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# Recognition of facial expression and identity in part reflects a common ability, independent of general intelligence and visual short-term memory

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## ABSTRACT

Recognising identity and emotion conveyed by the face is important for successful social interactions and has thus been the focus of considerable research. Debate has surrounded the extent to which the mechanisms underpinning face emotion and face identity recognition are distinct or share common processes. Here we use an individual differences approach to address this issue. In a well-powered ( $N = 605$ ) and age-diverse sample we used structural equation modelling to assess the association between face emotion recognition and face identity recognition ability. We also sought to assess whether this association (if present) reflected visual short-term memory and/or general intelligence ( $g$ ). We observed a strong positive correlation ( $r = .52$ ) between face emotion recognition ability and face identity recognition ability. This association was reduced in magnitude but still moderate in size ( $r = .28$ ) and highly significant when controlling for measures of  $g$  and visual short-term memory. These results indicate that face emotion and face identity recognition abilities in part share a common processing mechanism. We suggest that face processing ability involves multiple functional components and that modelling the sources of individual differences can offer an important perspective on the relationship between these components.

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Recognising someone's identity and their moods and feelings is critical to effective social interaction; identity recognition allows behaviour to be based on past experience and personal knowledge, whilst emotion recognition allows behaviour to be adjusted to current circumstances. In most everyday conditions, the face is a key source of information for both identity and emotion recognition (Bruce & Young, 2012), but the demands of these tasks differ in important ways (Young, 2018). In particular, a core requirement of face identity recognition is to be able to recognise the faces of people we know across different emotional expressions, whereas a core requirement of facial emotion recognition is to be able to recognise expressions across different identities. These differing demands imply that at some level there must be some degree of separation between mechanisms involved

in recognising identity and emotion, but considerable debate has centred on the extent and nature of this functional segregation (Calder & Young, 2005).

## *Association between face emotion recognition and face identity recognition abilities*

Classic cognitive (Bruce & Young, 1986) and neural (Haxby, Hoffman, & Gobbini, 2000) models have posited functionally distinct pathways for processing of changeable (i.e. expression) and stable (i.e. identity) facial characteristics that diverge after a common early stage in face perception. This perspective of substantial functional segregation is supported by evidence from clinical studies of brain-injured patients, which have reported double dissociations between recognition of facial expression and facial identity (Kurucz,

Feldmar, & Werner, 1979; Parry, Young, Shona, Saul, & Moss, 1991; Shuttleworth, Syring, & Allen, 1982; Young, Newcombe, de Haan, Small, & Hay, 1993).

Despite this evidence of functional separation between identity and emotion recognition, other data point to some degree of overlap. For example, Rhodes et al. (2015) reported that facial expression and identity aftereffects are positively associated, whereas no such association was observed with gaze or tilt aftereffects. In addition, fMRI studies have also been taken to argue against a complete independence of identity and expression processing; specialised brain areas thought to be involved in processing invariant facial signals (fusiform face area) and processing changeable signals (posterior superior temporal sulcus) can show sensitivity to changes in both types of facial cues (Fox, Moon, Iaria, & Barton, 2009). Similarly, interactions between identity and expression have also been noted in an early component of ERPs from neurologically normal participants (Fisher, Towler, & Eimer, 2016).

The potential discrepancy between reports of functional overlap and functional separation might be resolved if the evidence of overlap derives from the common perceptual stage posited in classic models (Bruce & Young, 1986; Haxby et al., 2000) and the evidence of separation pertains to later stages. Time-sensitive data such as ERPs suggest that this may indeed be the case (Martens, Leuthold, & Schweinberger, 2010; Fisher et al., 2016). Moreover, analysis of the image statistics that underlie recognition of identity and emotion shows that a common initial perceptual representation may be optimal. Calder, Burton, Miller, Young, and Akamatsu (2001) investigated the image statistics that underlie representations of facial identity and emotional expression through a principal component analysis (PCA) of the shape and surface properties of images from the Ekman and Friesen (1976) series of "Pictures of facial affect". They found that different combinations of principal components (PCs) can be used successfully to decode emotion or identity, but with two important caveats. First, multiple PCs are always needed. Second, whilst some PCs are mainly useful for decoding emotional expression and some are mainly useful for decoding identity, other PCs are useful for both identity and emotion. In other words, emotion and identity can be represented through combinations of PCs, but not in a fully exclusive manner. Hence while there are differences between the visual properties underlying identity and emotional expression, there

is also substantial covariation; the principal components coding facial identity and facial expression perception show a partial overlap, rather than absolute independence.

