



Brief article

Meaningful processing of meaningless stimuli: The influence of perceptual experience on early visual processing of faces

Shlomo Bentin^{a,b,c,*}, Yulia Golland^a^a*Department of Psychology, Hebrew University of Jerusalem, Jerusalem, Israel*^b*Interdisciplinary Center of Neural Computation, Hebrew University of Jerusalem, Jerusalem, Israel*^c*Institute des Sciences Cognitives, CNRS, Bron, France*

Received 27 February 2002; accepted 12 June 2002

Abstract

The N170 is an event-related potential component associated with extrastriate visual mechanisms involved in detecting human faces and leading to their characteristic structural encoding. Consequently the N170 discriminates the processing of stimuli providing physiognomic information from the processing of other, similarly complex, visual patterns. We have used this effect to explore the top-down influence of newly acquired experience on the initial visual categorization of physiognomic stimuli. Schematic faces having the inner components mislocated did not elicit an N170 effect in naive participants. However, after normally configured versions of the schematic faces were exposed, suggesting what the ambiguous patterns represented, the same patterns elicited an N170 effect as conspicuous as that elicited by regular schematic faces. This priming effect, which changed the visual processing of distorted faces in extrastriate regions, could not be explained by post-perceptual decisions. Although accounts based on changes in focal attention, or within-vision constraints could not be categorically rejected, this outcome might suggest cognitive penetrability of early visual categorization. © 2002 Elsevier Science B.V. All rights reserved.

Keywords: Early visual processing of faces; N170; Early visual processing of faces; Cognitive penetrability; Conceptual/perceptual priming

1. Introduction

Despite ample evidence suggesting that the end product of visual perception, that is, the conscious experience of what we see, is extensively modulated by cognitive factors such

* Corresponding author. Institute des Sciences Cognitives, CNRS, 67, boulevard Pinel, 69675 Bron, Cedex, France. Tel.: +33-4-37-91-12-57; fax: +33-4-37-91-12-10.

E-mail address: bentin@isc.cnrs.fr (S. Bentin).

as beliefs, expectations, and knowledge, the question of whether visual perception *per se* can be influenced by non-visual (top-down) information is still open (Pylyshyn, 1999). Indeed, according to a rigid modular view, at least at some levels, visual perception processes might be encapsulated. That is, they are unaffected either by the activity of other perceptual processes acting in parallel, or by information specified at higher (cognitive) levels that may feed back (Fodor, 1983). In the present study we explored the susceptibility of a visual mechanism associated with the detection and the initial processing of physiognomic information, to recently accumulated perceptual experience and non-visual knowledge.

The formation of a face image (henceforth structural encoding) is a very good candidate to act, at least partially, in a modular way: it is domain-specific to a great extent (Carmel & Bentin, 2002), it probably has innate components (e.g. Johnson, Dziurawiec, Ellis, & Morton, 1991; but see Simion, Cassia, Turati, & Valenza, 2001) and perhaps it captures attention automatically (Driver et al., 1999; Langton & Bruce, 1999).

Obviously the claim that visual processes are cognitively impenetrable is not about the subjective experience of perception, that is, it is not about what we decide that we see. Rather it is about one of the sources for information entering the high-level perceptual decision process – the actual visual input following the transformations imposed on this input while a 3-D image is reconstructed from the light energy changes impinging on a 2-D retina. This process, described in computational terms by Marr (1982), leads to the formation of a visual image that contains sufficient details to allow recognition but is not directly associated with its within category identification *per se*. Therefore, it has been sometimes labeled “early” vision. Since “early”, however, is an amorphous term, and many (including the present authors) would limit this label to the functions carried on in the primary visual cortex, we define the level of visual processing investigated here as “initial visual categorization”. More specifically, we suggest that in order to activate a structural encoding process that is characteristic to faces, it is first necessary to determine that the visual input contains physiognomic information. By this conceptualization, the initial categorization of faces is the process by which the existence of physiognomic features in the visual input is determined and a characteristic structural encoding system is triggered. We explored how experimentally imposed beliefs about the physiognomic characteristics of an ill-configured pattern change the manner in which the extrastriate visual system processes that pattern, and if such beliefs may induce a face-characteristic encoding process to non-face stimuli.

In the past 6 years, scalp-recorded event-related potentials (ERPs) in humans extended intracranial electrophysiological findings¹ revealing a negative component that peaks between 150 and 180 ms from stimulus onset (N170) and is significantly larger in response to faces than to other stimulus categories while not discriminating among non-face categories (Bentin, Allison, Puce, Perez, & McCarthy, 1996; George, Evans, Fiori, Davidoff, & Renault, 1996). The distinctive difference between the amplitude of the N170 elicited by faces and other stimulus types is the N170 face-specific effect. This effect is distributed over posterior-temporal regions, is larger at right- than at left-hemisphere sites and is much

¹ For an extensive review of the intracranial studies see Allison, Puce, Spencer, and McCarthy (1999), McCarthy, Puce, Belger, and Allison (1999), and Puce, Allison, and McCarthy (1999).

