Supplements

abbreviations: baseline pupil size (BPS), stimulus-evoked pupillary response (SEPR), mismatch-negativity-associated amplitude (MMN-amp), neural gain (NG)

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# supplement 1 – canonical pupillary response function



Supplement 1. The canonical pupillary response function (CPF) was estimated in an independent data set of a passive, auditory oddball task in adolescents. Top: Red - Data of the pupillary response for stimuli. Blue – Optimized fit of a gamma function (shape = 6.65 [6.47, 6.82], rate = 7.68 [7.47, 7.89]) to replicate the pupillary response. This optimized fit is used as a CPF in the current epoched data. Bottom: Residuals of the fit over time of a trial. Residuals appear randomly distributed with increasing variation over time.

# supplement 1 - descriptive statistics per participant

| Per-participant level: Descriptive statistics of baseline pupil size (BPS), stimulus-evoked pupillary response (SEPR), and mismatch negativity (MMN) | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- |
| variable | n | mean | sd | min | max | skew | kurtosis |
| BPS | 331 | 3.468 | 0.536 | 2.202 | 5.899 | 0.619 | 0.677 |
| SEPR - standard | 331 | 0.003 | 0.008 | -0.047 | 0.059 | 1.870 | 16.518 |
| SEPR - pitch oddball | 331 | 0.007 | 0.025 | -0.166 | 0.228 | 1.487 | 27.677 |
| SEPR - length oddball | 331 | 0.004 | 0.021 | -0.220 | 0.088 | -3.224 | 37.762 |
| SEPR - pitch+length oddball | 329 | 0.005 | 0.016 | -0.114 | 0.061 | -0.948 | 9.235 |
| MMN - standard | 257 | -10.706 | 3.423 | -22.095 | -3.065 | -0.639 | 0.210 |
| MMN - pitch oddball | 256 | -11.672 | 3.751 | -28.107 | -3.055 | -0.599 | 0.520 |
| MMN - length oddball | 256 | -12.107 | 3.728 | -22.484 | -3.872 | -0.583 | 0.049 |
| MMN - pitch+length oddball | 256 | -11.833 | 3.626 | -25.176 | -4.002 | -0.486 | -0.102 |

supplement 2 - descriptive statistics per trial

| Per-trial level: Descriptive statistics of baseline pupil size (BPS), stimulus-evoked pupillary response (SEPR), and mismatch negativity (MMN) | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- |
| variable | n | mean | sd | min | max | skew | kurtosis |
| BPS | 427296 | 3.462 | 0.586 | 1.982 | 7.415 | 0.671 | 0.914 |
| SEPR - standard | 347627 | 0.002 | 0.128 | -2.811 | 3.805 | 0.235 | 21.337 |
| SEPR - pitch oddball | 20595 | 0.007 | 0.127 | -1.345 | 2.275 | 0.442 | 11.226 |
| SEPR - length oddball | 24512 | 0.005 | 0.128 | -2.039 | 2.043 | 0.283 | 17.611 |
| SEPR - pitch+length oddball | 25489 | 0.006 | 0.132 | -2.776 | 2.118 | -0.273 | 20.083 |
| MMN - standard | 18227 | -10.691 | 9.403 | -91.488 | 50.221 | -0.805 | 2.975 |
| MMN - pitch oddball | 15295 | -11.521 | 9.502 | -94.139 | 37.635 | -1.014 | 3.253 |
| MMN - length oddball | 15404 | -12.012 | 9.673 | -88.872 | 32.803 | -0.901 | 2.630 |
| MMN - pitch+length oddball | 15436 | -11.678 | 9.537 | -87.129 | 68.538 | -0.828 | 3.210 |

supplement 3 - group comparisons on per-participant estimates

| Per-participant level: Group comparisons of baseline pupil size (BPS), stimulus-evoked pupillary response (SEPR), and mismatch negativity (MMN) | | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
|  | F | df1 | df2 | b | std. error | p |
| BPS - across stimuli | 6.645 | 1 | 329 | -0.287 | 0.111 | 0.01 |
| SEPR - standards | 2.456 | 1 | 329 | -0.175 | 0.112 | 0.118 |
| SEPR - pitch oddball | 0.092 | 1 | 329 | -0.034 | 0.112 | 0.761 |
| SEPR - length oddball | 0.073 | 1 | 329 | -0.03 | 0.112 | 0.787 |
| SEPR - pitch+length oddball | 1.818 | 1 | 327 | 0.151 | 0.112 | 0.178 |
| MMN - standards | 0.673 | 1 | 255 | 0.104 | 0.127 | 0.413 |
| MMN - pitch oddball | 2.157 | 1 | 254 | 0.186 | 0.127 | 0.143 |
| MMN - length oddball | 2.645 | 1 | 254 | 0.206 | 0.127 | 0.105 |
| MMN - pitch+length oddball | 1.183 | 1 | 254 | 0.138 | 0.127 | 0.278 |

