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Original Article

Kinship Recognition by Unrelated Observers Depends on Implicit and Explicit Cognition

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Abstract: Previous studies have shown that neutral observers are able to identify kinship in strangers by matching photographs of children with their parents. We asked whether this ability depended on implicit and/or explicit cognitive processes. Fifty unrelated male observers viewed triads of photographs (one woman in her early 20's and two older women) and had to select which of the two older women was the mother, and rate their confidence in their decision. Observers identified 62.5% of mother-daughter pairs correctly ($p < .001$). Signal detection analyses showed that confidence was related to accuracy ($d' = .28$) and observers could report the cues they utilized. However, those who failed to show a relationship between confidence and accuracy ($d' \leq 0$) still performed significantly above chance, and both confidence and d' decreased over trials whereas accuracy did not. Results show that neutral observers spontaneously used both explicit and implicit cognitive processes in the task. Recognition of kinship by neutral observers may be a task which allows the interplay between explicit and implicit cognition for a system relevant to ancestral social environments to be observed in the laboratory.

Keywords: kin recognition, facial perception, implicit cognition, explicit cognition

Introduction

There is evidence that humans are able to detect kinship relations among strangers. A number of studies have shown that unrelated observers can match photographs of parents with their offspring at levels significantly above chance (Brédart and French, 1999; Bressan and Grassi, 2004; Christenfeld and Hill, 1995; Nesse, Silverman and Bortz, 1990). For example, Brédart and French (1999) showed participants sets of four black-and-white photos, consisting of a child (1, 3, or 5 years old) and three adult men (or women), one of

whom was the child's biological father (or mother). None of the participants were familiar with any of the individuals in the photographs. Results showed that participants matched children of all ages with their parents at levels significantly greater than chance. Accuracy levels increased with the child's age, and there were no reliable differences between matching to mothers versus fathers. Research in which unrelated observers have rated the similarity of parents and offspring have found that newborns are more like their mothers (McLain, Setters, Moulton and Pratt, 2000), although a bias for related observers to report greater similarity to the father is well documented, especially among the mother's family (Alvergne, Faurie and Raymond, 2010). Overall, there is substantial evidence that humans are able to detect kinship among parents and children, although the magnitude of the effect is relatively weak, with the probability of correct detection ranging from 1.04 to 1.40 times better than chance across studies (Kaminski, Meary, Mermillod and Gentaz, 2010a).

How are humans able to detect whether or not strangers are related? Kaminski, Dridi, Graff and Gentaz (2009) suggested two possibilities. First, an ability to recognize kinship among strangers might have developed because of the potential advantage it would confer in social interactions – humans are likely to interact differently if they are related, so a neutral observer who could identify when others were related would be better able to anticipate their behavior. A second possibility is that a capacity for detecting kinship among strangers could have developed based on systems which evolved to recognize one's own kin, an ability which is shared with nonhuman animals and other species (Lieberman, Tooby and Cosmides, 2007; Park, Schaller and van Vugt, 2008).

The goal of the present study was to investigate the cognitive processes that underlie the ability of neutral observers to identify kinship among strangers. There is some evidence that kinship detection by neutral observers depends on the implicit cognitive system, meaning that it is fast, automatic, effortless and does not depend on conscious awareness (Evans, 2008; Reber, 1993). Kaminski et al. (2010a) found that participants' responses to a self-appraisal questionnaire administered after they completed the newborn-parents matching task were unrelated to overall performance on the task: Participants found matching newborns with parents to be difficult but responded significantly above chance even when they believed they were guessing.

We wanted to investigate whether humans' ability for kin detection among strangers also depends on explicit cognition. Whereas the implicit cognitive system is believed to depend on associative, trial-and-error learning, overlap to a considerable extent with cognition in nonhumans, and develop at an early evolutionary stage (Ashby and Maddox, 2005; Smith et al., 2010, 2011), explicit cognition involves conscious use of logic and reasoning and appeared later in evolutionary terms (Dienes and Perner, 1999; Evans, 2003). Although humans have elaborate cultural behaviors and displays which support kinship recognition (Park et al., 2008), we asked whether neutral observers would also use rule-based, explicit processing to identify kinship relations when such supports were not available.

