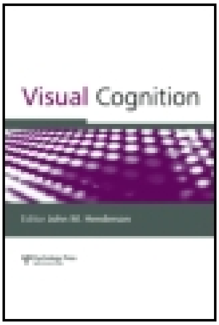

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Normal face-based judgements of social characteristics despite severely impaired holistic face processing

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Normal face-based judgements of social characteristics despite severely impaired holistic face processing

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Initial evidence indicates that face-based judgements of socially relevant characteristics such as people's trustworthiness or attractiveness are linked to the configural/holistic processing of facial cues. What remains a matter of debate, however, is whether such processing is actually necessary for normal social judgements to occur and whether it resembles the type of integrative processing as required for facial identification. To address these issues, we asked a well-characterized case of acquired prosopagnosia (PS) with a marked deficit in holistic processing for face identity to rate a series of faces on several dimensions of social relevance. PS provided ratings within the normal range for most of the social characteristics probed (i.e., aggression, attractiveness, confidence, intelligence, sociability, trustworthiness). Her evaluations deviated from those of healthy controls only when facial dominance was concerned. Taken together, these data demonstrate that the inability to integrate facial information during face individuation does not necessarily translate into a generalized deficit to evaluate faces on social dimensions.

Keywords: First impressions; Holistic processing; Person perception; Trait inferences.

Faces are, to say the least, a treasure trove of socially relevant information. Not only do they provide cues about a target's identity, sex, age, race, or emotional status, they even seem to signal people's apparent personalities (for reviews, see Macrae & Quadflieg, 2010; Todorov, Said, & Verosky, 2011;

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Zebrowitz, 2006). In fact, perceivers' inclination to infer social characteristics from faces tends to be so ubiquitous that a rapid glance often suffices to trigger speculations about how trustworthy, aggressive, or intelligent a person may be (e.g., Bar, Neta, & Linz, 2006; Oosterhof & Todorov, 2008; Todorov, Pakrashi, & Oosterhof, 2009; Willis & Todorov, 2006).

Although the inclination to read traits from faces can be traced back to the ancient Greeks (see Hassin & Trope, 2000), systematic studies demonstrating the far-reaching implications of such judgements across many domains in everyday life are of more recent origin. According to contemporary investigations, for instance, a facial appearance reflecting competence can be predictive of people's political voting decisions (e.g., Antonakis & Dalgas, 2009; Todorov, Mandisodza, Goren, & Hall, 2005) and facial signs of dominance in chief executive officers have been linked to company profits (e.g., Rule & Ambady, 2008, 2009).

Besides illustrating the real-world impact of facial looks, such research reveals that often different perceivers tend to agree on the impressions they form when beholding others. Surprisingly though, not much is currently known about the perceptual processes underlying this common inferential feat. Therefore, researchers have emphasized the need "to identify the specific visual cues that people use when they draw inferences from appearances" (Olivola & Todorov, 2010, p. 323).

From research on facial recognition, it is known that faces are typically processed in a configural/holistic manner. Put differently, when identifying others, facial features such as a person's eyes, nose, and mouth are considered in concert as forming a single entity rather than as independent pieces of information (e.g., McKone, 2004; Sergent, 1984; Tanaka & Farah, 1993; Young, Hellawell, & Hay, 1987). Just like identity judgements, social judgements require the extraction of fairly invariant facial markers associated with relatively stable characteristics of people. It seems therefore plausible that both types of face inferences rely on a common representational system of face perception that requires the holistic integration of visual information (Calder & Young, 2005; Todorov, Loehr, & Oosterhof, 2010).

In support of this idea, it has been found that facial inversion does not only impede judgements of identity but also judgements of intelligence, approachability, trustworthiness, and attractiveness (Santos & Young, 2008). Also, for the latter two, composite face effects (see Hole, 1994; Young et al., 1987) have been observed. That is, facial halves are considered less trustworthy (attractive) when paired with untrustworthy (unattractive) rather than trustworthy (attractive) halves (Abbas & Duchaine, 2008; Todorov et al., 2010). Given that face inversion is thought to disrupt the holistic processing of facial cues and that composite face effects typically signal just such type of processing (see, e.g., Hole, 1994; Young et al., 1987), these data suggest that inferring social characteristics from faces—just like determining a person's identity—also relies on the integration of facial information into a holistic representation.