smaller (if at all existent) at the more medially located sites (O1 and O2) where the content-non-specific N1 is most conspicuous (Carmel & Bentin, 2002). Because the N170 effect is enhanced rather than reduced by face inversion (Rossion et al., 1999, 2000), it is not sensitive to face familiarity (Bentin & Deouell, 2000), and it is elicited by isolated face parts (particularly eyes) as well as by full face-gestalts, Bentin and his collaborators suggested that the N170 effect is probably associated with a perceptual process responsible for the detection of physiognomic information in the visual field (i.e. initial categorization) and leading to the characteristic structural encoding of the face, that is, the formation of its visual representation, prior to its final within-category identification (cf. Bruce & Young, 1986). New evidence revealed that analogs of the N170 effect could also discriminate other visual categories for which humans may become experts through training (e.g. Gauthier, Skudlarski, Gore, & Anderson, 2000; Gauthier, Williams, Tarr, & Tanaka, 1998; Tanaka & Curran, 2001). Hence, the emergence of an N170 effect in response to a visual stimulus might index the initiation of a content-specific visual process that probably facilitates the formation of a detailed visual representation, leading to more efficient within-category identification (cf. Ullman, 1996).

In a recent study Sagiv and Bentin (2001) demonstrated that an N170 effect could be obtained using schematic faces as well as photographed natural faces. In contrast to natural faces, however, isolated components of schematic faces do not carry any physiognomic value and, therefore, do not elicit an N170 effect. Taking advantage of this fact, Bentin, Sagiv, Mecklinger, Friederici, and von Cramon (2002) demonstrated contextually induced priming effects on the elicitation of the N170 effect by schematic face components. That study showed that pairs of small line-shapes presented in isolation could, in fact, elicit a conspicuous N170 effect, following the presentation of a face context. The same stimuli did not elicit any face-specific brain activity either prior to the presentation of the face context or if a non-face context was induced. Hence, if correct “hints” had been provided, these pairs of line-shapes were processed as eyes, that is, triggered the face-characteristic structural encoding process.

Although the priming effect reported by Bentin et al. (2002) strongly suggests top-down influence on initial categorization of faces, it does not determine which visual process is, indeed, susceptible to accumulated experience. This is because attention or local perceptual mechanisms might also account for this priming phenomenon. For example, it is possible that following whole face presentation, schematic eyes, even though presented in isolation, could supply a sufficient degree of matching visual information to elicit an already encoded representation of a schematic full-face. Hence, albeit a visual illusion of seeing the entire face was not elicited, the face-specific structural encoding might have been initiated by a kind of visual completion mechanism (Reynolds, 1985; Snodgrass & Feenan, 1990; cf. Pessoa, Thompson, & Noë, 1998). In the present experiment we further explored the “face priming” phenomenon in an attempt to better understand its underlying mechanism and its possible influence on visual processes associated with the initial categorization.

Notice that the perceptual completion account for the priming effect on isolated schematic eyes is viable because the schematic eyes presented in isolation preserved the exact configuration and physical features of the schematic eyes that appeared in the context of the face. In contrast, a pattern containing all the inner components of the face but in a distorted configuration should reduce the possibility that it would be recognized as a face

using a visual completion strategy. To this end, in the present experiment our target stimuli were schematic faces in which the inner components have been randomly relocated. Because the physiognomic value of schematic faces depends upon the configuration of the inner components (Sagiv & Bentin, 2001), when the configuration is distorted, such patterns are not identified as faces. Consequently, distorted schematic faces should not trigger the face-characteristic process and should not elicit an N170 effect. Therefore, finding an N170 effect in response to distorted schematic faces following the presentation of an appropriate face context implies that perceptual experience influenced the initial categorization of such patterns. For example, such influence might consist of inducing a process of spatial reconfiguration through which the distorted pattern would gain physiognomic value.

2. Method

2.1. Participants

The participants were 30 undergraduate students from the Hebrew University, naive regarding the aim of the experiment. They participated for payment or as a requirement of an introductory course in psychology. They were right-handed and had normal or corrected to normal vision. Random assignment distributed the participants equally between an experimental group and a control group. At the analysis stage, however, one participant from the experimental group had to be excluded due to excessive eye movements and noisy EEG. Hence, the data reported are based on 14 participants in the experimental group and 15 in the control group.

2.2. Stimuli

The stimuli were based on the schematic faces used in Bentin et al. (2002). The distorted face stimuli were constructed by arbitrarily changing the configuration of the inner components while keeping the two “eyes” together (see examples in Fig. 1). There were 75 different pictures of distorted faces and their 75 equivalent normally configured faces. Additional stimuli were 75 schematic drawings of objects (Snodgrass & Vanderwart, 1980).

2.3. Task and design

The participants were presented with four blocks of stimuli and instructed to monitor the screen and press a button each time a flower appeared. The distorted faces were presented initially as non-flower distracters in block 1 and again in block 3. In block 2 the distracters were normally configured schematic faces in the experimental group and schematically drawn objects in the control group. In addition, in a last block, schematic faces were presented to the control group and objects to the experimental group.