Although some relevant lines of research already exist, then, we reasoned that the assessment of individual differences – the focus of the current study – represents a relatively novel route through which to gain further traction on this question. Existing models (Bruce & Young, 1986; Haxby et al., 2000) were formulated in an era in which it was assumed that most neurologically normal individuals will experience little difficulty in recognising facial identity and emotion. More recently, however, the existence of substantial individual differences in ability has become apparent (Burton, White, & McNeill, 2010; Duchaine & Nakayama, 2006; Lewis, Lefevre, & Young, 2016; Young & Burton, 2017, 2018), allowing the pattern of these differences to be informative concerning the underlying functional architecture. For example, if face emotion recognition and face identity recognition reflect contributions from a common functional component, one would expect to see an association between these abilities. Furthermore, if this common component is perceptual in nature, it should not link strongly to more general cognitive abilities (such as general intelligence), and if it is a relatively face-specific ability then it may not link strongly to other forms of perceptual aptitude (such as visual short-term memory).

Some initial work of this kind has already indicated that face emotion recognition ability and face identity recognition ability are associated. In three samples ( $N = 40$  in each) of individuals with schizophrenia, bipolar disorder, and normal health, Addington and Addington (1998) reported positive associations ( $r_{\text{range}} = .35-.65$ ) between performance on the Benton Test of Facial Recognition and a facial emotion expression labelling task. Borod et al. (2000) observed a similar positive correlation of  $r = .44$  ( $N = 100$ ) between these measures in a sample of healthy adults. In a study of undergraduate students ( $N = 80$ ), correlations of  $r = .40$  and  $r = .27$  were found between performance on the Cambridge Face Memory Test (CFMT: Duchaine & Nakayama, 2006) and tests of facial emotion-matching and emotion-labelling, respectively (Palermo, O'Connor, Davis, Irons, & McKone, 2013). In a meta-analysis of 8 studies of schizophrenic individuals, a correlation of .53 was reported between facial recognition and facial emotion processing (Ventura, Wood, Jimenez, & Helleman, 2013). Most recently, Rhodes

et al. (2015) reported a significant positive correlation of  $r = .38$  ( $N = 161$ ) between an individual's performance on the CFMT and a six alternative forced-choice facial expression recognition task.

The studies noted above provide fairly consistent evidence that individual differences in face emotion recognition ability and face identity recognition ability reflect some degree of shared processing. However, all of those examining a typical population have been based on relatively small samples (i.e.  $N_{\text{range}} = 40\text{--}161$ ). As such it is possible that the reported association between face emotion and identity recognition ability is reflective of publication bias and may be inflated in its magnitude (Ioannidis, 2008) (a point we return to shortly).

### ***Association between face emotion recognition, face identity recognition, and other cognitive abilities***

To the extent that emotion and identity recognition abilities overlap, a natural question concerns whether this shared variance is reflective of face-specific ability, or instead reflects broader cognitive ability (e.g. general intelligence). A range of studies have examined the relationship between emotion/identity recognition ability and general intelligence. In the domain of emotion recognition, Lewis et al. (2016) ( $N = 389$ ) reported a moderate positive association ( $r = .43$ ) between a latent variable of visual (face and body) emotion recognition ability and a brief general intelligence measure. Similarly, a comparable positive association ( $r = .44$ ) between multimodal emotion recognition ability (simultaneous cues of face, body, and voice) and a measure of non-verbal intelligence was observed in 128 participants by Schlegel and Scherer (2016). Borod et al. (2000) ( $N = 100$ ) observed a significant positive correlation ( $r = .25$ ) between facial emotion recognition and intelligence. In contrast, Palermo et al. (2013) ( $N = 80$ ) observed no significant association between non-verbal intelligence and either face emotion matching ( $r = .07$ ) or face emotion labelling ( $r = .04$ ). Similarly, in a sample of primary school-aged children ( $N = 968$ ), Nowicki and Duke (1994) reported that emotion recognition scores were not significantly associated with a standardised IQ measure.