Challenging this assumption, recent evidence indicates that people with a life-long impairment in face recognition (generally referred as cases of congenital or developmental prosopagnosia; for a review, see Behrmann & Avidan, 2005) are capable of making normal trustworthiness judgements from faces (Todorov & Duchaine, 2008). This observation shows that the extraction of social cues from faces can diverge from the extraction of facial identity cues. Since the study did not characterized the source of participants' face recognition deficits, however, the obtained data do not speak towards the nature of the perceptual processes involved (or not involved) in making normal social judgements from faces. In fact, sources of face recognition difficulties in cases of developmental prosopagnosia appear to be varied (see Behrmann & Avidan, 2005; Chatterjee, Russel, & Nakayama, 2009; Duchaine, Yovel, & Nakayama, 2007). For instance, it is yet unclear whether a lifelong impairment in face recognition is necessarily associated with impaired configural/holistic face processing. While some studies have reported such processing deficits (Avidan, Tanzer, & Behrmann, 2011; Behrmann, Avidan, Marotta, & Kimchi, 2005), others have failed to find evidence in support of this assumption (Le Grand et al., 2006; Schmalzl, Palermo, & Coltheart, 2008).

In contrast, a well-known case of acquired prosopagnosia—the brain-damaged patient PS (Rossion et al., 2003)—is known to be systematically impaired at holistic face processing. In particular, when individuating a face, PS relies on the analytical processing (i.e., the feature-by-feature based processing) of facial information, as indicated by the lack of a face inversion effect (Busigny & Rossion, 2010), whole-part and composite face effects (Ramon, Busigny, & Rossion, 2010), and as observable during the direct manipulation of holistic versus analytic face processing using gaze-contingency (Van Belle, de Graef, Verfaillie, Busigny, & Rossion, 2010). At the same time though, PS can categorize a face as a face readily, even when she has to rely on holistic processing and her impairment in holistic processing can be dissociated from a more general impairment at integrating local parts of a visual stimulus into a global structure (Busigny & Rossion, 2011; Rossion, Dricot, Goebel, & Busigny, 2011). Therefore, testing PS's ability to perform social judgements on faces offers a unique opportunity to assess whether such judgements specifically require holistic face processing at a fine-grained level of resolution (i.e., as required for face individualization).

In summary, in the current study, we examined for the first time how a brain-damaged patient with impaired holistic processing when facial identification is concerned succeeds at judging social characteristics that have recently attracted scientific attention such as aggression, attractiveness, confidence, dominance, intelligence, sociability, and trustworthiness from faces (see Bar et al., 2006; Bzdok et al., 2012; Hassin & Trope, 2000; Oosterhof & Todorov, 2008; Rule & Ambady, 2008; Santos & Young, 2008). In addition, we examined her ability to judge facial typicality (as probed by the question “How likely would you be to see a person who looks like this walking down the street?”). Not only do face-based social judgements tend to be highly correlated with judgements of face typicality (see Said, Dotsch, & Todorov, 2010), but judgements of typicality also capture the ability to code for individual faces with respect to a norm or a prototype. Given PS’s profound individualization deficits, one would therefore not expect her judgements of face typicality to be fully preserved.

METHOD

Participants

Patient PS (at the time of study participation 60 years old) has been described in functional and neuroanatomical detail. In brief, PS is a Caucasian woman who sustained closed head injury in 1992, which caused extensive lesions, mainly to the right inferior occipital and the left mid-ventral cortex (Sorger, Goebel, Schiltz, & Rossion, 2007). She can discriminate faces from other objects, but is impaired at recognizing faces at an individual level (Schlitz et al., 2006). PS performs below the normal range on standardized face recognition tests such as the Benton Face Recognition Test and the Warrington Recognition Memory Test (Busigny & Rossion, 2010; Sorger et al., 2007). Most intriguingly, during facial identity tasks, PS encodes local facial information independently of other facial features and thus shows a marked deficit in holistic processing (Busigny & Rossion, 2010; Ramon et al., 2010; Van Belle et al., 2010). At the same time, PS is not impaired at recognizing and discriminating objects (Busigny, Graf, Mayer, & Rossion, 2010; Rossion et al., 2003; Schiltz et al., 2006). Her visual field is almost full (with exception of a small left paracentral scotoma) and her visual acuity good (0.8 for both eyes as tested in August 2003).

In addition to PS, we asked a group of young control (YC) participants consisting of 30 Caucasian gender-matched undergraduate students (18 to 32 years, mean age: 20.2) from the University of Louvain to take part in the experiment. All of them had normal or corrected-to-normal visual acuity and participated in the study in exchange for course credit. Finally, we also collected data of two Caucasian age-matched female control (AC) participants (both 59 years old). This was done to ensure that differences observed between controls and PS could not merely be attributed to age-related variation. Both ACs had normal or corrected-to-normal visual acuity and received a small financial reward to cover travel expenses arising from study participation (10 Euros).

