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Covert face recognition without prosopagnosia

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An experiment is reported where subjects were presented with familiar or unfamiliar faces for supraliminal durations or for durations individually assessed as being below the threshold for recognition. Their electrodermal responses to each stimulus were measured and the results showed higher peak amplitude skin conductance responses for familiar than for unfamiliar faces, regardless of whether they had been displayed supraliminally or subliminally. A parallel is drawn between elevated skin conductance responses to subliminal stimuli and findings of covert recognition of familiar faces in prosopagnosic patients, some of whom show increased electrodermal activity (EDA) to previously familiar faces. The supraliminal presentation data also served to replicate similar work by Tranel *et al* (1985). The results are considered alongside other data indicating the relation between non-conscious, "automatic" aspects of normal visual information processing and abilities which can be found to be preserved without awareness after brain injury.

Keywords: Autonomic discrimination – Face processing – Identification without awareness – skin conductance

INTRODUCTION

In recent years there has been much research into the way faces are recognized (see Bruce, 1988; Young and Ellis, 1989), some of which has centred upon the study of prosopagnosic patients who, by definition, are profoundly unable to recognize previously familiar faces. Instead these patients rely on voice, gait or clothing to identify people (Bodamer, 1947; Ellis and Florence, 1991). The reports of prosopagnosic patients include a variety of associated symptoms that imply that there are different types displaying different symptoms. Hécaen (1981) suggested that there were two basic sorts of prosopagnosia: apperceptive (involving distorted or degraded visual input), and mnestic (where there is little or no perceptual problem but a failure to associate the face to stored representations). Damasio *et al.* (1990) also identify a third subtype which they call "amnestic" associative prosopagnosia which involves an inability to identify face or voice. They also locate the anatomy of the three types of prosopagnosia. The specificity of the face recognition impairment is apparent from the analysis by Sergent and Signoret (1992a) of a patient, RM, who has obvious perceptual difficulties when viewing faces yet shows an outstanding ability to make fine distinctions among pictures of similar cars.

Bauer (1984) made a remarkable discovery when he found that his prosopagnosic patient LF, with bilateral inferomedial temporal damage following a motorcycle accident, was significantly able to make autonomic discriminations to familiar correct face/name combinations compared with incorrect face/name pairings even though he could not consciously correct them. Tranel and Damasio (1985) confirmed Bauer's findings by demonstrating that prosopagnosic patients displayed larger skin conductance responses (SCRs) to familiar compared with unfamiliar faces presented in a random sequence. De Haan *et al.* (1987) and Young *et al.* (1988) then extended these observations by using behavioural techniques to reveal covert responses to familiar faces in PH, another motorcycle accident victim with posterior cerebral lesions. For example, PH displayed greater ability to learn correct face/name combinations than incorrect ones. Like normal controls, he was faster at deciding whether two photographs were of the same or different people when they were famous; and he showed an associative priming effect such that, for him, preceding a famous name by the face of a professional partner conferred the same latency advantage for declaring the name "familiar" as that caused by preceding the name by the partner's name. Sergent and Signoret (1992b) have discovered that such implicit access to information about previously known but now unrecognized faces only occurs in prosopagnosic patients without severe perceptual deficits.

The fact that some prosopagnosic patients have displayed covert responses to faces has a number of theoretical ramifications. The one we wish to explore here is the

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possibility that neurologically-intact subjects may also reveal increases in electrodermal activity to familiar faces presented at a level below that which normally produces overt awareness of recognition. This is an important experimental study, not least because the results may help clarify any role of unconscious processing in face recognition; and, in doing so, make us more confident when drawing lessons from studies of prosopagnosic patients for developing a general theory of face recognition.

A similar reasoning led Tranel *et al.* (1985) to examine electrodermal activity in neurologically-intact subjects shown, supraliminally, a series of 50 faces, each for 2 s. Eight of the faces were famous (e.g. Ronald Reagan, Bob Hope) and 42 were unknown. Tranel *et al.* found that the famous faces produced larger SCRs than did the unfamiliar ones. The famous faces were rated by other subjects as being more significant than the other faces, which suggested that this significance factor provides signal value to the stimulus face which is reflected in the orienting response as measured by increased autonomic activity.

