**Supplementary materials for:**

**No effect of age on emotion recognition after accounting for cognitive factors and depression**

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**[S1] Subsample methods**

***Participants***

After exclusion of participants (both outliers and cases for which it was not possible to fit functions), a subset of 113 cases remained (*Mage*= 52.97, *SDage* = 19.42, Range 20-90 years, 43 males).

***Scoring***

In the subsample the emotion-identity task data were analysed by fitting cumulative gaussians to estimate psychometric functions. Functions were fitted using the Palamedes toolbox (Prins, & Kingdom, 2009), implemented in Matlab. Functions were fitted separately for the emotion and identity task for each participant. The functions estimated two parameters of interest: the point of subjective equivalence (PSE) and the slope. The PSE represents the point at which participants were equally likely to judge the expression as anger or disgust (or the identity as Harold or Felix in the identity recognition task). As such, shifts in the PSE can be used to index any bias to respond anger or disgust (see also Cook et al., 2013). The slope is a measure of the precision with which the stimuli were categorised, with high scores representative of precise classification.

**[S2] Descriptive statistics for the subsample.**

|  |  |  |
| --- | --- | --- |
| **Measure** | **Mean** | **Standard Deviation** |
| **Age** | 52.97 | 19.42 |
| **Emotion (Slope)** | 7.53 | 3.86 |
| **Identity (Slope)** | 12.33 | 6.16 |
| **Emotion (PSE)** | .47 | .062 |
| **Identity (PSE)** | .54 | .04 |
| **Age normed-FSIQ-2** | 111.95 | 15.74 |
| **Processing Speed** | 52.43 | 13.95 |
| **Interoception** | 188.32 | 133.37 |
| **Alexithymia** | 41.40 | 10.33 |
| **Depression** | 5.62 | 4.69 |
| **State Anxiety** | 28.98 | 7.20 |
| **Trait Anxiety** | 34.85 | 8.31 |
| **Fluid IQ** | 64.84 | 15.76 |
| **Crystallised IQ** | 73.92 | 12.74 |

**[S3]** **Correlations in the subsample (N=113)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Measure** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** |
| **1. Age** | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **2. Emotion (Hits-FA)** | -.431\*\* | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **3. Identity (Hits-FA)** | -.300\*\* | .449\*\* | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **4. Emotion (Slope)** | -.265\*\* | .760\*\* | .306\*\* | 1 |  |  |  |  |  |  |  |  |  |  |  |  |
| **5. Identity (Slope)** | -.239\* | .347\*\* | .627\*\* | .309\*\* | 1 |  |  |  |  |  |  |  |  |  |  |  |
| **6. Emotion (PSE)** | -.120 | .069 | -.029 | -.045 | .034 | 1 |  |  |  |  |  |  |  |  |  |  |
| **7. Identity (PSE)** | -.045 | -.090 | -.231\* | -.049 | .131 | .027 | 1 |  |  |  |  |  |  |  |  |  |
| **8. PS** | -.689\*\* | .517\*\* | .304\*\* | .391\*\* | .222\* | .061 | -.059 | 1 |  |  |  |  |  |  |  |  |
| **9. Normed FSIQ-2** | .098 | .229\* | .129 | .154 | .205\* | .027 | .180 | .098 | 1 |  |  |  |  |  |  |  |
| **10. Interoception** | -.152 | .186\* | .073 | .124 | .037 | -.102 | -.147 | .167 | .207\* | 1 |  |  |  |  |  |  |
| **11. Interoceptiona** | -.063 | .105 | .025 | .075 | -.025 | -.114 | -.148 | .067 | .125 | .942\*\* | 1 |  |  |  |  |  |
| **12. Alexithymia** | .255\*\* | -.156 | -.063 | -.075 | -.151 | -.034 | -.059 | -.194\* | .019 | -.099 | -.057 | 1 |  |  |  |  |
| **13. Depression** | .153 | -.176 | -.119 | -.176 | -.218\* | -.027 | -.022 | -.082 | .001 | -.098 | -.008 | .369\*\* | 1 |  |  |  |
| **14. State Anxiety** | .005 | -.008 | -.080 | -.021 | -.225\* | .064 | -.004 | -.018 | -.040 | -.079 | -.007 | .282\*\* | .383\*\* | 1 |  |  |
| **15. Trait Anxiety** | -.114 | .021 | .015 | -.044 | -.124 | -.051 | .011 | .057 | .077 | -.082 | -.069 | .348\*\* | .653\*\* | .576\*\* | 1 |  |
| **16. Fluid IQ** | -.496\*\* | .450\*\* | .165 | .342\*\* | .140 | .070 | .123 | .540\*\* | .596\*\* | .254\*\* | .162 | -.105 | -.086 | -.057 | .077 | 1 |
| **17. Crystallised IQ** | .050 | .243\*\* | .272\*\* | .162 | .329\*\* | .022 | .101 | .025 | .841\*\* | .196\* | .107 | -.069 | -.006 | -.045 | .116 | .299\*\* |

