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Effects of Familiarity on the Perceptual Integrality of the Identity and Expression of Faces: The Parallel-Route Hypothesis Revisited

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The effects of familiarity on selective attention for the identity and expression of faces were tested using Garner's speeded-classification task. In 2 experiments, participants classified expression (or identity) of familiar and unfamiliar faces while the irrelevant dimension of identity (or expression) was either held constant (baseline condition) or varied randomly (filtering condition). Selective attention was measured by the difference in performance between these 2 conditions. Failure of selective attention was larger for familiar than for unfamiliar faces. In addition, failure of selective attention was found both for identity and for expression judgments. These findings show that familiarity increases the perceptual integrality between identity and expression, and they question previous studies arguing that identity judgments are always resistant to irrelevant variations in expression. The authors suggest that the systems processing identity and expression are interconnected in that facial identity serves as a reference from which expressions can be more easily derived.

According to orthodox face-recognition models (e.g., Bruce & Young, 1986; Burton, Bruce, & Johnston, 1990; Calder, Burton, Miller, Young, & Akamatsu, 2001), the processing of information regarding the identity of faces takes place within a dedicated cognitive route that is independent of the cognitive route that processes other types of face-related information. According to these models, identity-based processing relies on information that is stored in face-recognition units (FRUs), which are abstract, long-term memory representations of faces. In contrast, information that is not relevant for identification—for example, information regarding the expression, sex, or mouth shape of faces—is thought to be processed by a parallel pathway that does not involve the activation of FRUs (for a variation on these models, see Haxby, Hoffman, & Gobbini, 2000, 2002).

According to this *parallel-route hypothesis*, face-relevant processes are divided into two independent types. The first type, *face identification*, is based on semantic information regarding the identity of individual faces (i.e., Bruce & Young, 1986; Burton et al., 1990; Campbell, Brooks, de Haan, & Roberts, 1996). Face-identification processes include the extraction of the name of the person to whom a particular face belongs, that person's profession, or any other semantic-specific information that belongs to the face.

The second type of face-relevant process is termed *face classification*. Face-classification processes are not identity specific but are based on visual information that is common to all faces. Face-classification processes include the extraction of facial attributes, such as the expression of a face, its sex, its mouth shape, and the direction of gaze. The current article focuses on the relationship between the processing of expression and the processing of identity and examines whether these two processes are indeed independent.

The parallel-route hypothesis has captured the attention of face-perception researchers. These researchers have tested its validity with a variety of experimental measures, including behavioral measures in healthy (e.g., Calder et al., 2001) and in brain-injured participants (e.g., Humphreys, Donnelley, & Riddoch, 1993; Parry, Young, Saul, & Moss, 1991), as well as with neuroimaging techniques (e.g., Dubois et al., 1999; Rossion, Schiltz, Robaye, Pirenne, & Crommelinck, 2001).

The two face-classification tasks that have been most extensively examined are sex judgments and expression judgments. The sex-judgment task (*Is this a man or a woman?*; e.g., Hay, 1999; Rossion, 2002) has produced results that are at odds with the parallel-route hypothesis. Thus, recent neuroimaging (Dubois et al., 1999; Henson et al., 2003; Rossion et al., 2001) and behavioral studies (Baudouin & Tiberghien, 2002; Calder et al., 2001; Ganel & Goshen-Gottstein, 2002; Goshen-Gottstein & Ganel, 2000; Rossion, 2002) have provided strong evidence against the parallel-route hypothesis for the processing of the identity and the sex of faces.

For example, Goshen-Gottstein and Ganel (2000) found repetition-priming effects (defined as facilitated processing for studied as compared with unstudied items) for faces using sex judgments. Repetition-priming effects are considered to be the result of the reactivation of FRUs (for a review of repetition effects for different classes of stimuli, see Moscovitch, Goshen-Gottstein, & Vriezen, 1994; Moscovitch, Vriezen, & Goshen-Gottstein, 1993). Therefore, the demonstration that repetition effects can be found when sex judgments are used suggests that the processing of sex and the processing of facial identity (which is stored in FRUs) are performed within a common cognitive route.

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Yet further evidence for the idea that sex and identity are processed by a common route was provided by Ganel and Goshen-Gottstein (2002). Ganel and Goshen-Gottstein used Garner's speeded-classification task to test whether selective attention to sex could be achieved without being influenced by variations in the identity of faces and whether selective attention to identity could be achieved without being influenced by variations in the sex of faces. The results showed that selective attention to either one of these two dimensions could not be achieved independently of the other dimension. These results converge with Goshen-Gottstein and Ganel's (2000) earlier results in showing that sex and identity are processed by a common route. Hence, existing data are best accounted for by the idea that identity and sex are processed by a single functional (as well as neuroanatomical) route.

The second face-classification task whose relationship to identity has been explored, and which is the focus of this article, is the expression-judgment task. In contrast with the unequivocal support for a single route for the processing of identity and sex, some studies exploring the relationship between identity and expression have found evidence for parallel processing of these two dimensions (Breiter et al., 1996; Campbell et al., 1996; Schweinberger, Baird, Blumler, Kaufmann, & Mohr, 2003; Tranel, Damasio, & Damasio, 1988; Young, Newcombe, de Haan, Small, & Hay, 1993), whereas other studies have found support for the notion that the processing of identity and expression is handled by a common route (Baudouin, Sansone, & Tiberghien, 2000; Schweinberger, Burton, & Kelly, 1999; Schweinberger & Soukup, 1998; Sugase, Yamane, Ueno, & Kawano, 1999; Young, Hellawell, van de Wal, & Johnson, 1996).

In this article, we argue that existing data on the relationship between expression and identity cannot be interpreted by either a radical view of complete parallel processing or the opposing view of common processing of these two dimensions. Therefore, we propose a third view to describe the relationship between the systems that process identity and expression. We propose that there are two separate systems for the processing of identity and expression but that these systems are not completely independent but are, rather, interconnected. The nature of this interconnection is explored in this article using Garner's speeded-classification task. But first, we turn to a review of the evidence regarding the parallel processing of expression and identity.

Neuropsychological and neuroimaging studies have generally supported the parallel-route hypothesis for identity and expression. First, neuropsychological studies have described prosopagnosic patients who were impaired in recognizing faces yet preserved relatively intact abilities to process expression (Humphreys et al., 1993; Parry et al., 1991; Tranel et al., 1988). There are also reports of patients who have shown the reverse dissociation (Hornak, Rolls, & Wade, 1996; Humphreys et al., 1993; Kurucz & Feldmar, 1979; Kurucz, Feldmar, & Werner, 1979).

Second, results of neuroimaging studies have revealed that identity processing is mostly associated with activity in the inferior occipital and lateral fusiform gyri (George et al., 1999; Sergent, Otha, & Macdonald, 1992), whereas the processing of expression is primarily mediated by the amygdala (Breiter et al., 1996; Morris et al., 1996; Vuilleumier, Armony, Driver, & Dolan, 2003) and the superior temporal sulcus (STS; see Critchley et al., 2000; for a review, see Posamentier & Abdi, 2003). Third, single-cell recordings in monkeys have shown that different cells are activated during the processing of expression (and direction of gaze) than during the processing of identity (Hasselmo, Rolls & Baylis, 1989; Perrett et al., 1984).

Finally, the notion that expression and identity are processed independently is also supported by behavioral data from healthy participants. Ellis, Young, and Flude (1990; but see Goshen-Gottstein & Ganel, 2000) demonstrated that repetition-priming effects are found for face-identification processing (familiarity judgments) but not for expression judgments (speeded classification of smiling and nonsmiling faces). This pattern supports the parallel-route hypothesis because, according to that model, only face-identification tasks, which are based on the activation of FRUs, should benefit from FRUs' reactivation upon a repeated presentation (also see Goshen-Gottstein & Moscovitch, 1995a, 1995b; Reingold & Goshen-Gottstein, 1996). Expression judgments, however, are presumed to be processed in parallel routes from FRUs and should, therefore, not benefit from their reactivation.