The hallmark of implicit cognition in humans is the presence of knowledge in the absence of conscious awareness (Dienes and Berry, 1997). Although verbal self-reports of awareness have been criticized as susceptible to response bias (Eriksen, 1960; Shanks and St. John, 1994), researchers have developed methods for testing whether participants lack

metaknowledge about their own performance according to subjective criteria (see Dienes, 2008, for a review). The basic idea of these methods is to have participants make confidence ratings about their responses during the task. If responding is based entirely on implicit knowledge, there should be no correlation between accuracy and confidence ratings (*zero-correlation criterion*; Chan, 1992), and participants should perform at above-chance levels when they believe they are guessing (*guessing criterion*; Dienes, Altmann, Kwan and Goode, 1995). By contrast, a positive correlation between confidence and accuracy indicates metaknowledge and explicit cognition, as the participant is aware whether or not their responses are likely to be correct.

We examined the ability of unrelated male observers to correctly identify pairs of mothers and adult daughters. Male observers and adult mother-daughter pairs were used because to our knowledge, this combination has not been previously studied. On each trial, participants viewed three photographs (one woman in her early 20's (daughter) and two older women) and were asked to choose the correct mother from the two older women (Figure 1). No feedback was provided, and participants gave confidence judgments on each trial on a 1-7 scale ("no confidence at all" to "high confidence"). We used a measure of discriminability (d') based on signal detection theory (Macmillan and Creelman, 1991; Tunney and Shanks, 2003) to assess participants' metaknowledge. The advantage of d' is that it provides a measure of participants' ability to discriminate whether or not their responses are likely to be correct, based on their subjective state of confidence, that is independent of any response bias they might have (e.g., toward making either relatively high or low confidence ratings). Assuming that participants would be able to respond more accurately than chance, our primary question was whether this performance could be attributed to implicit cognition, explicit cognition, or both.

Materials and Methods

Color passport photographs (3.5 cm x 5.0 cm) for 20 women were obtained. All were students enrolled at the University of Minho of European Portuguese ethnicity, and provided similar photographs of their biological mothers, with whom they had all been raised. The average age of the daughters was 23.0 years (range = 21-29 years). The average age of the mothers was 48.5 years (range = 44-55 years). Photographs were digitized and backgrounds rendered similar via image processing software.

Fifty participants were recruited from the University of Minho community by advertisements on campus. All were male and of European Portuguese ethnicity with an average age of 22.0 years (SD = 2.97; range = 17-35 years). They were informed that the study would involve viewing a series of photographic triads, consisting of one young and two older women, and that their task would be to select which of the older women was the biological mother. All received a small gift in return for their participation. When debriefed, none of the participants indicated that they recognized any of the individuals in the photographs.

Stimuli were assembled into triads for display on the computer. In each triad, the daughter's photograph was centered at the top of the screen, and photographs of two women were shown to the left and right at the bottom of the screen. One was the correct

mother and the other was a distracter. The distracters were obtained by randomly selecting one photograph from the remaining mothers, such that each mother appeared in two triads, once as the correct choice and once as distracter. The left/right position of the mother and distracter was counterbalanced across triads.

The participants viewed a sequence of photographic triads on the computer screen (see Figure 1). The experiment was self-paced with no time limit and participants were allowed to examine each triad for as long as they wished. For each triad, participants indicated their choice of the correct mother (left/right), as well as their confidence that their choice was correct on a 7-point Likert scale (1 = “not confident at all”; 7 = “extremely confident”) on a sheet of paper. No feedback was provided after each response. Participants advanced to the next triad by clicking the mouse.

