Inclusive fitness theory (Hamilton 1964) predicts that cooperation and sexual inhibition among members of a group increase with their genetic relatedness. In line with the theory, which assumes an ability to identify genetic relatives, kin recognition has been observed in several types of living organisms, from plants (Dudley and File 2007) and social amoebas (Queller et al 2003) to invertebrates (Greenberg 1979), vertebrates (Hepper 1991), and humans (Lieberman et al 2007). More specifically, human social behaviour often depends on kinship, and it is not surprising that, in addition to the ability to recognise one’s own kin, an ability to detect kin among strangers has developed in our species (Kaminski et al 2009). The present study focuses on the ability to detect kinship, and attempts to identify the perceptual determinants of the visual detection of kinship.

People undeniably pay attention to faces, and facial resemblance may act as a kinship cue. However, previous studies have shown that the ability to detect kinship through facial resemblance is limited, and it has been suggested that this may be due to several types of perceptual factors. To further understand the processes that underpin kinship judgment, it is important to investigate which perceptual factors predict the probability of parent–child pairs being detected as related. To this end, we performed two experiments. In the first, we evaluated the ability of human observers to match newborns with one of their parents. In the second, we explored three perceptual factors that may have influenced kinship detection (gender discrimination, facial attractiveness, and perceptual similarity). Results showed that the participants were able to match newborns with one of their parents, even though the task was perceived as difficult. Moreover, our study goes further than previous findings, showing that the perceptual factors investigated may significantly contribute to kinship detection.

1 Introduction

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Perceptual factors affecting the ability to assess facial resemblance between parents and newborns in humans

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Abstract. People undeniably pay attention to faces, and facial resemblance may act as a kinship cue. However, previous studies have shown that the ability to detect kinship through facial resemblance is limited, and it has been suggested that this may be due to several types of perceptual factors. To further understand the processes that underpin kinship judgment, it is important to investigate which perceptual factors predict the probability of parent–child pairs being detected as related. To this end, we performed two experiments. In the first, we evaluated the ability of human observers to match newborns with one of their parents. In the second, we explored three perceptual factors that may have influenced kinship detection (gender discrimination, facial attractiveness, and perceptual similarity). Results showed that the participants were able to match newborns with one of their parents, even though the task was perceived as difficult. Moreover, our study goes further than previous findings, showing that the perceptual factors investigated may significantly contribute to kinship detection.

1 Introduction

Inclusive fitness theory (Hamilton 1964) predicts that cooperation and sexual inhibition among members of a group increase with their genetic relatedness. In line with the theory, which assumes an ability to identify genetic relatives, kin recognition has been observed in several types of living organisms, from plants (Dudley and File 2007) and social amoebas (Queller et al 2003) to invertebrates (Greenberg 1979), vertebrates (Hepper 1991), and humans (Lieberman et al 2007). More specifically, human social behaviour often depends on kinship, and it is not surprising that, in addition to the ability to recognise one’s own kin, an ability to detect kin among strangers has developed in our species (Kaminski et al 2009). The present study focuses on the ability to detect kinship, and attempts to identify the perceptual determinants of the visual detection of kinship.

People undeniably pay attention to faces, and facial resemblance may act as a kinship cue, as shown by DeBruine et al (2008). Previous findings have shown that adults can detect kinship in strangers’ faces. Kinship detection is undertaken by assessing facial similarities between a pair of individuals (Maloney and Dal Martello 2006), and its effectiveness increases with the degree of relatedness between the individuals who make up the pair (e.g. there is better detection of siblings’ faces than those of cousins—Kaminski et al 2009). In specific tasks associating parents and offspring, correct matching is possible even with newborn–parent pairs (McLain et al 2000; Alvergne et al 2007), and the detection rate increases with the age of the children in the pairs (Nesse et al 1990; Christenfeld and Hill 1995; Brédart and French 1999; Bressan and Dal Martello 2002; Bressan and Grassi 2004; Oda et al 2005). However, it is important to note that the magnitude of the kinship detection effect is rather weak, with the probability of selecting the correct parent being 1.04 to 1.4 times greater than chance. We may then question why the recognition rate is generally weak, and why it fluctuated in previous studies.

The varying results could be due to different factors favouring or impairing the detection of kin cues. We identified two kinds of parameters that could have influenced
the results of previous studies: those related to the characteristics of the individuals who assessed the parent–child resemblance, and those related to the characteristics of the evaluated faces.

