Priming global and local processing of composite faces: 
Revisiting the processing-bias effect on face perception

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Abstract

We used the composite face illusion and Navon stimuli to determine the consequences of priming local or global processing on subsequent face recognition. The composite face illusion reflects the difficulty to ignore the task-irrelevant half-face while attending the task-relevant half if the half-faces in the composite are aligned. In each trial, participants first matched two Navon stimuli attending either the global or the local level and then matched the upper halves of two composite faces presented sequentially. Global processing of Navon stimuli increased the sensitivity to incongruence between the upper and the lower half of the composite face relative to a baseline in which the composite faces were not primed. Local processing Navon stimuli did not influence the sensitivity to incongruence. Although incongruence induced a bias towards “Different” responses, this bias was not modulated by priming. We conclude that global processing of Navon stimuli augments holistic processing of the face.
Since the early days of the Gestalt school, the relative roles of the “whole” and its “parts” in object perception have been a major line of research. An important milestone along this line was set by Navon (1977) who, introducing his famous hierarchical letters stimulus and using the “forest and trees” metaphor, emphasized the distinction between global and local processing in the visual system (see also Navon, 2003). Since then, concepts such as global-to-local, global precedence (Navon, 1977; for a critical review see Kimchi, 1992), reversed hierarchy (Hochstein & Ahissar, 2002) or coarse-to-fine (Hughes, Nozawa, & Kitterle, 1996; Loftus & Harley, 2004; for a review see Hegdé, 2008) have been used to describe the time course and the dynamics of visual perception. However, contemporary research demonstrated that although global aspects of a visual scene are generally available before local details (e.g., Bar, 2004; also Goffaux et al., 2010), the relative importance of using global and local visual information for object recognition is actually modulated by factors such as visual expertise (e.g., Curby, Glazek, & Gauthier, 2009; Wong, Palmeri, & Gauthier, 2009), task (e.g., Morrison & Schyns, 2001), as well as the perceptual category of the perceived stimulus (e.g. McKone, Kanwisher, & Duchaine, 2007). Therefore, recent studies have focused on the circumstances which can bias the usage of global or local information during visual perception. Within this framework several studies demonstrated global or local level-specific priming effects (Forster, 2009; Hubner, 2000; Large & McMullen, 2006; Robertson, 1996; Robertson, Egly, Lamb, & Kerth, 1993; Shedden, Marsman, Paul, & Nelson, 2003; Ward, 1982). Level-specific priming effects are interesting because, beyond asking whether perceptual processing preferences can be induced top-down and maintained across time, the outcome of such priming sheds light on the level of processing which is appropriate for a particular stimulus while performing a particular task. A striking example of such research is the application of level-of-processing priming in studies of face perception.
It is widely acknowledged that human faces are processed holistically in the sense that the identification of one part is influenced by the identity of other parts (Tanaka & Farah, 1993; Young, Hellawell, & Hay, 1987; for a review see Farah, Wilson, Drain, & Tanaka, 1998). Although faces are distinguished at the individual level by the relative spatial position of the inner components (second-order relations; Maurer, Grand, & Mondloch, 2002), there is evidence that the processing of spatial configuration is also affected by the global face structure (Sergent, 1984; Tanaka & Sengco, 1997). Assuming that global processing is a pre-requisite of holistic perception, it has been hypothesized that face recognition should be impaired by priming local processes and might benefit from priming global processes. This hypothesis received some empirical support.