Figure 1. Sample photograph triad of a daughter and two possible mothers. Participants had to indicate which woman in the two bottom photos was the biological mother of the woman in the top photo. The correct answer is A.



Two sequences of triads were used. Sequence A was defined by randomly ordering the triads, and Sequence B was the reverse of Sequence A. Half of the participants were randomly assigned to each sequence. After the experiment, participants completed a debriefing questionnaire in which they were asked to list the features on which their responses were based.

Results

Participants responded correctly 65.2% of the time overall, which was significantly greater than chance ($t(49) = 9.23, p < .001$). Accuracy was similar for Sequence A and B, *Means* = 65.4% and 65.0%, respectively, ($t(48) = 0.12, p = .90$), and was not correlated with participants' age ($r = .12, p = .40$).

Table 1 provides a detailed breakdown of descriptive analyses by participant and triad. Overall, 65% of triads and 38% of participants were associated with above-chance accuracy. Significant below-chance performance was not obtained for any triad or participant. This confirms that overall accuracy levels were significantly above chance, but also heterogeneous across participants and triads, suggesting that some participants were more adept at the task and that some triads were more difficult than others.

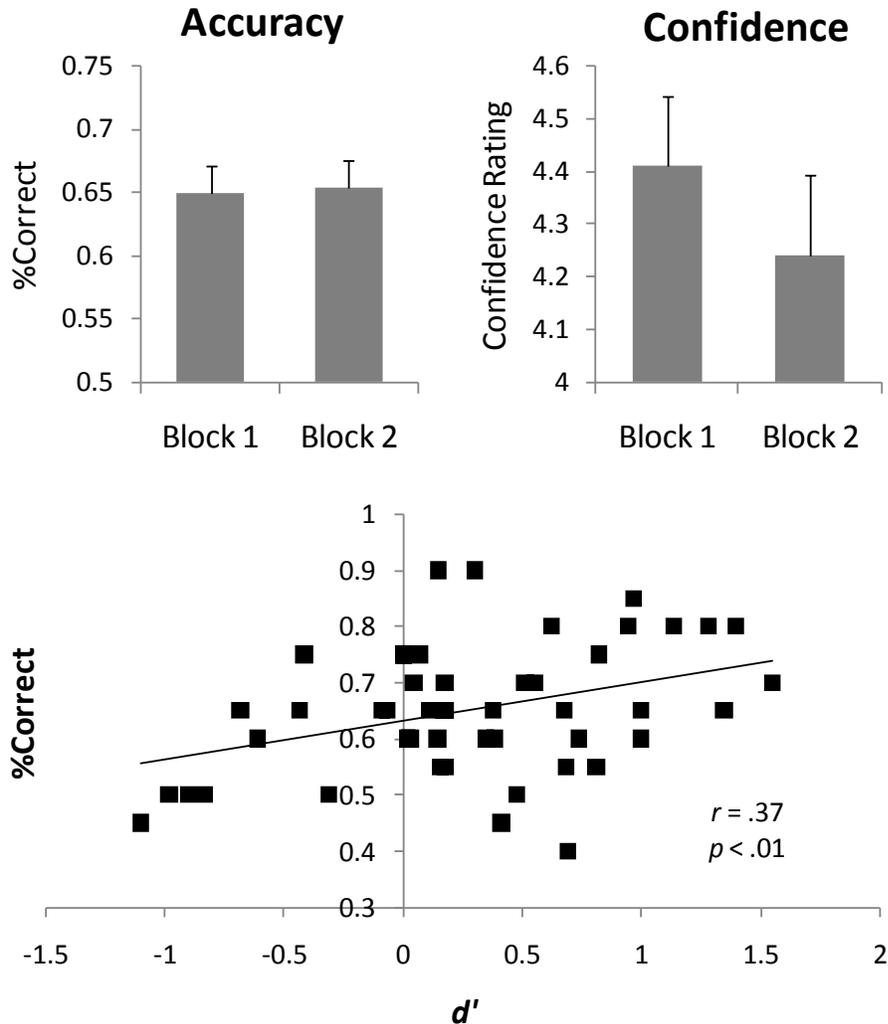
Table 1. Descriptive analyses by triad ($n = 20$) and participant ($n = 50$). For each participant, we calculated the percentage of correct responses across triads, and for each triad, we calculated the percentage of correct responses made by participants. The resulting values were assessed by exact binomial tests to classify participants and triads according to whether significant correct or incorrect detection was observed (i.e., accuracy deviated significantly from .50), or random-level detection was observed (i.e., accuracy not significantly different from .50). *SE* = standard error.