The evidence so far suggests that identity and expression are mediated by different systems. Still, this evidence does not exclude the possibility that these systems are interconnected. Indeed, at least three lines of research support the notion that the system that processes identity and the system that processes expression are not completely independent and so must be interconnected. First, Young et al. (1996; for a similar case, see Rivest, Moscovitch, & Cadieux, 2003) described an amygdalotomy patient, D.R., who was severely impaired in her ability to make expression judgments. This patient was, however, less impaired in her ability to perform identity matching of two simultaneously presented faces. It is critical to note that D.R. exhibited severe difficulties in a specific condition of identity matching when the two photos depicted the same individual with two different expressions. In this condition, D.R. mistakenly judged the two photos to be of two different individuals. Young et al. argued that D.R.'s failure to recognize expressions interfered with her ability to extract identity. In particular, they suggested that for the face-identification system to operate properly, it must receive accurate information about the expressions of faces from the system that processes expression. Thus, the pattern of performance of D.R. suggests some cross talk, in at least one direction, from the system that processes expression to the system that processes identity.

A second line of evidence for cross talk between the systems that process identity and expression comes from a study that examined single-cell recordings in macaque monkeys (Sugase et al., 1999). In this case, the researchers tested the relationship between cells that compute the identity and cells that compute the expression of faces. They reported that specific cells in the STS responded with different latencies to the identity and the expression of faces, suggesting that the systems that process these two facial dimensions may overlap. The finding of identity-specific cells in the STS (which is an area attributed to the processing of expression) suggests that for proper computation of expression, input regarding the identity of faces is required.

In summary, from the two first lines of evidence on the processing of expression and identity, it seems that although the hypothesis that these facial dimensions are processed by different cognitive systems has received much support, there are also good reasons to question the orthodox version of this hypothesis, which posits complete independence between these two systems. Indeed, a striking demonstration of an interaction between the processing

of expression and identity comes from a third line of research, in studies using Garner's speeded-classification task, which is described below.

Evidence From Selective Attention Against the View of Complete Independence Between the Processing of Identity and Expression

In two studies that were designed to explore the relationship between the processing of identity and expression, Schweinberger et al. (1999) and Schweinberger and Soukup (1998) provided evidence that the processing of expression depends on the identity of the faces. These results were replicated for both healthy and schizophrenic patients (Baudouin, Martin, Tiberghien, Verlut, & Franck, 2002). All three studies used Garner's speeded-classification task (Felfoldy & Garner, 1971; Garner, 1974, 1976; Melara & Algom, 2003).

Garner's speeded-classification task examines the ability to direct selective attention to a specific dimension of an object (Felfoldy, 1974; Ganel & Goodale, 2003) or a face (Schweinberger & Soukup, 1998) while ignoring its other irrelevant dimensions. For a given pair of dimensions belonging to a single object or a face, Garner's task can be used to measure whether one dimension (e.g., identity) can be processed without being influenced by the other, irrelevant dimension (e.g., expression) and, similarly, whether the other dimension (e.g., expression) can be processed without being influenced by the irrelevant first dimension (e.g., identity). Support for the independent processing of a given pair of dimensions is found if the processing of each of the dimensions, when it is defined to be the relevant dimension, is not influenced by the other, irrelevant dimension. In this case, the two dimensions are labeled *separable dimensions*. If, however, the processing of each of the dimensions cannot be made without interference from the other, irrelevant dimension, the two dimensions are labeled *integral dimensions*.

Garner's task has recently been used as an effective tool to test the relationship between several pairs of facial dimensions, including identity and sex (Ganel & Goshen-Gottstein, 2002), expression and direction of gaze (Ganel, Goshen-Gottstein, & Goodale, 2003), identity and mouth shape (Schweinberger & Soukup, 1998), sex and expression (Ben-Artzi & Gilboa-Schectman, 2001; Le Gal & Bruce, 2002), and identity and expression (Baudouin et al., 2002; Etcoff, 1984; Schweinberger et al., 1999; Schweinberger & Soukup, 1998). Below, we describe how Garner's paradigm has been used to test the relationship between identity and expression.

Garner's paradigm is typically composed of two experimental blocks. In each block, participants are asked to make speeded classification of one relevant dimension while ignoring the other, irrelevant dimension. In Schweinberger and Soukup's (1998) study, the stimuli were face photos, which were created as a factorial combination of two different identities (Person A, Person B) posing one of two different expressions (smiling, angry). In one of the experimental conditions, the *baseline block*, the relevant dimension (e.g., expression) varied while the irrelevant dimension (e.g., identity) was held constant. Participants were asked to make speeded expression judgments while only the photos of one person (Person A in a first baseline block or Person B in a second baseline block), bearing different expressions, were presented throughout the block.

Performance (reaction times [RTs] and accuracy) in the baseline blocks was compared with performance in the *filtering block*, in which both relevant and irrelevant dimensions varied randomly. Equal performance in baseline and filtering blocks is an indication that the expression (or identity) of faces can be perceived without being influenced by irrelevant variations in identity (or in expression). This would suggest that the processing of the one dimension is independent of the processing of the other dimension. However, worse performance in the filtering block as compared with the baseline block is labeled *Garner interference*. Garner interference between identity and expression suggests that these facial dimensions cannot be processed independently.

Schweinberger and Soukup (1998), Schweinberger et al. (1999), and Baudouin et al. (2002) all found robust Garner interference from identity to expression, with irrelevant variations in identity interfering with expression judgments. At the same time, these studies found that irrelevant variations in expression did not interfere with identity judgments. This asymmetric pattern of Garner interference between identity and expression suggests at least one direction of cross talk between the systems that process identity and expression.

The purpose of the current study was to elucidate the nature of the cross talk between the systems that process identity and expression. To this end, we advance a hypothesis that is based on the distinction made between invariant and changeable properties of faces (Haxby et al., 2000). Invariant facial properties are important for identification and include the unique facial configuration (i.e., structure) inherent in individual faces. Changeable properties of faces include variations from this structure produced by dynamic changes in the expression, mouth shape, or direction of gaze. Haxby et al. (2000) used this distinction to propose a neuroanatomical model for face perception in which the processing of invariant features of faces (i.e., identity) is mediated by different brain regions than the processing of changeable features of faces (e.g., expression).

Our hypothesis is also based on the distinction between invariant and changeable properties of faces. However, unlike Haxby et al. (2000), who emphasized the differentiation between the systems that process invariant and changeable face properties, we focus on trying to understand how, despite this differentiation, these systems nevertheless interact. Specifically, because expressions can be seen as variations in the structure of faces (i.e., the identity), differences between the facial configurations of individuals should lead to systematic differences in the way emotions are expressed by these individuals. Each individual, therefore, should have his or her unique way of expressing happiness, anger, surprise, and so forth. Because the underlying structure of a particular face will determine the unique way in which that face can express a specific emotion, knowledge of the underlying structure of an individual face can be used by the perceiver to process expression in a more efficient manner. We label this hypothesis the *structural-reference hypothesis* because it assumes that perceivers are equipped with the ability to use the fact that the structure of a face (i.e., the identity) determines its unique expression to compute expressions in a more efficient manner. In the same manner, perceivers are equipped with the ability to compute the identity of faces using their unique expression. Specifically, given a unique expression of an individual, it is easier to compute his or her identity because only a limited population of facial structures can produce that expression in precisely the same way.

Therefore, according to the structural-reference hypothesis, perceivers can use the facial structure of a face as a reference with respect to which they can compute expressions and also use the unique expressions to facilitate computations of facial structure (i.e., identity). Hence, the structural-reference hypothesis predicts that Garner interference should be found both from identity to expression and from expression to identity. The first half of this prediction, that of Garner interference from identity to expression, has been supported by previous studies (Baudouin et al., 2002; Schweinberger et al., 1999; Schweinberger & Soukup, 1998). However, the second half of this prediction, that of Garner interference from expression to identity, has never been observed. Still, the neuropsychological finding that an impairment in perceiving expressions can result in an accompanying impairment in perceiving identity (Young et al., 1996) is exactly the kind of finding one would expect if expression helps in the derivation of identity. Therefore, in this study, we sought to confirm this exact prediction in healthy participants.

We propose that the absence of interference from expression to identity does not invalidate the structural-reference hypothesis but is, rather, the result of an experimental artifact in earlier studies. In particular, the materials used in most experiments that have examined the dimensions of identity and expression did not control for the discriminability between these dimensions (Garner & Felfoldy, 1970; Melara & Mounts, 1993; see also Footnote 4). That is, identity judgments were inadvertently performed more quickly than expression judgments (i.e., identity was more discriminable than expression). We suggest that expression did not interfere with identity because while identity was already extracted, the computation of expression was not yet complete. Accordingly, we propose that if the discriminability between identity and expression were equated, or if the dimension of expression was made more discriminable than that of identity, interference effects should be found not only from identity to expression but also from expression to identity. Therefore, the first prediction of the structural-reference hypothesis is that, given the correct control over discriminability, Garner interference should be found not only from identity to expression but also from expression to identity. This prediction was examined in Experiment 2, in which the values of the dimension of identity were chosen such that identity would be less discriminable than expression.

