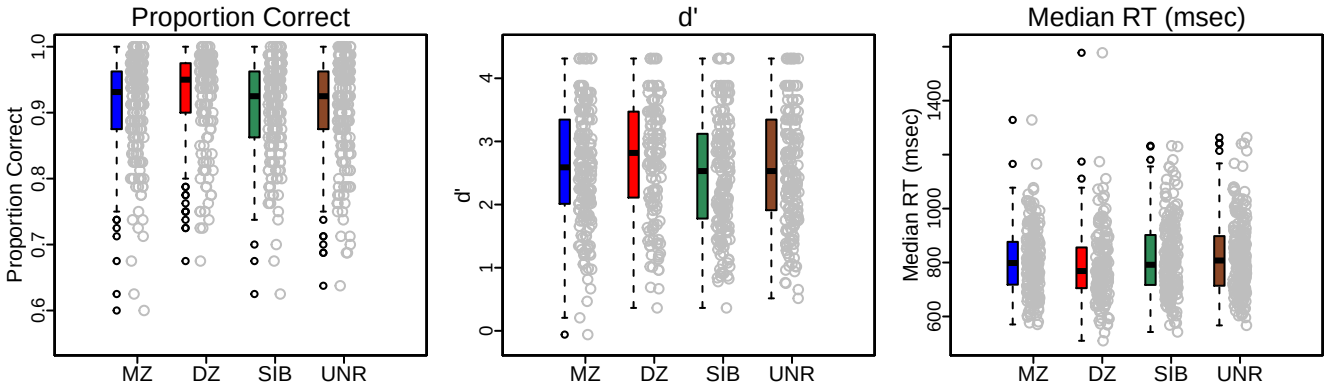
Results Supplement 1

source and input files available at `https://osf.io/p6msu/`
compiled September 6, 2019
Results Supplement 1 for "Pattern similarity analyses of frontoparietal task coding: Individual variation and genetic influences" by Joset A. Etzel, Ya'el Courtney, Caitlin E. Carey, Maria Z. Gehred, Arpana Agrawal, and Todd S. Braver.

This is a `knitr` file (`https://yihui.name/knitr/`); see the `.rnw` file with the same name as this `.pdf` for the R code to generate all figures and results. To compile, change the `in.path` variable to the location of the `input` directory downloaded from **https://osf.io/p6msu/**.

S1.1a Behavioral Performance: Face, Place, 0-back, 2-back

These are not expected to vary by subject group (MZ, DZ, SIB, UNR), since the statistics are calculated on each person by themselves. However, the results are calculated for each group separately as well as ALL for completeness, and to ensure that there aren't unexpected group differences.



Mean and standard error of the mean of the behavioral measures plotted above. Robust statistics, trimmed at 0.1. ALL is all subjects combined and listed in Table 1 of the main text.

	ALL	MZ	DZ	SIB	UNR
Proportion Correct	.92 {.003}	.92 {.005}	.932 {.006}	.913 {.006}	.917 {.006}
d prime	2.6 {.04}	2.61 {.07}	2.75 {.08}	2.51 {.07}	2.57 {.07}
Median RT	799.8 {4.8}	798.2 {8.5}	778.8 {9.9}	806.6 {9.8}	812.9 {10.1}

Below is the code testing for a group effect on each behavioral measure separately, using `t1way` (a robust anova). There isn't a significant group effect with d' or RT, but there is one for Proportion Correct: DZ larger than the other three groups.

```
## [1] "Proportion Correct"
## Call:
## t1way(formula = stats.tbl$stat ~ stats.tbl$pair.group)
##
## Test statistic: F = 3.3432
## Degrees of freedom 1: 3
## Degrees of freedom 2: 245.77
## p-value: 0.01988
##
## Explanatory measure of effect size: 0.14
## Call:
## lincon(formula = stats.tbl$stat ~ stats.tbl$pair.group)
##
##               psihat ci.lower ci.upper p.value
## DZ vs. MZ    0.01562 -0.00348  0.03472 0.13074
## DZ vs. SIB   0.02262  0.00224  0.04301 0.02340
## DZ vs. UNR   0.01773 -0.00261  0.03806 0.11438
```

```
## MZ vs. SIB   0.00701 -0.01340  0.02741 0.78563
## MZ vs. UNR   0.00211 -0.01825  0.02247 0.78563
## SIB vs. UNR -0.00490 -0.02647  0.01667 0.78563
## [1] ""
## [1] "d'"
## Call:
## t1way(formula = stats.tbl$stat ~ stats.tbl$pair.group)
##
## Test statistic: F = 2.2603
## Degrees of freedom 1: 3
## Degrees of freedom 2: 243.62
## p-value: 0.08203
##
## Explanatory measure of effect size: 0.12
## [1] ""
## [1] "Median RT"
## Call:
## t1way(formula = stats.tbl$stat ~ stats.tbl$pair.group)
##
## Test statistic: F = 2.1153
## Degrees of freedom 1: 3
## Degrees of freedom 2: 245.13
## p-value: 0.09885
##
## Explanatory measure of effect size: 0.12
```