<i>Triads</i>	<i>n</i>	<i>M (SE)</i>	Range
Significant correct detection	13	.74 ± .07	.62 - .82
Random-level detection	7	.50 ± .07	.40 - .60
Mean		.65 ± .13	
<i>Participants</i>	<i>n</i>	<i>M (SE)</i>	Range
Significant correct detection	19	.77 ± .06	.70 - .90
Random-level detection	31	.58 ± .07	.40 - .65
Mean		.65 ± .12	

Figure 2 (left upper panel) shows the average percentage of correct responses and confidence ratings over the two blocks of 10 triads per session. Accuracy was similar across the two blocks, *Means* = 65.0% and 65.4%, respectively ($t(49) = -0.13, p = .89$). However, average confidence ratings (Figure 2, right upper panel) were significantly greater in Block 1 than Block 2, *Means* = 4.41 and 4.24 ($t(49) = 2.09, p < .05$). The variability of confidence ratings also decreased; averaged across participants, standard deviations for Block 1 and 2 were 1.09 and 0.97, respectively ($t(49) = 2.31, p < .05$). Thus

confidence decreased and became less variable across the session whereas accuracy did not vary across the session.

Figure 2. The upper left and right panels show the percentage of correct responses and confidence ratings, respectively, averaged across participants, for blocks 1 and 2. Bars indicate +1 standard error. The lower panel shows a scatterplot of the percentage of correct responses (vertical axis) and d' (horizontal axis). Each point represents data from a single participant.



To assess the relationship between accuracy and confidence ratings we conducted an analysis based on signal detection theory (Macmillan and Creelman, 1991). For each participant, trials were sorted into a 2 x 2 table according to whether or not the confidence rating was greater or less than the median for that participant, and whether or not the response was correct. Trials with confidence ratings equal to the median were omitted. The cells in the 2 x 2 table correspond to the frequencies of hits (i.e., high confidence, correct

response), misses (low confidence, correct response), false alarms (high confidence, incorrect response), and correct rejections (low confidence, incorrect response). We then calculated d' as a bias-free measure of discriminability using the loglinear method (Hautus, 1995; Stanislaw and Todorov, 1999).

Averaged across participants, d' was significantly greater than zero, $M = 0.28$ ($t(49) = 3.15$, $p < .01$; 95% CI: 0.10-0.46). Because values of d' greater than zero indicate that the participant is able to discriminate whether or not their responses are likely to be correct (Kumimoto, Miller and Pashler, 2000; Tunney and Shanks, 2003), this confirms that overall, participants had metaknowledge about their performance.

The d' scores showed considerable variability across participants, suggesting that there were individual differences in the extent of participants' metaknowledge. Figure 2 (lower panel) shows overall accuracy plotted against d' for individual participants. There was a significant positive correlation between d' and accuracy ($r = .37$, $p < .01$), indicating that participants who were better able to discriminate whether their responses were likely to be correct had greater levels of overall accuracy. Across participants, average confidence was correlated with accuracy ($r = .29$, $p < .05$), but confidence was not significantly correlated with d' ($r = .19$, $p = .19$).