For instance, in what could be considered as a seminal study, Macrae and Lewis (2002) reported that the ability of participants to identify a face among 7 other faces as a previously seen individual was lower relative to a control group if between study and test participants spent 10 minutes attending to the local level of Navon stimuli. In contrast, participants who attended to the global level of the same stimuli during the study-test interval recognized the target face better than the control group. This pattern has been replicated in several other studies (Hills & Lewis, 2007; Lewis, Mills, Hills, & Weston, 2009; Perfect, 2003; Perfect, Weston, Dennis, & Snell, 2008; Weston et al., 2008; see, however, Lawson, 2007). The link between the global or local processing and holistic processing of faces has been also supported by a study in which participants were presented with composite-faces (in which the top and the bottom halves were of different faces) following a Navon-stimuli processing phase. In that study the participants learned a set of 4 intact faces at the beginning of the experiment, and selected between two composite faces the one including either the eyes or the mouth of a previously learned face
(Weston & Perfect, 2005). The results showed that processing Navon stimuli for 3 minutes at the local-level speeded the recognition of the components, suggesting that local processing strategy induced by priming helped overcome the detrimental effect of holistically processing the composite face (cf. Young et al., 1987). These data were presumed to support the transfer of processing-level strategies from the Navon to the face composite task. However, this conclusion should be qualified because, while affecting response speed, the Navon task did not influence the components’ recognition accuracy. Furthermore, processing the Navon stimuli to the global level did not interfere with the recognition of the components in the face composites albeit the participants were actually explicitly instructed to attend the local level. In fact, in a subsequent study Perfect and colleagues (2008) refined this interpretation suggesting that the effect of processing the Navon stimuli on face recognition does not reflect transfer of either global or local-level processing but, rather, whether the mode of processing the face, automatic or controlled, corresponds with the mode of processing the Navon stimuli. Specifically, matching only the upper half of composite faces requires the application of a controlled mechanism which allows ignoring the bottom halves, overcoming the automatic tendency to integrate the faces. Further, if the structure of the Navon stimuli induces global precedence, focusing their local level also requires controlled processing in order to overcome the automatic tendency to perceive the stimuli globally. The application of control mechanisms while processing the Navon stimuli might facilitate the application of control mechanisms while matching the face composites. Conversely, when Navon stimuli which induce global precedence are processed at the global level, the automatic strategy established at that time may interfere with the application of a control mechanism required for the composite faces matching. Consequently, according to this interpretation, if the Navon stimuli are structured to induce global precedence, addressing their
global level should reduce performance in composite-faces matching task whereas addressing their local level should improve performance in this task. Importantly, this account suggests a general effect of correspondence between perceptual strategies required is subsequent tasks and has no specific implication on face recognition.

An additional caveat about whether processing composite faces tell us much about face perception strategies is that decisional factors are also involved in the composite-face illusion (Richler, Gauthier, Wenger, & Palmeri, 2008). By extension, it is possible that the priming-level might also bias the decision criteria rather than perceptual strategies. However, even assuming that the composite face illusion reflects the joint effect of perceptual and decisional factors (see also Cheung, Richler, Palmeri, & Gauthier, 2008), and although the magnitude of this effect is not necessarily correlated with face identification accuracy (Konar, Bennett, & Sekuler, 2010), there is no argument that this illusion results from the tendency to process faces holistically (e.g., de Heering, Houthuys, & Rossion, 2007; Grand, Mondloch, Maurer, & Brent, 2004; Hole, 1994; Michel et al., 2006; Rossion & Boremanse, 2008; Schiltz, Dricot, Goebel, & Rossion, 2010; Young et al., 1987). Therefore, it is important to disentangle the possible effects of Navon priming on decisional and perceptual factors affecting the processing of composite faces. To address this challenge, in the present study we adopted the full composite face design (Gauthier & Bukach, 2007; Richler et al., 2008) and took a signal detection approach, which allowed us to analyze the priming effect on decisional bias as well as on perception sensitivity. In each trial participants first matched two simultaneously presented Navon stimuli and then matched the upper halves of two sequentially presented composite faces. Navon-matching required attention either to the global or the local level in separate blocks. Within each block the composite faces were presented both aligned and misaligned. In the congruent conditions both the upper and the
bottom halves of the two composite faces were either “same” or “different”, whereas in the incongruent conditions the upper and bottom halves lead to different responses. To probe if priming local processing facilitates processing the two halves of the composite face independently, whereas priming global processing encourages integration and, consequently, interferes with the independent processing of each half-face, we compared the congruency effect (congruent – incongruent) in each priming condition with a baseline. This baseline was contributed by a different group of participants who performed the composite face task without any priming. We predicted smaller congruency effects following the local than the global priming if the half-faces in the composite were aligned, but no such effects if they were misaligned. If both types of processing level priming affect sensitivity to the congruence between the two halves of the composite faces (in opposite ways), then the congruency effect should be larger following global priming relative to baseline, but smaller relative to baseline following local priming. Finally, if priming affects decision making processes we should find priming effects on the response criterion.