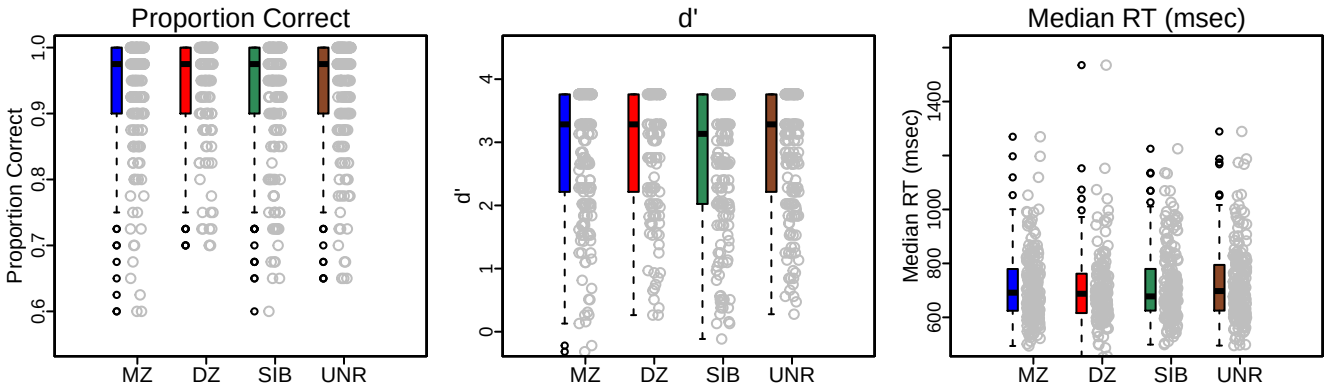
Below are the tests for a group effect on the three behavioral measures together, using `t3way` (a robust anova). There were no significant interactions with any of the three behavioral measures. There were category and load significant main effects with all three; pair.group only significant for RT.

```
##### propcorrect: no sig interactions; load, cat, and pair.group sig
t3way(stats.tbl$propcorrect~stats.tbl$load*stats.tbl$cat*stats.tbl$pair.group);

## Call:
## t3way(formula = stats.tbl$propcorrect ~ stats.tbl$load * stats.tbl$cat *
##     stats.tbl$pair.group)
##
##                                                    value p.value
## stats.tbl$load                                298.0925262  0.0001
## stats.tbl$cat                                   4.3305933  0.0380
## stats.tbl$pair.group                            7.9224817  0.0490
## stats.tbl$load:stats.tbl$cat                    2.7072842  0.1010
## stats.tbl$load:stats.tbl$pair.group             1.8438038  0.6070
## stats.tbl$cat:stats.tbl$pair.group              0.2644453  0.9670
## stats.tbl$load:stats.tbl$cat:stats.tbl$pair.group   0.7233316  0.8680

##### dprime: no sig interactions; load and cat sig
t3way(stats.tbl$dprime~stats.tbl$load*stats.tbl$cat*stats.tbl$pair.group);

## Call:
## t3way(formula = stats.tbl$dprime ~ stats.tbl$load * stats.tbl$cat *
##     stats.tbl$pair.group)
##
##                                                    value p.value
## stats.tbl$load                                344.0789410  0.0001
## stats.tbl$cat                                  13.8667891  0.0003
## stats.tbl$pair.group                            5.9921593  0.1140
## stats.tbl$load:stats.tbl$cat                    0.8063198  0.3700
## stats.tbl$load:stats.tbl$pair.group             1.3509716  0.7180
## stats.tbl$cat:stats.tbl$pair.group              0.7955156  0.8510
## stats.tbl$load:stats.tbl$cat:stats.tbl$pair.group   0.9454951  0.8150
```

```
##### RT: no sig interactions; load, cat, and pair.group sig
t3way(stats.tbl$RT~stats.tbl$load*stats.tbl$cat*stats.tbl$pair.group);
```

```
## Call:
## t3way(formula = stats.tbl$RT ~ stats.tbl$load * stats.tbl$cat *
##     stats.tbl$pair.group)
##
##                                                        value p.value
## stats.tbl$load                                    1540.0021067  0.0001
## stats.tbl$cat                                       20.0093481  0.0001
## stats.tbl$pair.group                                14.8489593  0.0030
## stats.tbl$load:stats.tbl$cat                         1.2117642  0.2720
## stats.tbl$load:stats.tbl$pair.group                  5.0631096  0.1690
## stats.tbl$cat:stats.tbl$pair.group                   0.3311474  0.9550
## stats.tbl$load:stats.tbl$cat:stats.tbl$pair.group    4.8995907  0.1810
```

S1.1b Behavioral Performance: Face, Place, 0-back



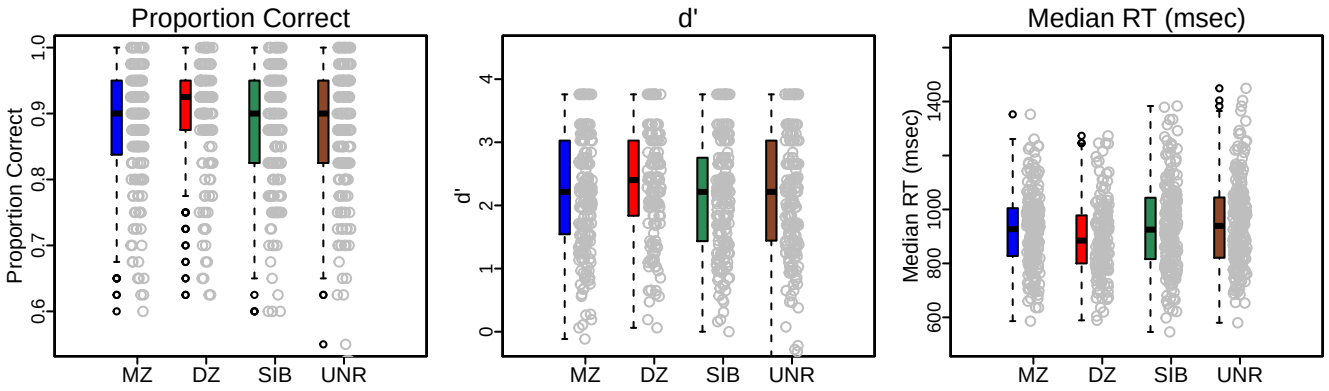
Mean and standard error of the measures plotted above. Robust statistics, trimmed at 0.1. ALL is all subjects combined.