2.4. ERP recording and analysis procedures

The EEG was recorded from 48 tin electrodes mounted on a custom-made cap (ECI-

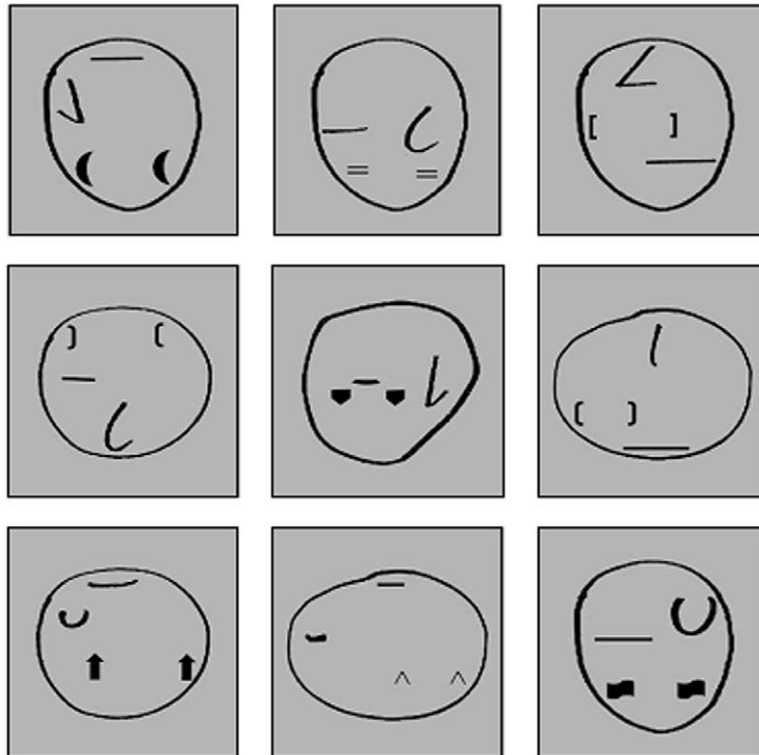


Fig. 1. Examples of the scrambled schematic faces presented in blocks 1 and 3.

Ohio). It was continuously sampled at 250 Hz, amplified at 20 K by a set of battery-operated amplifiers (SA Instrumentation, CO) with an analog band-pass filter of 0.1–70 Hz, and stored on disk for offline analysis. EOG was recorded by two electrodes, one located on the outer canthus of the right eye and the other at the infraorbital region of the same eye. Both the EEG and the EOG were referenced to an electrode placed at the tip of the nose.

ERPs resulted from averaging EEG epochs of 1000 ms starting 100 ms prior to stimulus onset. Average waveforms were computed for each subject in each condition separately, and digitally filtered with a band-pass of 0.5–22 Hz. Trials contaminated by EOG and/or EEG artifacts were excluded from the average by an automatic rejection algorithm with threshold amplitude of ± 100 mV. No ERP was based on less than 50 trials.

The N170 amplitude and latency were dependent variables for statistical analysis. These measures were defined as the amplitude and latency of the most negative peak between 120 and 210 ms from stimulus onset. Based on our previous studies, only six posterior temporal electrode sites were selected for statistical analysis, those at which the N170 was most conspicuous. These sites were the right mastoid (Rt Mast), PO8, and IM2² on the

² The IM1 and IM2 locations are halfway between theinion and the left and right mastoids, respectively.

right hemi-scalp, and the corresponding sites on the left hemi-scalp. For factors that had more than two levels, the Greenhouse–Geisser Epsilon was used to adjust the degrees of freedom.

3. Results

As expected, N170 was not elicited by distorted schematic faces in block 1, when first seen. By contrast, distinctive N170 potentials were elicited by regularly configured schematic faces regardless of whether they were presented in block 2 (to the experimental group) or in block 4 (to the control group). These potentials had a similar posterior temporal distribution as the N170 elicited by natural and schematic faces in previous studies (Fig. 3). The most important result, however, was that, in contrast to block 1, the same distorted faces presented in block 3 elicited a conspicuous N170 effect, if the face context was induced in block 2, but not if block 2 consisted of schematic objects (Fig. 2). Like the distribution of the N170, the distribution of the priming effect was occipito-temporal albeit slightly more central and less asymmetric (Fig. 3).

To validate the predicted difference between the priming effects induced in the experimental and the control groups by the stimuli presented in block 2, we first analyzed the pattern of between-group differences in the amplitude of the N170 by a mixed-model ANOVA with Group (experimental, control) as a between-subjects factor, and Block (block 1, block 2, block 3), Hemisphere (left, right) and Site (PO7/8, Mastoids, IM) as within-subjects factors. This analysis showed that neither the main effect of Group nor the main effect of Block were significant (both $F < 1.00$), but there was a significant interaction between these two factors suggesting that, indeed, the block effect was different in the experimental and in the control groups ($F(2, 54) = 6.5$, $MSe = 19.4$, $P < 0.005$). In addition, across groups and blocks, the N170 elicited at right hemisphere sites was larger ($-1.3 \mu\text{V}$) than that elicited at left hemisphere sites ($-0.6 \mu\text{V}$) ($F(1, 27) = 4.8$, $MSe = 15.13$, $P < 0.05$). The main effect of Site was also significant, revealing that the N170 was larger at the mastoids ($-1.9 \mu\text{V}$) than at the PO and IM sites (-0.5 and $-0.4 \mu\text{V}$, respectively) ($F(2, 54) = 9.0$, $MSe = 17.5$, $P < 0.001$).