The characteristics of individuals who assess parent–child resemblance are important for at least two reasons. First, female participants seem to better identify, recognise, and categorise female faces than male faces (Slone et al. 2000; Lewin and Herlitz 2002). In parent–child matching tasks, some works have also pointed out that the gender of the rater interacts with the gender of the judged faces (Nesse et al. 1990; Bressan and Dal Martello 2002). Second, from an evolutionary perspective, fathers and mothers (and their respective relatives) do not have the same interests, since fathers face paternity uncertainty and mothers do not. In this vein, paternal resemblance is alleged far more often than maternal resemblance by the maternal family (Daly and Wilson 1982; Regalski and Gaulin 1993; McLain et al. 2000; Alvergne et al. 2007), while there is no evidence of differential facial resemblance of newborns to their parents by the paternal family (Daly and Wilson 1982; Regalski and Gaulin 1993). To investigate actual parent–child resemblance, and thus to prevent bias in how maternal and paternal families assess resemblance, unrelated individuals are often used because they are more likely to give an objective measure of this resemblance, since they do not share the same genetic interests as the individual they are looking at.

The characteristics of the faces being evaluated may also influence kinship detection. Usually, assessment of parent–child resemblance is performed by identifying the biological parent (either the mother or father) of a child (whose face appears on a photograph), out of a selection of three adults of the same gender. The Alvergne et al. (2007) study described in detail several image properties that may affect assessment (e.g., background presence). However, to date, little is known of the other potential factors that may affect visual detection of kin. For example, distractor (false parent) parameters also seem to affect assessment (Vokey et al. 2004). Unfortunately, previous studies provided few indications of the way in which individual distractors were matched with biological parents, the quantity of images in the study database, or on the number of times each face was used.

To firmly establish the existence of visually based kinship detection ability in humans, and to further understand the perceptual processes that underpin kinship judgments, we ran two experiments. In experiment 1, we tested the ability to detect parent–child resemblance using a large sample of unrelated individuals. We chose to use newborns’ faces to exclude the possibility of phenotypic convergence of individuals sharing the same environment over long periods (Zajonc et al. 1987). We asked participants to match one newborn’s face with one of three adults’ faces (‘newborn target items’), as in previous studies (McLain et al. 2000; Alvergne et al. 2007), or to match one adult’s face with one of three newborns’ faces (‘adult target items’). We also used both colour and black-and-white facial photography, since it may affect kinship detection (Alvergne et al. 2007). Because people in an ecological context are more likely to compare parents to find the correct one than to compare different newborns, we anticipated that participants may have better detection rates in ‘newborn target items’ than in ‘adult target items’. This prediction is also supported by the assumption that newborn faces may be more similar to each other than adult faces, which may increase the difficulty of detecting kinship among ‘adult target items’. In experiment 2, we explored three perceptual factors that may affect the visual detection of kin. For each item presented in experiment 1, we tested facial attractiveness and the distinctiveness of newborns’ gender, and we used a computational model of visual processing to explore the role of perceptual similarity between the target faces and each of the three comparison faces.
2 Experiment 1. Detection of parent–newborn pairs

2.1 Method

2.1.1 Participants. All participants were undergraduate students from Grenoble University in southeastern France. The experiment involved ninety participants [mean age ± SD = 21.5 ± 1.4 years, sixty-six (73%) women] who all completed the kinship face-matching task. The participants were unaware of the purpose of the study, and to our knowledge, none was a relative of the individuals included in the database. The study was conducted in accordance with the Declaration of Helsinki, with the understanding and the written consent of each participant, and was approved by the local ethics committee.

2.1.2 Face database. The face-image database was made up of 275 full-term newborns and 87 parents. We used 64 newborn faces (32 boys) and 64 parent faces (32 men). All parents and newborns were Caucasian, and all photos were taken in a nursery. The mean age of newborns was approximately 101 hours. Their facial expressions and head orientations varied. All parents were photographed three days post-partum while adopting a neutral expression. Parents gave informed written consent for the limited use of their own and/or of their newborns' pictures. The facial areas and luminosity were equalised, and the faces were pasted on a uniform grey background (580 × 580 pixels). Details on image processing can be found in Kaminski et al (2009). Faces were grouped in pools according to gender, hair colour and quantity, head orientation, and state of the eyes and mouth (open or closed), in order to exclude differential clues making one face too salient with respect to its neighbours.