There is, of course, an obvious difference between the paradigm used by Tranel *et al.* and those used when studying covert recognition by prosopagnosic patients: the latter are not consciously aware that they have been presented with the face of a familiar person. The question then remains as to whether similar autonomic discriminations may be elicited from normal subjects who are shown faces under conditions designed to prevent conscious recognition.

The issue of subliminal perception has a long history and yet still no universally accepted solution. Numerous efforts were made immediately post-war to demonstrate its existence but all too often studies were methodologically flawed. Eventually, in an influential paper, Eriksen (1960) concluded that "At present there is no convincing evidence that the human organism can discriminate or differentially respond to external stimuli that are at an intensity level too low to elicit a discriminated verbal report" (p. 298). This conclusion from 30 years ago may be seen to be at variance with the subsequent work on covert recognition in prosopagnosics (and, indeed, that on implicit memory in amnesics, e.g. Schachter *et al.*, 1988).

A more recent theoretical analysis of subliminal perception by Marcel (1983b), however, may be viewed as much more sympathetic. Marcel (1983a) had revealed the operation of subliminally presented words upon subsequent word recognition (i.e. priming). On the basis of these and other findings, he was prepared to reject what he termed the "identity assumption", viz. that conscious and nonconscious representations of the same thing are identical. Marcel's position is not universally shared, owing largely to problems in defining thresholds and, therefore, ensuring that subjects do not have at least some opportunity consciously to perceive stimuli intended by the experimenter to be subliminal (see Holender, 1986; Merikle and Cheesman, 1987).

Nonetheless, the present authors, while mindful of the various methodological pitfalls, were concerned to link work on covert recognition in prosopagnosic patients with face processing by normal subjects. The most direct way to begin to do this, it was felt, would be to investigate autonomic orienting responses to familiar faces presented at a level designed to be subliminal. At the same time it was also considered that the findings of Tranel *et al.* (1985), using supraliminal presentation of familiar and unfamiliar faces, needed to be replicated. So in the following experiment subjects were presented with faces of famous and unknown people at both subliminal and supraliminal levels. For each type of face, SCRs were measured across the palm of the hand.

It is important to note that, when we refer here to faces as being supraliminal or subliminal, this is with respect to the *recognition threshold.* Our interest is in autonomic responses to faces presented for durations too brief to allow them to be recognized. We do not, though, seek to claim that these faces were presented for durations sufficiently brief to prevent their being detected. On some trials subjects may well have known that a face was presented; the important point is that they did not consciously know *whose* face it was. Nor, did it seem, were they able to gain any sense of familiarity from the faces shown on these trials.

This use of the terms supraliminal and subliminal with respect to the recognition threshold is, we believe, appropriate in the present context for two reasons. First, the literature on "unconscious" priming *does* show consistent effects when the threshold is defined in this way (e.g. McCauley *et al.*, 1980). Second, it represents the correct analogue or comparison to prosopagnosia. Prosopagnosic patients know when they are looking at a face, what they no longer know is whose face it is. We sought to create a comparable state in normal people using both brief presentation and pattern masking. This does not mean, of course, that we believe that prosopagnosics experience faces phenomenologically as do normals looking at briefly presented faces that are masked. But instead we wished to explore the possible analogy between the two processes as manifested by changes in the level of autonomic activity.

A similar rationale was provided by Meeres and Graves (1990), who used a paradigm adapted from work with blindsight patients. They found that subjects with normal vision could judge better than chance the location of a circle stimulus followed by a pattern mask even when they reported not having seen it. Meeres and Graves argue that their data may reveal in normals a dissociation between pattern localization and conscious awareness that has the same physiological basis as that involved in blindsight. In the following experiment this is explored using faces as stimuli and skin conductance levels as responses.

METHODS

Selection of stimulus slides

From a pool of more than 1000 slides with familiar and unknown faces, all taken from the same source and therefore of uniform quality, 100 slides (50 probably familiar and 50 probably unknown faces) were selected. The familiarity of these faces was then judged by a group of 13 German students on a 6 point scale (0 = completely unknown; 6 = completely familiar). Based on the results of these ratings, the 30 slides with the highest familiarity ratings and the 20 slides with the lowest familiarity ratings were finally selected as stimulus material and partitioned into five series of 10 slides each (three sets of 10 familiar faces, and two sets of 10 unfamiliar faces). These sets were balanced for gender and for the range of professions of the familiar people (i.e. actor, singer, politician). The mean familiarity ratings for the three series of familiar faces were 5.42, 5.49, and 5.52, respectively. For the two sets of unknown faces the ratings were 0.97 and 0.96.

