Face Recognition And Emotional Valence: Processing Without Awareness By Neurologically-Intact Participants Does Not Simulate Covert Recognition In Prosopagnosia.

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Abstract

Covert face recognition in neurologically-intact participants was investigated using very brief stimulus presentation to prevent awareness of the stimulus. In Experiment 1 skin conductance response (SCR) was recorded to photographs of celebrity and unfamiliar faces displayed for 220ms and for 17ms in a within-participants design. SCR to faces presented for 220ms was larger and more likely to occur to familiar faces than to unfamiliar faces. Face familiarity did not affect the SCR to faces presented for 17ms. SCR was larger to faces of good than to faces of evil celebrities presented for 17ms but valence did not affect SCR to faces displayed for 220ms. In Experiment 2 associative priming was found in a face familiarity decision task when the prime face was displayed for 220ms but no facilitation occurred from primes presented for 17ms. Experiment 3 found that participants were able to differentiate evil and good faces presented without awareness in a two-alternative forced-choice decision. The results provide no evidence of familiarity detection outside awareness in normal participants and suggest that, contrary to previous research, very brief presentation to neurologically-intact participants is not a useful model for the types of covert recognition found in prosopagnosia. However, a response based on affective valence appears to be available from brief presentation.

Introduction

Prosopagnosia is a neuropsychological condition in which patients cannot consciously identify familiar people from their faces but remain able to identify them from their names or voices. The conditions is due to neither memory loss nor visual impairment but to the dissociation of the percept of a face from stored memory representations (Young 1998). Prosopagnosic patients show impaired performance in direct tests of face recognition. For example, they cannot name familiar faces or make a forced choice between a familiar and an unfamiliar face. However there is a substantial body of evidence that some patients can demonstrate face recognition in indirect tests. Prosopagnosic patients can show a higher skin conductance response to familiar faces than to unfamiliar faces (e.g. Tranel & Damasio 1985; Tranel, Damasio & Damasio 1995), and a higher skin conductance response to correct face-name pairs of celebrities than to incorrect pairings (e.g. Bauer 1984; Bauer 1986; Bauer & Verfaellie 1988). Behavioural measures have demonstrated that some identity-specific semantic information about celebrities can be activated in some prosopagnosic patients. For example, the face of a celebrity, that is not overtly recognised, can facilitate recognition of a subsequently presented name of the same person (De Haan, Bauer & Greve 1992) or a closely associated individual (Young, Hellawell & De Haan 1988).

Two main explanations have been offered for the phenomenon of covert face recognition in prosopagnosia. Burton, Young, Bruce, Johnston and Ellis (1991) proposed that covert recognition in prosopagnosia can be simulated by a reduction in the connection strength between units that represent familiar faces and units that represent the identity of known individuals in an interactive activation and competition network. By this account the behavioural effects of covert recognition are the result of the sub-threshold activation of semantic information relating to a specific individual. The activation is insufficient to enable an overt familiarity decision to be made, but is sufficient to facilitate subsequent recognition of the names of related celebrities, which is unimpaired. The Burton et al. model does not address the finding of SCR discrimination between familiar and unfamiliar faces.

Breen, Caine and Coltheart (2000) proposed that face recognition is mediated by two functionally and anatomically separate neural routes. The “semantic” route is equivalent to the Burton et al (1991) model and mediates overt recognition, and the “affective” route mediates emotional arousal and hence the SCR to familiar faces. Damage to the “semantic” route results in prosopagnosia while the behavioural effects of covert recognition are mediated by residual functioning of this route. Alternative dual-route models have been proposed by Tranel et al. (1995) and by Bauer (1984;1986). Dual-route models are consistent with the view that affect and cognition are mediated by separate and partially independent systems, in which affective responses can occur in the absence of conscious recognition of a stimulus (Zajonc, 1980). They are also consistent with Ellis and Young’s (1990) suggestion that prosopagnosia and Capgras syndrome form a double dissociation, with overt recognition impaired in prosopagnosia and affective response impaired in Capgras syndrome. See Ellis, Young, Quayle and De Pauw (1997) for empirical support for this view.

Meeres and Graves (1990) employed the method of using brief exposure durations with neurologically-intact participants in order to simulate effects of pre-conscious perception in neuropsychological patients. They found effects analogous to the phenomenon of “blindsight”, where participants could define the location of stimuli presented too briefly for conscious perception. Similarly, Ellis, Young and Koenken (1993) claim to have demonstrated SCR discrimination of familiar and unfamiliar faces without overt recognition in neurologically-intact participants. However their method of determining the exposure duration relied on each participant’s ability to name, or provide unique autobiographical information about, celebrity faces as an index of overt recognition. This method may have been too insensitive. The authors acknowledge that some participants did achieve recognition of some faces. They quote an example exposure duration of 50ms, whereas pilot work in our laboratory showed that participants were able to identify some faces from a masked presentation of 33ms and recognition was good with a masked presentation of 50ms. Similarly, Mogg and Bradley (1999) found some overt recognition of facial expressions for a masked 33ms exposure duration. Ellis et al (1993) did not question participants after the experiment to determine whether any faces had been recognised. The thresholds were not measured again after the skin conductance recording task to investigate whether participants might have increased ability to detect masked faces as a result of practice.

