A strong role for nature in face recognition

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Do the genes that make us intelligent make us intelligent in all respects? Or can one inherit from one's parents high general intelligence but also a problem in one specific area, such as in reading or mathematics or the ability to recognize other people? Recent major reviews have emphasized the role of general intelligence, or "*g*," noting genetic correlations across different cognitive domains that are present even in cognitive disorders (1, 2). In contrast, a recent study in PNAS (3) demonstrates that heritability can also occur for specialist cognitive processes. Moreover, the ability for which this is established is one long suggested as a candidate for domain specificity: face perception.

The report by Wilmer et al. (3) is a twin study of face identity recognition. Twin studies use the logic that individual differences in a cognitive ability are heritable when the correlation in that ability is higher for monozygotic twins, who share 100% of their genes, than dizygotic twins, who share an average of 50%. Results of the Wilmer et al. study (3) demonstrate that face memory is heritable, neatly complementing results from a different laboratory conducted simultaneously (4). Heritability of face recognition was found in majority-Caucasian and Chinese participant samples; in children, teenagers, and adults; and on both a simple recognition memory task using the same face photographs at learning and test (4) and on the theoretically stronger Cambridge Face Memory Test (3), a task requiring new-photograph recognition that has both greater internal reliability and more accurately diagnoses clinical problems in face recognition (5). Heritability was also reported for the specific aspect of face perception long proposed to make visual processing of faces "special," namely holistic or configural processing, in two classic tasks: the face inversion and face composite effects. Importantly, the heritability was face-specific. In twins, heritability was reported for face recognition but not house recognition, and for upright faces but not upside-down (inverted) or split-apart faces. Data from singleton adults also demonstrated independence of upright face memory from both general cognitive ability (verbal paired associate memory and IQ), and from nonface visual recognition for abstract art. The key findings are summarized in Fig. 1.

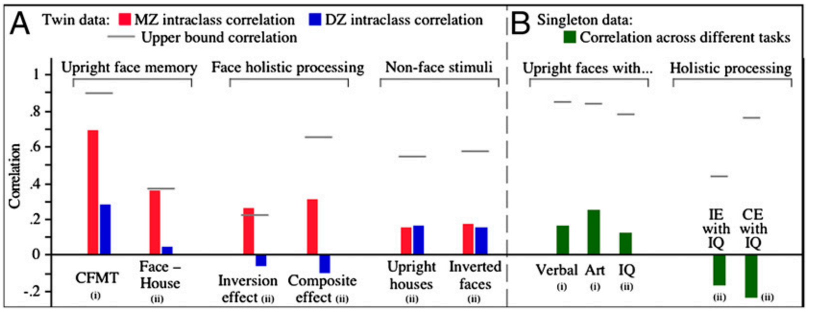

Fig. 1. Evidence of heritability of the specific cognitive ability of face recognition from the studies of Wilmer et al. (3) (*i*) and Zhu et al. (4) (*ii*). (*A*) Twin studies show a genetic contribution [i.e., monozygotic (MZ) correlation is greater than dizygotic (DZ) correlation] to face memory (Cambridge Face Memory Test), face memory minus house memory, and holistic/configural processing (inversion effect, composite effect); there is also a contribution of environment unique to each twin (i.e., nonfamilial environment) where MZ correlation is less than upper bound correlation (here determined via internal reliability). The difference between upper bound correlation and 1 is measurement error. For nonface stimuli (e.g., houses, inverted faces), there is no heritability. (*B*) Further evidence that heritability of face recognition cannot be attributed to heritability of general cognitive factors: faces show at most weak positive correlations with verbal memory, memory for abstract art, and IQ. IE, inversion effect; CE, composite effect.

These new results argue that at least one specific cognitive ability—face recognition—is heritable independent of the established heritability of *g* (2). In having tested behavior, the new studies complement results from a previous functional MRI twin study that showed heritability of neural activation patterns across the ventral visual stream for faces but not written words or chairs (6). In showing heritability in the normal range, they also extend developmental prosopagnosia studies reporting that severe face recognition deficits can run in families, independent of intelligence (7, 8) and sometimes with normal within-class discrimination of nonface objects (9).

It is neurally plausible that cognition has both domain-general and domain-specific heritable contributions. Let us assume the genetic contribution to ability in a given domain is determined by, at an abstract level, "how well" our brain is built in the regions and connections that contribute to that function. The specific variables determining this are not relevant here, but might include gray matter volume (1) or integrity of connecting white matter tracts (10). One or more of these variables could then be correlated across the brain, and correlated with *g*, with generalist genes underlying these correlations. However, unless the genetic correlation is 1—and it is not for reading and mathematics (1)—then there is nothing to rule out the idea that specialized genes might additionally affect the same or other variables in a specific cortical region or white matter tract.

Why does it happen to be face recognition that shows *g*-independent heritability? There has been much controversy regarding whether face recognition is "special." The historical view was that face recognition was driven entirely by experience, and was no different from expert recognition of other visual stimuli for which there clearly could be no evolutionary basis for coding that particular structural form (e.g., recent inventions such as cars or cell phones). Improved methodology, however, has clearly demonstrated domain-specificity for faces, and shown that experience plays a surprisingly small role in face recognition, and there is a strong contribution of genetics and evolution. The twin and developmental prosopagnosia findings support this view, as do findings of (*i*) different cortical activation patterns in response to faces and objects of expertise; (*ii*) lack of face-type holistic processing for objects of expertise; (*iii*) patient double dissociations; (*iv*) discrimination of individual faces by newborn babies and by monkeys raised from birth without seeing faces; (*v*) perceptual narrowing across infancy for face subtypes; and (*vi*) early

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maturity of face-specific cognitive mechanisms in children (11–14).

This newer view of face identity recognition fits well with evidence that nature also plays an important role for other aspects of faces, including gaze and expression. Newborns are sensitive to gaze cues (15), some basic expressions are recognized across all cultures (16), and a recent twin study (17) showed heritability of facial expression labeling ability. The latter study provided no evidence that this did not reflect heritability of general cognition, but other studies show at most a weak correlation between expression labeling and IQ in typical individuals (18).

The findings of a strong genetic component to face identity recognition do not, of course, show that the environment has no effect. Effects of experience are well established, for example in loss of ability to discriminate other-race faces across infancy, perceptual after effects following adaptation to distorted faces, and effects of face familiarity on matching a face to a degraded security camera image (13). The twin studies (3, 4) both show that nonfamilial environment contributes to face recognition.

Experience plays a surprisingly small role in face recognition.

At first glance, the two studies appear to conflict on how large this contribution is, but this is simply because one study (4) reports the total "E" component of their model (i.e., the sum of nonfamilial environment plus measurement error, with the latter being large in some cases), whereas Wilmer et al. (3) subtract measurement error. Taking task reliability into account, both studies indicate a modest but nontrivial effect of nonfamilial environment (Fig. 1).

There is one final implication of the Wilmer et al. (3) study. It is commonly claimed that "we are all face experts," but recent studies have made it clear that there are surprisingly large, stable individual differences in face recognition ability (5). From a research perspective, the twin studies show these individual differences can be harnessed for theoretical gain. From a practical perspective, the implications may be even more important. We know that individuals with developmental prosopagnosia can show serious psychosocial consequences such as heightened anxiety, chronic stress, feelings of inadequacy, social interaction and occupational difficulties, and avoidance of social situations (19). The existence of large individual differences even in the rest of the population leads us to ask whether there might also be psychosocial consequences of milder "deficits" in face recognition.

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