One of the slide series with familiar faces was later used to determine the individual recognition threshold of each subject. The remaining sets of 10 familiar and 10 unknown faces were mixed, which resulted in two series with 20 slides. The sequence of slides within each series was determined at random. Thus there were three series of slides:

(1) Series A with 10 slides of familiar faces to determine the individual recognition threshold of each subject.
(2) Series B with 20 slides (10 familiar and 10 unknown) for suprathreshold presentation, randomized for each subject.
(3) Series C with 20 slides (10 familiar and 10 unknown) for subthreshold presentation, randomized for each subject.

Four additional slides were used as buffer items which preceded each series of stimulus slides.

Subjects

Twenty-six psychology students aged between 19 and 24 years, from Christian-Albrechts Universität, Kiel, acted as subjects. They were paid for their participation. The first two subjects served as test and training subjects and were discarded from further data analysis. Thus, the final sample consisted of 24 subjects, each of whom was tested individually.

Experimental situation

The subject was seated on a reclining chair in a darkened and sound-proofed laboratory. A screen was placed at a distance of 2 m. The slides were projected from an adjacent room through a window which meant that any noise produced by the slide projectors could not be heard in the subject's room. Except for the initial information, all instructions were communicated to the subject through an intercom system.

Instructions

All subjects first received general information regarding the experimental procedure (i.e. determination of recognition threshold, supraliminal and subliminal presentation of slides with familiar and unknown faces). They were told that the goal of the study was the analysis of impressions which were produced by the photographs, and that they would be shown 50 slides with familiar and unknown faces. Some of the slides, they were told, would be presented very briefly, while some others would be shown for a longer duration. Their task, it was explained, would be to judge whether the photograph (not the face of the person) appeared pleasant or unpleasant. This judgement should be made exclusively on the basis of the photograph and not be influenced by the person. The pleasantness judgement should be indicated by lifting the middle finger. This would trigger a light sensitive receiver and be recorded by the computer.

During this explanation, two electrodes for the registration of the SCR were connected to the palm of the hand.

Presentation of stimuli

The projection of the slides was controlled by a computer (Data General Eclipse). One projector presented the stimulus slide for a predetermined time. After an interval of 2 ms a second projector displayed a mask slide containing random facial features onto the same place on the screen for 1 s.

Procedure

The experiment involved three phases. During the first phase the individual recognition threshold was determined. In the second phase, for half of the subjects the slides were presented subliminally; for the remaining half they were shown supraliminally. In the third phase, those subjects who had been shown the subliminal slides were now presented another set of slides supraliminally; and those who had received the supraliminal faces first were now shown the subliminal set. These phases were separated by pauses of 1 min.

Determination of recognition threshold

For each subject the recognition threshold was determined individually by the method of ascending limits. Ten slides with highly familiar faces were used for this task. Each slide was presented at an initial exposure duration of 40 ms, followed almost immediately (after 2 ms) by the mask slide. After a pause of 6.5 s either the same or the next slide was presented, depending on the subject's response. The projection duration was increased in steps of 10 ms until the subject indicated by lifting the index finger that s/he had recognized the person. The name of the person was communicated by the subject via the intercom system. After this response, the computer switched to the next slide. The maximum number of presentations of the

same slide was 10. Thus, the final possible projection duration was 130 ms. If the person had not been recognized after the tenth presentation of the slide, the next slide was presented, again starting with a duration of 40 ms.

The individual recognition threshold was defined as the *shortest* exposure duration at which the subject was able to give the name (or some equivalent such as providing unambiguous biographical information) of *any* person correctly.

