Research Article

Automatic Aspects in Face Perception

Evidence From Mandatory Processing of Distractor Facial Components

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Abstract. We examined the perceptual dependency of local facial information on the whole facial context. In Experiment 1 participants matched a predetermined facial feature that appeared in two sequentially presented faces judging whether it is identical or not, while ignoring an irrelevant dimension in the faces. This irrelevant dimension was either (a) compatible or incompatible with the target's response and (b) same or different in either featural characteristics or metric distance between facial features in the two faces. A compatibility effect was observed for upright but not inverted faces, regardless of the type of change that differentiated between the faces in the irrelevant dimension. Even when the target was presented upright in the inverted faces, to attenuate perceptual load, no compatibility effect was found (Experiment 2). Finally, no compatibility effects were found for either upright or inverted houses (Experiment 3). These findings suggest that holistic face perception is mandatory.

Keywords: faces, objects, perception, attention, automaticity, configural, featural

Holistic or configural processes are claimed to underlie face perception, and to differentiate between the manner in which faces and objects are perceived (Maurer, Le Grand, & Mondloch, 2002). The terms holistic or configural denote that facial recognition is based on perceiving the face as a whole and not just as a collection of its individual features. Objects, on the other hand, are claimed to be processed analytically, and, consequentially, local features in objects are perceived independently from the whole. But is the dependency of local facial information on the entire face context obligatory to face perception? The present study explores how the whole affects the perception of parts in faces and houses during a task designed to induce piecemeal processing of a relevant facial feature.

Although holistic and configural processing are used interchangeably, they emphasize different aspects of the unique way in which faces are processed (Gauthier & Tarr, 2002; Maurer et al., 2002). Holistic accounts of face processing propose that faces are primarily recognized as undifferentiated wholes or templates, with little part decomposition, while objects are recognized in a part-based manner (Farah, 2004; Farah, Tanaka, & Drain, 1995; Farah, Wilson, Drain, & Tanaka, 1998; Tanaka & Farah, 1993). The decreased accuracy in recognition of faces following inversion, which is more pronounced in faces than in objects (but see Ashworth, Vuong, Rossion, & Tarr, 2008; Husk, Bennett, & Sekuler, 2007 for exceptions), results, according to this view, from the inability to implement holistic processes and the need to apply part-based strategies which are not adequate for face perception (Farah et al., 1998). In contrast, configural accounts of face processing (Bartlett & Searcy, 1993; Diamond & Carey, 1986; Rhodes, 1988; Rhodes, Brake, & Atkinson, 1993; Searcy & Bartlett, 1996) suggest that recognition of faces is based on computing the spatial relations between facial features. While sensitivity to first-order relational information (i.e., the prototypical arrangement of features in the face so that the nose is above the mouth and the eyes are above the nose) determines perception of a face as such, the discrimination between individual faces is based on second-order relational information (i.e., the distance between features relative to the prototypical configuration of a face). This relational information is harder to extract from an inverted face, a difficulty which gives rise to the inversion effect (Diamond & Carey, 1986; Maurer et al., 2002).

At a behavioral level, however, both accounts claim that face processing relies on integrating information from a large facial area; either by perceiving the face as a gestalt, or by automatically computing the spatial relations across the internal space of the face, both descriptions suggest that the internal features and relations of the face are perceptually linked to one another and are represented in this fashion

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either implicitly or explicitly (see Bartlett, Searcy, & Abdi, 2003 for different formulations of this idea, formulations which, nonetheless, share the notion that facial features of upright faces are not encoded independently of each other). Thus, for example, Tanaka and Farah (1993) and Tanaka and Sengco (1997) showed that the identification of a facial feature was best when located in the same face configuration as during learning. Identification of the feature was less accurate when presented in a different face configuration or in isolation. This effect was not found for objects (e.g., houses) and disappeared when faces were inverted or their features were scrambled in relation to one another.

These studies strongly suggest that face parts are not represented independently from the context of the face. However, they do not answer unequivocally the question of whether the perceptual dependency of local facial features on the surrounding facial context is mandatory for face perception, or, in other words, whether faces are perceived as a whole. This issue was addressed by Farah et al. (1998). In their study a pair of faces was briefly presented followed by the name of a facial part (e.g., *eyes*). Participants were asked to judge whether the two faces shared the same name of the facial part, while the influence of the similarity or difference of an irrelevant feature (e.g., *mouth*) on their same/different judgment was monitored.

The investigators' rationale was that to the extent that specific features are encoded independently and explicitly, the identity of the irrelevant feature will not affect the comparison process of the relevant feature. In contrast, if faces are perceived holistically and features are not represented explicitly, the identity of the irrelevant features will affect the participants' judgment. As a result, incompatibility between the response to relevant features and the potential response to the irrelevant features will impede judgment of the probed feature in the simultaneous matching task. The findings showed that the incompatibility between the irrelevant features and the probed features delayed response latency and decreased accuracy, confirming the authors' hypothesis that little or no part decomposition occurs during perception of a feature in the face context.

Yet, even this study does not provide a definite answer to the question whether holistic processing of faces is obligatory during conditions that encourage part-based processing of local features. The reason is that the experimental manipulation, though not intended to do so, may have induced participants to adopt a holistic strategy in processing faces. Specifically, although Farah and her collaborators (1998) requested in their simultaneous matching task to judge specific features, these features were cued only *after* the faces were presented. It is possible, therefore, that while studying the faces participants engaged in holistic processing, since they were oblivious to the identity of the relevant feature that they will have to report until *after* the faces were presented. Consequently, it is not surprising that the irrelevant features influenced performance.

Some evidence exists in the literature that face perception can bypass holistic processes and that participants can focus solely on local facial characteristics. For example, Schwaninger, Ryf, and Hofer (2003) found that large overestimations were found when eye-mouth or inter-ocular distances were estimated. Importantly, these distortions were observed for both upright and inverted faces, indicating that holistic processes are not mandatory during face perception. Similarly, Barton, Deepak, and Malik (2003) also observed that cuing subjects to possible featural changes (e.g., eye position) eliminated the inversion effect in a change detection task.

In the present study, we explored whether face or house context can be ignored when the experimental task is designed to engage piecemeal processing of one attended feature. In order to assess whether individual features could be processed independently from the context in which they are embedded, a modified version of the matching task used by Farah et al. (1998) was employed. The main alteration performed in our task was to cue the participants to the relevant feature *before* the faces were presented. Thus, for example, at the beginning of each experimental block we defined in our stimuli (faces in Experiments 1 and 2 and houses in Experiment 3) specific local features as relevant dimensions and asked the participants to ignore the other components of the stimuli. We also cued the relevant dimension by two arrows pointing to its location which appeared before and during the presentation of the second face. In a sequential matching task, the participants were asked to determine whether the relevant features were identical or not between two stimuli. If holistic or configural processing is obligatory to the perception of upright faces, then the facial context will disrupt the task's performance when the response to the relevant dimension is incompatible with the irrelevant dimension. For example, performance will be slower and/or less accurate when the relevant eyes are the same but the irrelevant mouths are not than when both the relevant eyes and the irrelevant mouths are the same. This compatibility effect will be emphasized more for upright faces and reduced or nonexistent for inverted faces which are supposedly not processed in a holistic/configural fashion (but see Rakover, 2002; Sekuler, Gaspar, Gold, & Bennett, 2004; Valentine, 1988 for an alternative view of the inversion effect). In contrast, the absence of such an influence will indicate that piecemeal processing can occur when the task's manipulation encourages attending to a local feature which is distinct from its surrounding context (Bartlett et al., 2003). In the latter case, the findings for upright faces would be similar to those for inverted faces, which are processed in a part-based manner.

An additional question addressed in the present study was whether different aspects of the irrelevant facial context would show more interference than others when incompatible with the relevant dimension. Specifically, according to holistic accounts, both featural and relational variation (such as change of the inter-ocular distance) of the irrelevant dimension would result in compatibility effects for upright faces as both aspects comprise the face template (see, e.g., Maurer et al., 2007; Schiltz & Rossion, 2006; Yovel & Kanwisher, 2008 for recent support of this claim). Conversely, according to the configural account, featural variation may yield a milder interference than relational variation since the featural characteristics of the face may be processed independently of each other (Freire, Lee, & Simons, 2000; Leder & Bruce, 1998, 2000; Leder, Candrian, Huber, & Bruce, 2001; Le Grand, Mondloch, Maurer, & Brent, 2001, 2004). Previous research, supporting the latter account, has shown that face inversion disrupts relational more than featural information. For example, perceived grotesqueness for relational-altered faces was more sensitive to inversion than for featurally altered faces (Murray, Yong, & Rhodes, 2000; Searcy & Bartlett, 1996). In addition, performance in detecting differences between inverted faces is better when faces differ in features than in relations (Freire et al., 2000; Searcy & Bartlett, 1996). We, therefore, manipulated both featural and relational aspects of the irrelevant dimension to investigate the different versions of the processes underlying face perception.