**\*denotes significant at *p*<.05, \*\*denotes significant at *p*<.001. acontrolling for all confounds (time perception, systolic BP, HRV, resting HR, BMI and inaccuracy of beliefs)**

[S3]. Depicts the correlations between all factors in the sample for whom function fitting was possible. Age = age in years. Emotion (Hits-FA) = Emotion recognition scores calculated as Hits-FA. High scores indicate better performance. Identity (Hits-FA)= Identity recognition scores calculated as Hits-FA. High scores indicate better performance. Emotion recognition scores (Slope) = Emotion recognition scores estimated via the slope. High scores indicate better precision. Identity recognition scores (Slope) = Identity recognition scores estimated via the slope. High scores indicate better precision. Emotion recognition scores (PSE) = An estimate of bias. Identity recognition scores (PSE) = An estimate of bias. FSIQ-2 = WASI age-normed FSIQ-2; high scores indicate higher IQ. PS = percentage accuracy on the symbol search and coding subscales of the WAIS; high scores indicate faster processing speed. Interoception = interoceptive accuracy controlling for time perception abilities; high scores indicate better interoceptive accuracy. Alexithymia = TAS-20 scores; high scores indicate higher alexithymic traits. Depression = BDI scores; high scores indicate higher depressive traits. Trait anxiety = STAI scores; high scores indicate higher trait anxiety. State anxiety = STAI scores; high scores indicate higher state anxiety. Fluid IQ = percentage accuracy scores of the matrix subscale of the WASI; high scores indicate higher fluid intelligence. Crystallised IQ = percentage accuracy scores of the verbal subscale of the WASI; high scores indicate higher crystallised intelligence.

**[S4] Emotion recognition bias in subsample**

Given some evidence that there may be age-related biases in misattributions whereby older adults are more likely to label angry faces as disgust, and younger adults more likely to label disgust faces as angry (Ebner, He, & Johnson, 2011), we also checked for bias in our data using PSE estimates (for those for whom calculation of these estimates were possible; N=113). In these data, PSE estimates for the emotion (*r*(111) = -.120, *p*>.20) and identity (*r*(111) = -.045, *p*>.250) tasks were uncorrelated with age.

**[S5] *Model 1: intelligence measures as age-normed FSIQ-2 in subsample***

***Emotion task***

To examine the unique variance explained by each potential predictor, and whether age would account for significant variance after accounting for these potential predictors, an entry method robust regression was conducted predicting emotion recognition performance from gender (0 = female, 1 = male), age (years), FSIQ-2 (age-normed), processing speed, interoceptive accuracy (controlling for all confounds) alexithymia, depression, state and trait anxiety. Standardized beta values are reported for all regression analyses. Results from the model suggested that only processing speed (*b*= .356, *t* = 3.152, *p*=.002) uniquely predicted greater emotion recognition ability. No significant effect of any other factor, including age, was observed (all *p*>.15). R2 for the full model was 18.81%.

***Identity task***

The same regression analyses were conducted for identity recognition performance. Results from the model suggested that only age-normed intelligence scores (*b*= .208, *t* = 2.218, *p*=.029) uniquely predicted greater identity recognition ability, with a trending effect of age to predict worse identity recognition also observed (*b*= -.225, *t* = 1.665, *p*=.099). No significant effect of any other factor, including age, was observed (all *p*>.12). R2 for the full model was 17.64%.

**[S6] *Model 2: Fluid and crystallised measures of intelligence in subsample***

***Emotion task***

As in the first regression analysis, a hierarchical entry method robust regression was conducted predicting emotion recognition performance from gender (0 = female, 1 = male), fluid intelligence, crystallised intelligence, processing speed, interoceptive accuracy (controlling for confounds), alexithymia, depression, state and trait anxiety and age. Results revealed that increasing emotion recognition performance was only predicted by processing speed (*b* = .339, *t* = 2.933, *p*=.004). All other predictors were non-significant (all *p*>.16). R2 for the full model was 20.66%.