2.1.3 Procedure. The stimuli used in this experiment consisted of panels composed of one face at the top (the target face), and three faces below it (the comparison faces). The comparison faces included the related face and two distractors drawn from the same pool (see figure 1). 32 items were generated. In 16 of those items, the target face was a newborn’s face and the three comparison images were adults’ faces. This method replicates those used in previous studies. In the remaining 16 items, we reversed the situation: the target face was an adult’s and the three comparison images were newborns’ faces. This method, derived from the work of Porter et al (1984), has never before been tested. Both male and female sets were used for each of the two item types, leading to four subsets comprising four items each. The position of the related face in each panel (left, middle, or right) was randomly attributed.

The participants were asked to select the newborn–parent pair from the three possible pairs within each item. The items were each shown for 25 s. A 5-s interval separated each item with a black screen, during which time the participants were asked to reach a decision or randomly select one of the three previous comparison images. Each face was presented once, and each participant assessed all 32 items. However, to investigate the effects of colour cues, each item was shown to half of the participants in colour, and to the other half in black-and-white. In all other respects, the items were randomly presented to the participants. No feedback was provided. After the last item was judged, participants filled out a self-appraisal questionnaire on their success (judge ascription) and on the difficulty of the task.

2.1.4 Statistical analysis. The judge’s choice for each item was recorded as 0 for incorrect parent–newborn matching or 1 for accurate matching. For each judge (N = 90), we calculated the frequency of kinship detection for all 32 items and obtained a participant detection rate. We also computed an item detection rate using the sum of correct choices given for each by all ninety participants. We did not perform a classic binomial test on the entire group of items (number of correct responses in $N = 90 \times 32$, compared with $P = 1/3$), which would have required independence of the items and of the judges’ responses (Sokal and Rohlf 1995). We treated average item detection rates
as a frequency of success over \( n = 90 \) realisations of an event, with theoretical frequency \( f_\hat{=} = 1/3 \) and standard deviation \( S_f = \sqrt{\frac{f(1-f)}{n}} \). We then tested the \( Z \) score of the observed frequency (one-tailed). This procedure appeared more conservative to us than a binomial test. The judges’ ratings of their own performance (judged ascription) were compared with their kinship detection score by using a Spearman rank correlation (\( r_s \)).

We used multiple logistic regressions to examine the factors that influenced parent–newborn pair detection. Our dependent binary variable was judge’s choice. The independent binary variables were: (i) newborn gender, (ii) parent gender, (iii) matching test (adult target item versus newborn target item), and (iv) image colour. A preliminary analysis of the results revealed that participants’ gender had no effect. All factors were considered fixed-effect variables, except for participants and items, which were cross random-effect variables. We constructed our model using fixed and random variables, as well as the only two-way interaction that had a biological interpretation (newborn gender × parent gender). Statistical analyses were conducted with SAS software (SAS Institute Inc., release v.9.1, 2002–2003).

2.2 Results

Descriptive analyses, listed by item and participant, are displayed in table 1. The average item detection rate (0.42 ± 0.18) was significantly higher than the rate expected by chance (\( Z = 1.8, P = 0.035 \)). In addition, table 1 shows that the item detection rate of parent–newborn pairs was significantly higher than chance for 18 out of the 32 items. Regarding individual performance, we calculated the participant detection rate and found significant kinship detection (success \( \geq 15 \) items) for thirty-one participants (34.4%, table 1). Interestingly, participant ascription was not correlated with the number of correct answers given (\( r_s = 0.12, P = 0.242 \)). Most participants believed they were simply guessing, yet they made correct choices.
Next, we assessed the effects of parent gender, newborn gender, matching tests, and image colour on judge's choice by multiple logistic regressions (table 2). Only the effects of image colour and of newborn gender × parent gender interaction were significant. In black-and-white images, parent–newborn pairs were slightly more likely to be matched than in colour images (odd-ratio = 1.17). Moreover, girls were more frequently paired with their mothers than with their fathers (odd-ratio = 1.29), and boys were more frequently paired with their fathers than with their mothers (odd-ratio = 1.27).

Table 1. Descriptive analyses by item (N = 32) and participant (N = 90). For each item and for each participant, the detection rate (the frequency of correct parent–newborn detection) was compared with random levels (rate mean = 0.33) with exact binomial tests. The lines in bold show the overall mean (± SD) detection rate of items and participants.