Experiment 1

Method

Participants

Thirty-two undergraduate students (five males) at the University of Toronto participated in the experiment for course credit or pay. The participants were between the ages of 18 and 25 (mean age 18.89, *SD* = 0.81) and all had normal or corrected-to-normal vision. Five of the participants had performance under chance level in some of the experimental conditions, and one participant did not comply with the instructions; their data were replaced with those of six additional participants.

Materials

Two faces, one male and one female, were designed, using face composite software (FACES 4.0). For each of the two faces three modified versions of the original face were made, using the Adobe Photoshop graphics software program, by replacing the mouth, eyes, or both features with an alternative mouth and pair of eyes. This procedure resulted in eight faces. Then, for each of these faces we generated new faces in which the mouth-nose, inter-ocular distance or both distances were modified. The mouth-nose distance in the modified face was 0.64° of visual angle (compared to the 0.27° of visual angle in the original face), and the inter-ocular distance was 1.19° of visual angle (compared to the 0.82° of visual angle of the original face). In total 32 faces were created. All faces were sized to 67 × 86 mm and subtended 6.37° in width and 8.25° in height.

Using these 32 faces we created two sets of faces, a featural set and a relational set. In the featural set we paired each face with its identical copy or with a different face (from the same gender) to create four types of face pairs: identical faces, faces different in the relevant dimension (e.g., the mouth), faces different in the irrelevant dimension (e.g., the eyes), and faces different both in the relevant and irrelevant dimensions (see Figure 1a). Note that in the featural set the mouth-nose and inter-ocular distances were kept constant in each pair. In the relational set each face was paired with its identical copy, a face different in the relevant feature (e.g., the mouth), a face different in the irrelevant relation (e.g., the inter-ocular distance), or different in both the relevant feature and the irrelevant relation dimension (see Figure 1b). In the relational set the irrelevant feature was kept constant in each pair. Finally, inverted copies were generated for each of the above sets of faces.

The stimuli from the different sets were used to generate four blocks determined by orientation (upright/inverted) and the nature of the change in the irrelevant dimension (featural/relational). Each of the four blocks consisted of the following randomly presented four conditions: (1) same relevant feature (e.g., mouth) – same irrelevant dimension (either feature [eyes] or relations [inter-ocular distance]); (2) same relevant feature – different irrelevant dimension; (3) different relevant feature – same irrelevant dimension; and (4) different relevant feature-different irrelevant dimension. Conditions 1 and 4 were designated as compatible while conditions 2 and 3 were defined as incompatible. Note that in the relevant dimension, to which participants attended, only featural change was introduced.

The face's gender was counterbalanced between participants, so that half of the participants received the female face in the feature blocks and the male face in the relation blocks, and vice versa for the other half of the participants. In addition, half of the male and female faces were presented in the upright blocks and the other half in the inverted blocks. Thus, in each block (consisting of four conditions) 96 trials were presented with eight face pairs presented three times in each of the four conditions. The order of presentation of the four different blocks was counterbalanced between participants using a Latin square design, yielding four different orders. For half of the participants, the mouth was designated as the relevant dimension while for the other half it was the eyes.

Procedure

Participants were instructed to compare a specified target feature (mouth or eyes) between two faces presented sequentially in each trial. They were told to focus their attention on the target feature of the two faces and to respond as quickly and as accurately as possible whether the target feature of the second face was the same or different from the respective feature of the first face.

Stimuli were displayed on an IBM color monitor controlled by E-Prime software (Psychological Software Tools, Inc., 2000), implemented in an IBM PC-compatible computer. Each trial began with a fixation point for 750 ms, followed by the study face presented for 2,000 ms (see Figure 2). After the study face disappeared two arrows, pointing to the location of the target feature, appeared for 750 ms. The test face was then presented for 250 ms, the two side arrows still pointing to the target feature. Following the stimulus offset the participants were given 2,000 ms to respond before the initiation of the next trial. Participants responded on the keyboard, pressing "1" for *same* and "2" for *different*. Before the initiation of each experimental block participants performed eight practice trials with feedback.

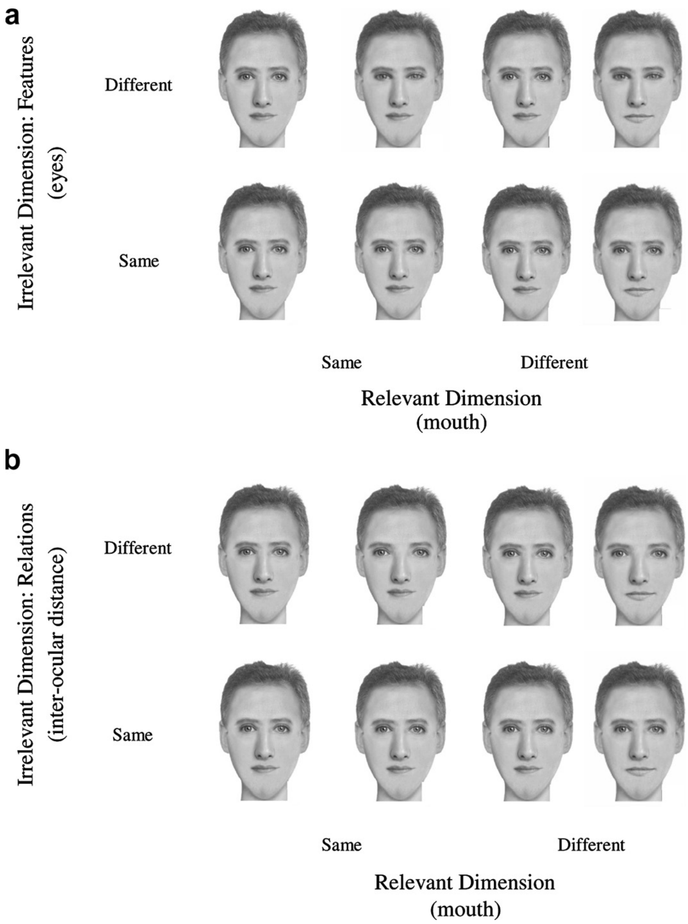

Figure 1. Example of stimuli used in Experiment 1. In both the featural (top) and relational (bottom) sets the relevant and irrelevant dimensions were manipulated orthogonally. In the featural set the four types of face pairs were either identical, different in the relevant dimension (e.g., the mouth), different in the irrelevant dimension (e.g., the eyes), or different both in the relevant and irrelevant dimensions. In the relational set (bottom) the four types of face pairs were either identical, different in the relevant feature (e.g., the mouth), different in relations in the irrelevant relation (e.g., the inter-ocular distance), or different in both the relevant feature and the irrelevant relation dimension.

Results

Mean response latency and accuracy are presented for the upright and inverted faces in Table 1. Only response times for correct trials were included in the analysis, after excluding those that were more than 2.5 *SD* above or below the mean RT of each participant in each condition.

Preliminary analyses did not reveal that the nature of the relevant dimension (eyes/mouth matching) interacted significantly with the other independent variables and therefore it was collapsed together. In addition, we did not examine in this study independently the type of responses (same/different) but collapsed together the compatible versus the incompatible responses, as detailed in the Materials section.

For upright faces the compatibility of the relevant and irrelevant dimensions influenced response latency regardless of whether the features or relations were varied in the irrelevant dimension (Figure 3). Response latency increased by 17 ms when the irrelevant features were incompatible with the relevant features (819 ms for compatible vs. 836 ms for incompatible features), and by 23 ms when the irrelevant relations were incompatible with the relevant features (from 801 to 824 ms, for compatible and incompatible features, respectively). Similarly, the accuracy decreased when the irrelevant features or irrelevant relations were incompatible with the relevant features (from 94% to 92%, for compatible and incompatible features, respectively, and from 94% to 91% for compatible and incompatible relations, respectively).

A different pattern was observed for inverted faces for which the compatibility effect was virtually nonexistent; Latency decreased slightly when either the irrelevant features or the irrelevant relations were incompatible with the relevant dimension (by 2 ms and 1 ms, respectively). Accuracy decreased by 1% and 0.5% when the irrelevant features and relations were incompatible with the relevant dimension, respectively.

These observations were confirmed in a repeated-measure ANOVA performed on latency and accuracy as a function of the following variables: orientation (upright/inverted), type of irrelevant dimension (feature/relation), and compatibility (irrelevant dimension compatible/incompatible with the relevant dimension).