The structural-reference hypothesis is yet more powerful in that it makes a second prediction—that of an interaction between Garner interference and familiarity with faces. This prediction is guided by the notion that representations of familiar faces contain richer and more detailed structural descriptions than representations of unfamiliar faces, for which only coarse, sketchy structural representations exist. Therefore, perceivers are more likely to be sensitive to the associations between invariant and changeable aspects of familiar faces than they are to those of unfamiliar faces. One consequence of this idea is that computations of expressions of familiar faces should rely to a larger extent on identity than do those of unfamiliar faces and, in the same manner, that computations of the identity of familiar faces should rely to a larger extent on their expressions than do computations of the identity of unfamiliar faces. Therefore, the structural-reference hypothesis predicts larger Garner interference between identity and expression for familiar as compared with unfamiliar faces.

Previous studies examining the relationship between the processing of identity and expression have only used unfamiliar faces (Baudouin et al., 2002; Schweinberger et al., 1999; Schweinberger & Soukup, 1998). Consequently, the nature of the processing underlying the interference between these dimensions could not be evaluated. In the current design, we presented both familiar and unfamiliar faces in Garner's speeded-classification task to test the validity of the structural-reference hypothesis.

Experiment 1

The purpose of Experiment 1 was to test the validity of the structural-reference hypothesis. Two predictions of this hypothesis were presented in the introduction: First,, that given control over discriminability, Garner interference should be found both from identity to expression and from expression to identity. Second, Garner interference should be larger for familiar as compared with unfamiliar faces.

The structural-reference hypothesis makes yet a third prediction. This hypothesis predicts a facilitated processing of the expression of familiar as compared with unfamiliar faces when identity is kept constant and does not attract attention (i.e., in a baseline condition). This third prediction is also derived from the notion that computations of expression of familiar faces, for which detailed structural representations exist, should be more efficient than computations of expression of unfamiliar faces. Thus, the structural-reference hypothesis predicts that a decrease in ability to selectively attend to familiar faces, a prediction measured by Garner interference, should be accompanied by an increase in ability to compute the expressions of the same faces when identity is kept constant, a prediction measured by performance in the baseline blocks.

The richer representations inherent in familiar faces should, in principle, also facilitate expression judgments in filtering blocks. However, in filtering blocks, identity varies randomly, presumably impairing selective attention more for familiar as compared with unfamiliar faces (i.e., the second prediction of the structural-reference hypothesis). Therefore, the facilitation in expression judgments for familiar faces may be offset (in part or in whole) by the reduced ability to selectively attend to their expressions. Our prediction of faster expression judgments for familiar faces is directed, therefore, to performance in baseline blocks but not to performance in filtering blocks.[1]

It is critical to note that the parallel-route hypothesis explicitly predicts that expression judgments for familiar faces should be equal to those for unfamiliar faces (Bruce, 1986). According to this hypothesis, expression judgments should not be affected by the

[1] Note that the third prediction of the structural-reference hypothesis is composed of two components. The first is that expression judgments should be faster for familiar as compared with unfamiliar faces. The second is that due to the impaired selective attention for familiar as compared with unfamiliar faces (i.e., the second prediction of the structural-reference hypothesis), the facilitation in expression judgments for familiar faces should be found only in baseline blocks. This second component of the prediction is logically derived from the prediction that there should be impaired selective attention for familiar faces. Therefore, the second and the third predictions of the structural-reference hypothesis can be considered as two aspects of the notion that selective attention should be impaired to familiar as compared with unfamiliar faces. However, the first component of the prediction is completely independent of the other two predictions of the hypothesis.

structure of the face but should be performed in a parallel route to that of identity. Hence, according to the parallel-route hypothesis, only expression judgments should not be facilitated by familiarity.[2]

Method

Participants. Forty-eight undergraduates, 24 from the Academic College of Tel Aviv–Yaffo (17 women and 7 men) and 24 from Tel Aviv University (19 women and 5 men), Tel Aviv, Israel, with normal or corrected-to-normal vision participated in the experiment. Participants received course credit for taking part in the experiment.

Design and materials. Task (identity judgments, expression judgments) and block (baseline, filtering) were manipulated within participant. Familiarity with the faces (familiar, unfamiliar) was manipulated between participants.

The stimuli were created from a factorial combination of Identity (Person A, Person B) × Expression (smiling, angry). To prevent undesired effects of visual differences between familiar and unfamiliar faces, we operationalized familiarity by presenting the same facial stimuli to two groups of participants (students from two different universities), one for which the faces were personally familiar and one for which the faces were unfamiliar (see also Campbell et al., 1996). Furthermore, the participants from Tel Aviv University were selected to include only those who were taking the psychology courses taught by the two professors whose photos were used in the experiment.

Each person was photographed with either a smiling or an angry expression. To discourage picture-based strategies (see Schweinberger & Soukup, 1998), two different photos of each person in each of the two expressions were used. Therefore, the complete stimulus set consisted of eight monochrome photos, four of Person A (two smiling, two angry) and four of Person B (two smiling, two angry).

To prevent hairstyle-based strategies in identity judgments (see Ganel & Goshen-Gottstein, 2002), hair and contours were deleted from the photos (see Figure 1), using the Adobe Photoshop (Version 6) software package. All photos were equated in size so that they were 7.5 cm long and 5.3 cm wide. The color of the background was set to white. The contrast between the faces and the background, subjectively determined by the experimenter, was kept constant.

In the *baseline* blocks, participants judged one dimension (e.g., expression) while the other dimension was held at a constant value (e.g., Person A). In the *filtering* blocks, participants again judged one dimension (e.g., expression), but the stimuli differed along the irrelevant dimension (e.g., both Person A and Person B were presented). Therefore, the baseline blocks consisted of four face photos, and the filtering blocks consisted of all eight photos.[3] In all blocks, each photo was presented 7 times in random order, resulting in a total of 28 presentations for each baseline block and 56 presentations for each filtering block. In all, four baseline blocks (two for the identity-judgment task, one of smiling faces and one of angry faces; two for the expression-judgment task, one of Person A and one of Person B) and two filtering blocks (one for the identity-judgment task and one for the expression-judgment task) were administered.

Four counterbalanced sets of faces were used. Within each set, the three (two baseline, one filtering) identity-judgment blocks were sequentially administered, as were the three expression-judgment blocks. The three identity-judgment blocks were positioned before the expression-judgment blocks for half of the sets and after the expression-judgment blocks for the remaining sets. Within each half, the baseline blocks were positioned before the filtering block in one set and after the filtering block in the other set.

Procedure. Participants were individually tested and were equally divided into the four counterbalanced sets. A preexperimental questionnaire confirmed that participants were familiar (students from Tel Aviv University) or not familiar (students from the Academic College of Tel Aviv–Yaffo) with the men whose photos were presented in the experiment.

Participants were told that during the experiment they would be asked to perform several face-relevant tasks as quickly and accurately as they could. Next, to acquaint participants with the task, four of the eight photos (two of Person A, one smiling and one angry; two of Person B, one smiling and one angry) were shown. Stimuli were presented on a 17-in. (43.18-cm) screen of a Pentium III–class computer.

The experimental blocks were then administered. In each block, participants were asked to make speeded classifications of either the expression (smiling or angry) of faces or their identity (Person A or Person B). To acquaint participants with the identities of the persons, photos of Person A and Person B (with neutral expressions) preceded each of the identity-judgment blocks. The photos were presented side by side on the computer screen, and participants were told that during the actual experiment photos of one of the two people were going to be presented on the center of the screen and that they were to press the right-hand key if the person (who now appeared) on the right was shown and the left-hand key for the person (who now appeared) on the left.

Each baseline block began with 8 practice trials (two random repetitions of each stimulus), and each filtering block began with 16 practice trials (two random repetitions of each stimulus). The practice trials were identical to the experimental trials in all respects and were immediately followed by the actual experimental block. Participants were given l-min breaks between blocks.