Methods

Participants

Twenty-four undergraduates from the Hebrew University (Mean age 22.8 ± 2.9 years; 17 females) were tested in the priming conditions, and 17 naïve participants (Mean age 22.2 ± 4.2 years; 10 females) were tested in the baseline condition. One female participant in the baseline group was excluded because of overall low accuracy. All participants had normal or corrected-to-normal visual acuity and no history of psychiatric or neurological disorders. Participants signed an informed consent form according to the requirements of the institutional review board of the Hebrew University and were paid for participation or received course credit.
Stimuli, Task and Design

The Navon stimuli consisted of black letters presented on a grey background. Each local letter was 0.85 cm wide × 1.14 cm high (0.7° × 0.9°); the local letters were spatially arranged on a 5 × 5 grid to form a global letter that was 5.8 cm wide × 6 cm high (4.7° × 4.9°). The letters were black Helvetica bold font D, E, F, and H in all their local and global combinations making 16 distinct Navon stimuli (Figure 1-a).

Face stimuli were generated from 96 grey-scale images of unfamiliar Caucasian faces, half males and half females. The original images were first cut to form an ellipse shape 5.30 cm wide × 7.40 cm high (4.3° × 6.0°) which excluded exterior face features. To create composite-faces we divided the vertical dimension of each face into two halves. The top and the bottom parts from same-gender faces were recombined leaving a 0.19 cm gap between the two parts. The top half of each face was recombined with its original bottom half as well as with the bottom half of a different face chosen at random without replacement. This resulted in 384 different composite-faces in total. Right shifting the bottom part of the aligned faces 2.65 cm, we produced 384 misaligned faces (Figure 1-b). Each composite-face was used only once in the experiment.

In the priming task, two Navon stimuli were presented simultaneously one in the left and one in the right visual field, each with the most medial edge 0.25° from fixation. The participants were instructed to match the two displays focusing either on the large letters ignoring the small letters (global level) or on the small letters (ignoring the large letters (local level). The global and the local prime processing tasks were blocked and the order of blocks was counterbalanced across participants.
In the composite face task, two composite faces were presented one after the other at fixation, and the participants were instructed to match the top halves of the two composites ignoring the bottom halves. The first face in each trial was composed from the top and the bottom halves of the same face, while the combination of the second composite-face defined one of 4 pair-type conditions, two congruent and two incongruent. In the congruent pairs, both the top and the bottom halves of the two composites were either taken from the same faces or from different faces: Top-same and Bottom-same or Top-different and Bottom-different. In the incongruent pairs, either the top or the bottom halves were taken from the same face while the other halves were taken from different faces: Top-same and Bottom-different or Top-different and Bottom-same (Figure 2). For the priming group, these 4 types of composite faces were presented aligned and misaligned to each participant. The 8 composite face task conditions were mixed and presented in random order within the global and the local priming blocks. The baseline group was tested only with aligned stimuli. The same 4 types of composite faces were randomized in one block.

Procedure

The stimuli were shown on a 17-inch CRT monitor with a vertical refresh rate of 100 Hz and a resolution of 1024 × 768 pixels. Participants were seated 70 cm from the screen in a dimly lit room. Trial timing was controlled by Presentation (Neurobehavioral Systems, Albany, CA) as depicted in Figure 3.