Latency

For latency the only significant main effect was compatibility, $F(1, 31) = 5.34$, $MSE = 1{,}003$, $p < .05$, $\eta_p^2 = .147$, resulting from faster RTs when the irrelevant dimension was compatible with the relevant dimension (827 ms vs. 836 ms for compatible and incompatible, respectively). In

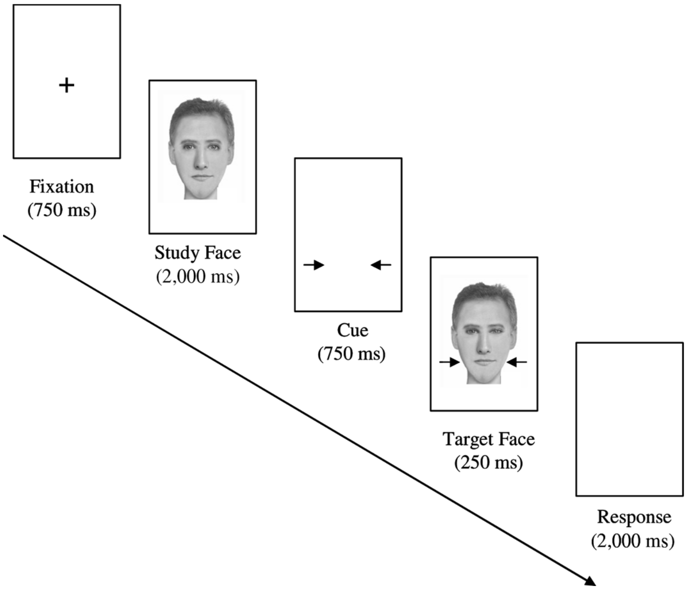

Figure 2. A typical trial in Experiment 1. Following a fixation point a study face was presented for 2,000 ms. After its disappearance a cue consisting of two arrows pointing to the relevant feature appeared for 750 ms, followed by the target face which appeared with the cue for 250 ms. Participants were then given 2,000 ms to respond.

Table 1. Mean (and *SD*) response latency and accuracy (in %) for upright and inverted faces as a function of irrelevant dimension type (feature/relation) in Experiment 1

	Response latency								Accuracy							
	Upright faces				Inverted faces				Upright faces				Inverted faces			
	Compatible		Incompatible		Compatible		Incompatible		Compatible		Incompatible		Compatible		Incompatible	
Type of irrelevant dimension	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*
Feature	819	186	836	189	841	175	839	163	94	04	92	07	94	06	93	06
Relations	801	180	824	199	845	206	844	203	94	05	91	08	94	06	94	07
Total	810	180	830	190	843	188	841	182	94	04	91	08	94	06	93	06

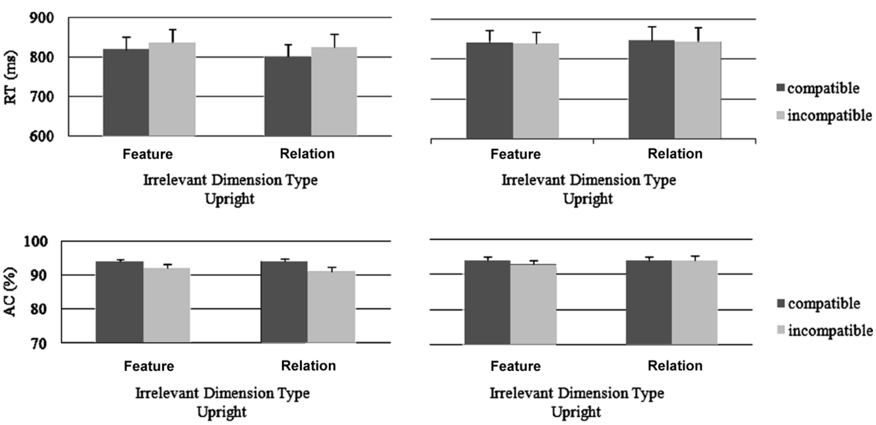

Figure 3. Response latency (top) and accuracy (bottom) in Experiment 1 for upright (left) and inverted (right) faces as a function of the irrelevant dimension type and compatibility between relevant and irrelevant dimension. Error bars represent standard errors.

addition, a significant two-way interaction between orientation and compatibility was obtained, $F(1, 31) = 5.11$, $MSE = 1{,}559$, $p < .03$, $\eta_p^2 = .142$, indicating a compatibility effect for upright (+20 ms; $F(1, 31) = 11.52$, $MSE = 1{,}146$, $p < .002$, $\eta_p^2 = .271$) but not for inverted faces (−2 ms; $F(1, 31) < 1$).

Accuracy

Analysis of the accuracy measure yielded similar performance as the latency. The main effect of compatibility, $F(1, 31) = 20.16$, $MSE = 0.001$, $p < .0001$, $\eta_p^2 = .394$, was significant as well as the Orientation × Compatibility interaction, $F(1, 31) = 6.90$, $MSE = 0.002$, $p < .01$, $\eta_p^2 = .182$. This interaction resulted from greater accuracy when the relevant and irrelevant dimensions were compatible than incompatible for upright faces (+3%; $F(1, 31) = 19.26$, $MSE = 0.002$, $p < .002$, $\eta_p^2 = .383$) but not for inverted ones (+0.7% ms; $F(1, 31) = 1.49$, $p > .23$).

Discussion

The results of Experiment 1 show that participants cannot ignore a facial attribute, presented in an upright face, even if it is irrelevant to the task. When asked to determine, in a sequential matching task, whether two mouths are identical or not, responses were longer and less accurate when the mouths were identical but the eyes were not, than when both facial features were the same. This interference was observed both when the irrelevant dimension was varied in its features, such as different eyes in the study-test faces, or in relations, such as a different inter-ocular distance between the study-test faces. In contrast to upright faces, a compatibility effect was not observed when the faces were presented upside-down. Participants were able to focus on the designated stimuli and to ignore the distractors.

These findings provide additional support to the view, advanced by Farah and colleagues (e.g., Farah et al., 1998), that individual face parts cannot be perceived separately without the perception of the entire face. The current study, however, provides a more stringent test to this hypothesis, since previous studies may have promoted, albeit implicitly, holistic perception and processing. In the present study, in contrast, participants were explicitly encouraged in advance to use a feature-level approach and to concentrate on a single, task-relevant, feature. The failure of the participants to adopt such a strategy emphasizes the mandatory nature of the holistic process in face perception.

In contrast to upright faces, inverted faces purportedly are not processed in a holistic fashion but analytically, with each part perceived individually. Assuming that these features are not processed in parallel it is feasible to claim that when faces are inverted it is possible to focus on a single relevant facial feature and ignore the others, as was demonstrated in Experiment 1.

Interestingly, both featural and relational variation of the irrelevant dimension interfered to the same extent with the feature matching task. This fits well with a holistic account which would claim that any of these changes produces a new face which will dominate over the individual feature processing. It is harder, however, to account for these results from a configural perspective which would have predicted that relational changes would have a greater impact on the relevant dimension processing than featural variation. Although the present findings are at odds with studies that have shown differential influences of features versus relations on face perception, findings which support the configural account (e.g., Bartlett & Searcy, 1993; Freire et al., 2000), they are compatible with current studies which have criticized past studies on methodological grounds and, more importantly, have failed to find such differences (e.g., McKone & Yovel, 2009; Riesenhuber, Jarudi, Gilad, & Sinha, 2004; Yovel & Kanwisher, 2004, 2008). For example, in a recent neuroimaging study comparable responses were found to relational and featural changes in a subregion of the fusiform gyrus (the fusiform face area, FFA, Kanwisher, McDermott, & Chun, 1997), which responds preferentially to faces, and probably generates their holistic representation (Schiltz & Rossion, 2006). Differential responses to relational and featural changes were found only outside the FFA (for similar findings see Liu, Harris, & Kanwisher, 2009).

In order to explain this discrepancy between studies that have found differences between featural and relational changes and those that did not Yovel and Kanwisher (2004; see also McKone & Yovel, 2009) have claimed that several of the previous studies (a) did not manipulate the shape of the face part but rather its brightness or color, which may reflect lower-level visual processes, and (b) failed to match the difficulty of the tasks in the featural and relational conditions. When these two concerns were addressed in their study no differences were found between the feature and relation tasks. We also attempted in the present study to overcome these caveats which may explain the similar results we obtained to those of Yovel and Kanwisher.

Before concluding that the lack of a compatibility effect in inverted faces stems from the fact that upside-down faces are not processed holistically, an alternative account should be considered. It could be argued that the task of matching inverted features demands more capacity-limited attentional resources than the matching of upright features. Consequently, the influence of the irrelevant dimension (whether featural or relational) will depend on the task's attentional demands; when the to-be-matched features are upright, attention can be allocated to the perception of the irrelevant dimension and it will affect the matching task. In contrast, when the to-be-matched features are inverted and require more attentional resources to process, fewer resources can be directed to perceive the irrelevant dimension and its influence will be marginal. Note that according to this account, the influence from an irrelevant dimension on the relevant dimension is not conditional upon the orientation of the *entire* face but rather on the orientation of the *relevant dimension* which is the task's primary target. To explore this issue further we modified the inverted face condition and presented the relevant dimension in an upright orientation.

