Emotion
2006, Vol. 6, No. 2, 269–278

1528-3542/06/$12.00 DOI: 10.1037/1528-3542.6.2.269

Very First Impressions

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First impressions of people's personalities are often formed by using the visual appearance of their faces. Defining how quickly these impressions can be formed has critical implications for understanding social interactions and for determining the visual properties used to shape them. To study impression formation independent of emotional cues, threat judgments were made on faces with a neutral expression. Consequently, participants' judgments pertained to the personality rather than to a certain temporary emotional state (e.g., anger). The results demonstrate that consistent first impressions can be formed very quickly, based on whatever information is available within the first 39 ms. First impressions were less consistent under these conditions when the judgments were about intelligence, suggesting that survival-related traits are judged more quickly. The authors propose that low spatial frequencies mediate this swift formation of threat judgments and provide evidence that supports this hypothesis.

Keywords: first impressions, threat, face perception, rapid personality judgment, intelligence

Our first impressions of others can be truthful. For example, humans are excellent in judging personality traits and complex social characteristics such as dominance, hierarchy, warmth, and threat (Ambady, Bernieri, & Richeson, 2000; Berry, 1990; Brothers, 1997; Funder, 1987; Hassin & Trope, 2000; Zebrowitz, 1997). Accurate first impressions of personality traits have been shown to be possible when observers were exposed to relatively short intervals (4–10 min) of ongoing streams of individuals' behavior, termed *thin slices* (Ambady et al., 2000; Ambady & Rosenthal, 1992; Funder, 1987). In fact, observers seem to be able to extract the cues required for impressions even from static photographs presented for 10 s (Berry, 1990). In these studies, impressions formed with "zero acquaintance" were typically compared with robust data to infer the accuracy of first impressions, generally resulting in significant correlations. As such, rapidly formed first impressions can facilitate our survival and interaction with the environment. (Of course, first impressions can sometimes be inaccurate and, consequently, misguide our behavior in a less desirable manner.) The goal of the study reported here was to test how quickly people can form impressions that are consistent across observers, independent of their validity. Revealing the speed of impression formation would enhance our understanding of social interaction and, by identifying this limit on processing time, will allow gaining novel insights about the type and complexity of the visual features used to create first impressions.

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This study was supported by the James S. McDonnell Foundation 21st Century Science Research Award #21002039 (to Moshe Bar) and by the MIND Institute.

We thank D. Carney, M. Fenske, K. Kveraga, J. Mitchell, and M. Vangel for their helpful comments.

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Until now there has not been a clear definition of such temporal lower limit on impression formation, but relevant studies have been conducted with relation to the detection of facial valence. When faces are emotionally expressive, people can detect the expressions they convey, particularly threatening and fearful expressions, rapidly and perhaps even nonconsciously (Blair, Morris, Frith, Perrett, & Dolan, 1999; Glascher & Adolphs, 2003; Kirouac & Dore, 1984; Pessoa, Japee, & Ungerleider, 2005; van Honk et al., 1998; Whalen, 1998; Williams et al., 2004). In the present study, however, threat judgments were made on neutral faces—faces with no obvious negative or positive expression—that were rigorously rated for neutral expression previously. There is a profound difference between a threatening impression elicited by a threatening face expression, such as anger, and a threatening impression of a face with a neutral expression. A face expression represents a certain emotional state, and a threatening expression in particular indicates a possible immediate danger, regardless of that person's personality otherwise. On the other hand, a person who seems threatening even with a neutral face expression gives the impression of being generally threatening but does not necessarily imply an immediate threat to the observer. Specifically, given that a person with a neutral expression is not perceived as immediately threatening may imply that the features required for inferring threat in this case are expressed to a lesser extent and thus will be detected at a higher perceptual threshold, compared with judgment of threatening expressions, where it is beneficial for these features to be extracted as quickly as possible.

We report here four experiments: The first measures the speed in which first impressions about a threatening personality and intelligence can be formed, the second examines the role of awareness in these judgments, and the third and fourth test our proposal that low spatial frequencies mediate the formation of such rapid first impressions.

Experiment 1: Speed of Impression Formation

Participants in the present experiment were shown one face at a time and were asked to rate, on a scale ranging from 1 to 5, the level at which they perceived each face to belong to a threatening person (or an intelligent person in the second part of this experiment). Given that responses in such an experiment are inherently subjective, the "correctness" of first impressions reported in the conditions in which these faces were presented briefly was inferred from their consistency with judgments made when the same faces were presented for a considerably longer exposure to a different group of participants. In other words, if we consider impressions that are formed when pictures are presented long enough to be easily recognizable as the baseline impressions, independent of how veridical these judgments are, then we can measure how quickly the same faces can be presented and still be judged similarly to this baseline. Therefore, by presenting the faces for different durations to different groups of participants and subsequently measuring the correlation between the judgments of each group and the group that judged the same faces during long presentations, we can identify how quickly observers judge a face as having a certain personality.

Method

Participants. Sixty adults (42 women; age range = 18–45) participated for either course credit or for a monetary compensation, 10 in each of the conditions (3 [exposure duration] × 2 [personality judgment]). All had normal or corrected-to-normal vision. None were aware of the purpose of the experiment. Informed written consent was obtained from each participant before the experiment. All procedures were approved by Massachusetts General Hospital Human Studies Protocol No. 2002-P-001754 and the Harvard University Committee on the Use of Human Participants in Research.