Morrison, Bruce and Burton (1999) claimed to demonstrate that a prime face presented too briefly for conscious recognition facilitates a familiarity decision to the face of a closely associated individual. However, they report using mean exposure durations intended to prevent overt recognition of 65 - 72ms in three experiments and their methods suffer the same criticisms applied above to Ellis et al (1993). It appears that in both Ellis et al (1993) and Morrison et al (1999) the participants are likely to have been aware of at least some of the primes presented at the quoted durations. So discriminative responding based on facial familiarity or semantic associations has yet to be clearly established in non-impaired participants.

There is, however, evidence that facial expressions of emotion presented without conscious awareness can result in differential SCR (see Ohman, Esteves & Soares 1995 for a review) or orienting of attention (Mogg & Bradley 1999). So it appears that differential responding can be obtained based on positive or negative affective valence of a stimulus of which the participant is unaware.

Breen et al (2000) ascribed the larger SCR for familiar than unfamiliar faces in prosopagnosics to greater affective arousal. So the SCR to familiar faces may be stronger to faces of greater affective significance regardless of valence. Some support for this hypothesis comes from previous related studies. Maltzman and Boyd (1984) showed that visual images rated as either strongly pleasant or unpleasant resulted in larger SCRs than neutral images. Ohman and Soares (1994) found that spider- or snake-fearful participants gave larger SCRs to feared stimuli than to neutral flowers or mushrooms.

The experiments reported here had the following aims. First, to establish whether neurologically-intact participants show a difference in SCR between familiar and unfamiliar faces when the stimuli are presented at a duration that unambiguously prevents awareness. Second, to establish whether SCR to famous faces is related to their affective significance, or to their affective valence, for both aware and unaware processing. The third aim was to establish whether a prime face of which a participant is unaware can facilitate subsequent overt recognition of a related face. The effects on SCR were tested by Experiment 1 and associative priming was investigated in Experiment 2.

The duration of 17 ms was selected to ensure that it was unambiguous that participants were unaware of the prime faces, and yet the prime faces would still be perceptible. Mogg and Bradley (1999) found evidence of the unconscious recognition of facial expressions at a duration of 14 ms suggesting that faces are perceptible at a duration of 17 ms.

Pilot data suggested that virtually no faces could be consciously identified at an exposure duration of 17ms, while some conscious recognition was possible at 33ms and substantial recognition at 50ms. The faces used in the pilot study were the same 18 famous faces and 12 unfamiliar faces used in the experiment and were displayed with the same forward and backward mask. Presentation of each face was initiated by the participant pressing a key and unlimited time was allowed following presentation for the participant to attempt to identify the face. Participants were strongly encouraged to guess the identity of each face. At 17ms, of the 8 participants tested, only one participant correctly identified only one face. At 33ms another 8 participants were tested with a total of 14 correct identifications, giving a mean number of correct identifications of 1.75 (10%) per participant. At 50ms, of the 2 participants tested, one identified 13 faces and one identified 6 faces, giving a mean of 9.5 (53%) faces per participant.

Experiment 1

Method

Participants: Forty-two students and staff of the Goldsmith’s College Psychology Department took part. The participants included 9 men and 33 women with ages ranging from 18 to 48 (mean age = 22.1 years, s.d. = 6.2). All participants were required to have been resident in the UK for a minimum of 18 years in order to ensure the prospect of recognition of the famous faces. None of the participants had taken part in the pre-experimental rating task.

Stimuli**:** Photographs of familiar and unfamiliar faces of a uniform quality were digitised to produce images of 16 greys, 256 x 256 pixels in size. The faces were rated for distinctiveness, familiarity, age of acquisition and affective valence by 16 participants (3 male and 13 female, mean age 29.5 years, s.d. 13.7). The ratings were collected in two phases: first the famous faces were rated for familiarity, age of acquisition and affective valence, and then all faces were rated for distinctiveness. Ratings of famous faces were recorded only where the participant gave an accurate identification, either by name or by unique autobiographical information. Faces were presented in a different random sequence to each participant. Participants were instructed that there were no right answers, that their personal opinion was the important factor, and that they should proceed at their own speed. Familiarity was rated on a 7-point scale (1 = unknown, 7 = extremely familiar) to reflect the number of times the face had been previously encountered in any form including TV, film, newspaper, magazine etc. Approximate age of acquisition was assessed on a 7-point scale (never seen before, under 3 years old, under 6, under 9, under 12, under 18, over 18) to reflect the age at which the face was first seen. It is recognised that age of acquisition can only be estimated by the participant. Nevertheless recent studies have shown that speed and accuracy of face processing is affected by age of acquisition (Moore & Valentine 1998; Moore, Valentine & Turner 1999). Therefore it was necessary that this attribute was matched across stimulus sets. Affective valence was assessed on a 7-point scale (-3 = evil/threatening, 0 = neutral, +3 = good/inviting) considering the participant's knowledge of the celebrity. Distinctiveness was rated on a 7-point scale (1 = very typical, 7 = very distinctive). Participants were asked to imagine they had never seen the person before, had been given this photograph and asked to meet the person at a busy station, and rate how easy it would be to spot them in the crowd. Ratings scales and questions for familiarity, age-of-acquisition and distinctiveness were derived from Moore and Valentine (1998).