Material

Sixty colour images of full-front Caucasian faces (30 females) with direct gaze and neutral expression taken from the lifespan database of adult facial stimuli (Minear & Park, 2004) served as targets. Displayed individuals were between 18 and 30 years of age without facial hair, earrings, glasses, or visible make-up. All faces were standardized to a common height of 400 pixels and inserted on a uniform black background of 400×400 pixels.

Procedure

Upon arrival at the laboratory, participants were seated at an iMac computer equipped with a 20 inch screen set to a resolution of 1680×1050 pixels, and asked to pay close attention to a set of directions that informed them about the study. Computerized instructions stated that participants were invited to rate a series of faces on several dimensions of social relevance. In line with previous investigations (e.g., Oosterhof & Todorov, 2008; Todorov & Duchaine, 2008), participants were further encouraged to rely on their "gut feeling" during these ratings. Finally, participants were informed that ratings would be requested in blocks of trials each of which would be related to only one specific dimension of judgement.

To ensure comparability between controls and the prosopagnosic patient, the order of required judgements (i.e., blocks) was fixed across participants such that participants began by completing ratings of typicality followed by attractiveness, trustworthiness, dominance, intelligence, sociability, aggression, and finally self-confidence. Within each block of trials, faces were presented three times to increase the reliability of judgements by reducing the measurement error for each participant. The order of faces per block was randomized for each participant.

On each trial, a target face was presented at the centre of black screen with a question above the photograph (e.g., "How trustworthy is this person?") and a response scale displayed below. The response scale ranged from 1 (e.g., "not at all") to 9 (e.g., "extremely"). Each face was visible until the participant responded with a buttonpress indicative of their rating (see Barton, Cherkasova, Press, Intriligator, & O'Connor, 2003). Trials were separated by an interstimulus interval of 500 ms. Blocks of trials were separated by a pause screen that remained visible until participants activated the next block of trials by pressing the spacebar at their own pace. The presence of the experimenter ensured that breaks between blocks of trials were kept to a minimum and were roughly comparable across participants (i.e., between 1 and 5 minutes).

Importantly, Patient PS was initially tested at the same time as the other participants. To ensure that our observations were replicable, however, we asked PS to complete the exact same experiment at a second occasion. Given that both testing sessions were precisely 1 year apart (first testing session: 26 November 2010; second testing session: 25 November 2011), we consider it highly unlikely that the later session was biased by her initial exposure to the task and its stimuli.

Analyses

We compared the obtained data for young controls (YCs), age-matched controls (AC1 and AC2), and the patient PS at Session 1 (PS1) and Session 2 (PS2) with regard to judgement consistency, judgement extremity, judgement agreement, and judgement interrelatedness.

To investigate *judgement consistency*, for each participant and social dimension of interest three correlation coefficients were determined by relating ratings of the first, second and third presentation of the full set of faces to each other. The person-specific mean of these intradimension correlations was then taken as an indicator of an individual's consistency of judgement. To statistically examine whether ACs' and/or PS's ratings differed in consistency from those of the YCs, we used a specialized *t*-test that was designed to compare correlation coefficients for single cases to a normative sample of coefficients (see Crawford, Garthwaite, Howell, & Venneri, 2003).

To address *judgement extremity*, for each dimension of judgement the mean rating across all 60 faces was computed for each participant. The mean ratings as provided by AC1, AC2, and PS were then compared to the mean ratings as provided by YCs, using again a specialized *t*-test developed to contrast an individual's mean score with a sample-based normative score (see Crawford & Garthwaite, 2002; Crawford & Howell, 1998).

To explore aspects of *judgement agreement*, we determined two related indicators as previously reported in the literature (see Todorov & Duchaine, 2008). For the first indicator, the average rating for each face per participant and dimension of judgement was computed. For YCs, we then collapsed across these ratings to receive an average rating per face and dimension. Subsequently, these average ratings were correlated with the ratings as obtained from ACs and PS. We then examined whether ACs' and PS's ratings correlated significantly less with the YC average ratings than those of the YCs themselves. Thus, ACs' and PS's correlation coefficients were compared to the distribution of correlations coefficients found for YCs. To construct a distribution of correlations for YCs, we computed the correlation between each YC's ratings and the mean of the ratings of the other YCs. To compare the resulting correlation coefficients statistically, we used the same specialized *t*-test for the comparison of correlation coefficients as before. This time, however, we adopted a one-tailed hypothesis-testing strategy to enhance our sensitivity towards a lack of agreement.