Stimuli and apparatus. The pictures were grayscale photographs of faces, 5° in their largest dimension, presented on a gray background. We used 90 different pictures of Caucasian male faces with a neutral expression collected from various sources. Three of these sources provided faces that were previously and rigorously rated to be neutral: 6 faces from the Ekman Pictures of Facial Affect (POFA; www.paulekman.com/), rated with the Facial Action Coding System; 7 from the Cornell University database (www.macbrain.org/faces/), rated with a card sorting task in which at least 60% of participants agreed that these faces are neutral; and 13 from a database from the University of Texas, El Paso (Zarate, Sanders, & Garza, 2000), rated on a scale from 1 (*very negative*) to 5 (*very positive*), from which those with an average rating of 3 were used. We excluded 2 of these faces because of visible moles. The additional 64 faces were taken from various sources, including the AR Face Database (Martinez & Benavente, 1998), the University of Stirling (http://pics.psych.stir.ac.uk/), the Database of Faces (http://www.uk.research.att.com/facedatabase.html), and Yale University (http://cvc.yale.edu/projects/yalefaces/yalefaces.html). These faces can also be considered generally neutral in their expression, but the rating of neutrality for these images is less well documented, compared with that of the subset of images mentioned earlier, which is used as the primary set of stimuli for the present purposes. The images were cropped to contain facial features only. Each face was followed by one of 15 alternating masks, which were designed to be effective for grayscale pictures of faces. Our masks consisted of black lines, approximately 2 mm in diameter on an abstract background of gray and white. These masks were randomly presented with a target face, so that each time a face was presented, a different mask immediately followed it. The image presentation and response collection were controlled by a Macintosh Power Mac G4, with a monitor resolution of 1024 × 768 pixels and a refresh rate of 75 Hz, using a MATLAB-based program.

Procedure. We started by testing threat judgments. Participants had to rate, on a scale of 1 to 5, the level at which they perceived each face to belong to a threatening person. The responses were counterbalanced so that the ratings ranged from *least threatening* (1) to *most threatening* (5) for one half of the participants and from *most threatening* (1) to *least threatening* (5) for the other half. Participants were explicitly instructed to follow their immediate gut reaction in judging the faces. Individual faces were presented on the computer screen for 26 ms (10 participants), 39 ms (10 participants), or 1700 ms (10 participants; see Figure 1). Each participant saw each face once. We then conducted an identical experiment, except that the participants' task was to rate, on the same counterbalanced 1–5 scale, the level at which they perceived each face to belong to an intelligent person. We used a new group of 30 participants for the intelligence rating. For each participant, the task was preceded by a practice block of 20 trials presented identically (i.e., face, mask, and fixation), using unique faces that were not presented in the actual experimental trials.

Results

We tested the speed with which people can form a first impression about how threatening is a face with a neutral expression. Specifically, we compared how consistently neutral target faces were ranked between groups that judged them during brief presentations of either 26 ms or 39 ms and how the faces were ranked

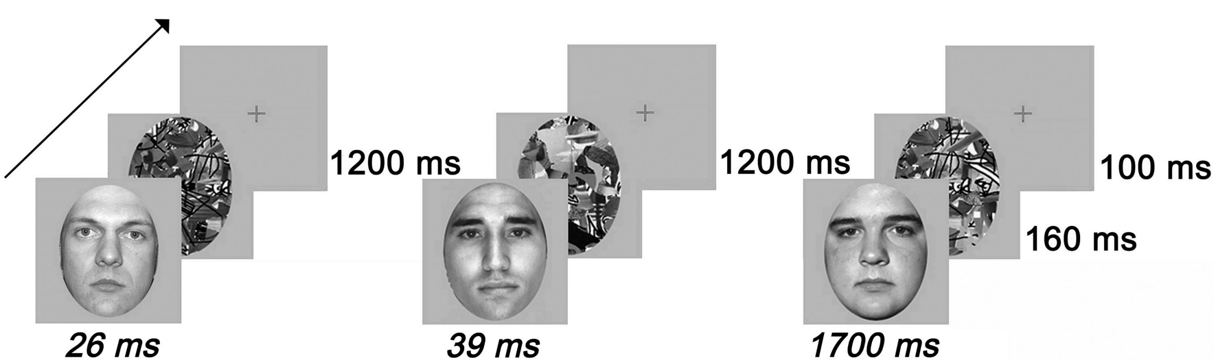


Figure 1. Threat judgment of static face images presented for different durations. Three different groups of participants saw all faces for one of the following exposures: 26 ms, 39 ms, or 1700 ms, followed by a mask and fixation. Participants' task was to judge the level at which they perceived each emotionally neutral face to be threatening (i.e., rate on a scale of 1 to 5), and they were instructed explicitly to follow their immediate gut reaction in judging the faces (see Experiment 1, Method section).

by a third group of participants who viewed the same faces for a baseline duration of 1700 ms (see Method and Figure 1).

There was a strong correlation (Pearson's correlation coefficient: $r = .774$, $p < .001$) between threatening ratings of the 24 previously rated faces obtained for the 39-ms and the 1700-ms groups. This result implies that the face features necessary to form threatening and nonthreatening impressions of neutral faces can be extracted and used by observers even when the target stimulus is available for only 39 ms. In contrast, the correlation between ranking the faces when they were presented for 26 ms and ranking them when they were presented for 1700 ms was not significant ($r = .256$, $p > .1$; see Figure 2A). The results were similar when we included all 90 faces: There was a strong correlation ($r = .546$, $p < .001$) between threatening ratings obtained for the 39-ms and the 1700-ms groups and a dramatic decrease in significance for ratings obtained for the 26-ms and the 1700-ms groups ($r = .084$, $p > .1$; see Figure 2B).