Six <u>evil</u>, six <u>neutral</u> and six <u>good</u> famous faces (listed in Appendix A) and two sets of six unfamiliar faces were selected such that the sets were matched on sex, race, approximate age in the photograph, facial expression (categorised simply as neutral, smiling or frowning) and distinctiveness (means: evil = 4.93, neutral = 4.74, good = 4.88, unfamiliar = 4.76 and 4.74). The three sets of famous faces were matched on rated familiarity (means: evil = 6.01, neutral = 6.15, good = 6.11), age of acquisition (means: evil = 5.79, neutral = 5.84, good = 5.54) and contrasted in affective valence (means: evil = -1.79, neutral = 0.95, good = 2.07)**.** There were no significant differences among the three sets of familiar faces on familiarity or age of acquisition, or among the five sets of familiar and unfamiliar faces on distinctiveness, all Fs <1. There was significant difference amongst the valence ratings of the famous faces, $F(2,15) = 63.7$, $p < 0.001$. Independent samples t-tests revealed that <u>evil</u> and <u>neutral</u> faces differed significantly, t(5.5; degrees of freedom adjusted for unequal variances) = 6.88, $p < 0.001$, and that <u>neutral</u> and <u>good</u> faces differed significantly, $t(10) = 6.03$, $p < 0.001$.

<u>Materials:</u> A personal computer running MEL2 software was used to display the faces at a 640 x 480 screen resolution. Skin conductance levels were measured by use of standard commercially available circular Ag/AgCl electrodes, of 1 cm diameter coated with a bio-adhesive gel, supplied by SLE Diagnostics. The electrodes were affixed to the thenar and hypothenar eminences of the participant's least preferred hand, as recommended by Martin and Venables (1980). Custom-built equipment using a constant voltage system sampled skin conductance level at a frequency of 100 Hz and the data were transferred to a separate personal computer.

<u>Design:</u> The experiment used a within-participants design, with two independent factors: exposure duration (17ms vs. 220ms) and face type (evil, neutral, good and unfamiliar). Two dependent variables derived from the skin conductance response were calculated: the proportion of stimuli for which a response occurred and the maximum amplitude of the response.

Procedure: Immediately on arrival, each participant was asked to wash their hands in soap and water in order to standardise conditions as far as possible, as recommended by Martin and Venables (1980). Participants were tested individually in a darkened, air-conditioned room.

Half the participants viewed faces first at 17ms and then at 220ms: for the remainder of the participants the order of exposure duration was reversed. A different set of unfamiliar faces was used for each exposure duration to ensure continued unfamiliarity. The two sets of unfamiliar faces were counterbalanced across order of presentation and across the two exposure durations. No indication was given about whether the same or different faces would be displayed in the two lists.

In the 17ms condition participants were informed that a series of familiar and unfamiliar faces would be displayed on the screen for 17ms each. They were told that each face would be preceded and immediately followed by a mask created from an assortment of facial features and that there would be a 12 second interval between faces. Participants were asked to concentrate on the screen and attempt to perceive the faces but were informed that the exposure duration was set deliberately to make this very difficult. Participants were seated comfortably at a distance of approximately two feet from the screen and the electrodes were fixed on their hand. Participants were asked to remain perfectly still for the duration of exposure to the stimuli (six minutes) with their hand resting in a relaxed position. No active response from the participant was required.

Two buffer faces, one familiar and one unfamiliar, were presented first, followed by the 18 familiar and six unfamiliar faces mixed in a different random sequence for each participant. Faces were displayed centrally on the monitor filling an area of 2.5 inches square. Skin conductance level was recorded throughout the presentation of faces.

After the skin conductance recording was complete the electrodes were removed and participants were asked whether they had been able to recognise any of the faces. They were informed that it was extremely unlikely that any confident identifications could be made, that any recognition of any of the faces would be at the level of a vague intuition, and were strongly encouraged to guess. Participants were asked whether they had experienced any names, or any other thoughts, popping into their mind. Finally, each participant was asked to produce the first three famous names that came to mind. In response to the last question five participants revealed names of faces used in the experiment which they had not previously articulated. By contrast, 35 undergraduates who had not participated in the experiment and who were asked to produce the first three famous names that came to mind produced just two instances of faces used in the experiment.

In the 220 ms condition the procedure was the same with the following exceptions : faces were displayed for 220ms; participants were informed that the exposure duration was sufficient to permit recognition of familiar faces; and no questions were asked to ascertain whether any faces had been recognised.

All participants were asked to identify the familiar faces and provide ratings on familiarity, age of acquisition and valence, and then to provide distinctiveness ratings for all faces used in the experiment, following the rating scales and procedures used in the pre-experimental selection of stimuli.

Results and Discussion

Data from five participants were omitted from the analysis. Four participants failed to show any valid responses to either 220ms or 17ms presentations or both, and one participant had previous experience with some of the unfamiliar faces used in the experiment. Data from the remaining 37 participants were analysed.

The mean familiarity, age of acquisition, valence and distinctiveness ratings provided by the experimental participants for each face were calculated. There were no significant differences among the three sets of familiar faces on familiarity or age of acquisition or among the five sets of familiar and unfamiliar faces on distinctiveness, all Fs < 1. There was significant difference amongst the valence ratings of the famous faces, $F(2,15) = 51.5$, $p < 0.001$. Independent samples t-tests revealed that evil and neutral faces differed significantly, t(6.24; degrees of freedom adjusted for unequal variances) = 5.81, $p < 0.001$, and that neutral and good faces differed significantly, $t(10) = 5.74$, $p < 0.001$. Faces were counted as familiar where the participant was able to provide an adequate identification, either the name or unique biographical information.