	ALL	MZ	DZ	SIB	UNR
Proportion Correct	.954 {.003}	.953 {.005}	.96 {.006}	.948 {.007}	.955 {.006}
d prime	3.01 {.04}	2.97 {.07}	3.09 {.08}	2.92 {.09}	3.03 {.08}
Median RT	700 {4.5}	701.8 {8}	689.2 {8.6}	702.1 {10}	707.3 {9.2}

Below is the code testing for a group effect on each behavioral measure separately, using `t1way` (a robust anova).

```
## [1] "Proportion Correct"
## Call:
## t1way(formula = stats.tbl$stat ~ stats.tbl$pair.group)
##
## Test statistic: F = 0.5708
## Degrees of freedom 1: 3
## Degrees of freedom 2: 242.8
## p-value: 0.63477
##
## Explanatory measure of effect size: 0.07
## [1] ""
## [1] "d'"
## Call:
## t1way(formula = stats.tbl$stat ~ stats.tbl$pair.group)
##
## Test statistic: F = 0.6065
## Degrees of freedom 1: 3
## Degrees of freedom 2: 242.25
## p-value: 0.61137
##
## Explanatory measure of effect size: 0.07
## [1] ""
## [1] "Median RT"
## Call:
## t1way(formula = stats.tbl$stat ~ stats.tbl$pair.group)
##
## Test statistic: F = 0.5959
## Degrees of freedom 1: 3
## Degrees of freedom 2: 244.97
## p-value: 0.61827
##
## Explanatory measure of effect size: 0.07
```

S1.1c Behavioral Performance: Face, Place, 2-back



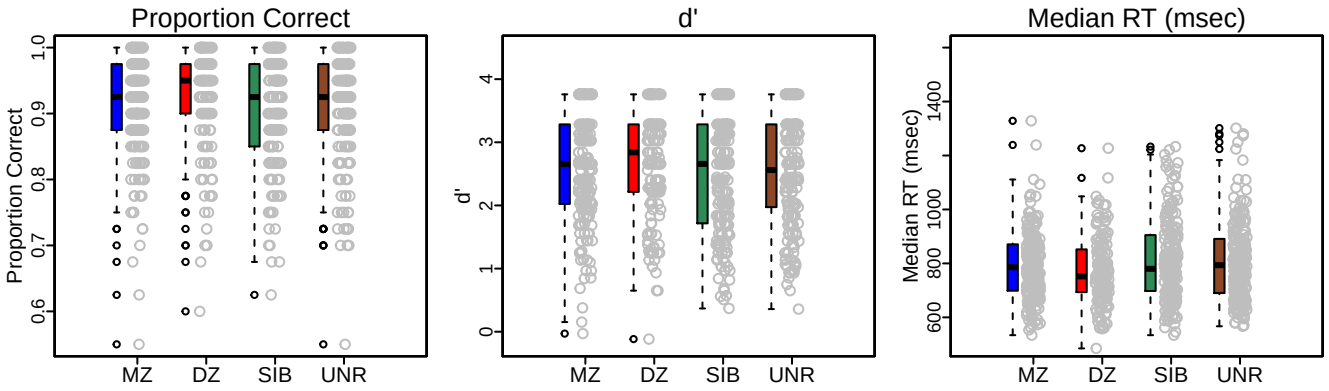
Mean and standard error of the measures plotted above. Robust statistics, trimmed at 0.1. ALL is all subjects combined.

	ALL	MZ	DZ	SIB	UNR
Proportion Correct	.896 {.003}	.896 {.007}	.911 {.007}	.891 {.007}	.889 {.008}
d prime	2.23 {.04}	2.24 {.07}	2.36 {.07}	2.16 {.07}	2.18 {.07}
Median RT	921.4 {5.8}	919.6 {10.3}	891.5 {11.4}	930.4 {12.2}	939.1 {11.9}