An important question was whether participants who lacked metaknowledge about their responding showed performance levels that were above chance. Participants were divided into two groups depending on whether their d' values were less than or equal to zero. For participants with $d' \leq 0$ ($N = 14$), the average accuracy was 61.79%, which was significantly greater than chance ($t(13) = 4.00$, $p < .01$). This result is consistent with implicit processing, because participants who were unable to discriminate whether their responses were likely to be correct still showed above-chance accuracy levels. For participants with $d' > 0$ ($N = 36$), average accuracy was 66.53% which was also greater than chance ($t(35) = 8.43$, $p < .001$) but was not significantly different from participants with $d' \leq 0$ ($t(48) = 1.30$, $p = .20$). Taken together, these results provide evidence of implicit processing but also suggest that participants showed greater individual differences in terms of their ability to report accurately about their performance than their performance *per se* (see Figure 2, lower panel).

For a more rigorous comparison of the variability in d' and accuracy values, we transformed accuracy scores by taking the log odds of a correct response, $\log(p / (1 - p))$, to produce a measure which is unbounded like d' , and then calculated coefficients of variation (i.e., standard deviation divided by the mean) as an index of relative variability for both measures. The coefficients of variation were 2.24 and 0.84 for d' and log-odds correct, respectively, confirming that participants showed greater individual differences in their metaknowledge than their overall accuracy in matching mother-daughter pairs.

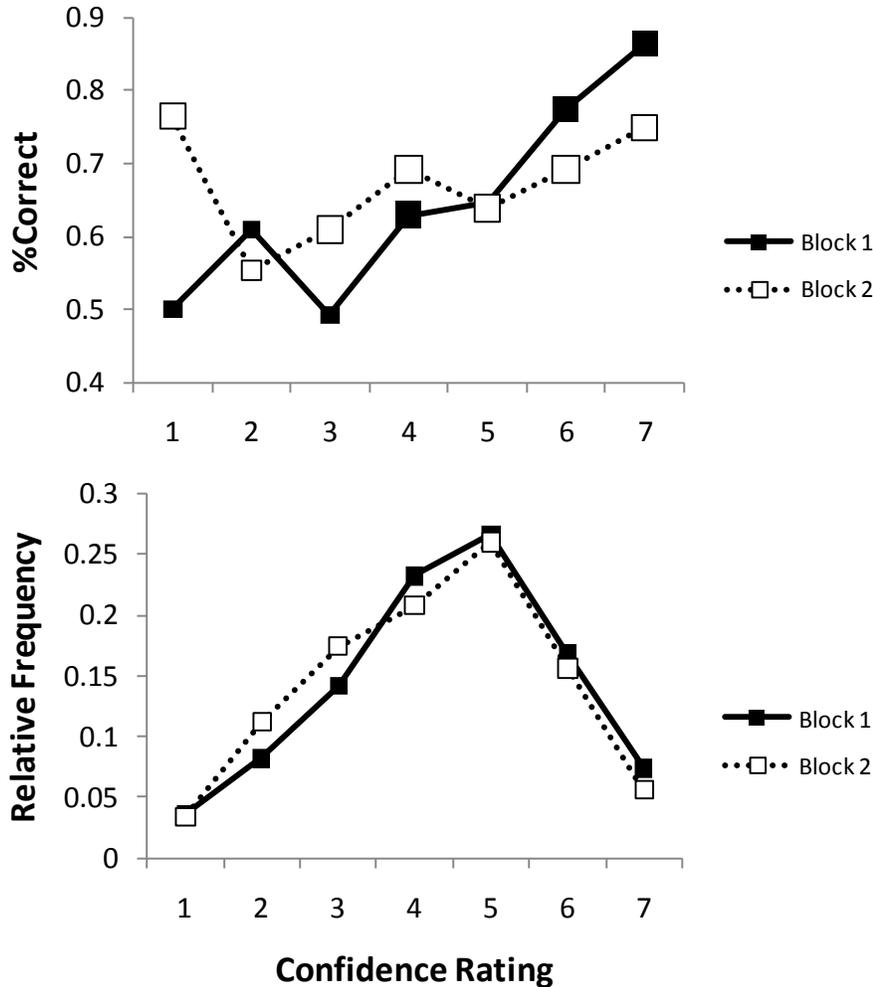
Because participants' confidence ratings decreased across blocks of 10 trials (see Figure 2, right upper panel), we checked whether their metaknowledge also decreased by computing d' values separately for each block. Our analysis showed that d' was significantly greater in Block 1 ($M = 0.32$) than Block 2 ($M = 0.09$; $t(49) = 1.72$, $p < .05$, one-tailed). Thus participants' ability to report accurately about their own performance declined over trials. The decrease in d' is linked with the reduction in variability of confidence ratings, noted above. In the second half of the session, participants' self-reports