We hypothesized that, because of the possible survival-related importance of hostility judgments, the more threatening the faces look, the higher the correlation between the 39-ms and 1700-ms groups. To evaluate the consistency of these impressions at the extreme ratings, we included only the third most threatening and the third least threatening faces, excluding those faces rated in the middle. Indeed, although threat judgments of faces were highly correlated for 39 and 1700 ms, the faces judged to be most threatening were highly correlated ($r = .935$, $p < .05$), whereas the faces judged to be least threatening were not ($r = .225$, $p = .72$; see Figure 2C). This supports our hypothesis that threat impressions can be formed accurately even at short presentations because of their general importance for survival.

To test whether threat judgments enjoy an exclusive status, we tested the speed of impression formation of another trait, intelligence, which presumably has less of a direct influence on our ability to survive. Subsequently, we made the same comparison of how consistently neutral target faces were ranked between groups that judged them during brief presentations of either 26 ms or 39 ms and by a third group of participants that viewed the same faces for a baseline duration of 1700 ms. We predicted that there would be significantly less correlation, if any, between the different groups of participants, in contrast to the threat ratings.

Indeed, there was neither a correlation between intelligence ratings obtained for the 39-ms and the 1700-ms groups ($r = .156$, $p > .1$), nor between intelligence ratings obtained for the 26-ms and the 1700-ms groups ($r = .311$, $p > .1$). The results were similar when we included all 90 faces: There was neither a correlation between intelligence ratings obtained for the 39-ms and the 1700-ms groups ($r = .15$, $p > .1$), nor one between intelligence ratings obtained for the 26-ms and the 1700-ms groups ($r = -.022$, $p > .1$). This result implies that although people form consistent first impressions about intelligence (Zebrowitz, Hall, Murphy, & Rhodes, 2002), the features required for these impressions are not extracted as quickly as the features used for threat impressions.

In summary, the results of Experiment 1 indicate that people can form consistent threat impressions of faces with neutral expressions presented for as briefly as 39 ms. These results imply that, although we usually see faces for a much longer duration in reality, we tend to form our impressions, at least about threat, primarily on the basis of whatever information is available within the first 39 ms. Presentations of 26 ms, on the other hand, were insufficient for the formation of consistent impressions. Is there a qualitative difference between these two exposure durations that may account for the substantial difference in the ability to form reliable first impressions? We addressed this question in Experiment 2.

Experiment 2: Is Awareness Necessary for Rapid First Impressions?

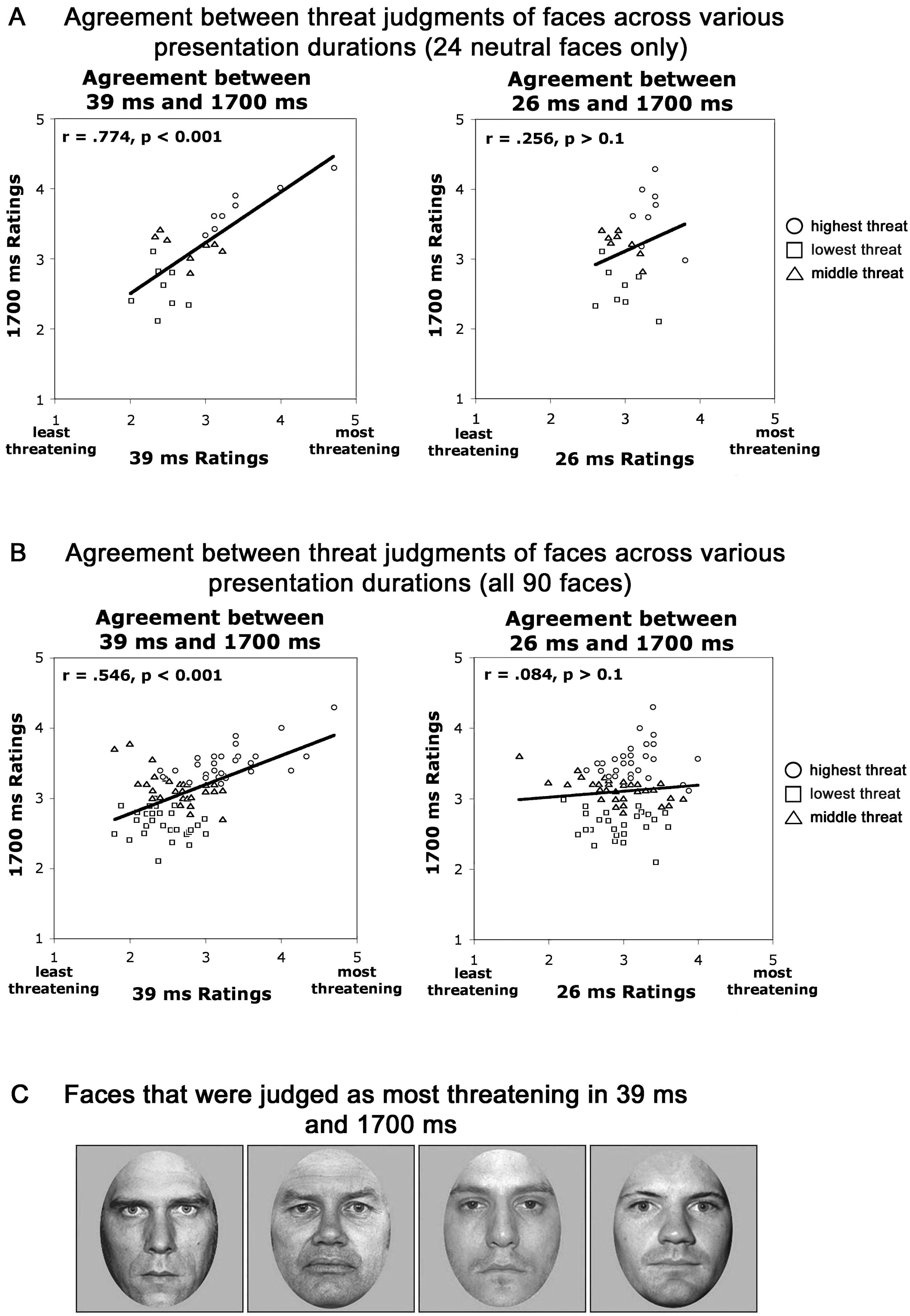
We hypothesized that, when masked faces were presented for 39 ms, participants were aware of at least some aspects of the face, especially features critical for the formation of a threatening impression (e.g., the angle of the eyebrows or the lips). Participants in the 26-ms experiment, on the other hand, may have not been aware of sufficient face information and, therefore, were not able to form consistent impressions of threat. To test this hypothesis, we examined to what extent participants were aware of face information when the faces were presented for 39 ms (to one group of 10 participants) and for 26 ms (to another group of 10 participants).