Each trial began with a blank white screen, which was presented for 1 s and immediately followed by a face photo. Face photos were always located at the center of the screen. The face remained on the screen until a response was recorded, after which the stimulus disappeared. The next trial began 2 s after the participant's response. Response keys were the left and right buttons of a Cedrus Corporation (San Pedro, CA) four-key

[2] Previous attempts to test whether familiarity facilitates expression judgments have yielded mixed results. Bruce (1986; also see Campbell et al., 1996; Young, McWeeny, Hay, & Ellis, 1986) found equal RTs for familiar and unfamiliar faces for speeded expression judgments (i.e., smiling–nonsmiling decisions). These results support the parallel-route hypothesis. In contrast, a recent study by Baudouin et al. (2000) found faster and more accurate expression judgments for familiar than for unfamiliar faces. The inconsistent pattern of results across studies was argued by Baudouin et al. to result from floor effects in Bruce's design, because highly exaggerated expressions appeared in the photos of Bruce's stimulus set. In support of this explanation, Baudouin et al. found effects of familiarity only under conditions in which floor effects were reduced, either by brief (30-ms) presentation times or by concealment of the mouth area of the faces. In the present design, floor effects in expression judgments were less likely than they were in Bruce's design because we created our stimuli without exaggerated expressions (see Figure 1). Therefore, our materials were more sensitive to the effects of familiarity on expression judgments and provide an opportunity to validate Baudouin et al.'s arguments.

[3] Because the number of stimuli presented in the filtering blocks is twice that of the number in the baseline blocks, it could be argued that any finding of Garner interference is not the result of the integrality between a given pair of dimensions but, rather, the result of the greater task demands of choosing between many alternatives as compared with choosing between fewer alternatives. Two arguments mitigate this possible criticism. First, previous Garner studies in domains other than face perception have shown that Garner interference reflects the relationship between a given pair of dimensions and is not likely the result of task demands (Melara & Marks, 1990a, 1990b). Second, specifically for the dimensions of identity and expression, previous Garner studies (Baudouin et al., 2002; Schweinberger et al., 1999; Schweinberger & Soukup, 1998) have found no interference from expression to identity despite the different task demands, which again suggests that by themselves, differences in task demands are not sufficient to produce Garner interference.

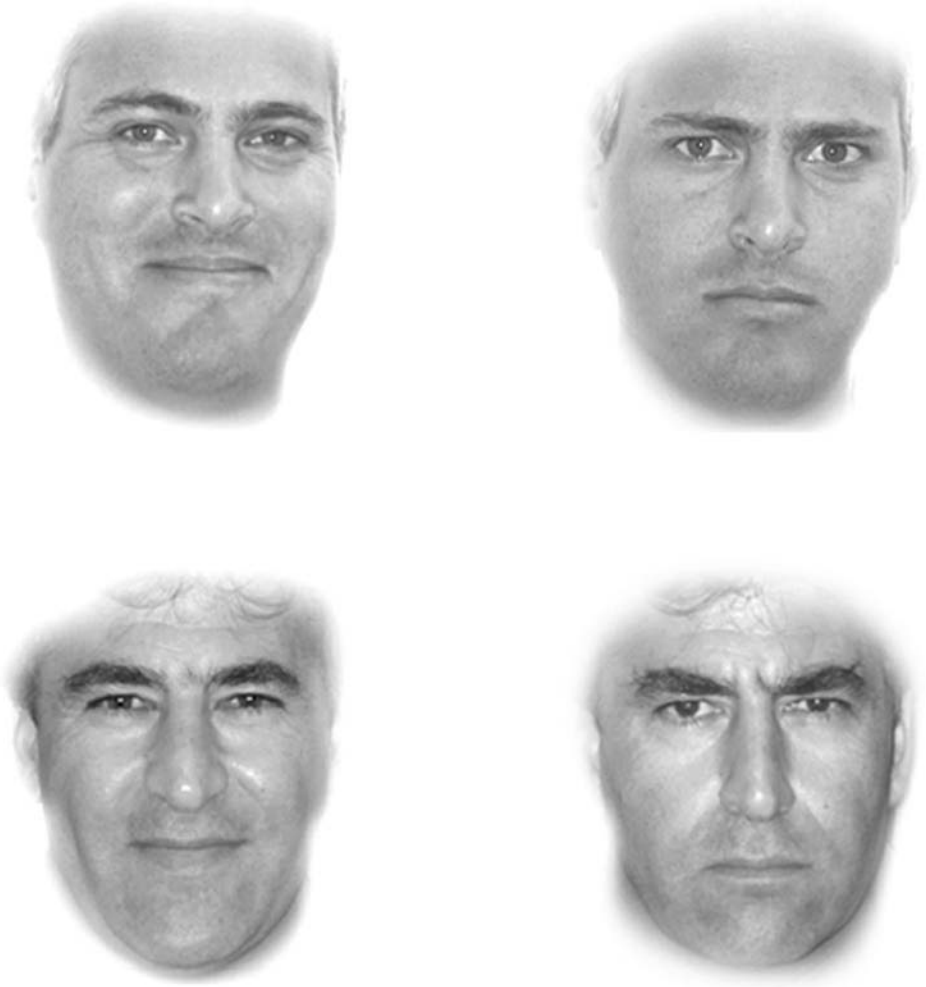

Figure 1. Stimuli used in Experiment 1. Top row: Smiling (left) and angry (right) expressions posed by Person A. Bottom row: Smiling (left) and angry (right) expressions posed by Person B. Both individuals whose faces appear here gave signed consent for their likenesses to be published in this article.

response box. Depending on the block, the left response key was assigned to *Person A* and *angry* judgments, and the right response key was assigned to *Person B* and *smiling* judgments.

Results

For each participant, mean RTs were calculated from the distribution of correct responses, with skewness reduced by eliminating outliers that were 2 standard deviations above the mean for each of the four combinations created by crossing block and task. In all, 4.09% of the responses were eliminated for this reason. The means were then averaged across the 48 participants in each of the eight experimental conditions. Table 1 displays the means and the mean percentages of error of the analysis.

The data were submitted to an analysis of variance (ANOVA) with task (identity judgments, expression judgments) and block (baseline, filtering) as within-participant variables and familiarity (familiar, unfamiliar) as a between-participants variable. For this and the subsequent experiment, only effects achieving significance at the $\alpha = .05$ level are reported, and unless otherwise noted, all hypotheses were treated as two-tailed.

An examination of the data revealed a 51-ms Garner-interference effect (i.e., filtering RT – baseline RT) for expression judgments and a smaller 8-ms interference effect for identity judgments. This Task $\times$ Block interaction was significant, $F(1, 46) = 14.5$, $MSE = 1{,}521$, $p < .01$, and replicated the asymmetric pattern reported by Schweinberger et al. (1999), Schweinberger and Soukup (1998), and Baudouin et al. (2002) for unfamiliar faces. The three-way Familiarity $\times$ Task $\times$ Block interaction did not achieve significance, $F(1, 46) = 0.84$, $MSE = 1{,}521$, $p > .10$. Because the interpretation of these results depends on the relative discriminability of identity and expression within each category of familiarity, we discuss their relevance to the structural-reference hypothesis further in the sections below, in which separate analyses for unfamiliar and familiar faces are reported.

Next, and most important, we tested the specific predictions of the structural-reference hypothesis. Regarding the prediction that familiarity should enhance Garner interference between identity

Table 1
Mean Reaction Times (RTs, in Milliseconds; With Standard Errors in Parentheses) and Percentages of Error for Identity- and Expression-Judgment Tasks in Experiment 1

	Block type					
	Baseline		Filtering		Garner interference[a]	
Task	RT	% error	RT	% error	RT	% error
			Familiar faces			
Identity	456 (9)	2.6	472 (11)	2.7	16	−0.1
Expression	477 (15)	4.0	546 (20)	3.9	69	0.1
Overall	467 (17)	3.3	509 (20)	3.3	43	0
			Unfamiliar faces			
Identity	487 (10)	2.2	486 (12)	2.8	−1	0.6
Expression	529 (15)	3.3	560 (16)	3.0	32	−0.3
Overall	508 (16)	2.8	523 (16)	2.9	16	0.2

[a] Baseline − filtering.

and expression, larger Garner interference was indeed found for familiar faces (43 ms) than for unfamiliar ones (16 ms). This effect was significant, as confirmed by the two-way Familiarity × Block interaction, $F(1, 46) = 10.46$, $MSE = 875$, $p < .05$.

With regard to the prediction that expression judgments should be faster for familiar than for unfamiliar faces, we compared RTs in the baseline blocks for expression judgments between familiar and unfamiliar faces. A 52-ms advantage for expression judgments for familiar faces was found. This effect achieved significance, $t(46) = 2.43$, $p < .05$.