The difference between the effect of Block on the experimental and control groups was explored by within-subjects ANOVAs, run separately in each group. We compared the N170 elicited by distorted faces before and after priming with that elicited by schematic faces and that elicited by objects (presented, of course, in different orders in the experimental and control groups). These data are presented in Table 1.

In the experimental group the ANOVA evidenced a significant main effect of Block ($F(3, 39) = 12.6$, $MSe = 16.1$, $P < 0.001$), and a significant main effect of Site ($F(2, 26) = 7.3$, $MSe = 14.9$, $P < 0.005$). The difference between the two hemispheres did not reach significance ($F(1, 13) = 3.12$, $MSe = 18.3$, $P = 0.1$). None of the interactions were significant. Post-hoc univariate analysis of the Block effect revealed that the N170 elicited by distorted faces in block 3 was significantly larger than that elicited by identical stimuli in block 1, before a face context was suggested ($F(1, 13) = 7.4$, $P < 0.025$), but not significantly different from that elicited by regularly configured faces ($F(1, 13) < 1.0$). The ERPs elicited by the objects in the experimental group

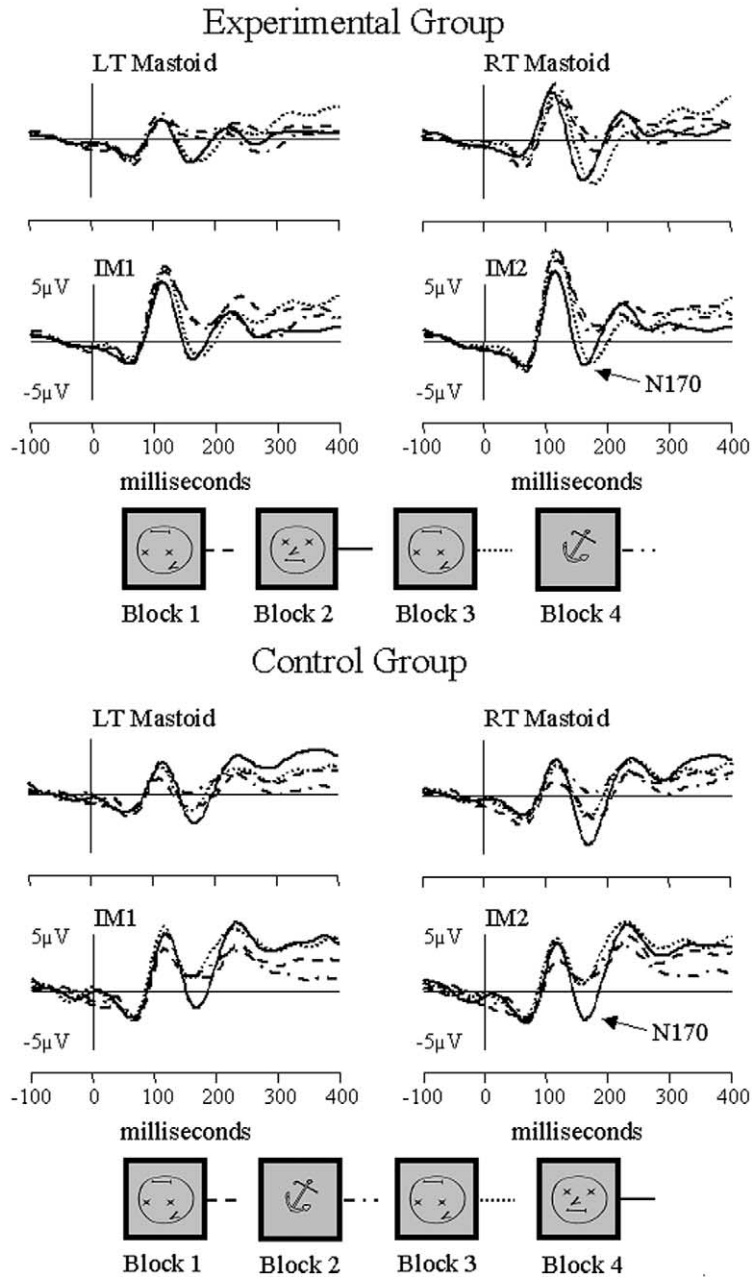


Fig. 2. ERPs elicited during the first 400 ms from stimulus onset in the experimental and control groups. Note the priming effect on the N170 effect, comparing block 1 and block 3 in each group.