Below is the code testing for a group effect on each behavioral measure separately, using `t1way` (a robust anova).

```
## [1] "Proportion Correct"
## Call:
## t1way(formula = stats.tbl$stat ~ stats.tbl$pair.group)
##
## Test statistic: F = 2.0949
## Degrees of freedom 1: 3
## Degrees of freedom 2: 245.35
## p-value: 0.10147
##
## Explanatory measure of effect size: 0.11
## [1] ""
## [1] "d'"
## Call:
## t1way(formula = stats.tbl$stat ~ stats.tbl$pair.group)
##
## Test statistic: F = 1.7448
## Degrees of freedom 1: 3
## Degrees of freedom 2: 243.89
## p-value: 0.15843
##
## Explanatory measure of effect size: 0.11
## [1] ""
## [1] "Median RT"
## Call:
## t1way(formula = stats.tbl$stat ~ stats.tbl$pair.group)
##
## Test statistic: F = 3.1457
## Degrees of freedom 1: 3
## Degrees of freedom 2: 243.55
## p-value: 0.02582
##
## Explanatory measure of effect size: 0.14
## Call:
## lincon(formula = stats.tbl$stat ~ stats.tbl$pair.group)
##
##               psihat  ci.lower ci.upper p.value
## DZ vs. MZ   -31.92594 -70.71341  6.86153 0.12625
## DZ vs. SIB  -39.53463 -82.92376  3.85451 0.08721
## DZ vs. UNR  -45.84327 -89.24522 -2.44133 0.03580
## MZ vs. SIB   -7.60869 -48.28537 33.06800 0.71335
## MZ vs. UNR  -13.91733 -54.60768 26.77301 0.71335
## SIB vs. UNR  -6.30865 -51.41826 38.80097 0.71335
```

S1.1d Behavioral Performance: Face, 0-back, 2-back



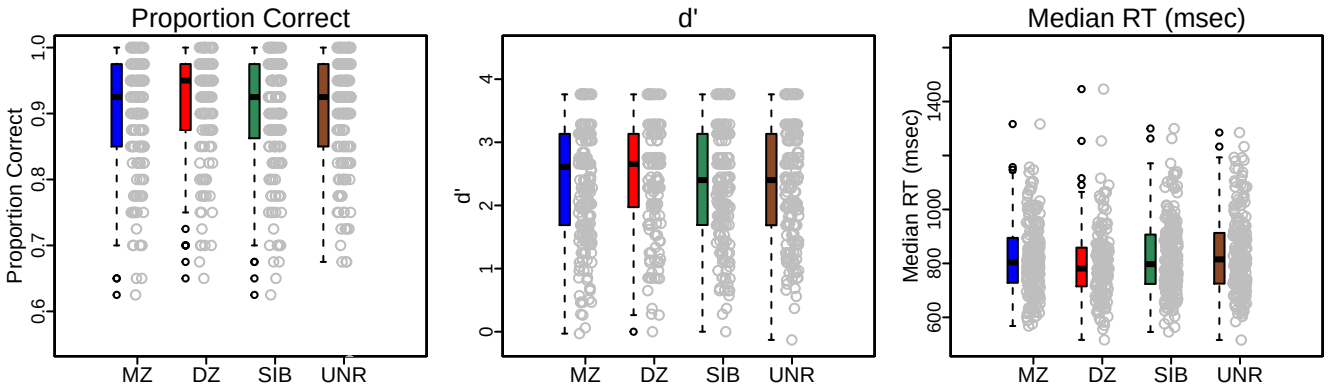
Mean and standard error of the measures plotted above. Robust statistics, trimmed at 0.1. ALL is all subjects combined.

	ALL	MZ	DZ	SIB	UNR
Proportion Correct	.926 {.003}	.926 {.005}	.94 {.006}	.917 {.006}	.923 {.006}
d prime	2.62 {.04}	2.63 {.07}	2.76 {.08}	2.52 {.08}	2.58 {.07}
Median RT	787.7 {5.1}	786.7 {8.9}	768.9 {10.7}	798.9 {11.2}	795.4 {10.1}

Below is the code testing for a group effect on each behavioral measure separately, using `t1way` (a robust anova).

```
## [1] "Proportion Correct"
## Call:
## t1way(formula = stats.tbl$stat ~ stats.tbl$pair.group)
##
## Test statistic: F = 3.0337
## Degrees of freedom 1: 3
## Degrees of freedom 2: 246.26
## p-value: 0.0299
##
## Explanatory measure of effect size: 0.14
## Call:
## lincon(formula = stats.tbl$stat ~ stats.tbl$pair.group)
##
##               psihat ci.lower ci.upper p.value
## DZ vs. MZ    0.01558 -0.00496  0.03612 0.18951
## DZ vs. SIB   0.02376  0.00081  0.04672 0.04223
## DZ vs. UNR   0.01722 -0.00342  0.03787 0.14678
## MZ vs. SIB   0.00819 -0.01549  0.03186 0.84056
## MZ vs. UNR   0.00164 -0.01980  0.02309 0.84056
## SIB vs. UNR -0.00654 -0.03031  0.01723 0.84056
## [1] ""
## [1] "d'"
## Call:
## t1way(formula = stats.tbl$stat ~ stats.tbl$pair.group)
##
## Test statistic: F = 2.4713
## Degrees of freedom 1: 3
## Degrees of freedom 2: 244.73
## p-value: 0.06241
##
## Explanatory measure of effect size: 0.13
## [1] ""
## [1] "Median RT"
## Call:
## t1way(formula = stats.tbl$stat ~ stats.tbl$pair.group)
##
## Test statistic: F = 1.6364
## Degrees of freedom 1: 3
## Degrees of freedom 2: 245.04
## p-value: 0.18153
##
## Explanatory measure of effect size: 0.11
```

S1.1e Behavioral Performance: Place, 0-back, 2-back



Mean and standard error of the measures plotted above. Robust statistics, trimmed at 0.1. ALL is all subjects combined.

