribute on which ratings for K responses exceeded those for R responses. Johnston, Milne, Williams, and Hosie (1997) suggested that faces vary along a distinctiveness–typicality continuum and that distinctive faces are more accurately recognized than typical faces. The present findings show that a distinctiveness–typicality continuum also determines the subjective experience of face recognition. Faces rated as distinctive are likely to be recollected, whereas faces rated as typical are more likely to be recognized on the basis of familiarity.

The effects of distinctiveness in face recognition have been explained in terms of the distinctiveness of encoding (Light et al., 1979; Valentine & Bruce, 1986). The farther away a face is from a prototype, the fewer the faces that will be similarly encoded. Distinctive faces are distinctively encoded because of their distance from a prototype. Typical faces, on the other hand, are closer to a prototype and are therefore encoded less distinctively. Valentine (1991) introduced the idea of a *face-space*, a multidimensional space in which faces can be located on the basis of their characteristics. According to this model, the distinctiveness–typicality continuum can be seen as a function of density. Typical faces are located in areas of high density closer to the center of the face-space, and distinctive faces are located in the less densely populated periphery. The face-space metaphor makes no predictions about the subjective experience of face recognition. However, the present findings indicate that faces located in areas of low density are more likely to be recollected than faces located in areas of high density, which in turn are more likely to be recognized on the basis of familiarity.

In summary, the present findings show that the subjective experience of face recognition is influenced by the structural features of a face. Faces categorized as R responses are associated with different factor structures than are faces categorized as K responses, suggesting that R and K responses reflect qualitatively distinct aspects of recognition memory. The observed factor structures indicate that R responses are influenced primarily by the distinctiveness of faces, and K responses are influenced by moderate ratings on all dimensions. Previous research into subjective experience in recognition memory has relied on analyses of the effects of manipulated variables on the numbers of R and K responses. The present study shows that the use of PCA can complement results obtained with traditional experimental methods, particularly in terms of identifying how the specific features of a studied item determine the manner in which it is subsequently recognized.

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