of their subjective states became more homogeneous across trials and thus were less able to discriminate between correct and incorrect responses.

Next we examined the relationship between confidence and accuracy using data pooled across participants and sorted according to the confidence rating. A positive correlation between confidence and accuracy would suggest evidence of explicit processing. Because confidence and d' decreased across blocks, we conducted the analysis separately for blocks 1 and 2. Figure 3 (upper panel) shows the percentage of correct responses for each confidence rating. For block 1, accuracy increased from 50.0% (confidence = 1) to 86.5% (confidence = 7), and the correlation was significantly positive ($r = .90, p < .01$). Thus in block 1, participants were guessing when they said so and had the highest accuracy when they were most confident. In contrast, for Block 2 the highest accuracy (76.5%) was obtained for confidence rating = 1, and the overall correlation between confidence and accuracy was not significant ($r = .27, p = .56$). This analysis suggests that block 1 responses were determined by explicit cognition (positive correlation between confidence and accuracy), but implicit processes were more influential in block 2 (accurate performance when guessing and no significant correlation between confidence and accuracy).

Figure 3 (lower panel) shows the relative frequencies of confidence ratings for blocks 1 and 2, pooled across participants. In both blocks, '5' was the modal response. The distributions were similar overall. The probabilities of '2' and '3' responses were somewhat greater in block 2, whereas participants were marginally more likely to make a '6' or '7' response in block 1.

Figure 3. The upper panel shows the percentage of correct responses for each confidence rating, separately for block 1 and block 2 trials. Data points shown in large type (10pt) were significantly greater than chance ($p < .05$). The lower panel shows the relative frequency of confidence ratings for block 1 and block 2 trials.



Finally we examined the specific cues that participants indicated they used during the debriefing. Overall, participants listed an average of 2.88 features or strategies used to solve the task ($SD = 1.62$; range = 1-7). The most common feature used was the eyes, which was noted by 50% of participants. Also commonly reported were nose (30%), overall facial features (30%), and facial expression (26%). Correlations of overall facial features ($r = .29$, $p = .04$) and nose ($r = .27$, $p = .06$) with accuracy were significantly positive or nearly so whereas those for eyes and facial expression were not significant (all $r < .17$, all $p > .23$). To determine how well use of specific cues could predict accuracy, we conducted a regression analysis. This showed that the best model for predicting accuracy included overall facial features ($\beta = 0.42$, $p = .003$) chin ($\beta = 0.40$, $p = .006$), and

facial expression ($\beta = 0.28$, $p = .04$; with $R^2 = .25$, $p = .004$).

Discussion

Overall, participants responded at levels significantly above chance (62.5%), and results suggest that detection by unrelated male observers of mother-daughter kinship depends on both explicit and implicit cognition. That participants showed metaknowledge of their performance suggests evidence for explicit processing. Signal detection analyses confirmed that participants were able to discriminate subjective states relating to more or less confidence, and their confidence ratings predicted whether or not the response on a given trial was likely to be correct. This is the same metaknowledge criterion ($d' > 0$) that has been used in studies of implicit learning to show that participants are aware, at least to some extent, of the basis of grammaticality decisions in artificial grammar learning (Pothos, 2007; Tunney, 2005; Tunney and Shanks, 2003). That participants reported specific cues which were significantly associated with higher accuracy also supports the view that kin recognition by unrelated observers depends on explicit processing. Those who were relatively successful were able to list the specific features that they used, suggesting that they were consciously aware of what they were doing.