	ALL	MZ	DZ	SIB	UNR
Proportion Correct	.918 {.003}	.916 {.006}	.928 {.007}	.915 {.006}	.915 {.007}
d prime	2.44 {.04}	2.44 {.08}	2.54 {.09}	2.36 {.08}	2.43 {.08}
Median RT	810.3 {5.1}	811.8 {9.5}	788.2 {9.8}	812.2 {9.7}	826 {10.9}

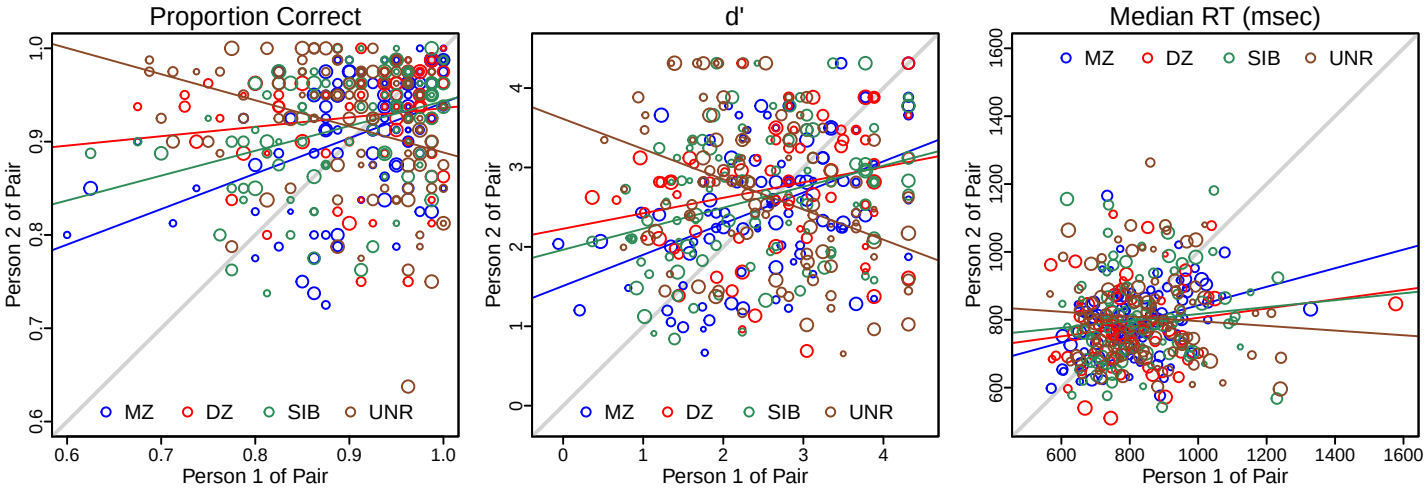
Below is the code testing for a group effect on each behavioral measure separately, using `t1way` (a robust anova).

```
## [1] "Proportion Correct"
## Call:
## t1way(formula = stats.tbl$stat ~ stats.tbl$pair.group)
##
## Test statistic: F = 1.3846
## Degrees of freedom 1: 3
## Degrees of freedom 2: 244.25
## p-value: 0.24803
##
## Explanatory measure of effect size: 0.11
## [1] ""
## [1] "d'"
## Call:
## t1way(formula = stats.tbl$stat ~ stats.tbl$pair.group)
##
## Test statistic: F = 0.9886
## Degrees of freedom 1: 3
## Degrees of freedom 2: 244.4
## p-value: 0.39876
##
## Explanatory measure of effect size: 0.08
## [1] ""
## [1] "Median RT"
## Call:
## t1way(formula = stats.tbl$stat ~ stats.tbl$pair.group)
##
## Test statistic: F = 2.0776
## Degrees of freedom 1: 3
## Degrees of freedom 2: 245.92
## p-value: 0.10373
##
## Explanatory measure of effect size: 0.11
## Call:
## lincon(formula = stats.tbl$stat ~ stats.tbl$pair.group)
##
##                psihat  ci.lower ci.upper p.value
## DZ vs. MZ   -22.26331 -57.40287 12.87625 0.45308
## DZ vs. SIB  -22.20603 -58.92885 14.51678 0.45308
## DZ vs. UNR  -33.70760 -70.84086  3.42566 0.10714
## MZ vs. SIB    0.05727 -37.02842 37.14297 0.99676
## MZ vs. UNR  -11.44429 -48.93646 26.04787 0.87704
## SIB vs. UNR -11.50157 -50.48155 27.47841 0.87704
```

S1.2 Correlation between paired participants: behavioral performance

0-back and 2-back trials; both Face and Place.

Correlation between paired participants on three performance-related measures. Median RT is calculated from correct trials only. Only Face and Place trials are used in these calculations (not Body or Tool), for consistency with the similarity analyses. Point size jittered to reduce overplotting.



Pearson correlation between the paired people for each behavioral measure and subject group. p-values for each in parentheses, from `hc4wtest`, uncorrected for multiple comparisons.

	MZ	DZ	SIB	UNR
Proportion Correct	.44 (<.001)	.14 (.13)	.36 (<.001)	-.32 (.004)
d prime	.43 (<.001)	.25 (.03)	.32 (<.001)	-.38 (.002)
Median RT	.34 (<.001)	.17 (.062)	.11 (.388)	-.07 (.4)

p-values for pairwise correlation differences. Asterisks mark differences with p <.0083, Bonferroni-corrected threshold for p <.05 with 6 comparisons.