Method

To estimate the level of perceptual awareness of the briefly presented faces, we presented individual faces for either 26 ms (10 new participants) or 39 ms (10 new participants). After the presentation of each face, which was identical to the presentation of faces in Experiment 1 (i.e., face, mask, and fixation; see Experiment 1, Method section), four faces appeared on the screen, and one of these four faces was the same face as the previously presented target. Participants were given as much time as they required to select the face that was the same as the target face (see Figure 3). Distractor faces were randomly chosen from the entire set of 90 stimuli, and each of the four faces was modified to a slightly higher contrast and a smaller size than the target face. Altering the appearance of the subsequently presented faces served to minimize priming effect from the preceding target face. Responses were made with a key press of 1, 2, 3, or 4 corresponding to the four faces. Target faces were presented in a random order. For each participant, the task was preceded by a practice block of 20 trials presented identically (i.e., face, mask, fixation, and four alternative faces), using unique faces that were not presented in the actual experimental trials.

Results

Participants in the 39-ms condition were correct in 44.2% of the trials for the 24 previously rated faces, performing significantly above chance ($t_{23} = 6.38$, $p < .001$), whereas participants in the 26-ms experiment were correct in only 28.3% of the trials, statistically performing at chance level ($t_{23} = 1.07$, $p > .1$; a significant difference between performance in the two conditions, $t_{23} = -3.40$, $p < .01$). The results were similar when we included all 90 faces: Participants in the 39-ms condition were correct in 38.6% of the trials, performing significantly above chance ($t_{89} = 7.29$, $p < .001$), whereas participants in the 26-ms experiment performed virtually at chance level (i.e., correct in only 25.4% of the trials; $t_{89} = 0.34$, $p > .5$; a significant difference between performance in the two conditions, $t_{89} = -6.35$, $p < .001$). This result indicates that the difference in Experiment 1 between the high 39–1700-ms correlation in impression formation and the low and insignificant 26–1700-ms correlation may indeed be attributable to differences in level of participants' awareness of face information. It is im-


A Agreement between threat judgments of faces across various presentation durations (24 neutral faces only)
Agreement between 39 ms and 1700 ms
r = .774, p < 0.001
1700 ms Ratings
39 ms Ratings
1 least threatening
5 most threatening
Agreement between 26 ms and 1700 ms
r = .256, p > 0.1
26 ms Ratings
highest threat
lowest threat
middle threat
B Agreement between threat judgments of faces across various presentation durations (all 90 faces)
Agreement between 39 ms and 1700 ms
r = .546, p < 0.001
Agreement between 26 ms and 1700 ms
r = .084, p > 0.1
C Faces that were judged as most threatening in 39 ms and 1700 ms