<table>
<thead>
<tr>
<th>N</th>
<th>Detection rates</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean ± SD</td>
<td>range</td>
</tr>
<tr>
<td>Items</td>
<td></td>
<td></td>
</tr>
<tr>
<td>significant correct detection</td>
<td>18</td>
<td>0.55 ± 0.11</td>
</tr>
<tr>
<td>random-level detection</td>
<td>8</td>
<td>0.32 ± 0.03</td>
</tr>
<tr>
<td>significant false detection</td>
<td>6</td>
<td>0.16 ± 0.09</td>
</tr>
<tr>
<td>mean</td>
<td></td>
<td>0.42 ± 0.18</td>
</tr>
<tr>
<td>Participants</td>
<td></td>
<td></td>
</tr>
<tr>
<td>significant detection</td>
<td>31</td>
<td>0.52 ± 0.05</td>
</tr>
<tr>
<td>random-level detection</td>
<td>59</td>
<td>0.37 ± 0.05</td>
</tr>
<tr>
<td>mean</td>
<td></td>
<td>0.42 ± 0.91</td>
</tr>
</tbody>
</table>

Table 2. Mixed-effect models of participants’ ability to match parent–newborn pairs in two experiments. The binary response variable was judge’s choice (JC). The identity of participants and items were used as a cross random effect.

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Predictor</th>
<th>Explained variation/%</th>
<th>F</th>
<th>df</th>
<th>P-value</th>
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<tr>
<td>Experiment 1. Detection of parent–newborn pairs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>JC for all 32 items</td>
<td>matching test</td>
<td>1.29</td>
<td>1.278</td>
<td>0.256</td>
<td></td>
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<tr>
<td></td>
<td>image colour</td>
<td>4.17</td>
<td>1.278</td>
<td>0.041</td>
<td></td>
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<tr>
<td></td>
<td>newborn gender (Ng)</td>
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<td>0.097</td>
<td></td>
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<tr>
<td></td>
<td>parent gender (Pg)</td>
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<td>1.278</td>
<td>0.905</td>
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</tr>
<tr>
<td></td>
<td>Pg × Ng</td>
<td>10.51</td>
<td>1.278</td>
<td>0.001</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>gender distinctiveness</td>
<td>1.20</td>
<td>2.278</td>
<td>0.302</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GWF perceptual similarity</td>
<td>50.24</td>
<td>1.278</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td></td>
<td>attractiveness rate</td>
<td>94.15</td>
<td>1.278</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Experiment 2. Role of perceptual factors in kin detection</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>JC for all 32 items</td>
<td>matching test</td>
<td>2.81</td>
<td>1.278</td>
<td>0.094</td>
<td></td>
</tr>
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<td></td>
<td>image colour</td>
<td>3.99</td>
<td>1.278</td>
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<tr>
<td></td>
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</tr>
<tr>
<td></td>
<td>parent gender</td>
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<td>1.278</td>
<td>0.978</td>
<td></td>
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<tr>
<td></td>
<td>Pg × Ng</td>
<td>10.01</td>
<td>1.278</td>
<td>0.002</td>
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<tr>
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<td>2.278</td>
<td>0.302</td>
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<td></td>
<td>GWF perceptual similarity</td>
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<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td></td>
<td>attractiveness rate</td>
<td>94.15</td>
<td>1.278</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>JC for the 18 correctly matched items</td>
<td>matching test</td>
<td>0.17</td>
<td>1.152</td>
<td>0.681</td>
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</tr>
<tr>
<td></td>
<td>image colour</td>
<td>3.98</td>
<td>1.152</td>
<td>0.046</td>
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<tr>
<td></td>
<td>newborn gender</td>
<td>6.14</td>
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<td>1.152</td>
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<td>Pg × Ng</td>
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<td>1.152</td>
<td>0.010</td>
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<tr>
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<td>gender distinctiveness</td>
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<td>2.152</td>
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<td>GWF perceptual similarity</td>
<td>117.11</td>
<td>1.152</td>
<td>&lt;0.001</td>
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<tr>
<td></td>
<td>attractiveness rate</td>
<td>94.15</td>
<td>1.152</td>
<td>&lt;0.001</td>
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</tr>
</tbody>
</table>
2.3 Discussion
Results from experiment 1 show that some unrelated individuals are able to match a newborn to one of his or her parents. The detection rate is significantly higher than chance for both parents. Participants are under the impression that they are responding randomly, and are incapable of assessing their actual recognition rates. Our tasks are thus perceived as difficult, but participants are unwittingly able to succeed. The magnitude of the overall detection rate, however, is slightly higher than chance (1.3× chance). These data support the results of two other studies (McLain et al 2000; Alvergne et al 2007) that demonstrated that newborns are phenotypically closer to their parent than to random men or women from a similar population. In addition, our results go further in showing that information present in parent−newborn items influences detection rates for at least two reasons. First, contrary to our predictions, the results showed the same success rate in the ability to detect parent−newborn pairs in both matching tests (‘adult target items’ versus ‘newborn target items’). If we assume, as stated above, that newborns’ faces are less variable than adults’ faces, these results suggest that humans possess an efficient kinship detection system. They also suggest that exposure (in this case, experience with newborn faces) plays a limited role in the ability to match parents’ faces with those of their newborns. Using participants from different countries in a similar matching task, Alvergne et al (2009) also found that the role likely played by exposure in kinship detection was a limited one. Second, the results showed that the detection rate was better when items were in black-and-white than when they were in colour. This suggests that participants were misled by colour cues.