A broadly equivalent pattern of findings has been noted for identity recognition ability and general intelligence. For example, work examining face memory (alongside broader face perception variables) has

reported modest-to-moderate links to general intelligence using a variety of study designs, including genetic analyses (Shakeshaft & Plomin, 2015 ( $r = .16$ ,  $N = 718$ )) and structural equation modelling, as in the current study (Wilhelm et al., 2010 ( $r = .21$ ,  $N = 209$ )). Similarly using a latent modelling approach, Gignac, Shankaralingam, Walker, and Kilpatrick (2016) ( $N = 211$ ) observed a moderate, positive association ( $r = .34$ ) between face recognition ability, as measured by the CFMT, and general intelligence. Finally, Hildebrandt, Wilhelm, Schmiedek, Herzmann, and Sommer (2011) ( $N = 448$ ) reported that general intelligence accounted for approximately half of the variance of face perception and face memory abilities. In contrast, other work has found no evidence of an association between face identity recognition and other cognitive abilities (Davis et al., 2011 ( $N = 137$ ,  $r = -.08$ ); Peterson & Miller, 2012 ( $N = 42$ ,  $r = .01\text{--}.21$ ); Palermo et al., 2013 ( $N = 80$ ,  $r = -.01$ )).

While the above findings show there is still some debate on whether these associations exist between general intelligence and face emotion/identity recognition, it is clear that any test of association between identity and emotion recognition ability requires additional examination of general intelligence in order to establish the degree to which such an association is reflective of broader cognitive ability.

### ***The current study***

We sought to overcome some of the limitations of previous studies in the field. To this end we used a structural equation modelling approach with data from a sample of healthy, age-diverse adults, which was well-powered (see Methods) to detect even a modest association between our face emotion and identity recognition measures. Indeed, the sample size of the current study ( $N = 605$ ) is larger than has previously been used in the field, and can therefore offer a more robust indication of the strength of the association between face emotion and identity recognition.

In line with previous work we predicted an association of  $r = .40$ , which represented the approximate weighted mean of previous studies in the field. We also sought to test whether this association (if present) was independent of broader perceptual or cognitive processes – specifically, visual short-term memory and general intelligence. Controlling for broader cognitive processes is necessary for our individual differences approach so that any association

between face emotion and face identity recognition ability that we present is not merely an artefact of a more general ability factor. For this question, we were exploratory with our analyses given the mixed findings reported in this literature to date (Gignac et al., 2016; Lewis et al., 2016; Palermo et al., 2013; Shakeshaft & Plomin, 2015), although we expected to see some attenuation of the association between emotion and identity recognition ability.

## Methods

### Participants

Data analysed in this study were collected by a different research group as part of a larger project – the Cambridge Centre for Ageing and Neuroscience (Cam-CAN) cohort ( $N=2681$ ) (Shafto et al., 2014). This cohort consists of a cross-sectional adult sample (aged 18–87 years), which was randomly selected from GP listings to be demographically representative of the UK population. The cohort completed demographic questionnaires and general cognitive and memory assessments in a home interview. Following this initial assessment, 700 individuals (50 males and 50 females for every age decile) who were MRI-suitable and showed no serious cognitive impairment were invited to complete a range of neuroimaging sessions and cognitive-behavioural tasks. A total of 656 participants were thus recruited and additional analyses of their data forms the basis for the current study.

The Cam-CAN data set includes many measures. To ensure a rigorous approach we chose the measures of interest and pre-registered the approach we adopted before analysing any of the data. Note, however, that we had access to the data prior to submitting this protocol (although no analyses were performed). This was because the data were not sufficiently documented prior to receipt to be able to formulate a precise analysis plan.