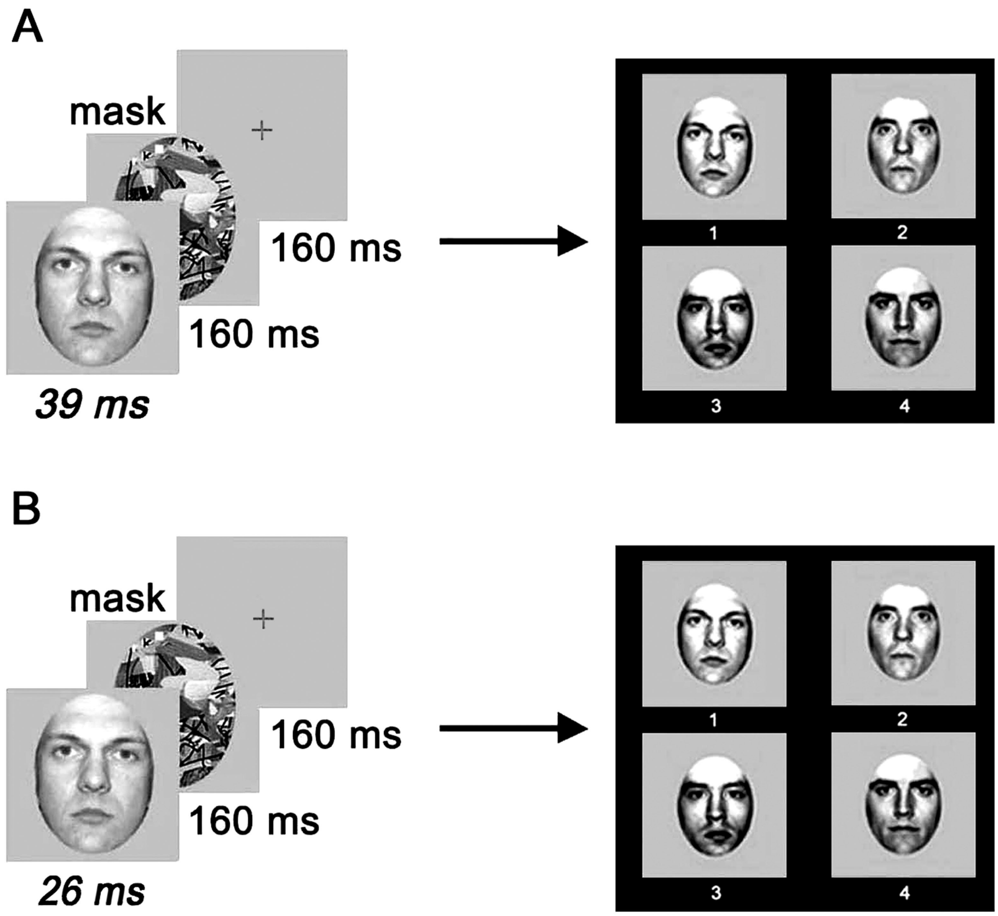


Figure 3. A four-alternative forced-choice test for evaluating awareness of face information. Following each face presentation, participants had as much time as they required for selecting the one face that matched the previously presented target face. A pilot study indicated that, when faces are presented for 1700 ms, the task is considerably easy (77% correct). The face was presented for (A) 39 ms to a group of 10 participants and for (B) 26 ms to a second group of 10 participants.

portant to note that we do not claim that participants were unaware of absolutely any information of the faces in the 26-ms presentations. Such a claim would require a different experiment that is beyond our present scope. We merely propose that in the 26-ms presentations, participants were not aware of sufficient face information to be able to form consistent first impressions. Consequently, at least for neutral faces, a certain level of awareness of face features seems to be necessary for the formation of first

Figure 2 (opposite). (A) Scatterplots showing the distribution of responses and the correlation of threat judgments in 39 ms versus 1700 ms (left) and in 26 ms versus 1700 ms (right) for the 24 neutral faces. To average counterbalanced responses, we flipped the responses for half the subjects during the analysis so that 1 = *least threatening* and 5 = *most threatening* for all subjects. (B) Scatterplots showing the distribution of responses and the correlation of threat judgments in 39 ms versus 1700 ms (left) and in 26 ms versus 1700 ms (right) for all 90 faces (which can also be considered generally neutral, but their rating for neutrality was not as well documented as the rating of the subset of 24 faces). (C) The four faces that were judged by both the 39-ms and the 1700-ms groups of participants as most threatening. All of these four faces were in the subset of 24 faces previously rated as neutral. The two faces on the left (most threatening) are from the Ekman Pictures of Facial Affect, the third face is from the Cornell University database, and the fourth face is from a database at the University of Texas, El Paso. Note that we neither address nor claim a correlation between the threat judgment of a certain face and the traits that the corresponding individual actually possesses. There is no objective measurement of how threatening (or nonthreatening) in reality each person was whose face was used as a target face. Therefore, there are no correct or incorrect responses in such a study. Our inferences rely merely on consensus between participants' responses.

impressions, even about a trait as critical as a threatening personality.

Taken together, these results imply that in the 39-ms presentations, participants were far from performing perfectly, but their performance was significantly above chance. This further suggests that the stimulus information required for forming consistent threat impressions are extracted very early and require some, but not complete, awareness. What might this information be? We propose that such first impressions are based primarily on the low spatial frequencies in the image, and we test this hypothesis in Experiment 3.

Experiment 3: First Impressions About Threat Rely on Awareness of Low Spatial Frequencies

Our observations led us to hypothesize that first impressions about threat are mediated by low spatial frequencies in the image. The rationale behind this hypothesis is that to form first impressions when the stimulus is available for such a short duration, these impressions have to rely on whatever visual information is available very early. Low spatial frequencies are known to be extracted rapidly (see Bar, 2003, for a review) and, furthermore, to involve neural circuitry implicated in processes related to threat perception (Adolphs et al., 1999; Vuilleumier, Armony, Driver, & Dolan, 2003).

The aforementioned findings indicate that, although consistent first impressions about emotionally neutral faces are formed very quickly (Experiment 1), awareness seems to be essential for these judgments (Experiment 2). Therefore, as a necessary first step, one would have to show that participants are aware of low spatial frequencies when faces are presented very briefly but long enough for consistent impressions. An even stronger demonstration would be if, at the same time, these presentations did not result in awareness of the high spatial frequencies, which would add support to our proposal about the unique role of low spatial frequencies in forming these impressions. Consequently, we tested these predictions here directly by assessing whether participants are aware of low spatial frequencies in 39-ms presentations, and significantly less aware of the high spatial frequencies, under the same presentation conditions as in Experiments 1 and 2.

Method

The method used was the same as for Experiment 2, except as follows: (a) the sets of four faces in the four-alternative forced-choice task were filtered to include either the low spatial frequencies (up to eight cycles per image) or the high spatial frequencies (higher than 24 cycles per image; see Figure 4), (b) individual faces were presented for 39 ms to all participants. There were 20 participants (16 women; age range = 18–45), 10 in each of the conditions.