The skin conductance data were analysed by an algorithm to derive the dependent variables. The criterion for a valid response was that there should be a clear increase in the skin conductance level following presentation of a face which should peak within a defined window. A valid response was scored when the maximum skin conductance level recorded within a window of 1 to 10 seconds after face onset was higher than the minimum skin conductance level recorded between face onset and the occurrence of the maximum. The maximum and minimum were required to be separated by at least 0.5 seconds and not more than 9.5 seconds. Thus a valid response could not be scored where the minimum occurred at 0 seconds and the maximum at 10 seconds after face onset. In this case, the skin conductance level was steadily rising throughout the window suggesting that some event other than the face stimulus was responsible for the skin conductance reaction. A response was deemed invalid if the baseline skin conductance level immediately preceding the response was lower than 3 microsiemens. At this baseline skin conductance responses to displayed faces cannot reliably be distinguished from random variation, and so the criterion of a clear increase in the skin conductance level following presentation of a face, peaking within a defined window, is not met. A response to a familiar face was deemed invalid if the face was not subsequently identified in a familiarity check for the stimuli. A response to a 17ms presentation was also deemed invalid if the face was subsequently identified from this presentation, since in these cases the brief presentation had not prevented awareness of the stimulus.

Range-adjusted response amplitude (Rara) was calculated as response amplitude divided by largest response for the participant. Probability of response (Prob) was defined as the number of faces producing a valid response divided by the number of faces which could, potentially, have produced a valid response (i.e. familiar faces were not recognised from 17 ms presentation and were subsequently correctly identified). Prob was zero where a participant had no responses for a particular face type and exposure duration. However no meaningful Rara could be recorded in such cases, so Rara was calculated only for the 20 participants with a minimum of two valid responses for both familiar and unfamiliar faces at 17ms and 220ms exposure duration. Means and standard deviations are shown in Table 1.

	Probability of Response			Range-Adjusted Response Amplitude		
	Mean	s.d.	n	Mean	s.d.	n
220 ms						
Evil	0.60	0.34	37	0.45	0.21	23
Positive	0.56	0.31	37	0.36	0.14	23
Familiar	0.57	0.30	37	0.39	0.11	20
Unfamiliar	0.47	0.35	37	0.29	0.15	20
17 ms						
Evil	0.45	0.36	37	0.23	0.15	14
Positive	0.48	0.33	37	0.32	0.14	14
Familiar	0.47	0.32	37	0.24	0.12	20
Unfamiliar	0.47	0.33	37	0.29	0.20	20

Table 1: Mean Probability of Response and Range-Adjusted Response Amplitude (Microsiemens) for SCR to Evil, Positive (neutral and good), Familiar and Unfamiliar Faces at 17ms and 220ms Exposure Duration

For the items analysis, each variable was calculated across the same participants who contributed to the participants analysis.

The comparison of familiar and unfamiliar faces gave no evidence of covert face recognition. Variables Rara and Prob were analysed separately in two-factor Anovas with exposure duration as a within-participants and within-items factor and face type as a within-participants and between-items factor. The main effect of exposure duration was significant for Rara [$F_p(1,19) = 4.90$, $p<0.05$; $F_i(1,22) = 8.02$, $p<0.01$] and for Prob in the items analysis [$F_p(1,36) = 2.42$, ns; $F_i(1,22) = 4.90$, $p<0.05$] indicating that responses tended to be larger and more probable at 220ms than at17ms. The main effect of familiarity was also significant for Rara in the items analysis [$F_p(1,19) = 0.98$, ns; $F_i(1,22) = 4.66$, $p<0.05$] and for Prob in the participants analysis [$F_p(1,36) = 5.25$, $p<0.05$; $F_i(1,22) = 2.97$, ns] reflecting the trend for responses to be larger and more probable to familiar than to unfamiliar faces. The interaction term was significant for Rara in both the participants and items analyses [$F_p(1,19) = 11.18$, $p<0.005$; $F_i(1,22) = 5.71$, $p<0.05$]. For Prob the interaction was significant by items and close to significance by participants [$F_p(1,36) = 3.47$, $p=0.07$; $F_i(1,22) = 4.90$, $p<0.05$]. Responses to familiar faces were more likely and were larger than responses to unfamiliar faces at 220ms [Rara: $t_p(19) = 3.22$, $p<0.005$; $t_i(22) = 3.26$, $p<0.005$ and Prob: $t_p(36) = 2.62$, $p<0.01$; $t_i(22) = 2.37$, $p<0.05$] but not at 17ms [Rara: $t_p(19) = 1.35$, ns; $t_i(22) = 0.02$, ns and Prob: $t_p(36) = 0.02$, ns; $t_i(22) = 0.17$, ns]. Responses were more likely and larger at 220ms than at 17ms for familiar faces [Rara $t_p(19) = 4.37$, $p<0.005$; $t_i(22) = 5.13$, $p<0.005$ and Prob $t_p(36) = 2.50$, $p<0.01$; $t_i(22) = 4.31$, $p<0.005$]

but there was no difference between 220ms and 17ms for unfamiliar faces [All t <1]. Figure 1 illustrates the interaction between the effects of exposure duration and face familiarity on the probability of response.