In line with our pre-registration protocol (<https://osf.io/e5zp8/register/565fb3678c5e4a66b5582f67>), participants were excluded if they showed chance levels of performance on two or more of the cognitive-behavioural tasks, or had not completed all of the cognitive-behavioural tests (see Measures). This required the omission of 51 participants, resulting in a final sample size of 605 (291 males). The mean age of participants was 54.0 years ( $SD=18.2$ ), and ethnicity was as follows: White ( $N=583$ ), Asian ( $N=7$ ), Black ( $N=1$ ), Mixed Race ( $N=8$ ) and undisclosed ( $N$

$=6$ ). All participants were native English speakers from birth.

## Measures

### Face emotion expression recognition test

This test is a measure of facial emotion recognition and stimuli were drawn from the Emotion Hexagon test (Young et al., 1997, 2002). This test was created using a model from the Ekman and Friesen (1976) “Pictures of facial affect” series displaying each of six basic emotions (anger, disgust, fear, happiness, sadness, and surprise). These images were each then morphed with another basic emotion to form emotional expressions with graded levels of difficulty (expression pairs morphed together consist of happiness-surprise, surprise-fear, fear-sadness, sadness-disgust, disgust-anger, and anger-happiness). In the Cam-CAN version of the test participants were shown faces with 70 or 90% of the target emotion, with a six alternative forced-choice response involving 20 trials for each of the emotions. Stimuli were shown for 3 s each. A percentage accuracy score for each of the six emotions was generated for use in subsequent analyses. The six Emotion Expression Recognition sub-scores were significantly associated:  $r$  ranged from .12 to .46, and all  $p < .003$ .

### Benton test of facial recognition

Participants completed the short-form of the Benton Test of Facial Recognition (Levin, Hamsher, & Benton, 1975), which measures an individual’s ability to match pictures of unfamiliar faces. The test consists of 27 trials in which the participant is shown one target face and an array of six faces. The participant has to find one or more examples of the target face in the array. Changes in head orientation or lighting can occur between the target and array faces. Each correct response receives a score of 1, and a total percentage accuracy score was generated for use in subsequent analyses.

### Cattell culture fair intelligence test

Participants completed the standard form of the Cattell Culture Fair Intelligence test, Scale 2 Form A (Cattell, 1973). The test contains four nonverbal subtests: Series Completion, Classification, Matrices, and Conditions, and participants are given 3, 4, 3, and 2.5 min to complete each subtest respectively. The Cattell test is a pen-and-paper test where the participant chooses a response on each item from multiple

response options, and records responses on an answer sheet. Correct responses are given a score of 1 and the percentage correct for each subtest was calculated for use in subsequent analyses. The four Cattell Culture Fair Intelligence subtests were significantly associated:  $r$  ranged from .53 to .64, and all  $p < .001$ .

### **Visual short-term memory (VSTM)**

This task assesses participants' short-term memory for colour, and is adapted from a previous experiment (Zhang & Luck, 2008). It is tested using a continuous colour-wheel paradigm, and consists of two blocks of 112 trials. On each trial, participants see a display for 250 ms containing a central fixation and one to four coloured discs in the surround. A blank screen is then displayed for 900 ms. Following this, one of the disc locations is highlighted and the participant has unlimited time in which to indicate the colour of the cued disc that was previously in the highlighted location using a continuous colour response wheel. The participant's accuracy of reported disc colour (precision) was generated for each learning set size (1, 2, 3 or 4 discs). Three out of the four visual short-term memory sub-scores were significantly associated with each other ( $r$  ranged from .17 to .42, all  $p < .001$ ), although the scores for learning set size 4 were not significantly associated to the other three learning set sizes ( $r$  ranged from .02 to .05,  $p$  ranged from .23 to .67). As such, we used learning set sizes 1, 2 and 3 to form an aggregate accuracy score. This variable was used in the reported analyses. As a sensitivity check we also ran our analyses where the VSTM accuracy score was derived just from learning set size 4 (see Supplementary Materials).