Proportion Correct

	MZ	DZ	SIB	UNR
MZ				
DZ	.027			
SIB	.503	.112		
UNR	<.001 ***	.001 **	<.001 ***	

d prime

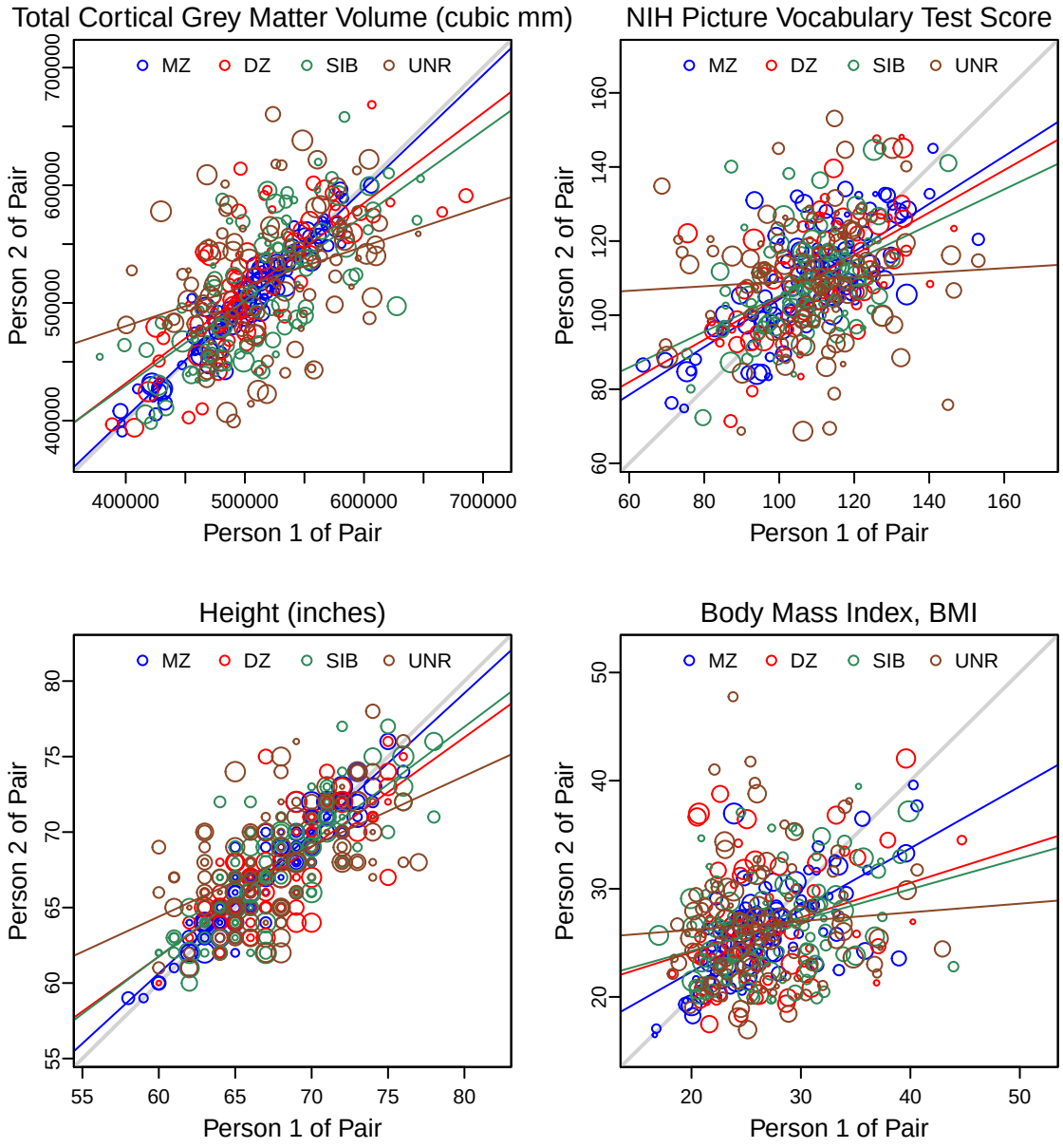
	MZ	DZ	SIB	UNR
MZ				
DZ	.185			
SIB	.394	.561		
UNR	<.001 ***	<.001 ***	<.001 ***	

Median RT

	MZ	DZ	SIB	UNR
MZ				
DZ	.3			
SIB	.165	.737		
UNR	.006 *	.134	.26	

S1.3 Correlation between paired participants: highly heritable measures

Correlation between paired participants on four highly heritable characteristics. Note that there is a great deal of overplotting, particularly for Height. Some correlation is present in the unrelated people, likely due to matching the pairs for age and gender. R squared and significance tests for these correlations follow.



Pearson correlation between the paired people for each highly heritable measure and subject group. p-values for each in parentheses, from `hc4wtest`, uncorrected for multiple comparisons.

	MZ	DZ	SIB	UNR
Total Grey Matter Volume	.96 (<.001)	.75 (<.001)	.69 (<.001)	.32 (<.001)
NIH Picture Vocabulary	.73 (<.001)	.57 (<.001)	.46 (.002)	.06 (.564)
Height	.94 (<.001)	.76 (<.001)	.79 (<.001)	.53 (<.001)
BMI	.66 (<.001)	.31 (.04)	.33 (.01)	.08 (.344)

p-values for pairwise correlation differences. Asterisks mark differences with p <.0083, Bonferroni-corrected threshold for p <.05 with 6 comparisons.