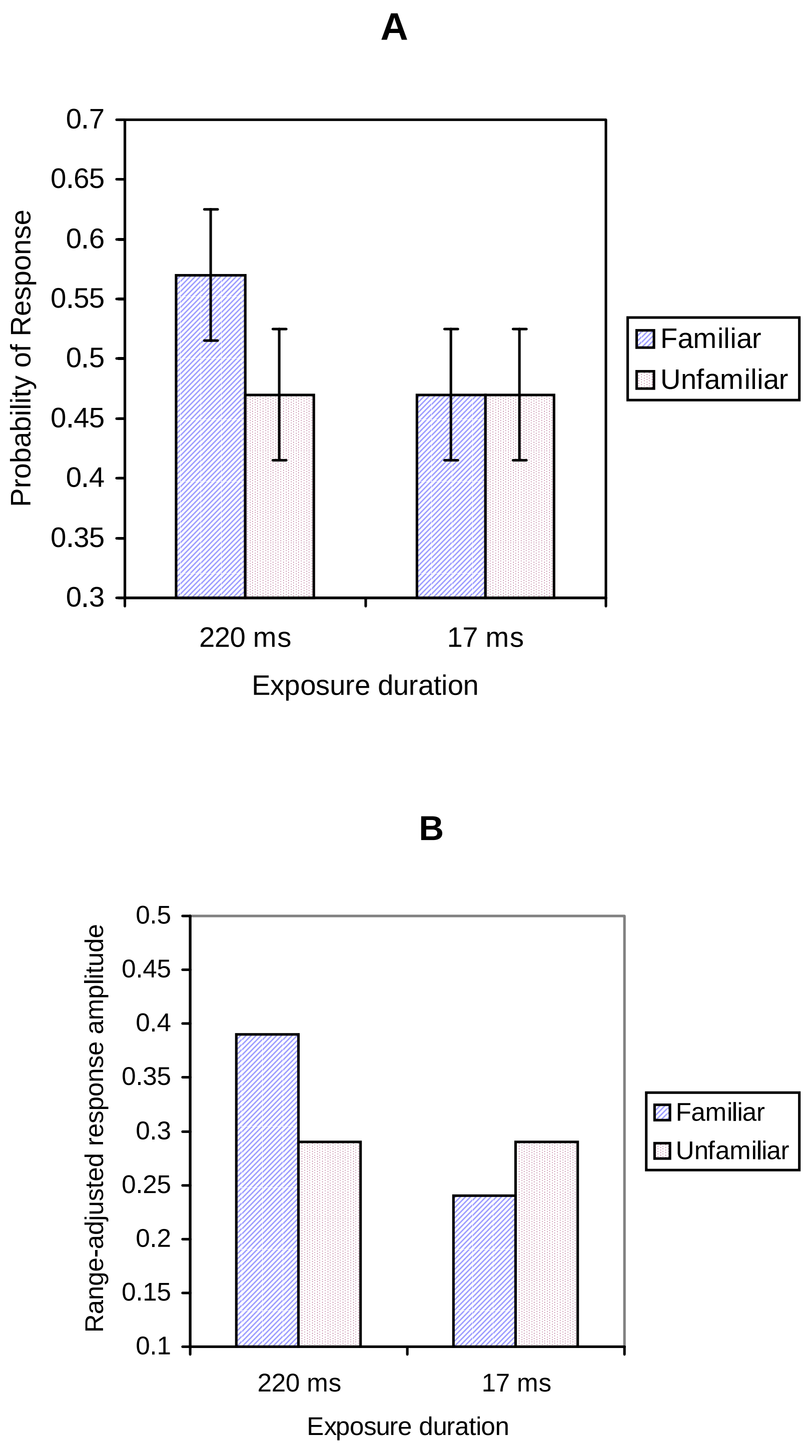

Figure 1. Interaction between exposure duration and face familiarity using participants data for the variables probability of response in panel A and range-adjusted response amplitude in panel B. The error bars represent within-participant 95% confidence intervals, calculated according to equation (4) in Loftus and Masson (1994) p485.

Specific contrasts had been planned among the evil, neutral and good faces. For the participants analysis, evil, neutral and good faces were defined according to each participant's own ratings. A face was defined as evil for a particular participant if the rating was less than zero, as neutral if the rating was zero or one, and as good if the rating was two or three. Data for the Rara variable were examined from those participants who yielded at least two valid responses for each face type. This method resulted in small numbers of participants (13 at 220 ms and 6 at 17 ms) with sufficient valid responses for the Rara analysis. Consequently the face types neutral and good were collapsed into one category of positive faces. This yielded a sample size of n=23 at 200 ms and n=14 at 17 ms. For the items analysis, faces were categorised as evil, neutral or good according to their intended category, and the neutral and good faces were collapsed into one category of positive faces for consistency with the participants analysis. The Prob variable was treated similarly to the Rara variable for consistency.

The specific planned contrasts of evil and positive faces were investigated using the polynomial difference method for the participants analysis and the linear contrasts method for the items analysis. The only significant result was the comparison of positive and evil faces on Rara in the 17ms condition, $F_p(1,13) = 5.27$, $p < 0.04$, $t_i(21) = 2.43$, $p < 0.03$, with positive faces (mean = 0.32, s.d. = 0.14) yielding larger SCRs than evil faces (mean = 0.23, s.d. = 0.15). At 220ms exposure the comparison of positive and evil faces on Rara showed the opposite trend but the contrast was not significant (positive: mean = 0.36, s.d. = 0.14; evil: mean = 0.45, s.d. = 0.21).