Results

Participants in the low spatial frequency condition were correct in 49.2% of the trials for the 24 previously rated faces, performing significantly above chance ($t_{23} = 6.20$, $p < .001$). Participants in the high spatial frequency experiment, on the other hand, performed correctly in 31.7% of the trials, which was statistically indistinguishable from chance level ($t_{23} = 2.03$, $p = .0541$), at least at a trend level given the marginal p value, and significantly different than performance in the low spatial frequency images ($t_{23} = 3.91$, $p < .001$). It is important to emphasize that, when presented long enough (1700 ms), recognition level in this task was identical for the high and low spatial frequency filtered faces ($t_{23} = -0.44$, $p > .1$), indicating that the difference in levels of awareness between the two conditions was not a result of an inherent difference in recognition difficulty between them. When comparing the results from all 90 faces, we found similar results: Participants in the low spatial frequency condition were correct in 38.7% of the trials, performing significantly above chance ($t_{89} = 7.64$, $p < .001$), whereas participants in the high spatial frequency experiment performed with less accuracy (i.e., correct in only 30.7% of the trials; $t_{89} = 3.92$, $p < .001$). However, although the accuracy of the participants in the high spatial frequency group was significantly above chance, it is critical to note here that the performance remained significantly different from the performance in the low spatial frequency condition ($t_{89} = 3.82$, $p < .001$).

In summary, 39-ms presentations are sufficient for participants to be aware of at least some of the low spatial frequencies in the image, but not of the high spatial frequencies. This result supports the idea that the information of which participants were aware in the 39-ms presentations is the low spatial frequency information. In the final experiment, we demonstrate that this early detection of low spatial frequencies actually mediates the rapid formation of threat impressions.

Experiment 4: Low Spatial Frequencies as the Basis for Rapid Threat Impressions

Our results from Experiment 3 indicate that observers have an increased awareness of the low spatial frequency information in a face relative to the high spatial frequencies. This result, taken together with the findings from Experiments 1 and 2, supports our hypothesis that a primary source of stimulus information mediating threat judgments is the low spatial frequencies in the image. The final step would be to show that observers actually use this earlier awareness of low spatial frequencies to derive their threat judgments. Therefore, a critical test of this hypothesis is whether threat judgments made with intact faces is more correlated with judgments made on the same faces when they are filtered to include primarily low spatial frequencies, compared with when they contain primarily high spatial frequencies. To be able to propose a specific range of spatial frequencies as the basis of these judgments, we used faces filtered at different spatial frequency thresholds.

Method

We used the same method as that in Experiment 1, with two exceptions. First, the target faces were spatially filtered to include various spatial frequency ranges: ≤8 cpi, ≤16 cpi, band-pass (BP) 8–16 cpi, BP 16–24 cpi, or ≥24 cpi (see Figure 5). Second, individual faces were presented for 39 ms to all participants. There were 50 participants (35 female; age range = 18–45), 10 in each of the five frequency conditions.

Results

We tested the accuracy with which people can form a first impression about how threatening is a face with a neutral expres-

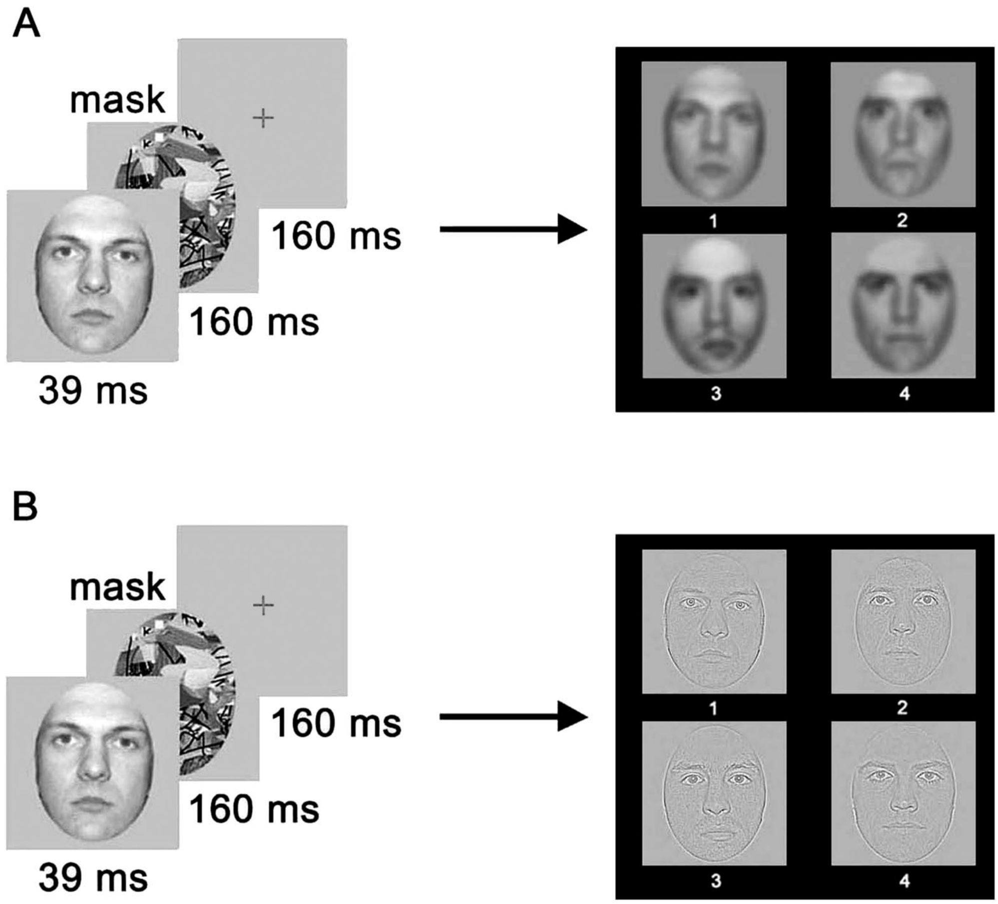


Figure 4. A four-alternative forced-choice test for evaluating awareness of different spatial frequency bands in face images. After each face presentation, participants had as much time as they required for selecting the one face, from a set of four, that matched the previously presented target face. (A) The set of four faces were of low spatial frequency images (8 cycles per image). (B) The set of four faces were of high spatial frequency images (24 cycles per image). A pilot study indicated that, when faces are presented for 1700 ms, performance is not significantly different for low versus high spatial frequency images.

sion when it was filtered to a particular spatial frequency bandwidth. Specifically, we compared how consistently neutral target faces were ranked between groups that judged intact faces during brief presentations of 39 ms (from Experiment 1) and five other groups of participants that saw filtered faces during brief presentations of 39 ms (see Method and Figure 5).