Experiment 2

In a series of studies, Lavie and her colleagues (Lavie, 1995, 2000; Lavie & Cox, 1997; for review, see Lavie, 2005) have investigated the mechanism of selective attention, and the interplay between the successful perception of relevant target(s), on the one hand, and the rejection of irrelevant distractors, on the other. Their *load theory* of attention postulates that selective attention can either succeed or fail to prevent distractors from perception depending on the level of perceptual load in the relevant task. According to this model, in situations of high perceptual load, such as when many relevant stimuli are presented, perception of distractors will be prevented since the available capacity is dedicated to the perception of the relevant stimuli. In contrast, in situations of low perceptual load, such as when only one relevant stimulus is presented, available capacity will be automatically allocated to the processing of the irrelevant items.

This theory could account for the results observed in Experiment 1 without alluding to the unique processes underlying face perception. According to this theory, the differences in the compatibility effect observed between upright and inverted faces are not the result of disrupting the holistic/configural processing by inversion but rather the result of inverting the individual relevant facial feature (either mouth or eyes). Since the perceptual load of processing inverted features is higher than that of upright features the perception of irrelevant distractors is relatively prevented compared to upright features where the available processing capacity is directed to the perception of the irrelevant dimension (Lavie, 1995, 2000; Lavie & Cox, 1997).

This alternative hypothesis could be directly examined by comparing performance for upright relevant features located in an upright or inverted face (a stimulus similar to the one which gives rise to the Thatcher illusion, Thompson, 1980). If the reduction in the compatibility effect observed in Experiment 1 in the inverted condition arose from the high perceptual load demand of processing inverted features, then a compatibility effect should be observed when the relevant feature is presented upright despite being placed in an inverted face. If, however, the compatibility effect is the result of the whole face inversion and the loss of holistic processing, no compatibility effects would be seen for inverted faces even though the orientation of the relevant facial attribute is upright.

Method

Participants

Sixteen undergraduate students (11 males) at the University of Toronto participated in the experiment for course credit or pay. The participants were between the ages of 18 and 30 (mean age 22.19, $SD = 1.52$) and all had normal or corrected-to-normal vision.

Materials

The preparation of the upright faces was identical to the procedure described in Experiment 1. The inverted faces, however, were slightly modified and consisted of an upright relevant dimension (either mouth or eyes) positioned in an inverted face (Figure 4).

As in Experiment 1, the different sets of stimuli were grouped into four blocks determined by orientation (upright/inverted) and the nature of the change in the irrelevant dimension (featural/relational) with 96 trials in each block. The presentation order of the blocks and the face's gender were counterbalanced among participants.

Procedure

The procedure was identical to Experiment 1.

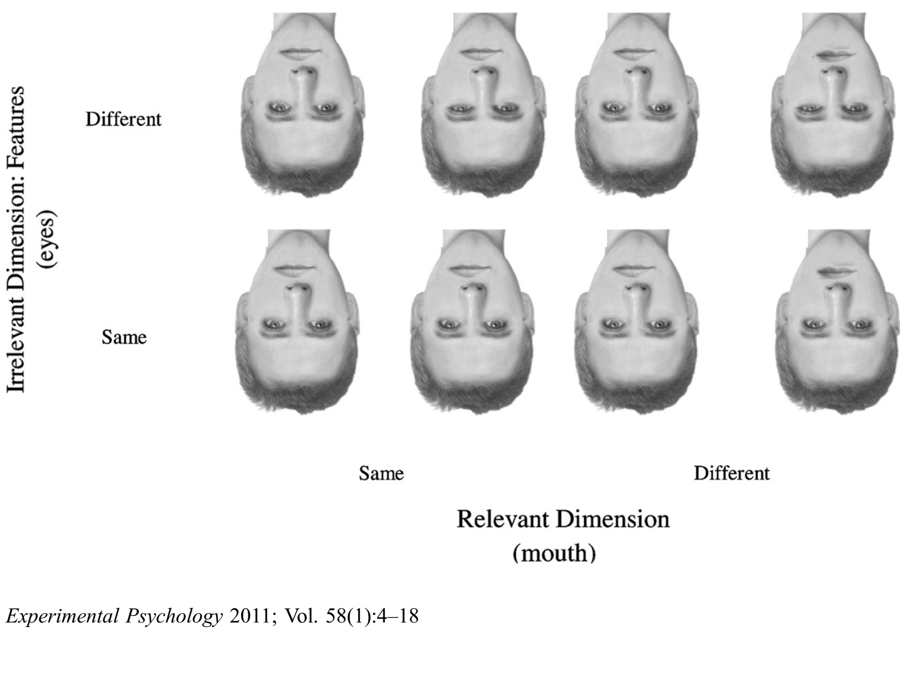

Figure 4. Example of stimuli used in Experiment 2 (featural set). For the inverted condition the relevant dimension (mouth) was presented upright. The four types of pairs were identical to Experiment 1. The relational set was created in a similar manner to Experiment 1.

Results

Mean response latency and accuracy are presented for the upright and inverted faces in Table 2. Only response times for correct trials were included in the analysis, after trimming those that were more than 2.5 *SD* above or below the mean RT of each participant in each condition.

The results are similar to those observed in Experiment 1, namely, a compatibility effect was found for upright faces but not for inverted faces (Figure 5). When faces were presented upright RT increased by 35 ms when the irrelevant features were incompatible with the relevant features (776 ms for compatible vs. 811 ms for incompatible features), and by 34 ms when the irrelevant relations were incompatible with the relevant features (from 771 to 805 ms, for compatible and incompatible, respectively). Similarly, accuracy also decreased when the irrelevant features or irrelevant relations were incompatible with the relevant features (from 95% to 94%, for compatible and incompatible features, respectively, and from 97% to 95% for compatible and incompatible relations, respectively). In contrast, no compatibility effect was observed for inverted faces even though the relevant dimension was presented upright. For latency minimal compatibility effects of −4 ms (compatible: 840 ms, incompatible: 836 ms) and +15 ms (compatible: 791 ms, incompatible: 807 ms) were found for the feature and relation conditions, respectively. For accuracy there was no compatibility effect in the feature condition (compatible: 96%, incompatible: 96%) and a 2% compatibility effect in the relation condition (compatible: 97%, incompatible: 95%).

These observations were confirmed in a repeated-measure ANOVA performed on latency and accuracy as a function of the following variables: orientation (upright/inverted), type of irrelevant dimension (feature/relation), and compatibility (irrelevant dimension compatible/incompatible with the relevant dimension).

Latency

The main effect of compatibility was significant, $F(1, 15) = 10.25$, $MSE = 1{,}287$, $p < .006$, $\eta_p^2 = .406$, resulting from reduced latency when the irrelevant dimension was compatible with the relevant dimension (795 ms) than when it was incompatible (815 ms). Moreover, a significant two-way interaction between orientation and compatibility was obtained, $F(1, 15) = 4.60$, $MSE = 1{,}329$, $p < .05$, $\eta_p^2 = .235$, resulting from compatibility effect for upright (+34 ms; $F(1, 15) = 13.57$, $MSE = 1{,}374$, $p < .002$, $\eta_p^2 = .475$) but not for inverted faces (+7 ms; $F(1, 15) < 1$).

Accuracy

Analysis of the accuracy measure yielded a main effect of compatibility, $F(1, 15) = 8.93$, $MSE = 0.001$, $p < .009$,

Table 2. Mean (and *SD*) response latency and accuracy (in %) for upright and inverted faces as a function of irrelevant dimension type (feature/relation) in Experiment 2

	Response latency								Accuracy							
	Upright faces				Inverted faces				Upright faces				Inverted faces			
	Compatible		Incompatible		Compatible		Incompatible		Compatible		Incompatible		Compatible		Incompatible	
Type of irrelevant dimension	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*
Feature	776	93	811	95	840	99	836	86	95	04	94	05	96	04	96	05
Relations	771	96	805	96	791	104	807	115	97	04	95	04	97	03	95	07
Total	774	92	808	93	815	101	822	99	96	04	95	04	97	03	96	06

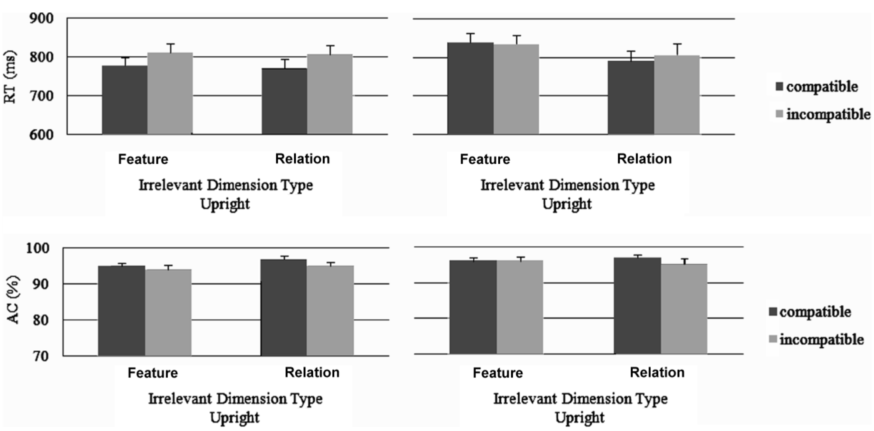

Figure 5. Response latency (top) and accuracy (bottom) in Experiment 2 for upright (left) and inverted (right) faces as a function of the irrelevant dimension type and compatibility between relevant and irrelevant dimension. Error bars represent standard errors.