In summary, SCR does not distinguish familiar from unfamiliar faces in the absence of awareness. However there is a suggestion that there may be a differential SCR to positive and evil faces of which the participant is unaware, with positive faces yielding higher SCR than evil faces. One possible explanation for this effect being observed at 17ms but not at 220ms exposure is offered by Mogg and Bradley (1999). They note that visible or near-visible stimuli may result in increased conscious efforts to process the stimuli (in this experiment perhaps participants were attempting to retrieve the celebrity's name) and this may interfere with the response of the autonomic system that results from unconscious processing. The SCRs may have been affected by this effortful cognitive processing rather than by an automatic response to the stimulus valence.

Experiment 2

Using a much stricter criterion for awareness than used in previous research, we have failed to find any evidence of a differential SCR to familiar and unfamiliar faces. In Experiment 2 a behavioural dependent variable, associative priming, rather than a physiological measure was used to explore further the possibility of familiar face processing below the threshold of awareness. Associative priming describes the effect where a familiarity decision to the face of a celebrity is speeded by the prior presentation of the face of a close associate (e.g. Hilary and Bill Clinton) compared to the prior presentation of a non-associated celebrity face. Bruce and Valentine (1986) demonstrated associative priming with a prime face exposure duration of

250ms and stimulus onset asynchrony of 250ms. In this experiment associative priming was compared between prime faces presented for 17ms and for 220ms.

Method

Participants: A total of 80 participants were recruited from among staff and students at Goldsmiths College. Data from six participants were omitted from the analysis: five participants generated more than 50% incorrect responses to familiar faces and one participant selected the response key incorrectly. Data were analysed from 37 participants in the 17 ms priming condition (mean age = 32.9, s.d. = 14.0) and 37 participants in the 220 ms priming condition (mean age = 31.3, s.d. = 9.1).

Stimuli: Twenty pairs of closely associated celebrities whose faces were expected to be familiar to the general population were selected (listed in Appendix B). Photographs were scanned to produce images in the same format as described for Experiment 1. A further twenty unfamiliar faces not used in Experiment 1 were also selected.

Apparatus: A personal computer running MEL2 software with a screen resolution of 640 x 480 was used to display the faces. Reaction time and response selection was logged by the computer.

Design: A mixed design was employed with prime face exposure duration (220ms vs 17ms) as a between-participants factor and prime-type (related vs unrelated) as a within-participants factor. There were two prime-types: related, with ten familiar targets preceded by related primes (e.g. Jerry Hall and Mick Jagger); and unrelated, with ten familiar targets preceded by unrelated primes (e.g. Hilary Clinton and Prince Charles). The familiar target faces were counterbalanced across prime-types so that each familiar target face was preceded by a related prime face for half the participants, and by an unrelated prime face for the remainder. Primes in the unrelated condition served as primes in the related condition for a different target face, and for different participants such that each participant saw each prime only once followed by a familiar target face. There were also twenty unfamiliar targets preceded by a famous prime face. The same twenty familiar primes served as primes for familiar and unfamiliar faces, so each prime occurred twice, once before a familiar face and once before an unfamiliar face. Only responses to familiar targets were relevant to the experimental hypothesis.

Procedure: Participants were asked to make speeded familiarity decisions to a series of familiar and unfamiliar target faces displayed on a computer screen one after the other. Half the targets were familiar and half were unfamiliar. A mask comprising jumbled face parts was presented in the centre of the screen for 500 ms, the prime face was then displayed for either 17 ms or 220 ms, the pattern mask was presented again for 500 ms, and finally the target face was presented until the participant entered a valid response on the keyboard. The stimulus onset asynchrony (SOA) was 517ms or 720ms.

Participants were instructed that they would see a series of familiar and unfamiliar faces on the screen and were to respond by pressing keys labelled Y or N to indicate whether or not the face was recognised. They were asked to respond as quickly and accurately as possible. They were informed that before each target face was displayed another face would be displayed for 17ms or 220ms, preceded and followed by a mask composed of a random assortment of facial features. In the 17ms condition participants were informed it was unlikely they would recognise any of these faces but they should attend carefully to the screen. Two practice trials using one familiar and one unfamiliar target face preceded the experimental trials.

Results and Discussion

The reaction time data were examined and responses with a z-score of more than 2.5, or responses less than 200 ms, were omitted as outliers. No participant reported recognising any of the prime faces in the 17ms priming condition. One target face, which generated an incorrect response from more than half of the participants, was omitted from the analysis. The data are shown in Table 2.

220ms				17ms			
Related		Unrelated		Related		Unrelated	
Mean	S.d.	Mean	S.d.	Mean	S.d.	Mean	S.d.
879	227	944	245	907	223	900	193

Table 2: Mean Reaction Time (Milliseconds) for Related and Unrelated Prime Type and for 17ms And 220ms Prime Exposure Duration

The data were analysed by two-factor Anova with one within-participants and items factors of prime-type (related vs. unrelated) and one between-participants but within-items factor of prime exposure duration (17ms vs. 220ms).

The main effects of prime-type [$F_p(1,72) = 2.79$, ns; $F_i(1,18) = 1.98$, ns] and prime exposure duration [both Fs < 1] were not significant, but the interaction was significant for participants and items [$F_p(1,72) = 4.11$, $p<0.05$; $F_i(1,18) = 5.34$, $p<0.05$]. Reaction times to recognise target faces were faster following a related prime than following an unrelated prime at 220ms prime exposure[$t_p(36) = 3.29$, $p<0.005$; $t_i(18) = 2.14$, $p<0.05$] but there was no facilitation from related primes presented for 17ms [t_p & $t_i < 1$].