For the experimental group, each trial began with a red fixation mark that appeared at the center of the screen for 500 ms. The fixation mark was followed by the two Navon stimuli to which the participants responded by pressing either a “match” or a “mismatch” key with their
non-dominant hand. The Navon stimuli were presented until response or up to 2 s. The offset of the Navon stimuli was followed by a 400 ms blank interval, after which the first of the two composite-faces was displayed for 250 ms. The second composite-face was displayed after an additional blank interval of 250 ms and exposed until a response or up to 2 s. The participants responded to the composite-face task using their dominant hand, selecting between a “same” or a “different” key. Accuracy rather than speed was emphasized. Following an inter-trial blank interval of 700-900 ms, a new trial began automatically.

For the baseline group, the procedure was identical except that the SOA between the fixation cross and the first composite face was 1300 ms (roughly equal to the SOA between the Navon and the first composite face in the priming conditions) and the red fixation was also presented during the blank interval between the two composite-faces.

There were 48 trials in each condition, with a total of 384 trials per priming-level block. Each experimental block was preceded by 32 practice trials. Each block was split into 4 sessions of 96 trials each, with a break of 5 minutes between sessions. The entire experiment lasted approximately 50 minutes for the priming group and about 15 minutes for the baseline group.

Results

We first analyzed the performance of the priming group by within-subjects ANOVA. The factors were Priming-level (global, local) × Alignment (aligned, misaligned) × Congruency (congruent, incongruent).
**Performance in the Navon priming task**

The structure of the Navon stimuli led to the frequently observed global precedence. Matching the Navon letters at the global level was more accurate and faster than at the local level, and the difference was not influenced by the congruency or the alignment of the subsequent composite-faces. ANOVA showed a significant main effect of Priming-level for accuracy [M global = 95%; M local = 93%; F(1,23) = 10.5, MSe = 0.002, p < 0.005; partial η² = 0.3] as well as for RT [M global = 830 ms; M local = 894 ms; F(1,23) = 7.7, MSe = 25606, p < 0.025, partial η² = 0.2]. There were no other significant main effects or interactions [All type I error probabilities > 0.25].

**Performance in the Composite-face Task**

Only trials in which the response to the prime was correct (94% of the trials) were included in the composite-face task analysis. Sensitivity to face-identity was determined by A_z, which is a monotonic transformation of d’ bounded between 0 and 1. Previous studies suggested that the A_z is more robust than d’ to the influence of response bias (Richler et al., 2008; Verde, Macmillan, & Rotello, 2006).

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Figure 4 about here

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As shown in Figure 4-a, in the aligned condition the processing level of Navon letters influenced the participants’ responses to faces, with the lowest sensitivity in the global-incongruent condition. No priming effects were found in any other condition.

ANOVA showed that the sensitivity was lower when the composite-faces were aligned (A_z = 0.95) than they were misaligned [A_z = 0.97; F(1,23) = 17.3, MSe = 0.001, p < 0.001; partial η² = 0.4], and lower in the incongruent condition (A_z = 0.95) than in the congruent condition [A_z = 0.97; F(1,23) = 13.6, MSe = 0.001, p < 0.001; partial η² = 0.4]. The Alignment ×
Congruency interaction was also significant \( F(1,23) = 40.3, MSe = 0.001, p < 0.001; \) partial η² = 0.6, indicating that the congruency affected sensitivity only in the aligned condition \( t(23) = 5.58, p < 0.001 \), yet there was no trend of congruency effect in the misaligned condition \( t(23) < 1 \). This pattern is the hallmark of holistic processing of faces.

Importantly, the second order Priming-level × Alignment × Congruency interaction was significant \( F(1,23) = 5.1, MSe = 0.001, p < 0.05; \) partial η² = 0.2, suggesting that the Priming-level × Congruency interaction was different for aligned and misaligned composite-faces. This interaction was investigated by separate two-way ANOVAs for aligned and misaligned conditions.