Total Cortical Grey Matter Volume

	MZ	DZ	SIB	UNR
MZ				
DZ	.042			
SIB	.001 **	.625		
UNR	<.001 ***	.001 **	.001 **	

NIH Picture Vocabulary Test Score

	MZ	DZ	SIB	UNR
MZ				
DZ	.255			
SIB	.047	.5		
UNR	<.001 ***	.002 *	.011	

Height

	MZ	DZ	SIB	UNR
MZ				
DZ	.018			
SIB	.034	.737		
UNR	<.001 ***	.043	.016	

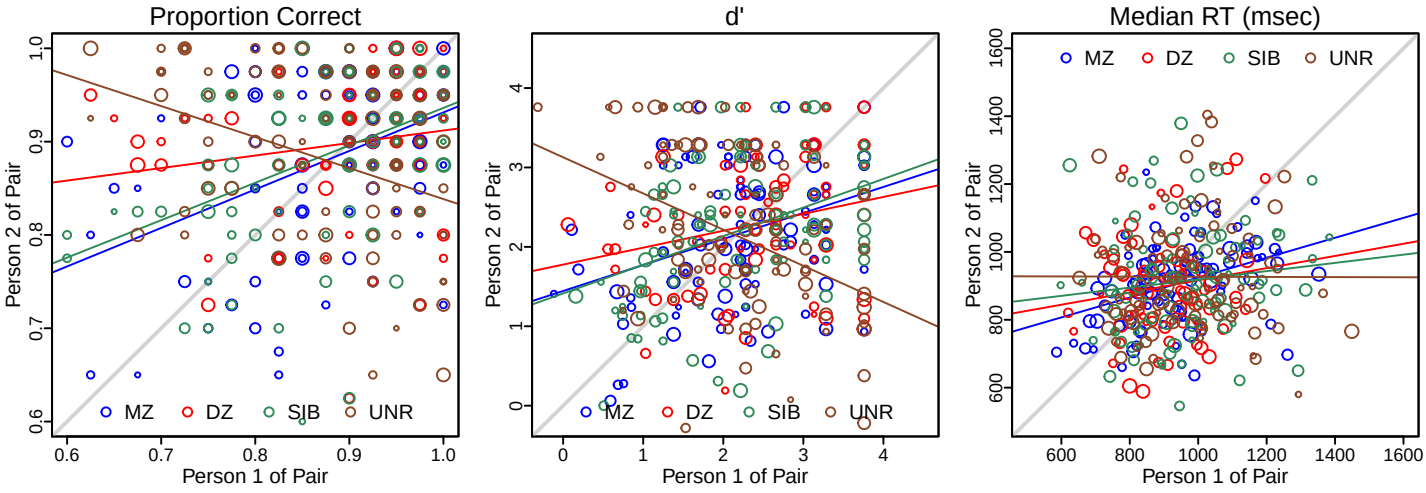
BMI

	MZ	DZ	SIB	UNR
MZ				
DZ	.051			
SIB	.04	.949		
UNR	<.001 ***	.139	.086	

S1.4 Correlation between paired participants: behavioral performance

2-back trials only; both Face and Place.

Correlation between paired participants on three performance-related measures. Significance tests follow. Median RT is calculated from correct trials only. Only Face and Place trials are used in these calculations (not Body or Tool), for consistency with the similarity analyses. Point size jittered to reduce overplotting.



Pearson correlation between the paired people for each behavioral measure and subject group. p-values for each in parentheses, from `hc4wtest`, uncorrected for multiple comparisons.

	MZ	DZ	SIB	UNR
Proportion Correct	.43 (<.001)	.16 (.16)	.44 (<.001)	-.3 (.004)
d prime	.35 (.004)	.25 (.038)	.38 (<.001)	-.38 (.002)
Median RT	.37 (<.001)	.18 (.194)	.12 (.26)	0 (.984)

p-values for pairwise correlation differences. Asterisks mark differences with p <.0083, Bonferroni-corrected threshold for p <.05 with 6 comparisons.