### **Analysis**

We used a structural equation modelling approach to address our research questions. Specifically, we modelled face emotion recognition ability as a latent variable loading on the six manifest variables of anger, disgust, fear, happiness, sadness and surprise recognition scores. We did not have access to the raw items for the Benton Test of Facial Recognition and so here we used the total score as a manifest variable. The latent face emotion recognition ability factor and the Benton Test score were allowed to covary in our model to assess if an association was present (see Figure 1). To assess if the association between face emotion and identity recognition ability was independent of

general intelligence and visual short-term memory in a second model (see Figure 2) we regressed these variables onto a latent factor of general intelligence (which was defined by the four Cattell subtests) and visual short-term memory.

We examined absolute fit of our models using the  $\chi^2$  value, the Comparative Fit Index (CFI) and the Root Mean Square Error of Approximation (RMSEA). The  $\chi^2$  value is the traditional measure of model fit, but is very sensitive to large sample sizes and often rejects sensible models on this basis (Jöreskog & Sörbom, 1993). For the CFI and RMSEA, values of  $\geq .95$  and  $\leq .06$  respectively are viewed as indicative of good model fit (Hu & Bentler, 1999).

## **Results**

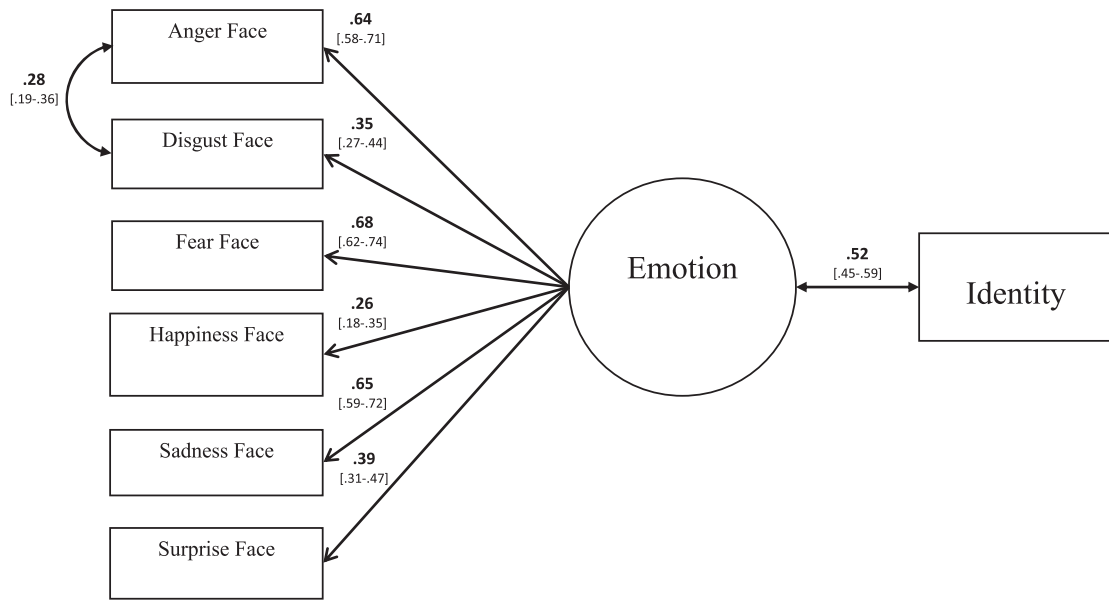
Descriptive statistics and correlations for study variables are shown in Table 1. All study variables were approximately normally distributed. In summary, of the 78 possible correlations, all were positively signed and 74 were significant at the 5% level.

### **Confirmatory factor analyses**

We first assessed the association between face emotion recognition ability (face emotion) and face identity recognition ability (face identity). This model showed an acceptable fit to the data (CFI: .91, RMSEA: .09), and in answer to our first research question, we observed a strong positive correlation between the face emotion and face identity recognition variables ( $r = .49$ ,  $p < .001$ ).