$\eta_p^2 = .373$. The Orientation × Compatibility interaction was not significant, due probably to the small participants' sample, $F(1, 15) < 1$, yet the trend was in the correct direction; greater accuracy was observed when the relevant and irrelevant dimensions were compatible than when incompatible for upright faces (+1.5%; $F(1, 15) = 5.42$, $MSE = 0.001$, $p < .03$, $\eta_p^2 = .265$) but not for inverted ones (+1% ms; $F(1, 15) = 3.13$, $p > .10$). No other effects were significant.

Discussion

The results of Experiment 2 mirror to a large degree those found in Experiment 1. A compatibility effect was found for upright faces, stemming from the influence of an irrelevant facial attribute on sequential matching. This effect was not obtained for inverted faces despite the fact that the relevant feature was presented upright, thus minimizing the perceptual load required by the target's processing. The fact that a compatibility effect was not found in this latter condition supports the notion that the loss of the compatibility effect did not result from the inversion of the relevant feature but rather from the inversion of the entire face.

An interesting option which was not investigated in the present experiment is whether a compatibility effect would emerge if *both* the relevant and irrelevant dimensions would be presented in an upright orientation while the entire face is inverted. Although not directly addressed in Lavie's (2005) load theory, it could be claimed that the perceptual load required to process the distractor might also play a role in the interactions between target and distractor. Accordingly, since the processing of the irrelevant dimension may be more attention demanding when presented inverted than upright, a compatibility effect might emerge in this latter condition. However, the findings of Experiment 2 in which we failed to find a compatibility effect for inverted faces, especially when the irrelevant dimension involved featural change (which is more immune to inversion), dissuaded us from pursuing this avenue, although it cannot be completely dismissed.

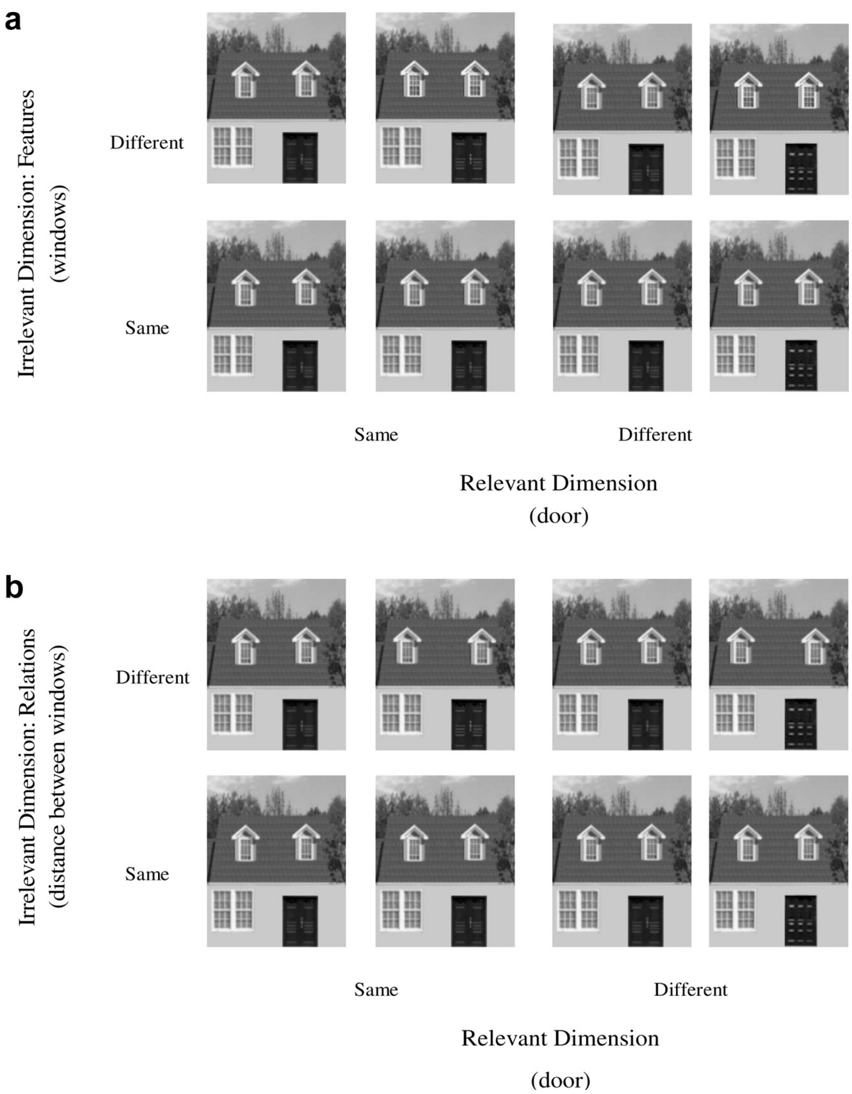

Figure 6. Example of stimuli used in Experiment 3. In the featural set (top) the houses differed either in their door or 2nd floor windows. In the relational set (bottom) houses differed in the distance between either 1st floor door and window or 2nd floor windows.

Although the processing of inverted faces resembles the type of processes which are employed in object perception, it is necessary to compare face and object recognition directly under the same experimental manipulations. In Experiment 3 we used the same paradigm as in Experiment 1 but houses were shown instead of faces. Participants were asked to judge whether two sequentially presented upright or inverted houses were similar or not in a predesignated feature (e.g., door) while an irrelevant dimension (e.g., windows) was varied. If the compatibility effects obtained for upright faces in Experiment 1 result from the holistic nature characterizing face perception, we hypothesize that these effects will not be found for houses, either upright or inverted.

Experiment 3

Participants

Thirty-two undergraduate students at the University of Toronto participated in the experiment for course credit or pay. The participants (15 males) were between the ages of 18 and 30 (mean age 20.90, *SD* = 2.44) and all had normal or corrected-to-normal vision.

Materials

The featural and relational sets of the house stimuli paralleled those of the face stimuli (Figure 6). The house sets were based on the design of two original houses. In the featural set, three modified versions of the original houses were made by replacing the door, 2nd floor windows, or both features with an alternative door and pair of windows. Each house was then paired with its identical copy or with a modified copy to create four types of house pairs: identical houses, houses different in the relevant dimension (e.g., the door), houses different in the irrelevant dimension (windows), and houses different both in the relevant and irrelevant dimensions (see Figure 6a). In the relational set, we used the original houses to generate houses in which the 1st floor door-window or 2nd floor windows' distances were modified. The 1st floor door-window distance in the modified houses was 1.37° of visual angle (compared to the 2.10° distance of the original houses), and the 2nd floor windows' distance was 1.37° of visual angle (compared to the 2.10° distance of the original houses). As in the featural set, each house was paired with an identical house, a house different in the relevant feature (e.g., the door), a house different in the irrelevant relation (the 2nd floor windows' distance), or different in both the relevant feature and the irrelevant relation dimension (see Figure 6b). For each of the above sets of houses inverted counterparts were created. All houses were sized to 67 × 86 mm and subtended 6.37° in width and 8.25° in height, and the distance between the relevant parts of the houses (windows and doors) was equated to the distance between the relevant and irrelevant parts of the faces in Experiments 1 and 2.

Similar to Experiment 1, the different sets of stimuli were grouped into four blocks determined by orientation (upright/inverted) and the nature of the change in the irrelevant dimension (featural/relational), with each block consisting of 96 trials. The identity of the house was counterbalanced between blocks and between subjects.

Procedure

The procedure was identical to Experiment 1.

Results and Discussion

Mean response latency and accuracy are presented for the upright and inverted houses in Table 3. Only response times for correct trials were included in the analysis, after excluding those that were more than 2.5 *SD* above or below the mean RT of each participant in each condition.