There was a strong correlation (Pearson's correlation coefficient: $r = .644$, $p = .001$) between threatening ratings of the 24

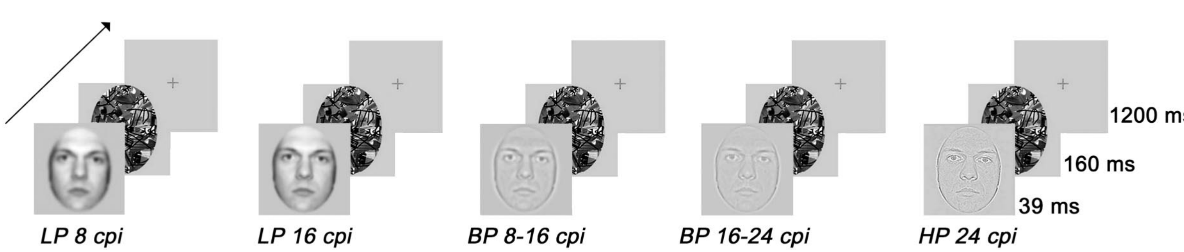


Figure 5. Threat judgments were made for static face images presented for 39 ms. Five different groups of participants saw all faces at one of the following spatial frequency filtering: Low-pass (LP; i.e., low spatial frequencies) 8 cycles per image (cpi), LP 16 cpi, Band-pass (BP) 8–16 cpi, BP 16–24 cpi, and High-pass (HP, i.e., high spatial frequencies) 24 cpi, followed by a mask and fixation. Participants' task was to rate, on a scale from 1 to 5, the level at which they perceived each emotionally neutral face to be threatening, and they were instructed explicitly to follow their immediate gut reaction in judging the faces (see Experiment 4, Method section).

previously rated faces obtained for faces filtered at a low-pass threshold of 16 cpi (i.e., all the low spatial frequencies up to 16 cpi) and the intact faces. This correlation was almost as strong ($r = .580$, $p < .005$) between threat ratings for faces filtered at a low-pass threshold of 8 cpi and the intact faces. The correlation between faces filtered at a band-pass of 8–16 cpi and intact faces was slightly smaller ($r = .556$, $p = .005$). Taken together, it seems that even a low threshold of 8 cpi is sufficient for a strong correlation with the same judgments for intact faces, and that the information conveyed by the 8–16 cpi band of spatial frequencies still adds to these judgments, resulting in maximal correlation for the low-pass range up to 16 cpi.

Critically, the correlation between the judgments of faces filtered at a higher band-pass of 16–24 cpi and intact faces was not significant ($r = .267$, $p > .1$), nor was the correlation between faces filtered at a high-pass threshold of 24 cpi (i.e., all the spatial frequencies from 24 cpi and up) and intact faces ($r = .201$, $p > .1$). In other words, the spatial frequencies contributing the majority of the information for threat judgments, at least in brief presentations, are the low spatial frequencies. The correlation value obtained for the 16 cpi low-pass band (0.644) was indeed the closest to the correlation between intact faces presented for 39 and 1700 ms (0.774) in Experiment 1.

These results were similar when we included all 90 faces: The strongest correlation ($r = .505$, $p < .001$) was obtained between threatening ratings of the faces filtered at a low-pass threshold of 16 cpi and the intact faces; the weakest, nonsignificant, correlation ($r = .088$, $p > .1$) was obtained for faces filtered at a high-pass threshold of 24 cpi and the intact faces (see Figure 6).

In summary, this experiment provide the critical support for our hypothesis that the features used to derive threat in a face are conveyed primarily by the low spatial frequencies.

General Discussion

Neutral faces were judged as threatening or nonthreatening similarly when they were presented for 39 ms and for 1700 ms durations. This result implies that appearance-based personality judgments can be formed very quickly, regardless of whether the judged face is seen for considerably longer. In other words, people base their first impressions of others on whatever information is available within the first 39 ms.

Because the activation of first impressions is so rapid, it is reasonable to predict that the perceptual properties that mediate their formation are processed quickly, either because of their primitive structure or their coarse level of analysis. Judgment of threat (as well as of fear, which indirectly implies the presence of a threat) is believed to be mediated by the amygdala (Adolphs et al., 1999; Pessoa, Japee, Sturman, & Ungerleider, 2005), possibly using the low spatial frequency content of the face images (Schyns & Oliva, 1999; Vuilleumier, Armony, Driver, & Dolan, 2003). Low spatial frequencies are known to be processed in the brain faster than high spatial frequencies, using rapid magnocellular projections (see Bar, 2003), and therefore are a likely candidate for mediating the swift formation of threatening impressions. Indeed, we demonstrated here that observers are aware of the low spatial frequencies necessary for forming consistent impressions already at 39-ms presentations and that these low spatial frequencies provide the basis for such rapid threat judgments.