As a second indicator of judgement agreement, the total set of 60 target faces was split into two 30-item subsets. Thus, for each dimension of judgement, we allocated those faces to Subset A that had received the lowest mean ratings from YCs, whereas faces with the highest mean ratings were assigned to Subset B. Given this selection criterion, for each social dimension the mean ratings for the two subsets of faces differed significantly from each other for YCs (see Results section). Importantly, having established these differences in YCs, we were able to examine whether for the identical subsets of faces the average ratings as provided by ACs and PS would differ in a similar fashion.

Finally, to address *judgement interrelatedness*, the average ratings for each face across YCs per dimension were computed and correlated across selected dimensions of judgement. Based on previous reports in the literature, it was expected that for YCs ratings of dominance and trustworthiness would be largely unrelated but that ratings of face typicality would be highly positively correlated with ratings of attractiveness, intelligence, sociability and trustworthiness (see, e.g., Hassin & Trope, 2000; Oosterhof & Todorov, 2008; Penton-Voak, Pound, Little, & Perrett, 2006; Said et al., 2010). We explored whether similar patterns of cross-dimensional correlations could be observed for ACs and PS.

RESULTS

Consistency of judgement

For YCs, intradimension correlations ratings of the first, second, and third presentation of the full set of faces to each other ranged from .11 to .94. The resulting mean consistencies across YCs ranged from .59 for face typicality to .75 for sociability (see Table 1). ACs' intradimension correlation coefficients did not deviate in a significant manner from YCs for any of

TABLE 1
Mean intradimension correlations for young controls (YCs), age-matched controls (AC1 and AC2), and patient PS (at Sessions 1 and 2)

	YCs			*AC1*	*AC2*	*PS1*	*PS2*
Dimensions of judgement	*n*	*Mean*	*SD*	*Mean*	*Mean*	*Mean*	*Mean*
Aggression	30	0.71	0.16	0.86	0.89	0.30	0.39
Attractiveness	30	0.75	0.16	0.92	0.84	0.59	0.41
Confidence	30	0.68	0.20	0.78	0.89	0.35	0.26
Dominance	30	0.72	0.16	0.84	0.76	0.57	0.38
Intelligence	30	0.74	0.18	0.86	0.87	0.44	0.34
Sociability	30	0.75	0.19	0.91	0.91	0.40	0.33
Trustworthiness	30	0.72	0.17	0.90	0.85	0.49	0.42
Typicality	30	0.59	0.16	0.70	0.66	0.52	0.19

the dimensions probed (see Table 1). The same was true for PS, despite her coefficients falling generally in the lower normal range (see Table 1).

Also, PS's own ratings were quite consistent between sessions performed at a one year interval. Significant correlations (all *p*s $<.05$) were found for judgements of aggression, $r(58) = .26$, attractiveness, $r(58) = .69$, confidence, $r(58) = .60$, dominance, $r(58) = .60$, intelligence, $r(58) = .56$, sociability, $r(58) = .60$, and trustworthiness, $r(58) = .64$. Interestingly, only for face *typicality*, $r(58) = .20$, $p = .13$, did no significant correlation emerge across sessions.

Extremity of judgements

When examining the judgements with regard to extremity, no systematic differences between YCs, ACs, and PS could be established (see Table 2). In particular, AC1 displayed significantly enhanced scores for sociability and trustworthiness judgements but the same effect was not observed for AC2. In fact, AC2 did not deviate from the judgements as provided by YCs on any of the dimensions probed. Finally, while PS displayed significantly enhanced typicality scores at Session 1, the effect was not replicated at Session 2. At Session t2wo, she showed reduced intelligence and sociability scores.