In contrast to perception of faces, perception of houses was not influenced by the irrelevant dimension when attention was focused on the relevant target. For upright houses a negligible compatibility effect of 8 ms in RT was obtained when the irrelevant dimension was varied in the feature condition (compatible: 775 ms, incompatible: 783 ms) and it was nonexistent in the relation condition (compatible: 777 ms, incompatible: 769 ms; Figure 7). A comparable pattern was found for inverted houses. Similar results were seen for accuracy.

Table 3. Mean (and *SD*) response latency and accuracy (in %) for upright and inverted houses as a function of irrelevant dimension type (feature/relation) in Experiment 3

	Response latency								Accuracy							
	Upright houses				Inverted houses				Upright houses				Inverted houses			
	Compatible		Incompatible		Compatible		Incompatible		Compatible		Incompatible		Compatible		Incompatible	
Type of irrelevant dimension	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*
Feature	775	172	783	173	770	181	773	172	95	05	95	05	96	05	96	03
Relations	777	179	769	171	788	188	782	186	96	04	94	06	96	05	96	03
Total	776	173	776	169	779	182	778	177	95	05	95	05	96	05	96	03

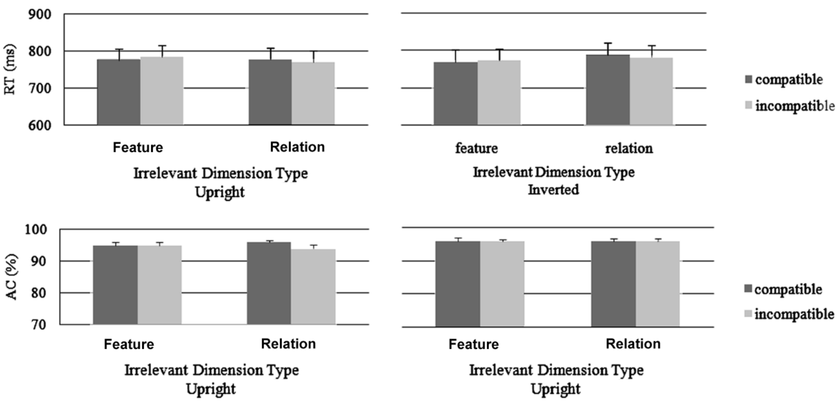

Figure 7. Response latency (top) and accuracy (bottom) in Experiment 3 for upright (left) and inverted (right) houses as a function of the irrelevant dimension type and compatibility between relevant and irrelevant dimension. Error bars represent standard errors.

A repeated-measure ANOVA performed on latency and accuracy as a function of orientation (upright/inverted), type of irrelevant dimension (feature/relation), and compatibility (irrelevant dimension compatible/incompatible with the relevant dimension) did not yield any significant effects. No significant main effects were found. Importantly, the significant two-way interaction between orientation and compatibility obtained in Experiments 1 and 2 for faces was not found for houses either in latency (a compatibility effect of +3 ms and −1 ms for upright and inverted houses, respectively) or accuracy (a compatibility effect of 0% for both upright and inverted houses, respectively; both F's < 1).

To further corroborate our findings, showing the existence of interference for upright faces but not upright houses, we conducted a three-way ANOVA for upright stimuli only (since no difference was obtained between faces and houses in the inverted condition), with Experiments 1 and 3 included as a between-subjects factor along with type of irrelevant dimension and compatibility as within-subject factors. The two-way interaction between compatibility and Experiment was significant for both latency, $F(1, 62) = 6.43$, $MSE = 997$, $p < .01$, $\eta_p^2 = .094$, and accuracy, $F(1, 62) = 9.36$, $MSE = .001$, $p < .003$, $\eta_p^2 = .131$, indicating that the differences seen for houses and faces are statistically valid when a direct comparison, across experiments, is performed.

The results of Experiment 3 clearly differ from those obtained in Experiment 1. Specifically, for houses, irrelevant dimensions did not interfere with the similarity judgment performed on the relevant feature. This finding was pertinent both for upright and inverted houses. Both orientations resembled the lack of interference that was seen in Experiment 1 for inverted faces and strengthen the notion that upright faces are processed in a manner which is qualitatively different than the one applied for houses and inverted faces.

General Discussion

The aim of the present study was to explore whether the perception of local facial features is dependent on the entire face context. In three experiments, five major finding were observed: (a) Perception of specific predetermined upright facial attributes could not proceed independently of other irrelevant facial attributes. Participants were unable to ignore the perception of these irrelevant attributes, expressed by the compatibility effect that was found. (b) The irrelevant dimension which influenced the perception of the relevant features could be either facial features or facial relations. Varying either a facial attribute or the metric distance between two facial features between a probe and a target face biased the way the participants responded to the relevant feature. (c) In contrast to upright faces, no compatibility effect was observed when faces were presented inverted. In the latter condition, participants were able to focus on the relevant dimension and ignore the irrelevant dimension. (d) This lack of a compatibility effect in the inverted condition cannot be attributed to increased perceptual load required to process the inverted relevant dimension, which may have prevented participants from processing the irrelevant distractor dimensions; even when the target features were presented in an upright orientation, but in an inverted face, no compatibility effect was observed. (e) Finally, for houses, no influence of the irrelevant dimension was observed, regardless of orientation. In the following discussion we will address the theoretical implications of these results to the understanding of the mechanisms and processes underlying face perception.

Farah and colleagues (Farah et al., 1998; Tanaka & Farah, 1993) had used a similar paradigm to demonstrate that faces are represented more holistically than other objects during perception. The definition they provided to the term *holistic* was that it characterizes a representation of a nondecomposed template, in which the local features themselves are not "explicitly represented." This definition was interpreted as expressing the view that face parts are less accessible to conscious perception than the whole face, and **not** that the face template is the primal component from which a representation is constructed (Carey & Diamond, 1994; see also Cabeza & Kato, 2000 who define this approach as a *moderate holistic view*). The present study replicates the original findings but also extends them by showing that even under stringent conditions that encourage perception of a face part but not the whole face, the perception of the former is strongly influenced by the latter. Moreover, the compatibility effect that was observed for upright faces, regardless of the type of variation in the irrelevant dimension, is consistent with the view that both feature and relation information were processed in an interactive holistic manner during the face part task (Yovel & Kanwisher, 2004).

Although the present study offers a rigorous test of holistic processing in face perception it may not be the ultimate one. As one reviewer suggested, the fact that the first face was not cued may have encouraged participants to encode the first face holistically. Yet, even if this occurred it is yet to be answered why did the participants prefer to encode the *second* face holistically although it impaired their performance. The holistic processing conducted on the second face despite the short presentation time and the spatial cuing to the relevant dimension highlights, in our view, the obligatory holistic processes that characterize face perception.

The experimental paradigm developed in the present study shares common attributes with the paradigm, first described by Young, Hellawell, and Hay (1987), which yielded the composite effect. In this latter paradigm composite faces are created by aligning the top half of a face with the bottom half of another. This alignment results in a fused novel face which disrupts the recognition of each half face. Recognition, however, improves when the two halves are misaligned or when the aligned face is inverted. This effect was replicated in numerous studies (e.g., Cheung, Richler, Palmeri, & Gauthier, 2008; de Heering, Houthuys, & Rossion, 2007; Gauthier, Curran, Curby, & Collins, 2003; Goffaux & Rossion, 2006; Michel, Rossion, Han, Chung, & Caldara, 2006; Schiltz & Rossion, 2006). The composite effect could be accounted for by both the configural and holistic hypotheses; With respect to the configural account, the relational metrics between facial features are changed when the two halves are combined. With respect to the holistic account, recognition of the half face is now required in the context of a new face. In the present paradigm as well, matching of a facial feature was required when the irrelevant features were either reconfigured or changed to create a new face. Note, however, that the present paradigm has attempted to reduce the likelihood of observing configural or holistic effects by focusing on a single relevant feature to encourage analytical processing, instead of requesting participants to recognize the entire half face as in the composite effect, which may promote holistic processes (see Leder & Bruce, 2000 who found inversion effects for half faces). Moreover, the present paradigm minimizes the changes in the irrelevant dimension, instead of changing completely the other half of the face as in the composite effect. The failure to prevent configural/holistic processing in our study is a dramatic demonstration of the robustness of the unique processes underlying face perception.