However, other aspects of our results indicate that participants' performance depended on the interplay between implicit and explicit cognitive processes. When results from the subgroup of participants ($n = 14$) who showed no metaknowledge of their performance ($d' \leq 0$) were analyzed separately, accuracy was still significantly greater than chance (61.2%). This shows that participants were able to respond accurately even when they failed to discriminate and/or report subjective states related to confidence, consistent with implicit processing. Additional evidence of implicit cognition is that whereas accuracy did not change systematically from the first to second trial block, there was a significant decrease in confidence ratings (see Figure 2, right upper panel), as well as a decrease in d' . Participants' confidence ratings and metaknowledge of their performance decreased as the session progressed, even though their accuracy did not. When responses were pooled over participants, there was a strong linear relationship between confidence and accuracy in the first block, but no systematic relationship in the second block. When subjects said that they were guessing in the first block (confidence = 1), they were (accuracy = 50%; 9 of 18 trials). But remarkably, in the second block participants were most likely to be correct on trials with the lowest confidence rating (76.5%; 13 of 17 trials; $p < .05$). Although the number of such trials in the second block was small, they were made by 11 participants so results cannot be attributed to one or two responding idiosyncratically.

These results show that matching of mother-daughter pairs by unrelated observers depends on both explicit and implicit cognition, and that these processes are independent, at least to some degree. Application of criteria used in research on implicit learning (zero-correlation and guessing; Dienes, 2008) suggests that control shifted from explicit processes in the first block to implicit processes in the second block. One possible explanation for the decrease in explicit control may be a buildup of proactive interference. Explicit cognition is known to depend heavily on working memory (Barrett, Tugade and Engle, 2004) which is susceptible to proactive interference (Jonides and Lee, 2006). As

participants viewed more triads, it may have become increasingly difficult for them to distinguish their subjective state from that on previous trials, leading to a decrease in d' and confidence ratings.

The self-reported strategy which most strongly predicted accuracy – overall facial features – did not correspond to a discrete cue but rather a molar pattern of similarity. Observers who reported using this strategy were likely aware that they were making an overall judgment of similarity without reference to a comparison of specific features. This demonstrates conscious, effortful control over input from an implicit system that indicated which mother showed greater similarity to the daughter (MacDonald, 2008).

Our results resemble those from studies of artificial grammar learning (AGL; Pothos, 2007) which have been widely used as an assay of implicit learning since Reber's (1967) seminal work. In a typical AGL paradigm, participants study a list of letter strings (e.g., MXRVXT, MXTRRR) which initially may appear random but actually are defined according to a set of complex rules (i.e., artificial grammar). Later, they are given a test in which they have to classify new strings as grammatical or not. The usual result is that participants are able to classify new strings accurately but are unable to describe the rules of the grammar. However, studies that have obtained confidence ratings concurrently with the AGL task have shown that d' values are significantly greater than zero, indicating that participants do have metaknowledge of their performance, even though they typically respond at levels greater than chance when they believe they are guessing (Tunney, 2005; Tunney and Shanks, 2003). Thus, performance in the AGL paradigm appears to depend on both implicit and explicit cognition, similar to results reported here for kin detection.

The magnitude of the effect was relatively large – on average participants classified 65.2% of mother-daughter pairs correctly, which corresponds to an odds ratio relative to chance of 1.87. This is greater than previous studies using newborn-parent pairs, which have obtained odds ratios in the range of 1.04 to 1.40 (Kaminski et al., 2010a). A possible explanation is that it might be easier to classify adult children rather than newborns with their parents due to phenotypic convergence – that is, adult children would likely have spent considerable time in the same environment with their parents, which could increase their physical similarity (Zajonc, Adelman, Murphy and Niedenthal, 1987).