Agreement of judgements

Correlations. When ACs' mean face ratings were correlated with the mean face ratings as provided by YCs for corresponding dimensions of judgement, all correlations were higher than zero ranging from .29 to .83 (all *p*s $<.05$; see Figure 1). A similar pattern of results was observed for PS. In both

TABLE 2
Mean ratings for the total set of faces as provided by young controls (YCs), age-matched controls (AC1 and AC2), and patient PS (at Sessions 1 and 2)

	YCs		*AC1*	*AC2*	*PS1*	*PS2*
Dimensions of judgement	*Mean*	*SD*	*Mean*	*Mean*	*Mean*	*Mean*
Aggression	4.37	0.73	5.18	4.39	4.75	3.93
Attractiveness	4.33	0.80	5.84	4.19	5.58	4.64
Confidence	5.28	0.51	6.17	5.06	5.47	5.76
Dominance	5.00	0.55	6.01	5.09	5.62	4.46
Intelligence	5.13	0.62	6.27	4.79	5.70	3.74*
Sociability	4.83	0.62	6.11*	4.95	4.82	2.21*
Trustworthiness	4.76	0.67	6.38*	4.20	5.37	3.61
Typicality	5.36	0.68	6.52	5.17	7.43*	6.07

Ratings were collected on a scale ranging from 1 ("not at all") to 9 ("extremely"). *indicates a significant difference from YCs ($p <.05$).

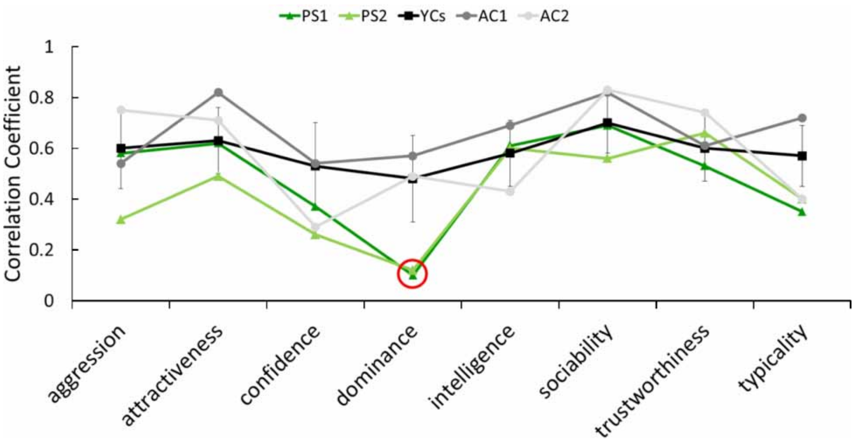

Figure 1. Agreement as measured in correlation coefficients between average face ratings provided by young controls (YCs), age-matched controls (AC1 and AC2), and patient PS (at Sessions 1 and 2). To construct a distribution of correlations for YCs, we computed the correlation between each YC's ratings and the mean of the ratings of the remaining YCs. The error bars for YCs show 1 standard deviation. The red circle indicates coefficients that are significantly reduced in comparison to YCs' coefficients. To view this figure in colour, please see the online issue of the Journal.

testing sessions, most correlation coefficients were significantly higher than zero, ranging from .26 to .69 (all *p*s $<.05$). Only for dominance did a significant correlation fail to emerge for PS at both testing occasions: Session 1: $r(58) = .10$, $p = .46$; Session 2: $r(58) = .12$, $p = .35$ (see Figure 1).

Further analyses revealed that while all ACs' correlation coefficients were within the normal range of coefficients (all *p*s $>.05$), PS had significantly reduced correlation coefficients for judgements of dominance at Sessions 1, $t(29) = 1.93$, $p = .03$, and 2, $t(29) = 1.83$, $p = .04$. No significant differences emerged for any of the remaining dimensions at either of the two testing sessions (all *p*s $>.05$). It is noteworthy, however, that her correlation coefficients for judgements of face typicality were the only other coefficients that approached significance on both testing occasions: Session 1, $t(29) = 1.65$, $p = .06$; Session 2, $t(29) = 1.31$, $p = .10$.

Subsets of faces. ACs' ratings on the two subsets of faces associated with the highest and lowest scores on each dimension as determined by YC's data also revealed significant differences across all dimensions (see Table 3). Such differences were consistently mirrored in PS's ratings of aggression, attractiveness, intelligence, sociability, and trustworthiness. For dominance, however, a significant mean difference failed to emerge for PS during both testing sessions (for example stimuli, see Figure 2). In addition, at Session 1, typicality scores differed only marginally across the two face sets for PS and at Session 2, a significant difference for confidence scores failed to emerge.