These analyses showed that the Congruency × Priming-level interaction was significant for the aligned condition \( F(1,23) = 6.7, MSe = 0.001, p < 0.025; \) partial η² = 0.2, but not for the misaligned condition \( F(1,23) < 1 \). Post hoc exploration of the Congruency × Priming-level interaction for aligned composite faces revealed that the congruency effect in the aligned condition was significant both in the global priming \( 0.98 \text{ vs. } 0.92; t(23) = 5.20, p < 0.001 \) and in the local priming condition \( 0.98 \text{ vs. } 0.95; t(23) = 5.20, p < 0.0025 \). This suggests that even after local priming there was a tendency to process the composite faces holistically. However, as predicted, the congruency effect was significantly lower after local priming than after global priming \( 0.03 \text{ vs. } 0.06; t(23) = 2.60, p < 0.025 \). There were no other significant effects \( \text{[All type I error probabilities > 0.25]} \).

The analysis of the response criterion was based on a similar ANOVA design (Figure 4-b). This analysis showed that the response bias towards “different” decisions was larger in the incongruent \( c = 0.8 \) than in the congruent condition \( c = 0.01; F(1,23) = 17.6, MSe = 0.02, p < 0.001; \) partial η² = 0.4, and larger for aligned \( c = 0.8 \) than for misaligned composite faces \( c =
0.01; \( F(1,23) = 19.6, MSe = 0.01, p < .001; \text{ partial } \eta^2 = 0.5 \). The Congruency \times \text{ Alignment} interaction was significant \([F(1,23) = 8.0 MSe = 0.02, p < 0.01; \text{ partial } \eta^2 = 0.3]\), indicating that the congruency effect was significant in the aligned condition \([t(23) = 4.19, p < .001]\), but not in the misaligned condition \([t(23) = 1.24, p = 0.23]\). The most important result of this analysis, however, was that there was no Priming-level effect overall \([F(1,23) < 1]\), and no Priming-level \times \text{ Alignment} interaction \([F(1,23) < 1]\). There was a tendency for Priming-level \times \text{ Congruency} interaction \([F(1,23) = 4.2, MSe = 0.008, p = 0.051; \text{ partial } \eta^2 = 0.16]\) which did not further interact with Alignment \([F(1,23) = 1.9, MSe = 0.011, p = 0.18; \text{ partial } \eta^2 = 0.07]\). Post hoc comparisons across alignment showed that the bias towards “Different” responses was slightly larger in the local than in the global priming conditions for congruent composite faces (Mean difference = 0.014) and slightly smaller in the local than in the global priming conditions for incongruent composite-faces (Mean difference = -0.04). However, none of these differences were significant \([t(23) < 1.0 \text{ and } t(23) = -1.46, p = 0.157, \text{ for the congruent and incongruent conditions, respectively}]. Finally, notwithstanding the absence of a second order interaction, since the congruency effect on the \( A_z \) was significant only in the aligned condition, we compared the congruency effect on the criterion in the global and local conditions focusing only on aligned composites. This analysis showed that the congruency effect was similar for the global (-0.13) and local (-0.12) priming conditions. In other words, the source of the Priming-level \times \text{ Congruency} interaction was in the misaligned condition, where the \( A_z \) was not influenced by the Priming-level.\(^1\)

\(^1\) Since we have explicitly emphasized accuracy at the expense of speed, the RTs were not very informative. Nevertheless we analyzed the RT data using the same design as for \( A_z \). This analysis revealed that in the aligned condition for both global and local priming the RTs were significantly longer in the incongruent condition than in the congruent condition. There were no significant RT effects in the misaligned conditions. Moreover, there was no speed-accuracy in the composite face task (The full analysis is available as supplementary material).
Comparison with baseline

Since the Priming level was nested only in the experimental group, to assess the effects of global and local priming relative to baseline, we compared the congruency effect of the experimental group with the control group separately for each priming condition. These comparisons were based on mixed-model ANOVAs with Group (experimental, control) as the between-subjects factor and Congruency (congruent, incongruent) as a within-subjects factor.