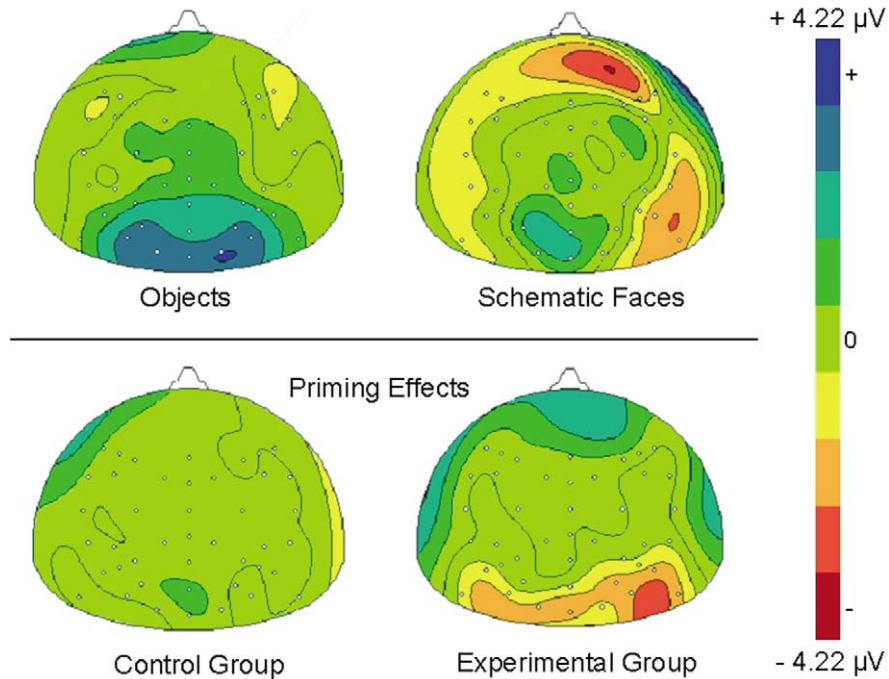


Fig. 3. Scalp distributions of the N170 elicited by the schematic faces and of the ERP elicited by the objects at the most negative peak between 150 and 200 ms. The distribution of the priming effect (block 3 minus block 1) in the experimental and control groups at the latency of the most negative peak between 150–200 ms.

(block 4) during the critical area were positive, and significantly different from those elicited in all other stimulus conditions ($F(1, 13) = 9.6, P < 0.01$). The post-hoc analysis of the Site effect showed that it was caused by the significantly larger amplitudes at the mastoids ($F(1, 13) = 6.4, P < 0.025$), without any reliable additional differences.

In the control group, the ANOVA also showed a significant main effect of Block ($F(3, 42) = 3.4, MSe = 26.0, P < 0.05$), a significant main effect of Site ($F(2, 28) = 4.5, MSe = 28.4, P < 0.05$), and a significant interaction between these two factors ($F(6, 84) = 3.5, MSe = 2.6, P < 0.005$), suggesting that the block effect was different in this group at different sites. No other effects were significant or approached significance. The source of the interaction between the effects of Block and Site was explored by ANOVAs that tested the Block effect separately at each site. These analyses showed that the Block effect was significant at the Mastoids ($F(3, 42) = 7.2, MSe = 7.6, P < 0.001$), approached significance at the IM sites ($F(3, 42) = 2.7, MSe = 11.7, P = 0.058$), but not at the more central sites PO ($F(3, 42) = 1.6, MSe = 11.7, P = 0.20$). Post-hoc tests for the amplitude at the mastoids showed that the ERPs elicited by distorted faces in block 3 tended to be *less* negative than in block 1 ($F(1, 14) = 4.4, P = 0.054$), that the ERPs elicited by objects in block 2 were positive and different than the ERPs elicited by distorted faces ($F(1, 14) = 4.7, P < 0.05$) and that the N170 elicited by faces was the most negative ($F(1, 14) = 5.9, P < 0.05$).

Table 1
Amplitudes in μV
(SEM) at the N170 latency elicited in each block in the experimental and control groups

	Experimental group: block 2 comprised of schematic faces							Control group: block 2 comprised of drawn objects						
	Lt Mast	PO7	IM1	Rt Mast	PO8	IM2	Total	Lt Mast	PO7	IM1	Rt Mast	PO8	IM2	Total
Block 1 distorted smiley	-1.004 (0.9)	0.104 (1.32)	0.213 (1.18)	-2.6 (0.9)	0.42 (1.54)	0.287 (1.2)	-0.428 (1.0)	-1.56 (0.9)	-0.65 (1.4)	0.817 (1.1)	-3.476 (1.1)	-0.946 (1.7)	-0.013 (1.2)	-0.972 (1.1)
Block 2 faces/objects	-2.487 (0.79)	-0.959 (1.34)	-2.291 (1.3)	-4.375 (1.5)	-2.654 (1.7)	-2.782 (1.3)	-2.591 (1.3)	-0.033 (0.8)	-0.318 (1.4)	0.947 (1.6)	-0.096 (1.0)	-0.494 (1.6)	0.678 (1.1)	0.114 (1.1)
Block 3 distorted smiley	-2.249 (1.0)	-0.808 (1.2)	-1.425 (1.4)	-4.242 (1.1)	-1.547 (1.3)	-1.987 (1.3)	-2.043 (1.2)	-0.876 (0.9)	0.194 (1.5)	1.336 (1.3)	-1.882 (1.1)	0.149 (1.7)	0.924 (1.4)	-0.026 (1.2)
Block 4 objects/faces	0.064 (0.9)	2.285 (1.2)	0.763 (1.1)	-0.171 (1.0)	1.609 (1.4)	0.336 (1.2)	0.814 (1.1)	-2.175 (0.9)	-1.076 (1.3)	-0.778 (1.6)	-4.105 (1.1)	-2.367 (1.5)	-1.583 (1.2)	-2.014 (1.1)

Table 2
Latencies in ms (SEM) of the N170 peaks (or those of the most negative peaks elicited between 120 and 210 ms) in each block in the experimental and control groups