TABLE 3
Mean ratings for face sets A and B as observed for young controls (YCs), age-matched controls (AC1 and AC2), and patient PS (at Sessions 1 and 2)

Dimensions of judgement	*Face set*	*YCs*	*AC1*	*AC2*	*PS1*	*PS2*
Aggression	A	3.38	4.33	3.40	4.21	3.57
	B	5.36	6.03	5.39	5.29	4.30
Attractiveness	A	3.39	4.11	3.32	4.73	3.86
	B	5.27	7.57	5.06	6.43	5.43
Confidence	A	4.53	5.27	4.64	5.09	5.69[a]
	B	6.04	7.08	5.48	5.84	5.83[a]
Dominance	A	4.25	5.10	4.49	5.43[a]	4.26[a]
	B	5.76	6.92	5.70	5.80[a]	4.67[a]
Intelligence	A	4.32	5.28	4.30	5.07	3.02
	B	5.93	7.26	5.28	6.33	4.47
Sociability	A	3.75	4.67	3.97	3.91	1.81
	B	5.91	7.56	5.93	5.73	2.61
Trustworthiness	A	3.86	5.50	3.31	4.66	2.79
	B	5.65	7.26	5.09	6.09	4.43
Typicality	A	4.58	5.38	4.69	7.12[b]	5.34
	B	6.13	7.66	5.64	7.74[b]	6.80

Set A contains faces that received the lowest mean ratings from YCs on the respective dimension of judgement, whereas Set B comprises faces with the highest mean ratings. [a]indicates mean ratings that fail to differ significantly across face sets ($p > .10$). [b]indicates mean ratings that differ only marginally across face sets ($p > .05$).

Relatedness of judgements

For YCs, the revealed cross-dimensional correlation coefficients replicated observations as previously reported in the literature. Most notably (see Table 4), judgements of trustworthiness and dominance were only weakly related and ratings of face typicality were strongly correlated with ratings of attractiveness, intelligence, sociability, and trustworthiness. The same pattern of results was found for both ACs (see Table 4). PS's ratings of typicality were also correlated with ratings of attractiveness, intelligence, sociability, and trustworthiness, but she additionally showed a surprisingly strong correlation between judgements of trustworthiness and dominance at both testing sessions (see Table 4).

DISCUSSION

In this experiment, a case of acquired prosopagnosia (PS) with a marked deficit in holistic face processing for face recognition rated a series of faces on a range of social characteristics. Her ratings were compared to ratings provided by healthy controls with regard to consistency, extremity,

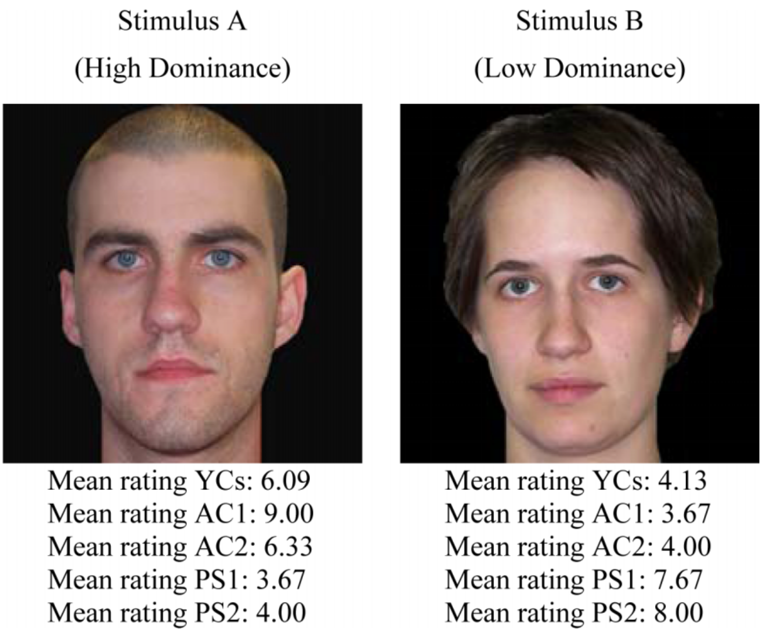

Figure 2. Example stimuli illustrating how PS' dominance ratings diverge from control ratings. To view this figure in colour, please see the online issue of the Journal. Images used with permission from Denise Park (see Minear & Park, 2004).

agreement, and interrelatedness. Overall, the data revealed that PS's ratings were generally within the normal range, with the exception of dominance. These data provide converging evidence to the observation for cases of congenital prosopagnosia that forming person impressions from faces involves processes that can be functionally independent of the processes for encoding the identity of faces (Todorov & Duchaine, 2008).