As shown in Figure 5-a, across the global, local and no priming conditions $\Delta z$ was consistently higher in the congruent than in the incongruent condition. Confirming this observation, the mixed ANOVA revealed higher sensitivity in the congruent than in the incongruent condition across groups in both priming conditions [$F(1,38) = 25.6, MSe = 0.001, p < 0.001; \text{partial } \eta^2 = 0.40$ for the global priming; $F(1,38) = 15.6, MSe = 0.001, p < 0.001; \text{partial } \eta^2 = 0.29$ for the local-priming]. However, whereas for the global priming condition there was a significant Congruency $\times$ Group interaction [$F(1,38) = 11.7, MSe = 0.001, p < 0.001; \text{partial } \eta^2 = 0.24$], this interaction was not significant for the local priming condition [$F(1,38) = 3.1, MSe = 0.001, p = 0.087; \text{partial } \eta^2 = 0.07$]. The analysis of the two-way interaction in the global condition showed that the congruency effect was significantly larger in the global priming condition than in the baseline (no-priming) condition [0.06; $t(38) = 4.138, p < 0.001$], but the latter was still significant (compared to zero, $t(15) = 3.897, p < 0.001$). Finally, overall sensitivity was higher in the baseline than in both experimental conditions [$F(1,38) = 14.1, MSe = 0.003, p < 0.001; \text{partial } \eta^2 = 0.27$, and $F(1,38) = 13.2, MSe = 0.001, p < 0.001; \text{partial } \eta^2 = 0.26$, for the global and local priming conditions, respectively], suggesting an overall effect of interference by the Navon task on the composite face task.
A similar analysis was conducted on criterion (see Figure 5-b). The mixed ANOVA showed that the response bias towards “different” decisions was larger in the incongruent than in the congruent condition across groups \([F(1,38) = 21.733, MSe = 0.232, p < 0.001; \text{partial } \eta^2 = 0.36]\) for the comparison with global priming; \([F(1,38) = 12.62, MSe = 0.206, p < 0.001; \text{partial } \eta^2 = 0.25]\) for the comparison with local priming. Critically, there was no Congruency \(\times\) Group for both priming levels [All type I error probabilities > 0.30], suggesting that the difference of congruency-effect revealed in A<r> was not influenced by the response criterion.

**Discussion**

The results of the present study revealed that the composite face illusion, as reflected by the sensitivity to the congruency between the upper and the lower halves of composite faces, was enhanced when participants attended to the global level of Navon stimuli prior to face processing yet attending to the local level was inconsequential.

To reiterate, the composite face illusion occurs while the participant attempts to match two identical halves of the same face, each of which is combined with a different bottom half. Since its initial demonstration (Young et al., 1987), numerous studies replicated the basic effect showing that the percentage of (correct) “same” responses is considerably lower when the top and the bottom half faces are aligned than when the two halves of each composite are misaligned. This effect has been frequently attributed to the unavoidable integration of the bottom half with the top half of each face and, therefore, the composite-face illusion has been considered a hallmark of holistic face processing (cf. Tanaka & Farah, 1993). This account has been also supported by recent ERP findings (Jacques & Rossion, 2009, 2010; Schiltz et al., 2010; Kuefner, Jacques, Prieto, Rossion, 2010). To this end, the pattern of priming effects in our present study
suggests that allocating attention to the global level of preceding Navon stimuli augments the tendency to process faces holistically.