The two experimental conditions differed in both prime exposure duration (17ms vs. 220ms) and prime – target SOA (517ms vs. 720ms). It could be argued that 17ms is sufficient duration for associative priming to occur but that the SOA is too short for the facilitation to be detected. However, Bruce and Valentine (1986) observed associative priming of a face familiarity decision from prime faces presented for 250ms with SOA set at 250, 500 and 750ms. Therefore, the SOA for both conditions of Experiment 2 lie within the range for which associative priming is known to occur. This does depend on there not being an interaction of exposure duration and SOA; such an interaction is considered unlikely.

This result suggests that a 17ms prime exposure, in the absence of awareness, generates insufficient activation of identity-specific semantic information to support associative priming.

Experiment 3

Experiment 1 reported that participants responded differently to faces of good and evil celebrities on a measure of skin conductance response, without conscious awareness of the facial identities. This raises the possibility that participants might be able to discriminate the valence of a celebrity face with better than chance accuracy in a direct test. Using the same stimuli and presentation conditions as Experiment 1, that is 17ms exposure with backward-masking to render the faces consciously undetectable, participants were simply asked to decide whether each face belonged to a good or an evil celebrity. It was reasoned that when faces were unconsciously recognised participants would be able to select the correct response with better than chance accuracy, either by detecting their emotional reaction to the face or from the influence of some entirely unconscious process.

Method

Participants: A total of 29 participants were recruited from among staff and students at Goldsmiths College. Data from six participants were omitted from the analysis: four failed to correctly identify a minimum of 50% of the celebrity faces, and two responded incorrectly by attempting to categorise the backward mask as good or evil. Data were analysed from the remaining 23 participants, with ages ranging from 21 to 37, mean = 26.9, s.d. = 3.9.

Stimuli: The celebrity faces from Experiment 1 were used again.

Apparatus: A personal computer running MEL2 software with a screen resolution of 640 x 480 was used to display the faces. Response selection was logged by the computer.

Design: A within-participants design was employed with a single factor of valence, good versus evil, categorised by the participants' own ratings.

Procedure: Participants were asked to make a two-alternative forced-choice decision on the valence of celebrity faces presented for 17ms and both forward- and backward-masked. The faces were presented one at a time centrally on the screen in a different random sequence for each participant. A mask comprising jumbled face parts was presented in the centre of the screen for 500 ms, the celebrity face was then displayed for 17 ms, the pattern mask was presented again for 500 ms, and finally the text "good or evil?" was presented until the participant entered a valid response on the keyboard. Participants were asked to guess if they were unable to see the face. They were not asked to respond as quickly as possible. The response keys were counterbalanced so that approximately half the participants pressed with their left hand for G and right hand for E, and the other half had the reverse responses. Six buffer faces preceded the 18 celebrity faces. After completing the task participants were asked if they had been able to detect the identity of any face. They were encouraged to guess identities if they were unsure. Any faces correctly identified were omitted from the analysis of results.

Following this task the participants were again presented with the faces one at a time in a random sequence and asked to identify each face, by name or description, and give their personal opinion of the valence of the celebrity. Each face was displayed until the participant initiated the next face. The rating scale was the same as that used in Experiment 1.

Results and Discussion

Responses to faces that were recognised from 17ms presentation, and to faces that were not subsequently correctly identified, were omitted from the analysis, leaving a total of 332 valid responses. Overall 62.7 % of the faces were rated as zero or positive and these were classified as good faces, and the remaining 37.3 % were rated negatively and classified as evil. The overall proportion of "good" responses was 54.2 % and the proportion of "evil" responses was 45.8 %. The probability of a correct response being made at random can be calculated according to the following equation, which yields an expected chance accuracy rate of 51.1 %.

P(good face) *x* P(good response) + P(evil face) *x* P(evil response)

The proportion of correct responses was calculated for each participant and separately for each item and the data were compared against the chance level in a one-sample t-test. For participants the overall mean proportion of correct responses was 0.579, s.d. 0.13, and for items the overall mean proportion was 0.584, s.d. 0.14. Correct responses were selected significantly more often than chance would predict: $t_p(22) = 2.55$, $p < 0.02$ (one-tailed) and $t_i(17) = 2.23$, $p < 0.02$ (one-tailed). An alternative method of analysis is the Chi-square test to compare the expected and actual frequencies of responses in a 2 x 2 table formed by the combinations of face-valence (evil vs good) and selected-response (evil vs good) over all participants and items. This also yielded a significant result, Pearson coefficient (1 d.f.) = 5.43, $p < 0.02$ (two-sided).

The conclusion can be drawn that participants were able to discriminate the affective valence of a celebrity face with better than chance accuracy in the absence of conscious awareness.

General Discussion

Skin conductance responses were larger and more probable to familiar than to unfamiliar faces at 220ms exposure, replicating the effect found by Tranel and Damasio (1985) and Ellis et al. (1993). However there was no evidence of differential skin conductance response to familiar versus unfamiliar faces at 17ms exposure. The associative priming task yielded evidence of a priming effect with a prime exposure duration of 220ms but not at 17ms prime duration. Thus there was no evidence of associative priming without awareness of the prime.