While the model fit was acceptable, it was not good by conventional standards. When global model fit is less than good, this can lead to biased estimates of local parameters (Tomarken & Waller, 2003) – in the current model we were concerned that this might inflate the estimate of the association between emotion and identity recognition. Therefore, we examined modification indices as a sensitivity analysis, in order to assess whether additional paths would improve model fit. These highlighted a covariance path between anger and disgust recognition which would enhance model fit. As such, we re-ran our model, but here including this additional parameter (see Figure 1). This model showed a good fit to the data (CFI: .95, RMSEA: .06), and we again observed a strong positive correlation between the face emotion and face identity recognition variables



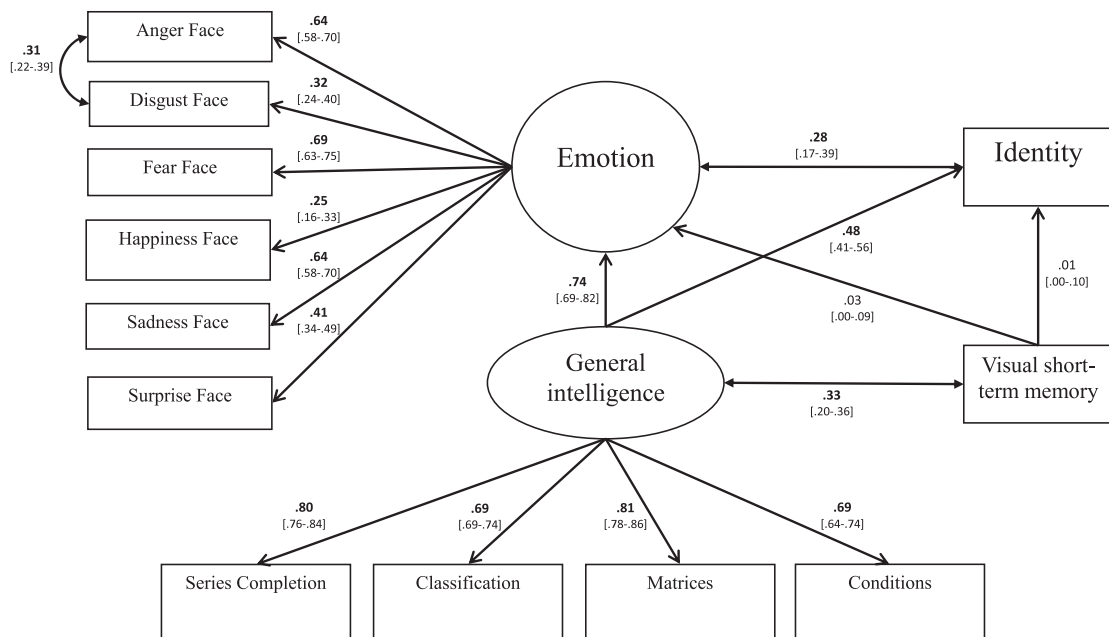


**Figure 1.** Graphical representation of the first theoretical model with standardised parameter estimates (and 95% confidence intervals) and the added Anger-Disgust pathway. All path coefficients in bold were significant at  $p < .001$ .

( $r = .52, p < .001$ ). No other model modifications were examined.

We then fitted a model (including the additional Anger-Disgust parameter as in Figure 1) which

included measures of general intelligence and visual short-term memory (VSTM) to assess whether the association between face emotion recognition and face identity recognition was robust to their effects.



**Figure 2.** Graphical representation of the second theoretical model with standardised parameter estimates (and 95% confidence intervals) and the added Anger-Disgust pathway. All path coefficients in bold were significant at  $p < .001$ .

**Table 1.** Correlations between the emotion recognition scores, the Benton Test of Facial Recognition, the Cattell Fluid Intelligence test and its four subtests, and the Visual Short-term Memory (VSTM) combined accuracy score.