Examination of the error data revealed neither significant main effects nor a significant interaction between task and block variables. The possibility that speed–accuracy trade-offs could account for any of the RT results was therefore dismissed.

Because we used a between-participants design, we next explored for which tasks and for which stimuli Garner interference emerged. To this end, we report separate analyses for familiar and unfamiliar faces below.

Analysis for unfamiliar faces. Across tasks, Garner interference was found, demonstrated by an overall significant main effect of block, $F(1, 23) = 6.06$, $MSE = 895$, $p < .05$. This main effect was mediated by a significant Task × Block interaction, $F(1, 23) = 3.53$, $MSE = 1{,}798$, $p < .05$ (one-tailed), which reflected significant interference from identity to expression, $t(23) = 2.54$, $p < .05$, but not from expression to identity, $t(23) = 0.14$, $p > .10$.

The absence of Garner interference from expression to identity in the unfamiliar group replicated earlier reports of asymmetric interference (e.g., Schweinberger et al., 1999; Schweinberger & Soukup, 1998). Still, the absence of interference from expression to identity may have been the product of the greater discriminability of the dimension of identity than of expression. If identity was in fact more discriminable, then expression did not interfere with identity because the computations of expression were not yet complete while identity was already extracted (for similar arguments with regard to other perceptual dimensions, see Algom, Dekel, & Pansky, 1996; Garner & Felfoldy, 1970; Melara & Mounts, 1993). To validate this interpretation, we compared performance between the baseline blocks for identity and expression judgments.

In the identity baseline blocks, RTs were 42 ms shorter than they were in the expression baseline blocks, $t(23) = 2.87$, $p < .01$. This unequal discriminability replicates the results of Schweinberger and Soukup (1998) and Baudouin et al. (2002) and could account for the absence of Garner interference from expression to identity.

Note that although the greater discriminability of identity could account for the absence of Garner interference from expression to identity, it also could serve to bolster the Garner effect from identity to expression. Still, at this juncture, it is critical to realize that such a difference in discriminability between the dimensions can in no way account for the enhanced interference effect for familiar faces as compared with unfamiliar faces, nor can it account for the faster expression judgments made for familiar as compared with unfamiliar faces. These two findings can be understood only by the structural-reference hypothesis. Nonetheless, in Experiment 2, we reversed the difference in discriminability, and (to anticipate our results) we show that, in line with our predictions, larger Garner interference and faster expression judgments can be found for familiar as compared with unfamiliar faces even when the dimension of identity is less discriminable than that of expression.

Analysis for familiar faces. Examination of the RTs revealed that, in contrast to the pattern found for unfamiliar faces, the 21-ms difference in discriminability between the two baseline blocks of the two tasks was not significant, $t(23) = 1.8$, $p > .05$. An overall Garner-interference effect of 43 ms was found for familiar faces, $F(1, 23) = 51.10$, $MSE = 855$, $p < .05$. This main effect was mediated by a Block × Task interaction, $F(1, 23) = 13.64$, $MSE = 1{,}245$, $p < .05$. Finally, the 69-ms Garner interference from identity to expression, $t(23) = 6.16$, $p < .05$, and more important, the 16-ms Garner interference from expression to identity, $t(23) = 2.30$, $p < .05$, were both significant. Whereas interference effect from identity to expression has been previously reported, ours is the first report of Garner interference from expression to identity. This interference effect emerged in a condition in which identity and expression were equally discriminable, and it confirms the predictions of the structural-reference hypothesis.

Discussion

A number of important results emerged in this experiment. First, expression judgments were made more quickly for familiar as compared with unfamiliar faces. Apparently, knowledge of the underlying structure of a face can help to facilitate processing of its expression, as predicted by the structural-reference hypothesis (see also Footnote 2).

Second, the results of Experiment 1 established that familiarity mediated the interference between identity and expression. Indeed, the structural-reference hypothesis predicted this greater interference for familiar than for unfamiliar faces.

Third, interference was found from expression to identity for familiar faces. To the best of our knowledge, this is the first report of interference in this direction. This interference from expression to identity is particularly informative because the dimensions of identity and expression were equally discriminable. Hence, this interference can only be attributed to participants' ability to facilitate the computation of identity given a unique expression and cannot be easily dismissed as an artifact of a fast dimension interfering with the processing of a slower one. Note that according to the structural-reference hypothesis, the total absence of interference from expression to identity for unfamiliar faces was coincidental and interference might well be found for another set of stimuli in which discriminability between the dimensions is equal or biased in favor of expression (see Experiment 2).

So far, we have interpreted the interference from expression to identity as supporting the structural-reference hypothesis. However, another interpretation exists for this interference, as well as for the fact that it was found for familiar faces only. According to this interpretation, people often carry a typical expression which deviates from the "normalized" expression (i.e., the representation of the average expression across all instances in which it was encountered). For example, it is difficult to imagine the face of actor Robin Williams without seeing his typical joyful expression. For this actor and for many familiar other people, a specific expression may have become a typical feature that forms part of people's semantic knowledge about them. It is possible, therefore, that familiar faces may carry identity-specific expressions and that perceivers may use their knowledge of these expressions to support identification.

If this *typicality hypothesis* is correct, then at least two predictions emerge. First, interference from expression to identity judgments is predicted to be found only for familiar faces (for which expression-specific representations exist) but not for unfamiliar ones (for which expression-specific representations do not exist). Second, performance should be faster for typical as compared with atypical expressions of familiar faces. To help choose between the structural-reference hypothesis and the typicality hypothesis, correlated blocks were added to the experimental conditions of Experiment 2, blocks in which only typical or atypical expressions were depicted.

As for the interference that was found from identity to expression, although it confirms the predictions of the structural-reference hypothesis and replicates earlier findings (e.g., Baudouin et al., 2002; Schweinberger et al., 1999; Schweinberger & Soukup, 1998), its interpretation is not unequivocal. Specifically, because the dimension of identity was more discriminable than that of expression, the importance of this interference may be dismissed as stemming from the faster dimension (identity) interfering with the processing of the slower dimension (Garner & Felfoldy, 1970; Melara & Mounts, 1993). Therefore, in Experiment 2, we reversed the discriminability between the dimensions to see whether interference would still be found from identity to expression even when identity was less discriminable than expression. This also allowed us to test whether our finding of increased interference for familiar as compared with unfamiliar faces would generalize to conditions in which expression was more discriminable than identity.

Experiment 2

In Experiment 1, Garner interference was greater for familiar than for unfamiliar faces. In that experiment, the dimension of identity was more discriminable than that of expression. A recent review of many perceptual dimensions (Melara & Algom, 2003; see also Algom et al., 1996; Garner & Felfoldy, 1970; Melara & Mounts, 1993) has revealed that differences in discriminability may produce Garner interference from the more discriminable to the less discriminable dimension. Therefore, to ensure that relative discriminability did not mediate this effect in Experiment 1, the discriminability between identity and expression was reversed in Experiment 2 such that identity would be less discriminable than expression. We asked whether even under this reverse discriminability, Garner interference from identity to expression would still be observed and would still be enhanced by familiarity. The discriminability between expression and identity has already been manipulated in a previous study by Schweinberger et al. (1999). These authors used a morphing technique to reverse the discriminability between identity and expression for unfamiliar faces, and they found that even when expression judgments were faster than identity judgments, identity still interfered with the processing of expression. It is surprising that although expression judgments were faster than identity judgments, no interference was found from expression to identity.

These findings were used by Schweinberger et al. (1999) to argue that an asymmetric pattern of interference exists regardless of discriminability, one in which identity always interferes with expression, but expression never interferes with identity. Unfortunately, critical examination of Schweinberger et al.'s study reveals a flaw in their experimental design, which may cast doubt on the validity of their findings. Specifically, the stimuli that Schweinberger et al. presented for identity judgments were different than those that were presented for expression judgments.[4] As a result, Schweinberger et al.'s design did not allow a comparison between the discriminability of identity and expression. Therefore, it is unclear whether identity was indeed less discriminable than expression in their study.