	Experimental group: block 2 comprised of schematic faces							Control group: block 2 comprised of drawn objects						
	Lt Mast	PO7	IM1	Rt Mast	PO8	IM2	Total	Lt Mast	PO7	IM1	Rt Mast	PO8	IM2	Total
Block 1 distorted smiley	166 (6.5)	167 (7.1)	170 (6.3)	174 (6.0)	173 (4.0)	174 (5.8)	171 (5.9)	166 (5.8)	159 (5.8)	165 (5.4)	170 (5.6)	161 (6.5)	164 (5.4)	164 (5.1)
Block 2 faces/objects	163 (5.0)	162 (5.6)	167 (5.2)	164 (4.3)	163 (4.3)	166 (4.5)	164 (4.7)	157 (3.7)	156 (2.9)	158 (3.4)	166 (4.5)	157 (4.2)	152 (2.6)	158 (2.9)
Block 3 distorted smiley	166 (6.6)	168 (5.4)	175 (5.1)	172 (5.0)	169 (4.2)	171 (4.4)	170 (4.8)	166 (4.6)	161 (4.4)	163 (4.3)	171 (4.3)	162 (4.2)	165 (4.7)	165 (4.1)
Block 4 objects/faces	172 (8.0)	175 (6.5)	179 (6.9)	176 (6.1)	176 (5.7)	175 (6.1)	175 (6.3)	171 (3.1)	168 (2.7)	166 (3.2)	167 (3.1)	162 (2.8)	164 (2.7)	166 (2.6)

The analysis of the N170 latency showed a significant effect of Block in the experimental group ($F(3, 39) = 4.5$, $MSe = 377.8$, $P < 0.01$), but not in the control group ($F(3, 42) = 1.8$, $MSe = 623$, $P = 0.18$). Post-hoc contrast showed that the main effect of Block in the experimental group was entirely explained by a slightly shorter latency of the N170 elicited by faces than for other stimulus categories (see Table 2).

4. Discussion

The conspicuous priming effect observed in the present experiment replicated and extended the priming effect found by Bentin et al. (2002) suggesting that top-down conceptual processes influence the initial categorization of faces. Visual patterns that, *prima facie*, do not look like faces and did not trigger a face-characteristic encoding process did elicit an N170 effect after the participants were suggested their physiognomic value. In concert, the results reported in these two studies could have been induced by a change in the initial categorization process and, therefore, might be taken as evidence for cognitive penetrability of an “early visual process”. A visual process is cognitively penetrable if it is altered in a way that bears some logical relation to knowledge and goals that originate outside the visual system (Pylyshyn, 1999). In the following discussion we will examine whether the currently reported priming effects pertain, indeed, to this definition.

4.1. In what sense is the visual process tapped by the N170 early?

Obviously, there is no way to draw a sharp demarcation line between processes associated with the structural encoding of a stimulus and those associated with its initial categorization. However, because face perception entails a characteristic, perhaps domain-specific structural encoding, such a distinction could be, at least conceptually, defended. As elaborated in Section 1, in order to trigger a face-characteristic structural encoding process, the perceptual system must “know” that the visual input contains physiognomic information. Detecting such information is, in essence, the role of the putative “initial categorization process”. While all visual input impinging the retina may enter the processor, its output, that is, the activation of face-characteristic encoding, is determined by the results of its internal computation. To be efficient, however, this process must be completed fast and can conceivably be based on very scarce information, such as the existence of particular primitive features and/or a particular configuration (i.e. it is data-driven; Carey & Diamond, 1977). Hence, although some local vision-specific memory might be involved, the initial visual categorization probably qualifies as “early” by the standards of Pylyshyn (1999), and the N170 effect associated with this mechanism (or its outcome) should be regarded as an index of an early visual process. This assertion is supported by the characteristics of the N170 effect. Its latency is relatively early,³ it is insensitive to either high-level identity information (Bentin & Deouell, 2000) or to semantic-associative priming (Schweinberger, 1996), and it is conspicuously present when natural face components (particularly eyes) are seen in isolation. Hence, the modulation

³ While it peaks at about 170 ms, its onset is, by necessity, a few tens of milliseconds earlier.

of the N170 effect by accumulated perceptual experience suggests that early vision, at least in the face-processing domain, can be modulated by top-down information.

4.2. Could the observed priming effects on the N170 be explained without assuming cognitive penetration?

As mentioned above, cognitive penetrability of a visual mechanism entails, by definition, a change induced by non-visual factors in the manner in which it processes its visual input. In the present case, a context-dependent change in the initial categorization process might account for the allocation of physiognomic value to visual patterns after, but not before the introduction of the context.

In their first study of N170 effects, Bentin et al. (1996) found robust N170 effects in response to spatially distorted natural faces. This is not surprising, however, because the physiognomic value of natural looking face components is preserved despite distortion. In fact, in concert with the conspicuous N170 effect elicited by isolated eyes, this finding supports the model suggesting that the N170 is modulated by the detection of physiognomic information rather than by processing the face configuration. However, as was demonstrated in previous studies, unlike natural faces, the perception of a schematic drawing as a face heavily depends upon its configuration rather than on the primitive visual features of its components. The present absence of a distinction between scrambled schematic faces presented in block 1 and objects supports this claim. Hence, a possible change in the initial categorization process might have been the inclusion of spatial reconfiguration, which was initially absent. Though this assumption was not directly tested and, therefore, it is only hypothetical, it stands to reason. Furthermore, the relevant question here is not what process has been added, but whether the same result (that is a change in the categorization outcome) could have been induced without assuming a change in the initial categorization process. Only a negative answer to this question would imply that the present results are evidence for cognitive penetrability of an early visual process.