	Mean	SD	Anger	Disgust	Fear	Happiness	Sadness	Surprise	Benton	Cattell Total	Series Completion	Classification	Matrices	Conditions
Anger	83.4	19.6												
Disgust	86.2	18.3	<b>.43</b>											
Fear	75.3	21.9	<b>.46</b>	<b>.28</b>										
Happiness	97.5	5.4	<b>.20</b>	<b>.18</b>	<b>.19</b>									
Sadness	92.5	13.3	<b>.40</b>	<b>.23</b>	<b>.43</b>	<b>.18</b>								
Surprise	89.5	11.1	<b>.26</b>	<b>.12</b>	<b>.18</b>	<b>.12</b>	<b>.31</b>							
Benton	85.0	8.5	<b>.30</b>	<b>.09</b>	<b>.38</b>	<b>.03</b>	<b>.35</b>	<b>.27</b>						
Cattell Total	69.5	14.6	<b>.43</b>	<b>.15</b>	<b>.48</b>	<b>.12</b>	<b>.42</b>	<b>.33</b>	<b>.42</b>					
-Series Completion	78.6	16.9	<b>.39</b>	<b>.17</b>	<b>.41</b>	<b>.12</b>	<b>.41</b>	<b>.34</b>	<b>.41</b>	<b>.84</b>				
-Classification	58.1	15.2	<b>.30</b>	<b>.06</b>	<b>.34</b>	<b>.07</b>	<b>.29</b>	<b>.22</b>	<b>.26</b>	<b>.81</b>	<b>.54</b>			
-Matrices	75.7	18.2	<b>.40</b>	<b>.15</b>	<b>.46</b>	<b>.13</b>	<b>.36</b>	<b>.27</b>	<b>.43</b>	<b>.85</b>	<b>.64</b>	<b>.58</b>		
-Conditions	66.2	23.0	<b>.32</b>	<b>.10</b>	<b>.37</b>	<b>.08</b>	<b>.31</b>	<b>.27</b>	<b>.29</b>	<b>.79</b>	<b>.56</b>	<b>.53</b>	<b>.54</b>	
VSTM	1.43	.37	<b>.13</b>	<b>.07</b>	<b>.26</b>	<b>.08</b>	<b>.13</b>	<b>.10</b>	<b>.17</b>	<b>.30</b>	<b>.24</b>	<b>.25</b>	<b>.28</b>	<b>.22</b>

Note: Performance scores ranged from 5 to 100% accuracy.

\* $p < .05$ .

\*\* $p < .01$ ; Bold indicates  $p < .001$ .

This model is detailed in Figure 2 and the overall model showed a good fit to the data (CFI: .97, RMSEA: .05). General intelligence was a strong predictor of face emotion recognition ( $\beta = .74, p < .001$ ) and face identity recognition ( $\beta = .48, p < .001$ ). In contrast, VSTM was unrelated to these two abilities. Of importance, controlling for general intelligence and VSTM, the association between face emotion and face identity recognition reduced to  $r = .28$ , albeit still remaining highly significant ( $p < .001$ ).

As noted in the Methods, we ran our models again exchanging our chosen measure for VSTM with an alternative formulation (i.e. one derived from learning set size 4, rather than the aggregate of learning set sizes 1, 2 and 3). This did not lead to any notable changes in parameter estimates with regard to our core tests; however, the association between general intelligence and VSTM was no longer significant (see Figure 3 and Table 2 in the Supplementary Materials).

## Discussion

In a well-powered and age diverse sample, we observed a large positive association between face emotion recognition and face identity recognition abilities. Importantly, this association – while reduced in magnitude – was still present and highly significant when general intelligence was modelled as a covariate. Moreover, the association remained even when visual short-term memory was modelled as a covariate, consistent with the notion that the overlap reflects face-specific processes.

The results observed here are interesting for a number of reasons. Firstly, the magnitude of the observed association between face emotion recognition and face identity recognition ability is in line – and in fact here largely exceeds – correlations reported in related studies in the field (e.g. Borod et al., 2000; Palermo et al., 2013). Concerns of sample-specific effects and inflated parameter estimates therefore appear to be unwarranted. Secondly, the observation that face emotion recognition and identity recognition ability are associated, over and above the effect of broader cognitive or perceptual processes, is consistent with the idea that that face processing ability reflects different contributions at multiple levels of individual differences that include general cognitive processing, generalised face-perceptual processes, and emotion- and identity-specific processes. This converges both with existing models drawn from other sources of data (Bruce & Young,



1986; Haxby et al., 2000) and with related individual differences research highlighting a hierarchy of abilities (e.g. Lewis et al., 2016). Thirdly, the current findings provide additional support for recent work reporting a general face perception factor “*f*”, distinct from other cognitive abilities (Verhallen, Bosten, Goodbourn, Lawrance-Owen, Bargary, & Mollon, 2017; McCaffery, Robertson, Young, & Burton, 2018). This work, however, only assessed identity and other non-expression relevant face tasks. As such, our observations both strengthen the likely existence and broaden the scope of the putative *f* factor. Finally, we observed moderate-to-strong positive correlations between general intelligence and identity recognition ability and emotion recognition ability, respectively. Given the relatively inconsistent reports in the literature of these associations (e.g. Gignac et al., 2016; Lewis et al., 2016; Palermo et al., 2013; Shakeshaft & Plomin, 2015), and the large and diverse sample of the current study, these findings offer a more robust indication of the strength of the association between these two face cognition abilities and general intelligence.