Two important aspects of our present design support this conclusion. First, using the complete design of the composite-faces matching task (Richler et al., 2008), we were able to attribute the priming effect induced by the processing of Navon stimuli to perceptual aspects of face processing. The sensitivity to the congruency of the composite faces in a pair was evident only in the aligned condition where the detrimental effect of incongruence on accuracy was enhanced by priming global perception and unaffected by priming local perception. In contrast, the analysis of the criterion showed that although there was a response bias to select the “Different” response in the critical aligned/incongruent condition, this bias was not modulated by the Priming-level. Hence, whereas our findings support the involvement of a response bias factor in the composite face matching performance (Cheung et al., 2008), processing-level priming does not affect this factor. This is, to our knowledge, the first direct evidence that the Navon-priming affects the perceptual rather the response/decisional level.

Second, the present trial-by-trial priming design provides a more direct test of the global and local priming effects on holistic and analytic processing of faces. In most previous studies the Navon stimuli were introduced between study and test phase. Hence, even when composite faces were used as targets, processing the study face was hardly influenced by processing level of the Navon stimuli. An exception to this rule is a recent study by Lewis and colleagues (Lewis, Mills, Hills & Weston, 2009). In that study participants learned a set of unfamiliar faces and were tested for subsequent recognition. Prior to learning as well as prior to the test phase, participants were presented three Navon stimuli and were instructed to name either the global

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2 A similar effect was found in a study exploring the effect of spatial frequency ranges on the composite effect (Cheung et al., 2008).
letter or the local letters. The most important result in this study was that processing the Navon stimuli at the same level prior to study and prior to test improved face recognition relative to conditions in which the required processing level of the Navon stimuli was different between study and test. Interestingly this improvement was observed regardless of the level at which the Navon stimuli were processed. This pattern suggests that the level of processing induced during the Navon task determines the kind of information which is encoded in episodic memory (cf. “transfer of appropriate processing”, Morris, Bransford, & Franks, 1977). However, additional evidence was necessary to conclude that perceptual (distinct from memory) processes are affected by the level at which the Navon letters are identified. Such evidence was provided by the present design, which invoked predominantly perception rather than memory, and both the first and the second composite-faces were presented after global or local processing of the Navon stimuli. Furthermore, the composite face illusion more clearly reflects holistic processes than simple face recognition, which, as suggested by the study of Lewis and colleagues, may involve both featural, configural as well as holistic processes (Maurer, Grand, & Mondloch, 2002).

Intriguingly, the present findings are different than those reported by Weston and Perfect, (2005) in two ways. First, whereas in that previous study local priming facilitated performance and global priming was inconsequential, in our present study the opposite was true: Global priming interfered with performance whereas local priming was inconsequential. Second, whereas the priming in Weston and Perfect’s study affected speed but not accuracy, here we found effects on accuracy whereas for RTs the effects were less convincing. Some of these differences could probably be explained by the difference between the two task settings. As we