[4] Schweinberger et al. (1999) used four unfamiliar face photos of two different individuals (Person A and Person B), posing two different expressions (anger and happiness). To create conditions in which identity was less discriminable than expression, these authors morphed the photo of Person A carrying an angry expression with that of Person B carrying an angry expression. They then chose two morphed photos from the continuum of relative morphing of the two individuals, thereby creating two morphed angry faces whose identities were difficult to distinguish. A similar morphing procedure was applied to the photos of Person A and Person B carrying smiling expressions to create two morphed smiling faces whose identities were difficult to distinguish. These four identity-morphed stimuli were used for identity judgments. It is critical to note that the four stimuli that were used for expression judgments were morphed on the basis

In Experiment 2, we used a different procedure to reverse discriminability between identity and expression while maintaining the same stimuli for expression and identity judgments. To reverse discriminability, we used the faces of two brothers who were very similar in their appearance. As a result, we anticipated that identity would be less discriminable than expression.

To test the typicality hypothesis, in addition to the criterion of similarity in appearance, a second criterion was used to select familiar stimuli. Specifically, the two familiar faces whose photos were used in Experiment 2 were celebrities who differed in their typical expression; the first celebrity was a host of a TV comedy show and was readily associated with his smiling expression. In contrast, the second celebrity was a TV news reporter who was associated with a serious, neutral expression. According to the typicality hypothesis, identity-specific expression should support identification for familiar faces. Therefore, identity judgments for familiar faces should be made faster for faces carrying their identity-specific expression.

To test this prediction, additional experimental blocks were used. In these *correlated* blocks, the dimensions of identity and expression were presented in covariation. That is, in one type of the correlated block—the *positively* correlated block—Person A was always presented carrying his typical smiling expression, whereas Person B was always presented carrying his typical neutral expression. In the second type of correlated block—the *negatively* correlated block—Person A was always presented carrying an atypical, neutral expression, whereas Person B was always presented carrying an atypical, smiling expression. Adding the correlated blocks to the design allowed us to choose between the typicality and the structural-reference hypotheses because only the typicality hypothesis makes the strong prediction of faster performance in the positively correlated than in the negatively correlated block.

As in Experiment 1, familiar and unfamiliar faces were also used in this experiment. However, unlike in Experiment 1, familiarity was now manipulated between stimuli in a within-participant design in which familiar and unfamiliar face photos were presented to the same participants.

A replication of the effects of familiarity on the interference between identity and expression would also enhance the external validity of the results of Experiment 1; in particular, although previous studies have used only a single photo for each Identity × Expression combination (Baudouin et al., 2002; Schweinberger et al., 1999; Schweinberger & Soukup, 1998), it can be argued that this small number of stimuli allows for a low external validity because it may entail idiosyncratic processing. Therefore, replicating the effect of familiarity on the interference between identity and expression with different stimuli, in a different (within participant) design and under the reverse pattern of discriminability, should enhance the external validity of the structural-reference hypothesis.

Method

Participants. Thirty-two undergraduates from Tel Aviv University (21 women and 11 men) with normal or corrected-to-normal vision participated in the experiment. Participants received course credit for taking part in the experiment.

Design and materials. Task (identity judgments, expression judgments), block (baseline, filtering, correlated), and familiarity with the faces (familiar, unfamiliar) were manipulated within participant.

The stimuli were created from a factorial combination of Identity (Person A, Person B) × Expression (smiling, neutral) × Familiarity (familiar faces, unfamiliar faces). The familiar photos were of two Israeli brothers (see Figure 2); the first (Dan Shilon) is a famous news reporter and analyst on Israeli TV. The second (Igal Shilon) is a famous comedian who hosts a popular weekly hidden-camera type show on Israeli TV. Smiling and neutral photos of the two brothers were digitized from video recordings of their TV shows. The unfamiliar photos were of two brothers who were chosen because they generally matched, in age and appearance, the two familiar brothers. Hence, the stimulus set used in Experiment 2 was composed of eight different photos (2 expressions × 4 identities). The photos of the familiar and unfamiliar people were graphically equated for quality, contrast, and brightness and then manipulated in the same manner as the Experiment 1 stimuli.

The experimental blocks were created in the same manner as in Experiment 1, with the addition of two new blocks: the positively correlated and the negatively correlated blocks. In the positively correlated blocks, participants judged one dimension (e.g., identity; Person A, Person B) while the other dimension (e.g., expression) was positively correlated to the first dimension (i.e., Person A was always smiling and Person B was always neutral). In the negatively correlated blocks, participants judged one dimension (e.g., identity) while the other dimension was negatively correlated to the first dimension (i.e., Person A was always neutral and Person B was always smiling).

In all, four baseline blocks were administered for familiar faces (two for the identity-judgment task, one of smiling faces and one of neutral faces; two for the expression-judgment task, one of Person A and one of Person B), and four baseline blocks were administered for unfamiliar faces. In addition, two filtering blocks were administered for familiar faces (one for each task) and two filtering blocks were administered for unfamiliar faces. Finally, four correlated blocks were administered for familiar faces (2 correlation types × 2 tasks), and four were administered for unfamiliar faces.

The order of blocks was counterbalanced as in Experiment 1 so that the identity-judgment blocks were sequentially administered, as were the expression-judgment blocks. Within each counterbalancing order, the identity-judgment blocks were positioned before the expression-judgment blocks for half of the sets and after the expression-judgment blocks for the remaining sets. Within each half, all of the baseline blocks, all of the correlated blocks, and all of the filtering blocks were administered in sequence. Order of presentation of block type (baseline, filtering, correlated), order of presentation within each block type, and order of presentation of blocks of familiar and unfamiliar faces within each sequence were also counterbalanced between participants.

Procedure. The procedure was identical to that used in Experiment 1, with the exception of the additional correlated blocks and the presentation of familiar and unfamiliar faces to each participant. A preexperimental questionnaire confirmed that all participants recognized the two familiar faces and did not recognize the two unfamiliar faces. To reduce response mapping between identity and expression, the allocation of participants for a specific combination of response key for identity judgments (Person

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of an entirely different pairing of the stimuli. Thus, smiling and angry photos of Person A were used to create the first two facial morphs, whereas smiling and angry photos of Person B were used to create the other two facial morphs. Therefore, the four stimuli that were used for identity judgments were completely different from the four stimuli that were used for expression judgments. This confounding of stimuli with task prevents a meaningful comparison between performance for identity and expression and does not allow, therefore, for an effective comparison of discriminability. Hence, it is difficult to know if it was the discriminability that contributed to Schweinberger et al.'s results or some other differences between the stimuli.

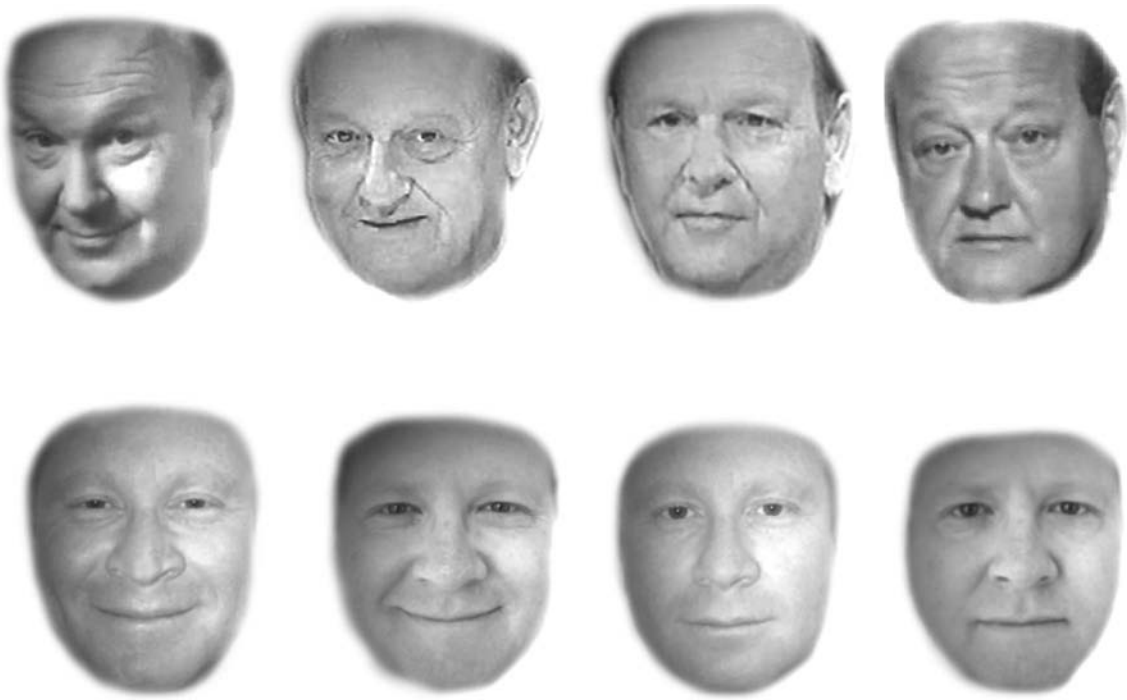

Figure 2. Stimuli used in Experiment 2. Top row, left to right: Smiling and neutral expressions posed by each of the two Israeli celebrities (Igal and Dan Shilon, respectively). Bottom row, left to right: Smiling and neutral expressions posed by two unfamiliar brothers. Both individuals whose faces appear here as unfamiliar gave signed consent for their likenesses to be published in this article.