Experiment 1 revealed that not all items were significantly detected; merely 18 out of 32 were. There are at least two potential reasons why the items were not all correctly detected. First, it is likely that the actual facial resemblance between newborns and their parents is differently displayed in each pair in our sample. Thus, it is conceivable that the newborn population is distributed along a parental resemblance gradient, with newborns who have developed facial features useful for assessing kinship at one end, and those without (or with weak) facial kinship features at the other. Second, several factors related to the characteristics of the matching tasks may have influenced kinship detection by limiting or enhancing the probability of selecting the correct comparison face. In experiment 2, we explored the second possibility by investigating three perceptual factors.

3 Experiment 2. Role of perceptual factors in kin detection
3.1 Method
3.1.1 Participants. Sixty-seven students (mean age ± SD = 19 ± 3 years, 94% women) participated in this experiment. The participants were unaware of the purpose of the study; none had participated in experiment 1, and none was, to our knowledge, a relative of the individuals included in the database. Each participant completed both the newborns' gender distinctiveness and image attractiveness tasks.

3.1.2 Newborns’ gender distinctiveness task. In experiment 1, the outcomes showed an interaction between parental and child gender: there was a higher same-gender detection rate (mother−girl or father−boy) than opposite-gender detection rate. Such interaction may be explained by a link between facial sexual features and facial kinship cues. Variation in resemblance according to the gender of individual pairs is not new; it was first proposed by Porter et al (1984), and more recently shown in three studies (Alvergne et al 2007; Debruine et al 2009; Kaminski et al 2009). To delve deeper into the gender effect on kinship resemblance, we can assume that a face with salient sexual features may also display numerous kinship cues. To test this hypothesis, we evaluated
the distinctiveness of gender in newborns’ faces. We predicted that the more sexually distinct the newborn face was, the higher the detection rate would be.

We assessed the distinctiveness of newborn’s gender by employing a gender discrimination task that used all of the 64 newborn faces from experiment 1. We assumed that gender discrimination would be perfect for the adult faces (Wild et al 2000). The participants’ task was to guess the gender of the newborn’s face. The newborns’ faces were shown for 5 s, and participants then had another 5 s to reach a decision or to make a random selection. The number of times each newborn’s gender was correctly identified was compared to a binomial test ($P = \frac{1}{2}$ under the null hypothesis). We obtained a variable (gender distinctiveness) comprising three categories (those with a significantly high degree of sexual distinctiveness, those with a significantly low degree of sexual distinctiveness, and those who fall in-between).

3.1.3 Image attractiveness task. In the matching task used in experiment 1, participants’ choices may have been based on an intrinsic preference for one face over another. One can easily imagine certain assessments being based on choices made by default, ie those made by eliminating the two least probable or least appealing faces, without the third face actually being detected as the parent. To assess the possibility that the selection of a comparison image is mediated by perceptions of differential attractiveness of (preference for) one face over another, we conducted a task in which we asked the participants to indicate their preferred face for each assortment of faces presented in experiment 1 (16 adult and 16 newborn comparisons). Thus, the items (the three comparison faces, but not the target face) were exactly the same as those used in experiment 1. For each face, the comparison between the ‘attractiveness assessment’ and the ‘matching assessment’ measured in experiment 1 was meant to help clarify (and quantify) whether facial attractiveness affected judges’ choices in the kinship detection task.