***Identity task***

The same regression analyses were conducted for identity recognition performance. Results revealed that only crystallised intelligence (*b* = .378, *t* = 4.015, *p*<.001) predicted better identity recognition performance, whereas age predicted poor performance (*b* = -.286, *t* = -2.213, *p*=.029). All other predictors were not significant (all *p*>.12). R2 for the full model was 26.38%.

**[S7] Control variables for the heartbeat counting task**

***Body Mass Index***

BMI was calculated using the following standard equation: mass(kg)/(height(m))2.

***Systolic blood pressure***

Blood pressure was taken using an electronic upper arm monitor (Omron M2) whilst participants were seated. High scores indicate higher systolic blood pressure.

***Resting heart rate & heart rate variability***

Average resting heart rate was taken as a measure of resting heart rate. This was estimated from the last 60 seconds of the longest duration. Where this was not available, a comparable interval from one of the other trials was used as a replacement. As a proxy of heart rate variability (HRV), the root mean square of successive differences was calculated from the second by second pulse rate given by the pulse oximeter. Higher scores indicate higher resting heart rate or increased heart rate variability.

***Knowledge of average resting heart rate***

After the heartbeat counting task participants were requested to estimate the average person’s resting heart rate “how many times do you think the average person’s heart beats in 60 seconds when they are at rest?”. The absolute difference between the participant’s estimate and average resting heart rate (reported in large studies of human physiology; 72.26; Agelink et al., 2001; Ramaekers, Ector, Aubert, Rubens, & Van de Werf, 1998) was taken as a measure of accuracy. This was favoured over asking participants to estimate their own heart rate to avoid effects of estimation on the HCT and vice versa. High scores on this variable indicate greater deviation between the participant’s estimate and average resting heart rate, and therefore greater inaccuracy.

**[S8] Imputation of missing data**

A small amount of randomly-distributed data was missing (0.74%; three blood pressure measurements, two belief estimates, and one measure of heartrate variability and resting heartrate) and these missing values were imputed using multiple imputation in SPSS. The Mersenne-Twister algorithm with a starting point fixed to 2000000 was utilised for random number generation. All variables where entered into the model, the automatic method was selected, and all variables were used as predictors. No participant had more than one missing data point across blood pressure, beliefs or heart estimates.

**[S9] Descriptive statistics for control variables**

|  |  |  |
| --- | --- | --- |
| **Measure** | **Mean** | **Standard Deviation** |
| **Total sample (N=134)** |  |  |
| **Time perception** | 296.60 | 63.51 |
| **Blood pressure** | 128.08 | 20.62 |
| **Proxy of HRV** | 5.43 | 2.01 |
| **Resting HR** | 69.89 | 10.24 |
| **BMI** | 24.83 | 5.12 |
| **Belief inaccuracy** | 13.13 | 13.20 |

**[S10] Correlations between control variables and heartbeat counting (N=134)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Measure** | **1** | **2** | **3** | **4** | **5** |  |
| **1. Heartbeat counting** | 1 |  |  |  |  |  |
| **2. Time perception** | .126 | 1 |  |  |  |  |
| **3. BMI** | -.200\* | .071 | 1 |  |  |  |
| **4. Proxy of HRV** | .068 | -.086 | .024 | 1 |  |  |
| **5. Average heart rate** | -.089 | -.029 | .011 | -.247\*\* | 1 |  |
| **6. Inaccuracy of beliefs** | -.242\*\* | -.002 | .152 | -.152 | -.051 | 1 |
| **7. Systolic blood pressure** | -.170 | -.099 | .352\*\* | .029 | -.052 | .018 |

**\*denotes significant at *p*<.05, \*\*denotes significant at *p*<.001.**

**[S11] Non-linear relationships between age and emotion/identity recognition ability**

Given some evidence that emotion and identity may follow an inverted U-shaped curve across the lifespan (e.g., Horning et al., 2012; Williams et al., 2008; Germine, Duchaine, & Nakayama, 2011) we also assessed whether a non-linear relationship between age and emotion recognition could be found.

For emotion recognition ability, results revealed a significant linear trend whereby age was a significant negative predictor of emotion recognition ability (*b* = -.466, *t* = -6.047, *p*<.001). When the quadratic term was added neither the linear nor quadratic terms were predictive of emotion recognition ability (both *p*>.150). For identity recognition ability, results revealed a significant a significant linear trend whereby age was a significant negative predictor of identity recognition ability (*b* = -.333, *t* = -4.060, *p*<.001). When the quadratic term was added neither the linear nor quadratic terms were predictive of emotion recognition ability (both *p*>.080).

**Supplementary References**

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