The interference incurred by the incompatible dimension despite its disadvantageous consequences has implications regarding the role of attention in face perception (for review see Palermo & Rhodes, 2007). One of the key characteristics of automatic processing is its mandatory nature, occurring unavoidably without the perceiver's intentions (e.g., Coltheart, 1999). Several findings have shown that faces attract attention in visual arrays, and distractor faces that are-to-be ignored are nevertheless processed and disrupt performance (Farah, Wilson, Drain, & Tanaka, 1995; Khurana, Smith, & Baker, 2000; Young, Ellis, Flude, McWeeny, & Hay, 1986). For example, Lavie and colleagues (Lavie, Ro, & Russell, 2003; see also Jenkins, Lavie, & Driver, 2003) have found that the perception of irrelevant distractor faces was not affected by the attentional load exerted on the target's task of name search. On the basis of these findings they concluded that distractor faces may be the exception to the effects usually observed on processing distracters under different conditions of perceptual load, since face processing may be mandatory (but see Jenkins, Lavie, & Driver, 2005 with conflicting results). It should be noted, however, that the present study diverges from these previous studies in demonstrating mandatory processing of elements within a face while the abovementioned studies focus on the mandatory processing of faces as such, as compared to objects. In this respect, our study is similar to Suzuki and Cavanagh's (1995) which showed that both feature and conjunction visual searches are influenced by the facial organization of the search set. Specifically, in the feature search, participants were *slower* at detecting the curvature of a single arc when it appeared within a schematic face than in a meaningless configuration. Conversely, they were *faster* in performing a conjunction search (detecting one upward and two downward arcs) when the target appeared within a schematic face. Thus, both findings clearly show, as in the present study, that the global representation of the face is processed during the speeded matching of one of its constituent features or patterns and cannot be ignored. It should be emphasized, however, that the present study underscores the mandatory aspects embedded in face processing, namely, that holistic computation can commence without an act of will. Yet, it does not preclude the possibility that late inhibition processes can override or stop these holistic processes (MacLeod, 2007). Thus, for example, Hole (1994) has shown that the composite effect is greatly reduced at long stimulus durations.

The influence of the irrelevant facial attribute on processing the relevant facial dimension stands in contrast to what has been found for houses in the present study, where no compatibility effects were found, regardless of the house's orientation. The ability to attend selectively to a specific component of an object (e.g., window) while ignoring other components of the object is consistent with several models of object recognition (e.g., Biederman, 1987; Marr, 1982). These models emphasize that an object is first decomposed into its constituent parts before being integrated into a coherent object (see Kimchi, 2003 for a different view). Accordingly, it may be possible to bias attention to process individual relevant parts of an object without processing obligatorily all its components and their finer details (although the representation of the global object may be automatically activated, Dell'Acqa & Job, 1998). Research has recently began to examine selective attention to specific features within objects (e.g., Fanini, Nobre, & Chelazzi, 2006; Nobre, Rao, & Chelazzi, 2006) revealing that individual features of a single object can be differentially processed as a result of attention. However, the investigative focus of these studies was the role of selective attention in processing perceptual features of an object (e.g., color, motion, and orientation), and not the processing of object parts, as in the present study. At present, it is not clear whether a direct comparison is possible.

The mandatory characteristic of face perception is also at odds with word recognition. Traditionally, semantic activation, namely the retrieval of a word's meaning, has been assumed to occur automatically without the perceiver's intent and allocation of attention. The strongest evidence for this view has been demonstrated in the Stroop task (Stroop, 1935), where the identification of a printed word's color is impeded if the word itself denotes a different color (e.g., the word *blue* in a *red* color). The interfering influence of the word on the color's identification has been interpreted as supporting the claim that, under most circumstances, reading is obligatory despite the fact that it is detrimental to the task at hand (MacLeod, 1991). More recent findings, however, have shown that the Stroop interference is subject to attentional control, and if, for example, only one letter is colored or when one letter is cued by an arrow, the Stroop interference diminishes and sometimes even disappears (Besner & Stolz, 1999a, 1999b; Besner, Stolz, & Boutilier, 1997). Thus, task demands can modulate the types of processes performed on a stimulus, and deviations from default modes of processing can occur when proven ineffective. The results of the present study, however, indicate that the processes involved in face perception are more immune to task demands than either word or object perception. In this view, face perception can be considered a strong automatic process.

In conclusion, the present study joins previously published studies which highlight the automatic aspects that characterize face perception. In particular, it underscores the fact that individual facial features cannot be perceived independently of each other and that the whole, upright face is attended during perception. Yet, attention and automaticity are complex terms encompassing several attributes which may apply in tandem or separately to processes involved in face perception. Faces themselves may be perceived more or less automatically depending on their familiarity (e.g., Jenkins, Burton, & Ellis, 2002; Lavie et al., 2003), expression (Vuilleumier, Armony, Driver, & Dolan, 2001), and their significance (e.g., Bindemann, Burton, Langton, Schweinberger, Doherty, 2007). Moreover, attentional factors may modulate differently the various processes involved in face perception (e.g., Williams, Moss, & Bradshaw, 2004). It is hoped that further research will elucidate these issues.

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References

Ashworth, A. R. S. III, Vuong, Q. C., Rossion, B., & Tarr, M. J. (2008). Recognizing rotated faces and Greebles: What properties drive the face inversion effect? *Visual Cognition, 16*, 754–784.

Bartlett, J. C., & Searcy, J. (1993). Inversion and configuration of faces. *Cognitive Psychology, 25*, 281–316.

Bartlett, J. C., Searcy, J., & Abdi, H. (2003). What are the routes to face recognition? In M. A. Peterson & G. Rhodes (Eds.), *Perception of faces, objects, and scenes* (pp. 21–52). New York: Oxford University Press.

Barton, J. J. S., Deepak, S., & Malik, N. (2003). Attending to faces: Change detection, familiarization, and inversion effects. *Perception, 32*, 15–28.

Besner, D., & Stolz, J. A. (1999a). What kind of attention modulates the Stroop effect? *Psychonomic Bulletin & Review, 6*, 99–104.

Besner, D., & Stolz, J. A. (1999b). Unconsciously controlled processing: The Stroop effect reconsidered. *Pyschonomic Bulletin & Review, 6*, 449–455.

Besner, D., Stolz, J. A., & Boutilier, C. (1997). The Stroop effect and the myth of automaticity. *Psychonomic Bulletin & Review, 4*, 221–225.

Biederman, I. (1987). Recognition-by-components: A theory of human image understanding. *Psychological Review, 94*, 115–147.

Bindemann, M., Burton, A. M., Langton, S. R. H., Schweinberger, S. R., & Doherty, M. J. (2007). The control of attention to faces. *Journal of Vision, 7*(10), 1–8.

Cabeza, R., & Kato, T. (2000). Features are also important: Contributions of featural and configural processing to face recognition. *Psychological Science, 11*, 429–433.

Carey, S., & Diamond, R. (1994). Are faces perceived as configurations more by adults than by children? *Visual Cognition, 1*, 253–274.

Cheung, O. S., Richler, J. J., Palmeri, T. J., & Gauthier, I. (2008). Revisiting the role of spatial frequencies in the holistic processing of faces. *Journal of Experimental Psychology: Human Perception and Performance, 34*, 1327–1336.

Coltheart, M. (1999). Modularity and cognition. *Trends in Cognitive Sciences, 3*, 115–120.

de Heering, A., Houthuys, S., & Rossion, B. (2007). Holistic face processing is mature at 4 years of age: Evidence from the composite face effect. *Journal of Experimental Child Psychology, 96*, 57–70.

Dell'Acqa, R., & Job, R. (1998). Is object recognition automatic? *Psychonomic Bulletin & Review, 5*, 496–503.

Diamond, R., & Carey, S. (1986). Why faces are and are not special: An effect of expertise. *Journal of Experimental Psychology: General, 115*, 107–117.

Fanini, A., Nobre, A. C., & Chelazzi, L. (2006). Selecting and ignoring the component features of a visual object: A negative priming paradigm. *Visual Cognition, 14*, 584–618.

Farah, M. J. (2004). *Visual agnosia*. Cambridge, MA: MIT Press.

Farah, M. J., Tanaka, J. W., & Drain, H. M. (1995). What causes the face inversion effect? *Journal of Experimental Psychology: Human Perception and Performance, 21*, 628–634.

Farah, M. J., Wilson, K. D., Drain, H. M., & Tanaka, J. R. (1995). The inverted face inversion effect in prosopagnosia: Evidence for mandatory, face-specific perceptual mechanisms. *Vision Research, 35*, 2089–2093.

Farah, M. J., Wilson, K. D., Drain, M., & Tanaka, J. N. (1998). What is "special" about face perception? *Psychological Review, 105*, 482–498.

Freire, A., Lee, K., & Symons, L. A. (2000). The face-inversion effect as a deficit in the encoding of configural information: Direct evidence. *Perception, 29*, 159–170.

Gauthier, I., Curran, T., Curby, K. M., & Collins, D. (2003). Perceptual interference supports a non-modular account of face processing. *Nature Neuroscience, 6*, 428–432.

Gauthier, I., & Tarr, M. J. (2002). Unraveling mechanisms for expert object recognition: Bridging brain activity and behavior. *Journal of Experimental Psychology: Human Perception and Performance, 28*, 431–446.