Our reason for using only ascending series to determine each person's recognition threshold was that we were concerned to ensure that we were measuring the threshold for recognition when subjects did not know which faces to expect (as would be the case in the main series of trials). However, the use of an ascending series can overestimate thresholds if subjects are not always willing to "guess" at the face's identity, and hold back for a few trials to gain confidence. For this reason, we both encouraged our subjects to guess and used the very conservative procedure of defining the threshold as the shortest duration at which any of the faces was identified correctly. In addition the effectiveness of this procedure was determined in a separate test with seven subjects who were presented faces subliminally (using the same method of calculating individual recognition thresholds). A reward was promised for each correct recognition response. Each subject saw 10 faces of familiar people. Thus, a total of 70 test responses were recorded (seven subjects with 10 slides each). Of those 70 responses, only four were correct recognitions. These correct responses were given to four different slides. We are therefore content to assert that the overwhelming majority of faces presented subliminally in the main experiment could not be identified.

Subliminal presentation

Subliminal presentation was defined as a projection duration which was 10 ms shorter than the shortest threshold for recognizing one of the faces, i.e. if a subject gave correct recognition response to slides at projection durations of 70 ms, 60 ms and 90 ms, the individual recognition threshold was defined as 60 ms and the subliminal projection duration would then be 50 ms.

For the experiment itself, two buffer slides were initially presented, one with a familiar and one with an unknown face. Following these buffer slides the first series of slides was presented (10 familiar faces, and 10 unfamiliar faces, in random order). Almost immediately (2 ms) after the projection of each slide, a mask slide was projected onto the same spot on the screen for 1 s. This was followed by a constant ISI of 10 s during which skin conductance was recorded.

Supraliminal presentation

For half the subjects there was a presentation of all 20 slides of series 1, and a pause of 1 min was then inserted. Following this pause, two buffer slides and the 20 slides for the supraliminal projection were presented (10 familiar faces, and 10 unfamiliar faces, in random order). Each slide was presented for 220 ms, again followed by the mask and a pause of 10 s while electrodermal activity (EDA) was recorded.

Recording and processing of electrodermal activity

The SCR was registered by two Ag/AgCl0.7 cm electrodes coated with Beckman electrolyte and placed hypothenar/thenar. They were amplified by a special constant voltage amplifier before the data were transferred to the computer. They were analog-digital converted with a frequency of 50 Hz and then stored on magnetic tape for later analysis. Before this analysis, the data were digitally filtered to eliminate any noise produced by the pulse.

In the analysis, the following SCR parameters were determined: maximum amplitude of skin conductance, beginning of response, peak latency, and maximum slope of the curve. These parameters were determined by a computer program according to specially devised algorithms. The curve and the parameters were then displayed on a computer screen and visually controlled. In some cases, corrections were applied (e.g. if two peaks occurred and the first was too quick to be a response to the slide; the parameters were semi-automatically corrected, i.e. the second peak was defined as the response and the computer automatically determined the related parameters). Of the 960 responses measured, fewer than 20% occurred after 5 s. All but two peak responses were recorded within 7 s.

RESULTS

The study was designed as a 2 (subliminal vs supraliminal projection) $\times$ 2 (familiar vs unknown faces) factorial experiment, with repeated measures on both factors. The data were analysed according to a randomized block model (see Kirk, 1968).

ANOVAs were computed with peak amplitude, peak latency, response onset latency, and slope of the curve as dependent variables. The analyses showed a significant effect only for the peak amplitude. For this variable the main effect for familiarity of the face was significant [F1,858) = 8.20; $p < 0.001$].[1] Amplitudes (in μS) for familiar and unknown faces were 3.62 (S.D. = 3.64) and 3.11 (S.D. = 3.28), respectively. There was no interaction between familiarity and stimulus condition. For the four experimental conditions the mean peak amplitudes are displayed in Table I.

[1] The residual d.f.s were 858 but even if the treatment within-subjects error term is substituted the result is still significant ($F(1,23) = 8.20$; $p < 0.05$).

TABLE I. Peak amplitude EDA (in μS) for familiar and unfamiliar faces presented above (supraliminal) and below (subliminal) the recognition threshold

	Familiar faces	Unfamiliar faces
Subliminal	3.6	3.1
Supraliminal	3.7	3.1

These results show that only the familiarity of the face, but not the duration for which it was shown, had an influence on the SCR. Thus, subjects showed different physiological responses (higher peak amplitudes of EDA) to familiar than to unknown faces, regardless as to whether or not they consciously recognized the faces.