To assess facial attractiveness, participants were asked to select the face they spontaneously preferred among the three choices. To this end, each item was shown for 25 s, and a 5-s response period followed. The level of attractiveness of each face in the item was estimated by using the percentage of judges who voted for it. This is the attractiveness rate variable.

3.1.4 Computational model. In the matching task in experiment 1, the participant’s decisions were presumably based on specific information (eg similar hair colour, presence of a mole ...) contained in the target face and each of the three comparison faces. In this way, many previous studies used similarity assessments as a measure of kinship assessment (Christenfeld and Hill 1995; Brédart and French 1999; Bressan and Dal Martello 2002; Bressan and Grassi 2004; Maloney and Dal Martello 2006). To further investigate the influence of the perceptual similarity effect on kinship judgment, we chose to quantify it using a computational model of visual processing, based on Gabor Wavelet Filtering (GWF) (Wiskott 1997; Dailey and Cottrell 1999). This model quantifies the perceptual similarity between the target face and each of the three comparison faces used in experiment 1. Each item was therefore associated with three values of GWF perceptual similarity, one for each target–comparison pair. Our aim was to assess whether our measure of perceptual similarity between target and comparison items could predict performance on the kinship detection task considered in experiment 1. We predicted that the higher the GWF perceptual similarity between two faces was, the higher the detection rate would be.

GWF is a neurobiologically plausible model of vision (Daugman 1985; Jones and Palmer 1987; Jones et al 1987) which has successfully been applied to different models of visual scenes (Mermillod et al 2005a, 2005b), to facial expressions (Mermillod et al
2009a), and to facial recognition (Wiskott 1997; Dailey and Cottrell 1999). In practice, each image was transferred to the Fourier domain (figure 2) and was then encoded as a 56-length vector, corresponding to the magnitude of the 56 responses provided by the GWF. More details on GWF technique are available in Mermillod et al (2009a, 2009b). Then, we measured the Euclidean distance between each vector. Finally, we computed the visual perceptual similarity between the target faces and each of its three comparison faces by means of the standard perceptual similarity measure, using an exponential decay function of their Euclidean distance (Kruschke 1992; Shepard 1987). While physical distance refers to the ‘objective distance’ between different stimuli (ie the Euclidean distance), perceptual distance refers to the ‘subjective’ or ‘perceived distance’ between these stimuli. For each of the three target–comparison pairs who make up one item, we then expressed the GWF perceptual similarity values as percentages, using the sum of the similarities of the three images. This is the GWF perceptual similarity variable.

![Figure 2. The perceptual model. Each original image (far left) was filtered by a Hann window in order to avoid an artifactual overrepresentation of cardinal orientations due to image edges. The images were then transferred into the Fourier domain and a bank of 56 Gabor filters was applied to compute a 56-length vector.](image)

3.1.5 Statistical analysis. To investigate the effects of the three perceptual factors, derived both from the behavioural experiment (gender distinctiveness, attractiveness rate) and the computational model (GWF perceptual similarity), we used multiple logistic regressions. Our dependent variable was judge’s choice. The independent variables were: (i) newborn gender, (ii) parent gender, (iii) matching test, (iv) image colour; and the three perceptual factors were (v) gender distinctiveness, (vi) attractiveness rate, and (vii) GWF perceptual similarity. Gender distinctiveness was considered to be a categorical predictor, while the two other perceptual factors were included as continuous predictors. We performed two multiple logistic regressions: in the first, we used judge’s choice in the entire set of 32 items, while in the second we used judge’s choice in a subset comprising the 18 significant items of experiment 1.

3.2 Results
The results of a logistic regression on the 32 items that took into account the three perceptual factors are given in table 2. This regression showed that attractiveness rate and perceptual similarity significantly affected judge’s choice. It is interesting to note that the attractiveness rate and perceptual similarity effects moved in opposite directions, as shown in figure 3. Correct kinship assessments decreased as the attractiveness rate increased, and rose as perceptual similarity increased. Note that GWF analysis showed that only 14 items (43.7%) could be classified as similar and recognisable on the basis of perceptual similarity alone. Finally, we observed a significant effect of gender distinctiveness, in addition to the previously observed results, when we ran the logistic model on the 18 correctly matched items. Among these off-correctly matched newborns, those showing high gender distinctiveness had a greater chance of being associated with their parent (odd-ratio = 1.29).
4 General discussion

Results from experiment 2 showed that several perceptive factors influenced the probability of parent–newborn pairs being detected as related. In this experiment, we explored the effects of facial attractiveness, gender distinctiveness, and of perceptual similarity between the target faces and each of the three comparison faces.