Goffaux, V., & Rossion, B. (2006). Faces are "spatial" – Holistic face perception is supported by low spatial frequencies. *Journal of Experimental Psychology: Human Perception and Performance, 32*, 1023–1039.

Hole, G. J. (1994). Configurational factors in the perception of unfamiliar faces. *Perception, 23*, 65–74.

Husk, J. S., Bennett, P. J., & Sekuler, A. B. (2007). Houses and textures: Investigating the characteristics of inversion effects. *Vision Research, 47*, 3350–3359.

Jenkins, R., Burton, A. M., & Ellis, A. W. (2002). Long-term effects of covert face recognition. *Cognition, 86*, B43–B52.

Jenkins, R., Lavie, N., & Driver, J. (2003). Ignoring famous faces: Category-specific dilution of distractor interference. *Perception & Psychophysics, 65*, 298–309.

Jenkins, R., Lavie, N., & Driver, J. (2005). Recognition memory for distractor faces depends on attentional load at exposure. *Psychonomic Bulletin & Review, 12*, 314–320.

Kanwisher, N., McDermott, J., & Chun, M. M. (1997). The fusiform face area: A module in human extrastriate cortex specialized for face perception. *Journal of Neuroscience, 17*, 4302–4311.

Khurana, B., Smith, W. C., & Baker, M. T. (2000). Not to be and then to be: Visual representation of ignored unfamiliar faces. *Journal of Experimental Psychology: Human Perception and Performance, 26*, 246–263.

Kimchi, R. (2003). Relative dominance of holistic and component properties in the perceptual organization of visual objects. In M. A. Peterson & G. Rhodes (Eds.), *Perception of faces, objects, and scenes: Analytic and holistic processes* (pp. 235–267). New York: Oxford University Press.

Lavie, N. (1995). Perceptual load as a necessary condition for selective attention. *Journal of Experimental Psychology: Human Perception and Performance, 26*, 451–468.

Lavie, N. (2000). Selective attention and cognitive control: Dissociating attentional functions through different types of load. In S. Monsell & J. Driver (Eds.), *Attention and performance XVIII* (pp. 175–194). Cambridge, MA: MIT Press.

Lavie, N. (2005). Distracted and confused? Selective attention under load. *Trends in Cognitive Sciences, 9*, 75–82.

Lavie, N., & Cox, S. (1997). On the efficiency of attentional selection: Efficient visual search results in inefficient rejection of distraction. *Psychological Science, 8*, 395–398.

Lavie, N., Ro, T., & Russell, C. (2003). The role of perceptual load in processing distractor faces. *Psychological Science, 14*, 510–515.

Leder, H., & Bruce, V. (1998). Local and relational aspects of face distinctiveness. *Quarterly Journal of Experimental Psychology: A. Human Experimental Psychology, 51*, 449–473.

Leder, H., & Bruce, V. (2000). When inverted faces are recognised: The role of configural information in face recognition. *Quarterly Journal of Experimental Psychology: A. Human Experimental Psychology, 53*, 513–536.

Leder, H., Candrian, G., Huber, O., & Bruce, V. (2001). Configural features in the context of upright and inverted faces. *Perception, 30*, 73–83.

Le Grand, R., Mondloch, C. J., Maurer, D., & Brent, H. P. (2001). Early visual experience and face processing. *Nature, 410*, 890.

Le Grand, R., Mondloch, C. J., Maurer, D., & Brent, H. P. (2004). Impairment in holistic face processing following early visual deprivation. *Psychological Science, 15*, 762–768.

Liu, J., Harris, A., & Kanwisher, N. (2009). Perception of face parts and face configurations: An fMRI study. *Journal of Cognitive Neuroscience*.

MacLeod, C. M. (1991). Half a century of research on the Stroop effect: An integrative review. *Psychological Bulletin, 109*, 163–203.

MacLeod, C. M. (2007). The concept of inhibition in cognition. In D. S. Gorfein & C. M. MacLeod (Eds.), *Inhibition in cognition* (pp. 3–23). Washington: American Psychological Association.

Marr, D. (1982). *Vision*. San Francisco: Freeman.

Maurer, D., Le Grand, R., & Mondloch, C. J. (2002). The many faces of configural processing. *Trends in Cognitive Sciences, 6*, 255–260.

Maurer, D., O'Craven, K. M., Le Grand, R., Mondloch, C. J., Springer, M. V., Lewis, T. L., et al. (2007). Neural correlates of processing facial identity based on features versus their spacing. *Neuropsychologia, 45*, 1438–1451.

McKone, E., & Yovel, G. (2009). Why does picture-plane inversion sometimes dissociate perception of features and spacing in faces, and sometimes not? *Psychonomic Bulletin and Review, 16*, 778–797.

Michel, C., Rossion, B., Han, J., Chung, C.-S., & Caldara, R. (2006). Holistic processing is finely tuned for faces of our own race. *Psychological Science, 17*, 608–615.

Murray, J. E., Yong, E., & Rhodes, G. (2000). Revisiting the perception of upside-down faces. *Psychological Science, 11*, 492–496.

Nobre, A. C., Rao, A., & Chelazzi, L. (2006). Selective attention to specific features within objects: Behavioral and electrophysiological evidence. *Journal of Cognitive Neuroscience, 18*, 539–561.

Palermo, R., & Rhodes, G. (2007). Are you always on my mind? A review of how face perception and attention interact. *Neuropsychologia, 45*, 75–92.

Psychological Software Tools, Inc. *E-prime (version 1.0b) [Computer Software]*. Pittsburgh, PA: Psychological Software Tools.

Rakover, S. S. (2002). Featural vs. configurational information in faces: A conceptual and empirical analysis. *British Journal of Psychology, 93*, 1–30.

Rhodes, G. (1988). Looking at faces: First-order and second-order features as determinants of facial appearance. *Perception, 17*, 43–63.

Rhodes, G., Brake, S., & Atkinson, A. P. (1993). What's lost in inverted faces? *Cognition, 47*, 25–57.

Riesenhuber, M., Jarudi, I., Gilad, S., & Sinha, P. (2004). Face processing in humans is compatible with a simple shape-based model of vision. *Proceedings of the Royal Society of London, B, Biological Sciences, 271*, S448–S450.

Schiltz, C., & Rossion, B. (2006). Faces are represented holistically in the human occipito-temporal cortex. *NeuroImage, 32*, 1385–1394.

Schwaninger, A., Ryf, S., & Hofer, F. (2003). Configural information is processed differently in the perception and recognition of faces. *Vision Research, 43*, 1501–1505.

Searcy, J. H., & Bartlett, J. C. (1996). Inversion and processing of component and spatial-relational information in faces. *Journal of Experimental Psychology: Human Perception and Performance, 22*, 904–915.

Sekuler, A. B., Gaspar, C. M., Gold, J. M., & Bennett, P. J. (2004). Inversion leads to quantitative, not qualitative, changes in face processing. *Current Biology, 14*, 391–396.

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 18*, 643–662.

Suzuki, S., & Cavanagh, P. (1995). Facial organization blocks access to low-level features: An object inferiority effect. *Journal of Experimental Psychology: Human Perception and Performance, 21*, 901–913.

Tanaka, J. W., & Farah, M. J. (1993). Parts and wholes in face recognition. *The Quarterly Journal of Experimental Psychology, 46A*, 225–245.

Tanaka, J. W., & Sengco, J. A. (1997). Faces and their configuration in face recognition. *Memory & Cognition, 25*, 583–592.

Thompson, P. (1980). Margaret Thatcher – A new illusion. *Perception, 9*, 483–484.

Valentine, T. (1988). Upside-down faces: A review of the effect of inversion upon face recognition. *British Journal of Psychology, 79*, 471–491.

Vuilleumier, P., Armony, J. L., Driver, J., & Dolan, R. J. (2001). Effects of attention and emotion on face processing in the human brain: An event-related fMRI study. *Neuron, 30*, 829–841.

Williams, M. A., Moss, S. A., & Bradshaw, J. L. (2004). A unique look at face processing: The impact of masked faces on the processing of facial features. *Cognition, 91*, 155–172.

Young, A. W., Ellis, A. W., Flude, B. M., McWeeny, K. H., & Hay, D. C. (1986). Face-name interference. *Journal of Experimental Psychology: Human Perception and Performance, 12*, 466–475.

Young, A. W., Hellawell, D., & Hay, D. C. (1987). Configural information in face perception. *Perception, 16*, 747–759.

Yovel, G., & Kanwisher, N. (2004). Face perception: Domain specific, not process specific. *Neuron, 44*, 1–20.

Yovel, G., & Kanwisher, N. (2008). The representations of spacing and part-based information are associated for upright faces but dissociated for objects: Evidence from individual differences. *Psychonomic Bulletin & Review, 15*, 933–939.

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