Low spatial frequencies may be augmented by other types of information in forming threat impressions, such as the angle of the eyebrows (Ekman & Friesen, 1975), which can be extracted rapidly using selective attention and anticipation. Furthermore, low spatial frequencies are not expected to play the same central role for impressions of all personality traits. Indeed, that under the same presentation conditions intelligence impressions were not as consistent as threat impressions implies that different types of information may mediate different judgments. It is conceivable that our visual system has evolved to detect face information pertaining to threat evaluations at a lower threshold, and thus at a faster rate, on the basis of the information that is available first. Personality traits for which detection is less critically time-sensitive, on the other hand, can be judged on the basis of finer information that is analyzed relatively later (e.g., high spatial frequencies).

When the same faces were presented for 26 ms, the correlation with 1700-ms judgments was reduced dramatically. The results from our subsequent test of awareness imply that a 26-ms exposure was insufficient for forming impressions because participants in this condition were unaware of the minimal information required for creating consistent threat impressions of neutral faces. Awareness of visual information is not an all-or-none phenomenon (Bar et al., 2001); rather, it changes along a continuum. Participants may not have been aware of all aspects of a face presented for 39

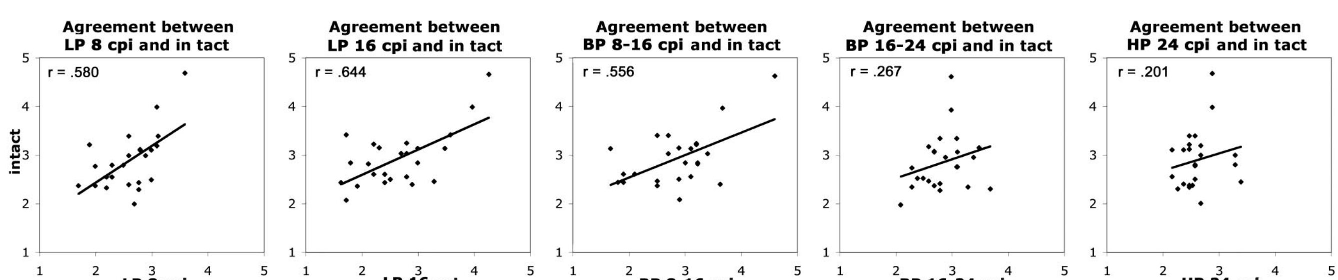


Figure 6. Scatterplots showing the distribution of responses and the correlation of threat judgments in 39 ms when the faces are filtered, versus in tact, for the 24 neutral faces. Correlations between judgments of the filtered faces and the intact faces were significant only for the stimuli containing low spatial frequencies (i.e., LP 8, LP 16, BP8-16).

ms, but they seem to have been aware of the necessary information (i.e., low spatial frequencies), which was sufficient for consistent impressions.

Note that, in studies that presented faces with a threatening expression (e.g., anger) rather than neutral faces, threat was reported to be detected even without awareness (Anderson, Christoff, Panitz, De Rosa, & Gabrieli, 2003; Blair et al., 1999; Glascher & Adolphs, 2003; Kirouac & Dore, 1984; Pessoa et al., 2005; van Honk et al., 1998; Whalen, 1998; Williams et al., 2004). One possible explanation is that the assessment of awareness in those earlier studies may have not been sufficiently sensitive for detecting participants' partial awareness of only some of the face information. Another possibility is that, although the same physical features that signal threat exist both in faces that express threatening emotions and in neutral faces that seem inherently threatening, they are present to different degrees. Specifically, because those features are significantly more pronounced in expressive than in neutral faces, they may be detected with different levels of ease and perceptual thresholds. An expressive face represents an "active" threat, and people may therefore be more sensitive to this stimulus and detect it at a lower threshold. When faces have a neutral expression, on the other hand, like the ones that we used here, the threat characteristic that they may convey can be considered "passive." Therefore, combined with previous reports, our findings suggest that the threshold of awareness for detecting threat is lower when the threat is immediate and can be directed toward the observer.

It is important to elaborate further on the relation between the perceptual properties that convey threat in emotionally neutral faces, such as the ones used here, and the features that constitute a threatening face expression. As we suggested earlier, the same features mediate threat impression in both neutral and expressive faces, but they are present to different degrees in the two cases. Indeed, the faces in Figure 2C, which were judged as highly threatening by both the 39-ms and 1700-ms groups, seem at first as if they actually convey a threatening expression, although they were rigorously rated for neutrality (e.g., Ekman & Frieson, 1975). In other words, the specific features that signal threat are present in those faces to such a high degree on the continuum that the faces seem to be actually angry. It is interesting to note that studies that attempt to explain veridical correlations obtained between personality judgments and the targets' actual personality have postulated that personality traits such as threat (or hostility) may modulate facial appearance because their repeated expression affects the vascular, skeletal, and muscular properties of the face (Malatesta, Fiore, & Messina, 1987; Zajonc, 1985). We propose that personality judgment of individuals with a neutral expression may be dictated by how closely their inherent face features resemble possible expressions. For example, a person whose face features largely overlap with typical features of a threatening expression (e.g., anger), even if these features are present to a lower extent when the face expression is neutral, will be perceived as a threatening person; a face with features that largely overlap with the features that signal a compassionate or a happy expression, on the other hand, will be perceived positively.

In conclusion, we showed that first impressions about a threatening personality can be made consistently on the basis of the information that is available within the first 39 ms of exposure. Furthermore, these impressions require a minimal level of awareness and seem to rely primarily on low spatial frequency information in the image.

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Received August 1, 2005
Revision received December 12, 2005
Accepted December 15, 2005 ■