Cognitive penetrability is clearly not the only possible account for top-down influences on the outcome of an early visual process. Most conspicuous among alternative accounts are (a) the possibility that previous knowledge affects spatial attention re-allocating its focus in the display, and (b) the suggestion that some of the assumed top-down effects are, in fact, within-vision effects governed by natural constraints of the visual mechanism. Common to both is that they might change the outcome of a visual process by changing the *input* to it without penetrating the process itself.

The argument for the focal attention effect is that “hints” or previous knowledge about the meaning of the stimulus might direct the visual attention to the relevant spatial location from which a specific visual percept could be generated (e.g. Kawabata, 1986; Peterson & Gibson, 1991). Regarding scrambled faces, the argument might be that previous knowledge about the patterns’ meaning might direct attention to the most important physiognomic component that is to the “eyes” (Bentin et al., 1996). Hence, as in the case of scrambled “natural” faces, the initial categorization process would be based on finding the “eyes” without the necessity to reconfigure the pattern. Note, however, that unlike natural eyes, outside an actual or imaginary face context, schematic eyes do not yield physiognomic information. Hence, although priming effects similar to those presently reported

were observed with isolated schematic eyes (Bentin et al., 2002) it is not evident that the N170 effect would have appeared here without reconfiguration of the percept. Yet, as unlikely as it might be, the attention allocation hypothesis cannot be rejected because, in principle, the present data cannot refute the possibility that the scrambled configuration has been completely ignored and completion processes suggested as an account for the priming of isolated schematic eyes were also applied here.

The argument for within-vision alterations is that the allegedly top-down effect reflects, indeed, within-vision changes constrained by internal regularities of the visual processing. That is, while implicitly representing our knowledge of the external world, they do not imply cognitive penetration. According to this argument, the detection of the physiognomic diagnostic features in the scrambled schematic faces resulted from a visually constrained regrouping of the stimuli according to the knowledge of its meaning. Such a constrain might be, for example, “global-to-local” processing (characteristic to the processing of faces) such as suggested to explain the gestalt completion (Street, 1931) or “filling in” effects (e.g. Pessoa et al., 1998) without assuming cognitive penetration. However, whereas such effects could, indeed, explain the priming effects observed with isolated schematic eyes in Bentin et al. (2002), we cannot think of any “natural constraint” embedded in the visual system that might induce the reconfiguration of the scrambled schematic faces. Moreover, assuming that the initial categorization triggers a global process that is characteristic to faces, in the present case such a claim becomes circular: why would global (or any other face-characteristic) perception be applied unless the face quality of the stimulus is detected? Finally, corroborative evidence against reconfiguration of the scrambled face prior to the initial categorization is the absence of a latency difference between the N170 elicited before and after priming. If an early visual reconfiguration process preceded the initial categorization the N170 in block 3 would have probably been delayed. Consequently, whereas the present empirical evidence does not categorically reject a within-vision account for the present priming effect it makes a strong case against it.

In conclusion, the present results suggest that an appropriate (face) context may change the content of what we see while looking at a pattern representing a scrambled schematic face. Furthermore, this change has been observed without requesting the participants to identify the meaning of the scrambled faces; hence, no problem-solving factors had been involved. On the basis of these data we could not confidently suggest the nature of the putative change in the initial categorization process, but the need for spatial reconfiguration is a good candidate. Therefore, while we cannot categorically reject either an attention allocation account for the priming effect or the hypothesis that the reconfiguration process was based on within-vision constraints, at the very least, the present results strongly suggest that relatively early visual processes are consistent with conceptual knowledge and perhaps affected by it.

Acknowledgements

This study was supported by a grant from the US-Israel Science Foundation (98-00057) to Shlomo Bentin. We thank Dr Stefan Schweinberger and an anonymous reviewer for important comments on a previous version of this report.