Given that this experiment found some recognition at 17ms, and a pilot study found substantial recognition at 50ms, it appears likely that the exposure durations used by Ellis et al. (1993) and Morrison et al. (1999) were sufficient to allow awareness. A post-experiment check on awareness is a necessary precaution. It is recognised that the awareness check in this experiment may have lacked sensitivity and that it would have been preferable in principle to have questioned participants after each stimulus presentation (although impossible in practice without interfering with SCR recording). However, the observation that SCR discriminated familiar from unfamiliar faces at 220ms and failed to do so at 17ms suggests no or very little undetected awareness.

Our results suggest that the participants did not discriminate familiar from unfamiliar faces or show evidence of associative priming when the faces were presented too briefly for awareness.

The Burton et al. (1991) model proposes that prosopagnosia results from a partial disconnection of face processing system from the person recognition system. The dual-route models (Breen et al. 2000; Bauer 1984; Tranel et al. 1995) suggest that prosopagnosia is due to damage to a neural pathway responsible for conscious recognition. In the current experiment, conscious recognition in neurologically-intact individuals was prevented by brief presentation. However, we found no evidence of covert recognition of face familiarity or associative priming. Thus, the data suggest that very brief presentation does not provide an adequate model of the types of covert recognition reported in prosopagnosia, although it remains possible that there may be an exposure duration above 17ms that will permit familiarity detection without conscious awareness.

Experiment 1 presented evidence that SCR to 17ms presentations were significantly larger to positive faces than to evil faces. Although this result should be treated with caution in view of the small sample size (n=14), Experiment 3 (n = 23) reported behavioural evidence of discrimination of good from evil faces in the absence of conscious awareness. In order to produce differential responses to evil and positive faces in the absence of differential responses to familiar and unfamiliar faces, it would need to be the case that the valence of a stimulus is activated and becomes able to influence participants' responses when the stimulus familiarity is not. From an evolutionary perspective, it seems plausible that the adaptive function of face recognition arises from establishing the "friend or foe" status of an individual, therefore affective valence may have played an important role in the evolution of our face recognition skills.

The finding of differential SCR to the faces of evil and positive celebrities without awareness is also consistent with the research of Ohman, Dimberg, Esteves and colleagues (reviewed in Ohman et al 1995 and Dimberg, Thunberg and Elmehed 2000). These authors have consistently reported differential SCR to positive and negative facial emotional expressions presented without awareness.

It is interesting to note that good faces yielded larger SCRs than evil faces. We had predicted the opposite effect, in line with the effects reported by Ohman et al (1995). This result is in need of replication and extension and so warrants further research.

The current experiment raises the possibility of a confound in previous work. Experiments demonstrating higher SCRs to familiar than unfamiliar faces in prosopagnosia (e.g. Tranel & Damasio 1985; Tranel et al 1995) have used as their familiar stimuli celebrities who are likely to have been regarded, on average, positively rather than negatively. Hence the familiarity of the famous faces was confounded with their positive affective valence. If the result of the current experiment showing higher SCR to positive faces proves replicable it will become an empirical question which of these factors was responsible for the differential responding. Replication with faces of celebrities regarded by the participant as evil would clarify this question.

In conclusion, we found no evidence of covert face familiarity recognition or associative priming in neurologically-intact participants under strict conditions designed to prevent awareness. Claims of discrimination of familiar from unfamiliar faces and associative priming of famous faces in circumstances in which a neurologically-intact participant is unaware of the presented faces need to be established under more carefully controlled conditions. A check on the awareness of stimuli is required before claims of covert recognition can be substantiated.

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Appendix A. Stimuli used in Experiment 1.

Evil celebrities

Myra Hindley (murderess)
Adolf Hitler
Saddam Hussein
Richard Nixon
OJ Simpson
Mike Tyson

Good celebrities

Clive Anderson (TV presenter)
David Bellamy (TV botanist)
Roy Castle (children’s TV)
Lenny Henry (comedian)
Nelson Mandela
Claire Rayner (agony aunt)

Neutral celebrities

Craig Charles (TV actor)
Paul Daniels (TV magician)
Chris Evans (TV, radio)
Mikhail Gorbachev
Danny-John Jules (TV actor)
JF Kennedy

+ 12 unfamiliar faces

Appendix B. Stimuli used in Experiment 2.

Prime	**Target**	
Cherie Blair	Tony Blair	UK Prime Minister and wife
Hilary Clinton	Bill Clinton	USA President and wife
Princess Diana	Prince Charles	UK Royal family
Sarah Ferguson	Prince Andrew	UK Royal family
Sophie Rhys-Jones	Prince Edward	UK Royal family
Nicole Kidman	Tom Cruise	Media celebrity couple
Jerry Hall	Mick Jagger	Media celebrity couple
Liz Hurley	Hugh Grant	Media celebrity couple
Oliver Hardy	Stan Laurel	Comedy Duo
Hale	Pace	Comedy Duo
Jennifer Saunders	Dawn French	Comedy Duo
Ronnie Barker	Ronnie Corbett	Comedy Duo
Eric Morcomb	Ernie Wise	Comedy Duo
Judy Finnegan	Richard Madeley	“Richard and Judy” TV presenters
Dominic Brunt	Lisa Riley	Soap Opera couple: Emmerdale Farm
William Tarmey	Elizabeth Dawn	Soap Opera couple: Coronation Street
Sid Owen	Patsy Palmer	Soap Opera couple: EastEnders
Gillian Anderson	David Duchovny	Fictional couple: The X Files
Neil Morrissey	Martin Clunes	Sitcom friends: Men Behaving Badly
Sharon	Tracy	Sitcom sisters: Birds of a Feather