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3 Overall, as expected, the responses to incongruent composite faces were slower than to congruent ones in the aligned but not in the misaligned condition. However, the difference between global and local priming in the aligned condition was not significant in either the congruent or the incongruent condition (see supplementary materials).
noticed, the specific instructions that the participants received in the former study were to attend to particular components (either the eyes or the mouth). This task might have induced a much stronger tendency for local processing than our “half-face” matching task. This could explain why local-level priming facilitated performance in the former study but not in ours. Along the same line, it is possible that the explicit requirement to allocate attention to a face component could reduce the default holistic face processing strategy, or even eliminate it. Hence, priming global-level processing might have not been effective. On the other hand, since in our present study the composite faces were presented one at a time and the participants needed to pay attention to the entire upper part of the face, priming local processing might have not helped much, while priming global processing, could have enhanced the normal tendency to integrate the two halves of the face into one whole. Whereas this interpretation stands to our reason, we should consider it with caution because, compared with baseline, even following local priming the congruency effect tended to be larger in the priming group than in the experimental group. Although this tendency was insufficient to lend a significant interaction between Congruency and Group the numerically higher effects in the local priming condition than in the baseline condition was contrary to what we expected and intriguing. Note, however, that this pattern cannot be explained by Perfect and colleagues (2008) hypothesis as well. Since the structure of the presently used Navon stimuli induced global precedence (Flevaris et al., in press), processing the local level should have triggered a control mechanisms which, according to Perfect and colleagues, was supposed to reduce the congruency effect relative to baseline. Finally, regarding the RTs, perhaps the fuzzy pattern reflects the fact that we explicitly emphasized accuracy at the expense of speed.
While suggesting that the present priming effects reflect the modulation of holistic face processing, lower-level vision factors which might affect performance should also be considered. One is that, in the local priming condition, participants might have adopted the strategy to foveate local letters in the upper half of the global letter and continued fixating the upper part of the visual field while processing the composite-faces. This strategy might explain the smaller congruency effect in the local-priming conditions. Since we did not monitor eye movements we cannot exclude this possibility. However, we considered this account unlikely. This is because the Navon stimuli were always preceded by a fixation mark and were vertically centered to this mark while the monitor was elevated to the participants’ eye level. Moreover, in the baseline experiment the fixation mark was continuously displayed during the ISI between the two faces as well as preceding the first face composite. Nevertheless, the more stringent control of eyes movements in the baseline condition did not change much the congruency effect relative to the local priming condition in which the fixation mark was only presented prior to the Navon stimuli.

Another possible interpretation is that the level of processing of the Navon stimuli (global or local) does not influence directly the face processing strategy (holistic or component based). Rather, this influence is mediated by a biased selection of spatial frequencies (SF) during visual perception (Hills & Lewis, 2009; see also Weston & Perfect, 2005). Evidence that processing Navon stimuli can bias the selection of SF in a subsequent image has been recently provided by a study which demonstrated that allocating attention to the global or local levels of Navon stimuli facilitates respectively the processing of LSF or HSF in subsequently presented compound-frequency gratings (Flevaris, Bentin, & Robertson, in press; Flevaris, Bentin, & Robertson, 2010). Evidence that holistic processing relies primarily on LSF while component-based processing relies primarily of HSF, has also been provided (e.g., Goffaux & Rossion, 2006;
Robertson 1996; Shulman et al., 1986). Hence, it is possible that biasing the selection of SF in the image is the mechanism by which global processing facilitates holistic processing.

Furthermore, in a recent study we demonstrated that the accumulation of LSF in visual short-term memory (VSTM) is prioritized (Gao & Bentin, in press). Similarly, Goffaux and colleagues (2010) showed that LSF are also prioritized in the perception of faces. Since in the present study the two composite faces were presented in sequence with 500 ms SOA, the prioritized accumulation of LSF in both perception and VSTM might partly explain why we found effects following global but not following local priming.

In conclusion, the current study allowed teasing apart the influences of global and local priming on perceptual and decisional factors which contribute to the composite face illusion. Specifically, we showed that priming global-level processing augments the tendency to integrate the two half-face and increases the sensitivity to the congruency between them. In contrast, although a response-bias factor contributes to the composite face illusion, it is not modulated by priming. This outcome provides additional evidence for the traditional argument that holistic perception is an important factor inducing the composite face illusion and, by extension, that faces are processed holistically by default (Young et al., 1987).
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Figure Captions

*Figure 1.* Examples of (a) Navon letters used in the current study; (b) aligned and misaligned composite faces used in the current study.

*Figure 2.* Illustration of the conditions adopted in the composite paradigm for the aligned conditions. Different letters represent different identities.

*Figure 3.* Illustration of the time course of a trial in the current study.

*Figure 4.* Mean $A_z$ (a) and criterion (b) for the composite face task adopting the complete design calculation. (Error bars show standard error)

*Figure 5.* The congruency effects following global, local, or no priming and the respective response criteria.