A–Person B) and expression judgments (smiling–neutral) was counterbalanced. To this end, half of the participants responded with the same key for Person A and for smiling faces, and the other half of the participants responded with the same key for Person A and for neutral faces.

Results and Discussion

For each participant, mean RTs were calculated as in Experiment 1 for each of the 16 combinations of block (baseline, filtering, positively correlated, negatively correlated), task (expression judgments, identity judgments), and familiarity (familiar faces, unfamiliar faces), eliminating 6.11% of outliers. Table 2 displays these means and the mean percentages of error.

Examination of the data from the correlated blocks revealed small differences between the positively correlated and the negatively correlated blocks for familiar faces. These differences were significant for neither expression (445 ms in the positively corre-

Table 2
Mean Reaction Times (RTs, in Milliseconds; With Standard Errors in Parentheses) and Percentages of Error in Baseline, Filtering, and Correlated Blocks for Identity- and Expression-Judgment Tasks in Experiment 2

	Block type							
	Baseline		Filtering		Correlated		Garner interference[a]	
Task	RT	% error	RT	% error	RT	% error	RT	% error
				Familiar faces				
Identity	481 (15)	3.9	619 (27)	7.3	495 (16)	3.5	138	3.4
Expression	433 (12)	3.6	534 (18)	4.0	447 (11)	3.4	101	0.4
Overall	457 (12)	3.7	577 (19)	5.7	471 (12)	3.5	120	1.9
				Unfamiliar faces				
Identity	557 (21)	5.2	675 (36)	8.6	497 (14)	4.6	118	3.4
Expression	448 (13)	4.4	497 (15)	4.2	444 (12)	2.9	48	−0.1
Overall	503 (16)	4.8	586 (21)	6.4	487 (12)	3.7	83	1.7

Note. Faces of two similar Israeli celebrities and two similar, unfamiliar brothers were used to reverse discriminability between identity and expression.
[a] Baseline − filtering.

lated block; 449 ms in the negatively correlated block), $t(31) = 0.51$, $p > .10$, nor identity (486 ms in the positively correlated block; 504 ms in the negatively correlated block), $t(31) = 0.83$, $p > .10$. The equal performance in the positively correlated and negatively correlated blocks suggests that typicality of the expression does not play a critical role in the identification of familiar faces in Garner's paradigm. This equal performance goes against one of the predictions of the typicality hypothesis.

As can be seen in Table 2, RTs in the correlated blocks were comparable to RTs in the baseline blocks in all conditions, with the exception that for unfamiliar faces, RTs in the correlated block for identity judgments were 53 ms shorter than RTs in the baseline block. This difference was significant, $t(31) = 3.09$, $p < .05$, and probably reflects the fact that participants used the values of the (highly discriminable) dimension of expression to make identity judgments.

It has often been suggested that performance in correlated blocks is not informative about whether two dimensions are separable or integral (Green & Kuhl, 1991; Maddox, 1992; Schweinberger & Soukup, 1998), particularly in cases of unequal discriminability, such as in the current experiment. Specifically, it has been argued that performance in a correlated block strongly depends on differences in discriminability, and it is considered, therefore, to be based on decisional strategies rather than on the perceptual relationship between the two dimensions (see also Le Gal & Bruce, 2002; Schweinberger & Soukup, 1998). For this reason, studies using correlated blocks have sometimes discarded the data from the correlated blocks from the analysis (Schweinberger & Soukup, 1998), and in other studies, these blocks have not been included (Ganel & Goshen-Gottstein, 2002). Indeed, our main motivation in using the correlated blocks in Experiment 2 was to test whether performance in the positively correlated block would be better than performance in the negatively correlated block for familiar faces, which it turned out not to be. Therefore, for sake of brevity, we did not include these blocks in any further analyses and focused only on our theoretically driven predictions of performance in the baseline versus the filtering blocks.

An additional prediction of the typicality hypothesis was that interference from expression to identity would be found for familiar but not for unfamiliar faces. Clearly, the results of Experiment 2 did not support this prediction, with significant interference effects from expression to identity not only for familiar faces, $t(31) = 5.46$, $p < .01$, but for unfamiliar faces as well, $t(31) = 5.35$, $p < .01$. Therefore, the typicality hypothesis cannot be used to interpret the interference found from expression to identity, and this interference is better interpreted by the structural-reference hypothesis.

To confirm the other predictions of the structural-reference hypothesis, we submitted the RT data to an ANOVA with task (identity judgments, expression judgments), block (baseline, filtering), and familiarity (familiar faces, unfamiliar faces) as within-participant variables. The overall Garner-interference effect (102 ms) was significant, as indicated by a main effect of block, $F(1, 31) = 80.90$, $MSE = 8{,}164$, $p < .01$. In addition, expression judgments were 105 ms faster than identity judgments. This main effect of task was significant, $F(1, 31) = 63.10$, $MSE = 11{,}169$, $p < .01$, and established that our attempt to reverse the pattern of discriminability was successful.

Specific comparisons showed that this reverse discriminability was significant for both familiar faces (48-ms difference), $t(31) = 4.94$, $p < .01$, and unfamiliar faces (108-ms difference), $t(31) = 6.50$, $p < .01$. A significant Task $\times$ Familiarity interaction, $F(1, 31) = 16.10$, $MSE = 5{,}827$, $p < .01$, showed that the difference in discriminability was larger for unfamiliar as compared with familiar faces. In addition, the Task $\times$ Block interaction, $F(1, 31) = 8.63$, $MSE = 5{,}335$, $p < .01$, showed that the surprisingly larger interference from expression to identity than that from identity to expression was significant.

Despite the finding that identity judgments were slower than expression judgments (i.e., identity was less discriminable), we predicted that interference from identity to expression should nevertheless be found because the processing of expression is derived from the structural representations of faces, which constitute their identity. To examine this, we compared performance in the baseline and filtering blocks. The interference from identity to expression was significant for both familiar faces, $t(31) = 10.39$, $p < .01$, and unfamiliar faces, $t(31) = 5.05$, $p < .01$, thereby establishing that computations of expression are truly derived from identity, even when identity is the less discriminable dimension.

A few important conclusions can be drawn on the basis of these results. First, our results question the claim that discriminability does not affect the pattern of Garner interference between expression and identity (Schweinberger et al., 1999). Instead, it seems that, as in other perceptual domains (e.g., Melara & Marks, 1993), discriminability plays an important role in determining the pattern of performance in Garner's task. Second, these results show that the interference from identity to expression, which was found in Experiment 1, can be found even when identity is less discriminable than expression. Third, unlike the generalization made by previous studies (Schweinberger et al., 1999), identity is sensitive to variations in expression when identity and expression are equally discriminable (Experiment 1; familiar faces) or identity is less discriminable (Experiment 2; familiar and unfamiliar faces) than expression. Thus, our results strongly question the characterization of the interference between identity and expression as asymmetrical.

Finally, and most important, the main purpose of Experiment 2 was to test the idea that the effects of familiarity on the magnitude of Garner interference between identity and expression could be found even when identity was the less discriminable dimension. A significant Familiarity $\times$ Block interaction, $F(1, 31) = 5.67$, $MSE = 3{,}842$, $p < .05$, showed larger Garner interference between identity and expression for familiar as compared with unfamiliar faces, thereby strengthening the validity of the structural-reference hypothesis.

As in Experiment 1, we compared RTs in the baseline blocks for expression judgments between familiar and unfamiliar faces to see if, as predicted by the structural-reference hypothesis, familiarity would mediate expression judgments. As predicted, the 16-ms advantage for expression judgments for familiar faces as compared with unfamiliar faces was significant, $t(32) = 2.99$, $p < .05$.