The current study is particularly interesting since it has previously been shown that our patient's visual recognition impairment is strictly restricted

TABLE 4
Correlations between selected dimensions of judgements as observed for young controls (YCs), age-matched controls (AC1 and AC2), and patient PS (at Sessions 1 and 2)

Correlations between . . .	*YCs*	*AC1*	*AC2*	*PS1*	*PS2*
Dominance & trustworthiness	.25	−.17	.05	.75*	.71*
Attractiveness & typicality	.88*	.82*	.65*	.61*	.39*
Intelligence & typicality	.76*	.32*	.64*	.61*	.36*
Sociability & typicality	.70*	.47*	.46*	.62*	.26*
Trustworthiness & typicality	.82*	.29*	.54*	.70*	.37*

*significant at $p < .05$.

to faces, and is clearly defined as an impairment of holistic processing of face identity (Ramon et al., 2010 ; Van Belle et al., 2010). Given that it has been demonstrated that healthy controls spontaneously process faces in a holistic manner when asked to draw personality and attractiveness inferences (Abbas & Duchaine, 2008; Santos & Young, 2008; Todorov et al., 2010), how can we account for the present findings?

One possibility to reconcile both sets of data is that some social judgements based on information from the whole face are strongly correlated with judgements made based on facial parts alone (as previously suggested by Todorov & Duchaine, 2008). In other words, for certain dimensions of social relevance, incomplete face information may suffice for normal inferences to occur. In this perspective, social judgements on faces, unlike judgements of facial identity, may not *depend* on normal holistic face processing. Especially for full face colour images, as used in the current study, it may be the case that featural information (that can also be embedded in a person's hairstyle, hairline, or skin colour) can carry sufficient information for different perceivers to arrive at similar social inferences.

Another possibility to reconcile the existing findings is that social judgements need holistic face processing, but at a coarser level than face identity judgements. Indeed, patient PS or other cases of pure acquired prosopagnosia can process faces holistically if the task is merely to categorize the stimulus as a face (i.e., classifying Mooney images as faces), not individuate it (Busigny et al., 2010; Rossion et al., 2011). Finally, a third explanation may be that PS is after all capable of integrating facial information in a holistic manner but can only use the resulting representations during specific types of face judgements. Further research will need to distinguish between these alternatives.

Besides challenging the idea that acquired prosopagnosia leads to a general impairment of inferring social characteristics from faces, the present data also indicate that not all social judgements are alike. Rather, the abnormal processing of an individual face in acquired prosopagnosia seems to depend on the specific type of judgement probed. Many social judgements are highly correlated with each other and previous work adopting statistical techniques to reduce data dimensionality has shown that two orthogonal factors—valence/trustworthiness and power/dominance—can account for a majority of the variance in face-based personality judgements (Hassin & Trope, 2000; Oosterhof & Todorov, 2008). Intriguingly, the current data suggest that PS was consistently impaired at providing normal ratings on only one of the two fundamental dimensions, namely dominance.

For dominance, PS's ratings failed to correlate with those provided by normal controls—an effect that replicated across both testing sessions and that was in marked difference to the distribution of correlations obtained for normal controls. In addition, her ratings did not reveal a significant mean difference for the two sets of faces that were considered as the most and least dominant for controls. Moreover, unlike normal participants in this study and previous studies, PS's ratings of dominance were strongly correlated with her ratings of trustworthiness (Hassin & Trope, 2000; Oosterhof & Todorov, 2008). Indeed, this pattern of cross-dimensional correlations indicates that she treats inferences of dominance similar to valence-based inferences such as judgements of trustworthiness or sociability.

There is initial evidence to assume that perceptual markers of dominance share morphological characteristics with facial expressions of anger (Hess, Adams, & Kleck, 2009; Oosterhof & Todorov, 2009; Said, Sebe, & Todorov, 2009) as well as with facial signs of maleness/masculinity (Oosterhof & Todorov, 2008; Pivonkova, Rubesova, Lindova, & Havlicek, 2011; Swaddle & Reierson, 2002). Intriguingly, PS has previously been shown to also perform slightly less accurately than healthy controls when asked to differentiate between joyful, fearful, and angry facial expressions and when trying to determine the sex of faces displayed without gender-diagnostic hair styles (Rossion et al., 2003). So what could account for these specific deficits?

In healthy controls, it is well known that sex judgements of faces based on internal features alone typically require the integration of several internal facial features (Baudouin & Humphreys, 2006; Brown & Perrett, 1993; Bruce et al., 1993; Roberts & Bruce, 1988; Schyns, Bonnar, & Gosselin, 2002). In addition, the detection of both anger expressions and biological sex from faces has been found to rely in particular on the incorporation of information coming from the eye region (Brown & Perrett, 1993; Roberts & Bruce, 1988; Smith, Cottrell, Gosselin, & Schyns, 2005). PS, like other cases of acquired prosopagnosia, struggles with using eye information when processing faces (Caldara et al., 2005) and fixates the eyes less often than normal observers (Orban de Xivry, Ramon, Lefèvre, & Rossion, 2008). Ignoring the diagnosticity of the eye region in this manner has been linked to the fact that the region consists of many individual elements that themselves require integration (Ramon & Rossion, 2010). Thus, PS's tendency to rely less on the eye region when processing faces could potentially explain the observed deviation in her dominance ratings.