An important question is whether performance on the task depended on a specific ability to recognize kin relationships in strangers or perceptual processes related to similarity. That is, perhaps unrelated observers are able to match photographs of children with their parents not because humans have an evolved capacity for detecting kinship via visual cues that are also effective with unrelated conspecifics, but because humans have a perceptual mechanism for detecting similarity between complex stimuli in general. Although it is not possible to give a definitive answer to this question, there are several reasons to expect that parent-child matching tasks such as that used here and in other research with unrelated observers (e.g., Kaminski et al., 2010a; McLain et al., 2000) are a valid method for testing humans' ability to detect relatedness. First, there is evidence that neutral observers judge similarity in terms of relatedness. Maloney and Dal Martello (2006) found that similarity ratings of pairs of related and unrelated children almost perfectly predicted the probability that the pairs would be judged as related by an independent group of participants. Because similarity did not vary with age or gender differences, Maloney

and Dal Martello concluded that when participants were asked to rate similarity they had spontaneously elected to judge relatedness, and thus that perceived similarity was effectively a graded kin recognition signal. This finding is qualified to some extent by DeBruine, Smith, Jones, Roberts, Petrie and Spector (2009), who replicated Maloney and Dal Martello's (2006) results with photographs of adult siblings, and found that similarity predicted kin recognition when age and sex were controlled for, suggesting that similarity ratings for adult targets convey additional information (related to age and sex). Second, Kaminski et al. (2010a) found that perceptual similarity, as measured by an image processing model that has been shown to detect angry faces as accurately as human observers (Gabor Wavelet Filter; Mermillod et al., 2009), was able to correctly predict less than half of newborn-parent pairs. This suggests that kinship detection, while correlated to some extent with perceptual similarity processes, cannot be explained entirely in terms of such processes. It is also interesting to note that Kaminski, Ravary, Graff and Gentaz (2010b) found that later-borns performed better than first-borns in a task in which they had to match photos of newborns with their parents. They suggested that because first-borns could have relied on the perinatal association of their mother with younger siblings, they would have been less likely than later-borns to develop alternative methods of kin recognition, for example those based on similarity of facial cues. Overall, these results provide some support for the view that the parent-child matching task with unrelated observers does tap into humans' evolved capacity for kinship detection (Lieberman et al., 2007).

Our results suggest that humans spontaneously apply both implicit and explicit cognitive processes when asked to detect relatedness among strangers. Use of explicit function makes sense because adult humans have a history in which they have likely been exposed to situations where they had commented on specific features that were similar between genetically-related individuals, or observed others making such comments, and so it is reasonable to expect that they would approach a task like that in the present study by looking for common features that would identify parent-child pairs. In this regard, it is interesting that the strongest predictor of accuracy in the regression analysis was 'overall facial features', which implies that omnibus judgments of similarity were more effective than basing choices on any specific feature or set of features. That participants were able to report their use of overall similarity shows that responses were under conscious control, and thus the present data suggest that participants were able spontaneously to adopt a response strategy in which the implicit system worked under control of the explicit system. This is notable because detection of relatedness arguably represents an evolutionarily older ability compared to other domains in which the interplay between implicit and explicit cognition has been studied, such as the AGL paradigm reviewed above, but also skill acquisition (Sun, Slusarz and Terry, 2005), serial reaction time (Keele, Ivry, Mayr, Hazeltine and Heuer, 2003), and sequence learning (Jimenez, Vaquero and Lupianez, 2006). From an evolutionary perspective, these laboratory paradigms may seem somewhat contrived and far removed from the ancestral conditions which shaped the implicit system. Evolutionary psychologists have theorized about how explicit processes may control implicit modules related to functions such as aggression, sexuality, and ethnocentrism, which are difficult to study experimentally with humans (MacDonald, 2008). By contrast,

recognition of kinship by neutral observers may represent an experimental task which affords a unique opportunity to observe the interplay between explicit and implicit cognition in the laboratory for a system relevant to ancestral social environments.

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