One difference between the results of Experiment 2 and those of Experiment 1 is that the overall Garner-interference effect was noticeably larger in Experiment 2 (an interference effect of 102 ms as compared with an interference effect of 30 ms in Experiment 1). We believe that there are different reasons for the larger interference to expressions than the larger interference to identity. A possible explanation for the larger interference effect from identity

to expression in Experiment 2 is based on the notion that the processing of expression is derived from identity (i.e., on the structural representation of the face). Therefore, in cases in which identity is difficult to extract (as with the faces in Experiment 2), this would lead to difficulties (i.e., longer RTs) in the processing of expression. Because such slower performance should be found primarily in filtering blocks (in which identity changes) but not in baseline blocks (in which identity is constant), this would lead to the larger Garner-interference effects found in Experiment 2.

As for the overall larger interference found from expression to identity in Experiment 2 as compared with Experiment 1, we believe that the difference in discriminability between the two experiments mediated this result. Specifically, previous Garner studies (e.g., Algom et al., 1996; Melara & Marks, 1990a, 1990b) have shown that when one dimension (identity) is less discriminable than the other dimension (expression), the processing of this specific dimension (identity) is more hurt by irrelevant variations in the other dimension. This is precisely what the comparison of the interference effects in the two experiments reveals.

An examination of the error data revealed a main effect of familiarity (4.29% for familiar faces; 4.98% for unfamiliar faces), $F(1, 31) = 5.06$, $MSE = 9$, $p < .05$; a main effect of task (3.74% for expression judgments; 5.53% for identity judgments), $F(1, 31) = 19.20$, $MSE = 16$, $p < .01$; and a main effect of block (4.27% in the baseline blocks; 3.60% in the correlated blocks; 6.03% in the filtering blocks), $F(1, 62) = 18.80$, $MSE = 11$, $p < .01$. In addition, a significant Block $\times$ Task interaction was found, probably due to the larger decrease in performance in the filtering blocks as compared with performance in the baseline blocks for identity judgments than for expression judgments, $F(1, 62) = 7.74$, $MSE = 13$, $p < .01$. The worse performance in the filtering blocks than in the baseline blocks rules out the possibility that speed–accuracy trade-offs could account for any of the RT results.

The results of Experiment 2 provide strong support for the structural-reference hypothesis by showing that familiarity has predictable effects on expression judgments in baseline blocks and on the magnitude of Garner interference between identity and expression. These results replicate the results of Experiment 1 under conditions in which expression was more discriminable than identity. We now turn to an elaboration of the theoretical implications of our findings.

General Discussion

The purpose of the present study was to explore the mechanisms that underlie the interconnections between the system that processes the identity and the system that processes the expression of faces. To this end, we presented unfamiliar and familiar facial stimuli in Garner's speeded-classification task.

The results suggest that the interference between identity and expression is best explained by the structural-reference hypothesis, which posits that perceivers can use the structure of a face (i.e., its identity) as a reference with respect to which they can compute expressions and that they can also use unique expressions to facilitate computations of identity. This hypothesis was tested by comparing the interference effects between identity and expression for familiar and unfamiliar faces.

Three different results confirmed the predictions of the structural-reference hypothesis. First, Garner interference was found both from identity to expression and, for the first time, from expression to identity. Second, larger Garner interference between identity and expression was found for familiar than for unfamiliar faces. Finally, expression judgments were faster for familiar faces than for unfamiliar faces in baseline blocks. Together, these findings support the notion that the structure of individual faces can be used as a reference from which their expressions can be more readily derived and that, given a unique expression of an individual, it is easier to compute his or her identity because only a limited population of individuals can express the same emotion in precisely the same manner.

The effects of discriminability on the magnitude and direction of Garner interference have been demonstrated in perceptual domains other than face perception and are considered to be a general principle of perceptual processing (Algom et al., 1996; Melara & Marks, 1990b; Sabri, Melara, & Algom, 2001); the more discriminable dimension usually interferes with the less discriminable dimension. Our results agree with this principle, and they suggest that discriminability, which was often overlooked in previous studies that applied Garner's paradigm to the study of face perception (Baudouin et al., 2002; Schweinberger & Soukup, 1998), should be considered an important factor in the design of experiments.

In this article, we have advanced the structural-reference hypothesis to argue that expressions can be derived from the structure of faces. A related idea is that the structure of the face may also constrain other variant facial features, such as mouth shape or age, as well as invariant facial features, such as sex or race. In fact, our recent demonstration of Garner interference between identity and sex (Ganel & Goshen-Gottstein, 2002) was another illustration of the structural-reference hypothesis, in that it showed how the structure of a face constrains its sex (for a demonstration of how this constraint affects memory, see Goshen-Gottstein & Ganel, 2000). Indeed, it is easy to see that structure and sex covary in real life, with a particular structure leaving few degrees of freedom for the sex that the structure can represent. It is probably for this reason that people are so often able to correctly identify the sex of a person by merely looking at his or her face. Therefore, the ideas that structure constrains expression and that structure constrains sex are intimately related.

In Experiment 1, identical nominal cues were presented to two groups of participants that only differed in their history with the stimuli (i.e., familiarity with the faces). We have uncovered how one variable, familiarity, can change the way stimuli are perceived and can increase the integrality of the dimensions. This finding adds to previous studies from perceptual domains other than faces, which have shown other variables that affect the pattern of Garner interference for the same nominal cues, such as mode of response (Sabri et al., 2001) and type of attentional training (Melara, Rao, & Tong, 2002). The question of whether the effects of familiarity with stimulus can also be found for perceptual domains other than faces awaits further research.

The results of Experiment 2 demonstrated that the identity of faces interfered with expression, even under a pattern of discriminability that was disadvantageous for the processing of identity (i.e., when identity was less discriminable than expression). This interference was found for both familiar and unfamiliar faces. However, when discriminability was disadvantageous for the processing of expression (Experiment 1), interference from expression to identity was found only for familiar faces, not for unfamiliar faces. Therefore, the question that remains is why, under disad-

vantageous pattern of discriminability, the interference from identity to expression was more robust than the interference from expression to identity, in that it was found not only for familiar faces but for unfamiliar faces as well.

A possible explanation for why the interference from identity to expression was more resistant to disadvantageous discriminability may be found by noting that different sources of changes cause variations in identity and variations in expressions. In particular, variations in the identity of faces can result from either of two types of changes in the visual aspects of a scene, whereas changes in facial expression are limited to only one type of change. Variations in the identity of faces may result from either spatial (edge-based) variations between the configurations of different identities (i.e., facial structures) or from nonspatial variations between different identities, such as pigmentation, shading, and texture (Bruce & Humphreys, 1994; Vuilleumier et al., 2003; White, 2001). In contrast to changes in facial identity, changes in facial expression are limited to edge-based variability (e.g., changes in the shape of the mouth for smiling expressions or changes in the shape of the eyebrows for angry expressions).

The idea that information about the identity of faces entails both spatial and nonspatial aspects whereas information about expression entails only spatial aspects can provide an explanation for why the interference from identity to expression was more resistant to disadvantageous discriminability than the interference from expression to identity. Specifically, when expression was the relevant dimension and different identities were presented throughout a filtering block, the task of selectively attending to expression was difficult because it required participants to detect (relatively subtle) changes of only spatial information (i.e., expression) while ignoring both spatial and nonspatial variations that resulted from changes in identity. In contrast, when identity was the relevant dimension, the task of selectively attending to identity was relatively easy because now participants tried to ignore subtle variations of spatial aspects (i.e., expressions) while detecting gross changes in the visual scene (which included both spatial and nonspatial variations).

The idea that information about the identity of faces entails both spatial and nonspatial aspects whereas information about expression entails only spatial aspects can also help to explain the observation that, in most cases, the dimension of identity is found to be more discriminable than that of expression. In particular, because face identification can be based on either the spatial or the nonspatial aspects of faces, it is more easily discriminable than expression judgments, which are based only on the spatial aspects of faces.

Even if the idea of spatial and nonspatial aspects of face processing is embraced, it is limited in its explanatory power to account only for why the interference from identity to expression is more resistant to disadvantageous discriminability than the interference from expression to identity. This idea cannot account for the main finding of the two experiments that were described in this article—namely, of larger Garner interference between identity and expression for familiar than for unfamiliar faces. To account for this finding, one cannot invoke variables that are limited to the visual scene (i.e., spatial vs. nonspatial attributes); one must also incorporate top-down variables that include prior representations of this visual scene. It is to this end that we have introduced the structural-reference hypothesis.

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