References

- Allison, T., Puce, A., Spencer, D. D., & McCarthy, G. (1999). Electrophysiological studies of human face perception I. Potentials generated in occipitotemporal cortex by face and non-face stimuli. *Cerebral Cortex*, *9*, 416–430.
- Bentin, S., Allison, T., Puce, A., Perez, A., & McCarthy, G. (1996). Electrophysiological studies of face perception in humans. *Journal of Cognitive Neuroscience*, *8*, 551–565.
- Bentin, S., & Deouell, L. Y. (2000). Structural encoding and identification in face processing: ERP evidence for separate mechanisms. *Cognitive Neuropsychology*, *17*, 35–54.
- Bentin, S., Sagiv, N., Mecklinger, A., Friederici, A., & von Cramon, D. Y. (2002). Conceptual priming in visual face-processing: electrophysiological evidence. *Psychological Science*, *13*, 190–193.
- Bruce, V., & Young, A. (1986). Understanding face recognition. *British Journal of Psychology*, *77*, 305–327.
- Carey, S., & Diamond, R. (1977). From piecemeal to configurational representation of faces. *Science*, *195*, 312–314.
- Carmel, D., & Bentin, S. (2002). Domain specificity versus expertise: factors influencing distinct processing of faces. *Cognition*, *83*, 1–29.
- Driver, J., Davis, G., Kidd, P., Maxwell, E., Ricciardelli, P., & Baron-Cohen, S. (1999). Shared attention and the social brain: gaze perception triggers automatic visuospatial orienting in adults. *Visual Cognition*, *6*, 509–540.
- Fodor, J. A. (1983). *The modularity of mind: an essay on faculty psychology*. Cambridge, MA: MIT Press.
- Gauthier, I., Skudlarski, P., Gore, J. C., & Anderson, A. W. (2000). Expertise for cars and birds recruits brain areas involved in face recognition. *Nature Neuroscience*, *3*, 191–197.
- Gauthier, I., Williams, P., Tarr, M. J., & Tanaka, J. (1998). Training ‘greeble’ experts: framework for studying expert object recognition processes. *Vision Research*, *38*, 2401–2428.
- George, N., Evans, J., Fiori, N., Davidoff, J., & Renault, B. (1996). Brain events related to normal and moderately distorted faces. *Cognitive Brain Research*, *4*, 65–76.
- Johnson, M. H., Dziurawiec, S., Ellis, H., & Morton, J. (1991). Newborn preferential tracking of face-like stimuli and its subsequent decline. *Cognition*, *40*, 1–19.
- Kawabata, N. (1986). Attention and depth perception. *Perception*, *15*, 563–572.
- Langton, S. R. H., & Bruce, V. (1999). Reflexive visual orienting in response to the social attention of others. *Visual Cognition*, *6*, 541–567.
- Marr, D. (1982). *Vision: a computational investigation into the human representation and processing of visual information*, San Francisco, CA: W.H. Freeman Press.
- McCarthy, G., Puce, A., Belger, A., & Allison, T. (1999). Electrophysiological studies of human face perception II. Response properties of face-specific potentials generated in occipitotemporal cortex. *Cerebral Cortex*, *9*, 431–444.
- Pessoa, L., Thompson, E., & Noë, A. (1998). Finding out about filling in: a guide to perceptual completion for visual science and the philosophy of perception. *Behavioral and Brain Sciences*, *21*, 723–780.
- Peterson, M. A., & Gibson, B. S. (1991). Directing spatial attention within an object: altering the functional equivalence of shape descriptions. *Journal of Experimental Psychology: Human Perception and Performance*, *17*, 170–182.
- Puce, A., Allison, T., & McCarthy, G. (1999). Electrophysiological studies of human face perception III. Effects of top-down processing on face-specific potentials. *Cerebral Cortex*, *9*, 445–458.
- Pylyshyn, Z. (1999). Is vision continuous with cognition? The case for cognitive impenetrability of visual perception. *Behavioral and Brain Sciences*, *22*, 341–423.
- Reynolds, R. I. (1985). The role of object-hypotheses in the organization of fragmented figures. *Perception*, *14*, 49–52.
- Rossion, B., Delvenne, J. -F., Debatisse, D., Goffaux, V., Bruyer, R., Crommelinck, M., & Guerit, J. -M. (1999). Spatio-temporal localization of the face inversion effect: an event-related potentials study. *Biological Psychology*, *50*, 173–189.
- Rossion, B., Gauthier, I., Tarr, M. J., Despland, P., Bruyer, R., Linotte, S., & Crommelinck, M. (2000). The N170 occipito-temporal component is delayed and enhanced to inverted faces but not to inverted objects: an electrophysiological account of face-specific processes in the human brain. *NeuroReport*, *11*, 69–74.

- Sagiv, N., & Bentin, S. (2001). Structural encoding of human and schematic faces: holistic and part-based processes. *Journal of Cognitive Neuroscience*, *13*, 1–15.
- Schweinberger, S. R. (1996). How Gorbachev primed Yeltsin: analyses of associative priming in person recognition by means of reaction times and event-related brain potentials. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *22*, 1383–1407.
- Simion, F., Cassia, V. M., Turati, C., & Valenza, E. (2001). The origins of face perception: specific versus non-specific mechanisms. *Infant and Child Development*, *10*, 59–65.
- Snodgrass, J. G., & Feenan, K. (1990). Priming effects in picture fragment completion: support for the perceptual closure hypothesis. *Journal of Experimental Psychology: General*, *119*, 276–296.
- Snodgrass, J. G., & Vanderwart, M. A. (1980). A standardized set of 260 pictures: norms for name agreement, image agreement, familiarity, and visual complexity. *Journal of Experimental Psychology: Human Learning and Memory*, *6*, 174–215.
- Street, R. F. (1931). *A gestalt completion test: a study of cross section of intellect*. New York: Bureau of Publications, Teachers College, Columbia University.
- Tanaka, J. W., & Curran, T. (2001). A neural basis for expert object recognition. *Psychological Science*, *12*, 43–47.
- Ullman, S. (1996). *High-level vision: object recognition and visual cognition*. Cambridge, MA: MIT Press.