Regarding image attractiveness, our results showed that comparison faces perceived as being the least attractive (either newborn or adult faces) were the most likely to be correctly matched with the target face (figure 3). However, an increase in the attractiveness of a comparison face decreases the likelihood that it will be matched with the target, without the likelihood exceeding the threshold of random discrimination (figure 3). In other words, for some items (the difficult ones), certain judges may hesitate in their responses, and their answers may be influenced by the attractiveness of a comparison face (biological or distractor faces). Alternatively, this phenomenon may be explained by a relationship between attractiveness and distinctiveness (Little and Hancock 2002; Wickham and Morris 2003). Distinctive facial features may provide useful information for assessing kinship. Because most highly distinctive faces are also usually unattractive, this premise may also explain why the least attractive faces were more likely to be correctly associated with the target.

Regarding parent and newborn gender, two results are worth emphasising. First, our results showed that there is a same-gender effect in the expression of resemblance, with girls being more easily matched with their mothers and boys more easily matched with their fathers. However, in contrast to two other studies (McLain et al 2000; Alvergne et al 2007), we failed to show that mothers were more often matched with their offspring than fathers. Until now, only Alvergne et al (2007) had studied and found an interaction between parental gender and child gender. Although their findings varied with the age of the children being studied, they found the same pattern of interaction, except in newborns, in which both boys and girls resemble their mother more. Our results confirm the pattern of interaction, even with newborns. Second, as one might expect, our results for the 18 correctly matched items indicated that kin detection increases when the newborns’ faces have distinct sexual traits. We can presume that the more accentuated newborns’ sexual facial features are the more they will provide
a salient signal for the evaluation of relatedness. We can interpret the differential parental resemblance (a higher same-sex detection rate than opposite-sex detection rate between parent and offspring) and this latter effect as byproducts of sexual distinctiveness present in each newborn. These effects should be closely examined in future studies, by using eye-tracking techniques, for example.

Finally, we evaluated the perceptual similarity between the target and comparison images using Gabor filters. We predicted that the more GWF perceptual similarity exists between two faces, the higher the detection rate will be. Our results validated this prediction. But even with a very strong similarity (figure 3), the probability of recognition never exceeds 0.55, which does not explain the recognition rate obtained with half the significant items (table 1). Thus, the correlation between perceptual similarity and the detection of relatedness is not perfect. These results lead to two conclusions. First, they confirm that perceptual similarity plays some role in the kinship judgment. However, it is plausible that not all perceptual similarity cues are equally relevant to kinship detection. Some perceptual similarities, such as head orientation or hair style, may not provide useful information and may lead to mistakes (Vokey et al 2004). Second, we also need to consider the possibility that human perceptual processes do not fit our GWF model exactly. Indeed, our computational simulation of V1 receptive fields may not be a sufficiently precise simulation of perceptual processes with regard to facial recognition. However, other simulations (Dailey et al 2002; Littlewort et al 2006; Mermillod et al 2009a, 2009b) reveal that this model of visual perception allows for categorisation and recognition of emotional facial expressions with the same degree of accuracy as human participants. Nonetheless, these facial recognition models usually add an ‘associative layer’ (ie a ‘cognitive layer’) in order to associate the output provided by the perceptual layer with the appropriate label (a specific emotion in a categorisation task, or the name of a specific individual in an identification task, for example). In the present study, we simply simulated the perceptual layer in order to analyse the importance of pure perceptual similarity in kin detection. However, further studies are planned in order to add an associative layer and therefore determine if an artificial neural network is able to match human performance in kin detection tasks, based on these perceptual inputs.

5 Conclusion
Overall, the findings show that, although adults are able to match newborns with one of their parents, only a third of participants detected kinship at a significant rate (Kaminski et al, in press) and only 18 out of 32 parent–newborn pairs were significantly detected. Furthermore, our research reveals how participants’ decisions may be influenced by multiple pieces of information present in the kinship task. The study is the first to show that several perceptual factors may affect the ability to assess facial resemblance, and opens a vast array of cognitive and evolutionary research possibilities to determine the proximate mechanisms used in kinship detection.

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