DISCUSSION

The finding that supraliminal face stimuli elicit differential EDA for familiar and unfamiliar faces may be taken as confirmation of the data reported by Tranel *et al.* (1988). In our study the experimental paradigm including ratio of famous to unknown faces, stimulus duration and interstimulus interval were all quite different from that employed by Tranel *et al.* The fact that our results agree with theirs provides compelling support for the notion that familiar and unfamiliar faces are indeed processed differently (Ellis *et al.*, 1979).

More importantly, the results of this investigation provide support for the idea that, despite not being overtly recognized, familiar faces may elicit a greater SCR than do unfamiliar faces. This finding is entirely consistent with Marcel's (1983b) position regarding the invalidity of the "identity assumption". Moreover, it provides yet another useful theoretical bridge between the findings on face recognition from normal and neurologically damaged populations.

Information-processing models of face recognition such as Bruce and Young's (1986) have as yet had little to say on the issue of awareness. But evidence of covert recognition in prosopagnosic and other brain-injured patients has already signalled the need to consider awareness at each stage of processing (Young and De Haan, 1990, 1991), which has provoked attempts to deal with these issues more systematically both in neuroanatomical (Bauer, 1984; Tranel *et al.*, 1985) and computational theories (Burton *et al.*, 1991).

Our results are congruent with Bauer's (1984) view that orienting responses to emotionally significant stimuli and conscious, overt recognition of the same stimuli are mediated by neurologically dissociable mechanisms. Bauer reached this conclusion from consideration of the neuroanatomical pathways likely to be involved, and from the evidence that his prosopagnosic patient showed an increased skin conductance response to faces he did not recognize overtly. The results presented here show a parallel phenomenon in normal subjects, in that elevated skin conductance response can be measured even when overt recognition does not occur.

In fact, there are now a number of lines of evidence pointing toward parallels between the consequences of brain injury and "automatic" effects which can be elicited under subliminal conditions in normal subjects. For example, Young *et al.* (1988) drew attention to the parallel between the associative priming effects they demonstrated for the prosopagnosic patient PH and associative priming from stimuli presented below the threshold of recognition to normal subjects. Similarly, Greve and Bauer (1990) reported a particularly interesting study in which they demonstrated that patient LF (the same prosopagnosic patient as in Bauer's original GSR study) showed a "preference" for faces he had seen before but did not overtly recognize as having seen earlier. Again, this type of preference can be found for normal subjects with subliminally presented stimuli (Zajonc, 1980).

These parallels between non-conscious aspects of normal and brain-injured performance are not confined to the visual recognition system. For example, the findings of Meeres and Graves (1990), mentioned earlier, indicated that accurate localization can occur without a pattern being detected (a normal analogue of "blindsight"). Hence these phenomena are not specific to faces, or even to visual recognition, but instead appear to reflect a more general property of visual information processing which will need to be fully mapped out and accounted for in future work. The present data serve to enrich the evidence favouring the idea championed by Marcel (1983a,b) that information that is not consciously perceived may, nonetheless, be processed to a high degree and the results of this activity may become manifest behaviourally or psychophysiologically.

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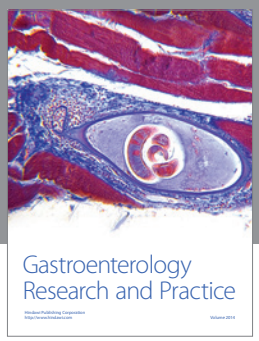

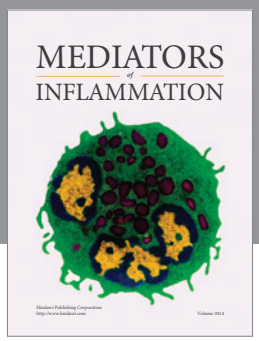

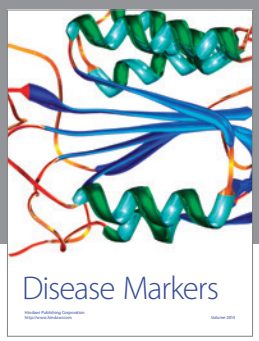

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