Our use of the Cam-CAN data set restricted us to using the Benton Test of Facial Recognition as our measure of face recognition ability. As a test that involves matching relatively standardised images of unfamiliar faces, this has the limitations that it does not tap key skills of familiar face recognition (Young & Burton, 2017) and the ability to cope with everyday image variability (Bruce, 1994; Burton, 2013). It has also been suggested that the Benton Test allows the use of atypical feature-matching strategies, even by prosopagnosic individuals (Bowles et al., 2009; Newcombe, 1979), though in fact many normal participants rely on feature matching in a variety of matching tasks with unfamiliar faces (Hancock, Bruce, & Burton, 2000). As noted, we observed a strong positive correlation between general intelligence and our measure of face identity recognition ability (the Benton Test of Facial Recognition). This is consistent with the idea of a strategic component and is also of interest because some previous studies did not find a correlation between general intelligence and the related Cambridge Face Memory Test (CFMT: e.g. Wilmer, Germine, & Nakayama, 2014) which, as its name implies, has an additional face memory component. One such example is Verhallen et al. (2017), who reported no significant correlation between CFMT performance and scores on the standard British school qualification: *General Certificate of Secondary Education* (GCSE).

It is possible that our observed association between face emotion and identity recognition abilities may have been bolstered by the relatively high perceptual demands of both the Benton Test and the face emotion expression recognition test. We note that a weaker relationship may have been observed if a different face identity test had been used that required less contribution from earlier perceptual processes and more contribution from later cognitive stages (as in the case of the CFMT). Nonetheless, we consider it informative that the correlation between our face identity (Benton test) and face emotion (Ekman expressions) recognition tasks remained evident when intelligence was modelled as a covariate.

Some further caveats should be noted. Firstly, our model fit was improved by adding an Anger-Disgust parameter. We had not anticipated a need to do this, but it is in line with modern research that points to a close relation between some forms of anger and disgust (Calder et al., 2010). Indeed, the modern meaning of the word “disgust” seems to be moving away from mere physical revulsion emphasised by Darwin (1872) toward a kind of moral outrage (people say they are disgusted by the greed of bankers, etc.) (Rozin, Haidt, & Fincher, 2009). Secondly, our participants were Western and so we cannot infer that the overlap in face emotion and identity recognition ability necessarily extends to other ethnicities and cultures. Thirdly, we acknowledge that our data here do not make it possible to examine the underlying processes of face emotion and face identity recognition or to detect asymmetric associations between them. We are able only to model covariances between the two abilities, and whilst these are undoubtedly informative, we note that this may be considered a relative limitation of the current design. Finally, it is somewhat difficult to directly compare the association between facial expression and identity recognition that we have observed here with other studies that have measured these abilities using different tasks (e.g. emotion-matching and the CFMT in Palermo et al., 2013). Future studies that can corroborate the pattern we report using a variety of tests and measures will support the stability of these associations.

## Conclusions

In summary, we took an individual differences approach to understanding the extent and nature of

overlap between emotion and identity recognition abilities. We observed a strong positive correlation between face emotion recognition ability and face identity recognition ability. While this association was reduced in magnitude when controlling for measures of g and visual short-term memory, it remained moderate and highly significant. These results show a common component involved in face emotion and face identity recognition that is distinct from other cognitive and perceptual mechanisms. We suggest that face processing ability reflects contributions from multiple levels of individual differences, ranging from general cognition to general face processing to emotion-specific and identity-specific processes, and that modelling individual differences can offer an important new perspective on these.

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## Disclosure Statement

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