Proportion Correct

	MZ	DZ	SIB	UNR
MZ				
DZ	.11			
SIB	.938	.044		
UNR	<.001 ***	.001 **	<.001 ***	

d prime

	MZ	DZ	SIB	UNR
MZ				
DZ	.526			
SIB	.761	.33		
UNR	<.001 ***	<.001 ***	<.001 ***	

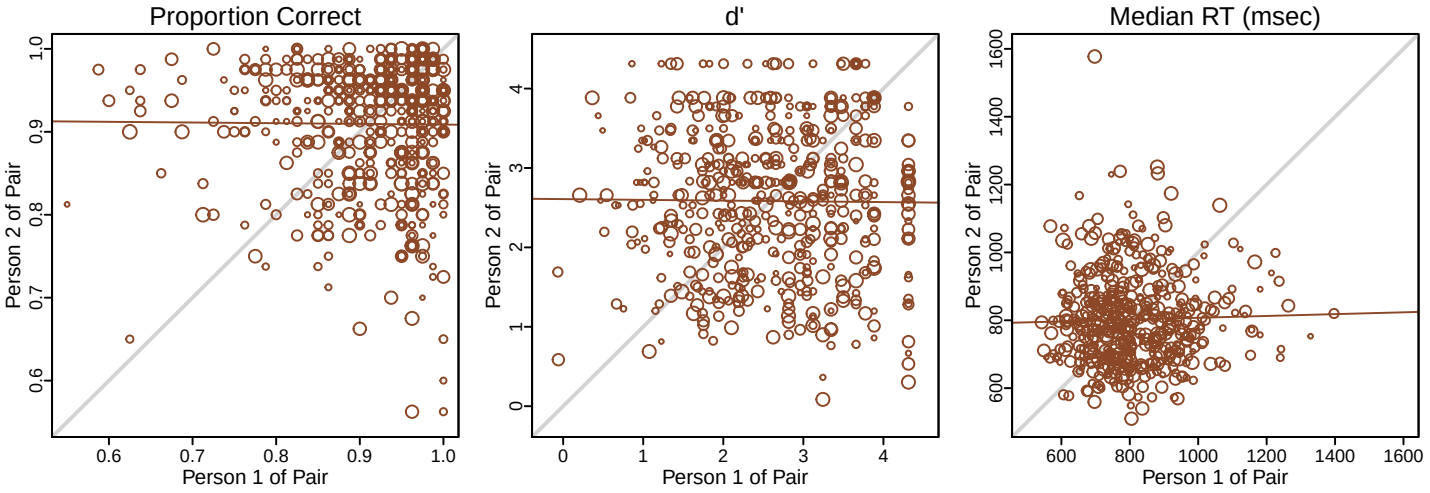
Median RT

	MZ	DZ	SIB	UNR
MZ				
DZ	.278			
SIB	.101	.719		
UNR	.014	.276	.408	

S1.5 Correlation of behavioral performance in unrelated paired participants

The significant negative correlations between unrelated paired people in proportion correct and d' (S1.2) are surprising. Suspecting this is was a quirk of the 100 pairs chosen for the UNR, this section calculates the same measures as S1.2, but for a larger set of unrelated people. Specifically, these unrelated pairs were made with the same requirement of matched genders and age within 3 years, but without the restriction that the people not be in any other subject groups (so a person in this set may also be in MZ). This allowed 514 unrelated pairs to be made.

With this larger set of unrelated people there isn't a significant negative correlation for Proportion Correct or d', though they still have negative slope. The Pearson correlation for each measure is listed below, along with p-values in parentheses, from `hc4wtest`, uncorrected for multiple comparisons.



	unrelated
Proportion Correct	-.01 (.844)
d prime	-.01 (.828)
Median RT	.03 (.504)

S1.6 Correlation between paired participants: heritability estimates

A model specifying additive genetic (A), common environmental (C) or non-additive genetic (D), and individual-specific environmental (E) influences were fitted to raw data from individual twins and siblings were using Full Information Maximum Likelihood estimation in Mx (code in `input/dprime.mx`).

Broadly speaking, these estimates derive from twin and sibling pair correlations whereby similarity in MZ pairs is due to, on average, sharing 100% of their additive genetic, non-additive genetic and common environmental influences (where C refers to those environmental influences that both members of a twin pairs perceive or receive to a similar extent - also referred to as familial environment) while similarity in DZ and non-twin sibling pairs is attributed to sharing, on average, 50% of their genetic background, 25% of non-additive genetic factors, and under the equal environments assumption, 100% of their common environment. When data on pairs of MZ and DZ/SIB pairs is available, either C or D can be modeled as the additional source of variance to A and E (where E is roughly calculated as 1=rMZ, the extent to which identical twin pairs differ on their trait values, which for a purely genetically determined condition, such as a Mendelian disorder is 1.0).

To select between ACE and ADE models, we compared the MZ correlation with the DZ/SIB correlation. If the latter was equal to or greater than half of the former, we utilized an ACE model, which was primarily the case. The comparison of DZ twins and non-twin siblings (SIB) also provides important information regarding a potential additional source of variance T, or special twin environment, which when significant can reflect prenatal effects that are shared to a greater degree by twins than SIBS or other age-delimited factors. However, a statistical comparison of DZ and SIB correlations did not reveal statistical differences, plausibly because we specifically selected SIBS close in age to each other. Thus, in the absence of T, DZ and SIB data were combined and a single DZ/SIB correlation was used to determine whether C or D should be estimated, and for further estimation. This also significantly increased the sample size for the DZ/SIB pairs, affording greater precision to disentangle A from C. Even though the sample size was too small to test for quantitative sex differences (i.e., different estimates of A, C and E in male and female twins; qualitative sex differences could not be tested as opposite sex DZ pairs were not collected in HCP), we regressed the mean of each measure on sex so as to prevent it from confounding estimates of heritability. Sub-models tested whether inclusion of sex as a covariate in the means model was statistically significant (1 degree of freedom), and whether the estimate of A, or C, or both could be constrained to zero. Akaike's Information Criterion (AIC) was used to select the best-fitting sub-model when either an AE or CE fit the data equally well.

	rMZ	R(DZ/SIB)	A [95% CI]	C [95% CI]	E [95% CI]	Delta chi squared for AE	Delta chi squared for CE	Delta chi squared for mean sex adjustment
Proportion Correct			0.42 [0.28-0.54]	-	0.58 [0.46-0.72]	0.49	1.8	9.004
d prime			0.44 [0.30-0.56]	-	0.56 [0.44-0.70]	0.86	1.54	8.247
Median RT			0.36 [0.17-0.51]	-	0.65 [0.49-0.83]	0	3.99	0.14

N.B. for the final three columns, Δdf = 1.