On a closer look, PS's judgements of face typicality also seem impaired. First, they were not correlated across sessions, suggesting that she used different perceptual cues to base her judgements on at both testing sessions—an effect not noted for any of the other dimensions probed. Second, her typicality ratings tended to be rather high (mean average rating at Session 1: 7.43; mean average rating at Session 2: 6.07), indicating that she struggled to differentiate targets along this dimension and that to her, most faces look typical. Third, her typicality ratings showed low correlations (i.e., low overlap) with the mean judgements of controls on both testing occasions (albeit these effects were of mere marginal significance). This lack of correlation for ratings of facial typicality is in line with observations that a case of acquired prosopagnosia may use fewer dimensions than normal observers to judge the similarity/distinctiveness of pairs of faces, an observation that may not apply for cases of congenital prosopagnosia (Nishimura, Doyle, & Behrmann, 2010). PS's deviating typicality judgements are particularly interesting given that typicality and trustworthiness ratings tend to be highly correlated in controls, suggesting that both judgements normally rely on similar perceptual cues. Nevertheless, PS appears to manage using these cues normally when judging trustworthiness but not during typicality trials.

Finally, overall, PS seemed less consistent in her judgements than normal controls. Though the specialized *t*-test was insensitive to this pattern (due to a large variability in consistency in young controls), it can easily be seen from Table 1 that on average the intradimension correlations of the young control group ranged from .59 to .75 with a mean of .71 and the intradimension correlations of the two age-matched controls ranged from .66 to .92, with means of .85 (AC1) and .83 (AC2). In comparison, PS's intradimension correlations at Time 1, ranged from .30 to .59 with a mean of .46 and at Time 2, they ranged from .19 to .42 with a mean of .34. That is, the strongest intradimension correlation of PS equalled the lowest average intradimension correlation of the young controls and was lower than the weakest intradimension correlation of age-matched controls.

Importantly, in the context of the current study, a nonperceptual factor might have influenced judgement consistency. Compared to PS, healthy controls have an enhanced ability to recognize faces. Thus, when they are asked to rate the same face several times, the ability to recognize a target allows them to consider the memory of previous response during their latest judgement. Given that humans strive to act in a consistent manner (Cialdini, 2001; Festinger, 1957; Heider, 1958), such memory traces may artificially enhance judgement consistency over time. PS, in contrast, is less likely to be biased by mnemonic factors given her impaired ability to detect that she is rating the exact same face multiple times.

However, if her lower consistency was solely related to reduced mnemonic bias, PS's ratings should be less consistent than those of healthy controls in a similar manner across all dimensions of judgement. Instead, variations as seen in Table 1 suggest that additional factors contribute to her reduced consistency scores. Thus, PS appears to be able to use the perceptual face information in a more consistent manner during some judgements than during others. Why certain judgements (such as those regarding aggression or confidence) are particularly inconsistent compared to those provided by healthy controls remains at this stage a matter of speculation. It could be argued, for instance, that for certain types of social judgements relying on a subset of facial cues rather than the full amount of available information may enhance the variation in a person's judgement across repeated occasions of evaluation. Also, since the patient had not been instructed to make her judgements based on a specific cue, she may have changed the cues that she used during the experiment more when judging some attributes than others.

Taken together, the current data demonstrate that deficits to individuate faces and the inability to integrate facial information during face recognition are not necessarily associated with a generalized deficit to evaluate faces on social dimensions. This finding is noteworthy given that social judgements, like identity judgements, require the extraction of fairly invariant facial markers and have been argued to also rely on the holistic processing of facial information. The obtained data may signal that some social judgements (e.g., dominance and typicality) rely more strongly on the holistic integration of facial information than others (e.g., attractiveness and trustworthiness), and thus pose a tougher challenge for perceivers with holistic face processing deficits. Further experimentation is necessary to establish whether there is a relationship between the fine-grained degree to which a judgement relies on the integration of person-specific facial information and atypical social judgements in prosopagnosic patients with holistic face processing deficits.

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