supplement 4 - covariate effects: BPS group difference

| Per participant: Full Linear model of baseline pupil size (BPS) with all potential covariates | | | | |
| --- | --- | --- | --- | --- |
|  | Sum Sq | df | F | p |
| intercept | 0.287 | 1 | 0.360 | 0.549 |
| group | 2.156 | 1 | 2.705 | 0.101 |
| age | 46.796 | 1 | 58.711 | 0.000 |
| perceptual IQ | 2.643 | 1 | 3.315 | 0.070 |
| sex | 1.158 | 1 | 1.453 | 0.229 |
| sampling rate | 1.272 | 1 | 1.595 | 0.207 |
| gaze center deviation | 6.620 | 1 | 8.306 | 0.004 |
| data quality | 0.003 | 1 | 0.004 | 0.951 |
| residuals | 257.449 | 323 | NA | NA |

| Per participant: Reduced Linear model of baseline pupil size (BPS) with significant covariates | | | | |
| --- | --- | --- | --- | --- |
|  | Sum Sq | df | F | p |
| intercept | 1.022 | 1 | 1.271 | 0.260 |
| group | 2.456 | 1 | 3.053 | 0.082 |
| age | 43.779 | 1 | 54.437 | 0.000 |
| gaze center deviation | 10.049 | 1 | 12.496 | 0.000 |
| residuals | 262.974 | 327 | NA | NA |

supplement 5 - effect of medication on group differences

A higher proportion of autistic versus non-autistic individuals received medication (ASD: 46.4%, non-ASD: 20.4%, Chi² = 15.88, p < .001). 11 autistic and 3 non-autistic participants received more than one medication. Medication was primarily related to comorbid symptoms in those receiving medication (melatonin: 23%, methlphenidate: 22%, selective serotonin reuptake inhibitor: 15%, antiepileptics: 11%, risperidone: 7%, atomoxetine: 6%, other: 16%). We calculated a variable whether participants received any medication (yes versus no), which was included as a covariate into models that reported group differences.

On a per participant level, the inclusion of medication did not have an effect on baseline pupil size (BPS) and did not alter the group differences (BPS: F(1, 328) = 6.63, p = .010). For the dynamic BPS model, medication also had no significant effect on the cubic fit of BPS (F(1, 317) < 1) and did not alter the dynamic group difference (group x task progression: F(3, 426980 = 42.27, p < .001).

For the dynamic SEPR and MMN model, medication did not have a significant effect on SEPR or MMN (F < 1).

supplement 6 - BPS association with age, IQ, biological sex



supplement 7 - SEPR association with age, IQ, biological sex



supplement 8 - MMN-amp association with age, IQ, biological sex



supplement 10 - correlation table of BPS, SEPR, MMN-amp, NG

| correlations of baseline pupil size (BPS), stimulus-evoked pupillary response (SEPR), and mismatch negativity (MMN) for different stimuli. | | | |
| --- | --- | --- | --- |
| correlation | coefficient (r) | p | p adjusted |
| SEPR (standard) and BPS | 0.164 | 0.003 | 0.036 |
| SEPR (pitch oddball) and BPS | 0.043 | 0.436 | 1.000 |
| SEPR (length oddball) and BPS | 0.167 | 0.002 | 0.024 |
| SEPR (pitch+length oddball) and BPS | 0.060 | 0.279 | 1.000 |
| SEPR (standard) and MMN (standard) | -0.200 | 0.001 | 0.012 |
| SEPR (pitch oddball) and MMN (pitch oddball) | -0.143 | 0.022 | 0.264 |
| SEPR (length oddball) and MMN (length oddball) | -0.121 | 0.054 | 0.648 |
| SEPR (pitch+length oddball) and MMN (pitch+length oddball) | -0.027 | 0.669 | 1.000 |
| BPS and MMN (standard) | -0.177 | 0.004 | 0.048 |
| BPS and MMN (pitch oddball) | -0.195 | 0.002 | 0.024 |
| BPS and MMN (length oddball) | -0.214 | 0.001 | 0.012 |
| BPS and MMN (pitch+length oddball) | -0.213 | 0.001 | 0.012 |

supplement 11- polynomial fit comparison for BPS, SEPR; MMN-amp

| Model comparison on the linearity of trial number on baseline pupil size (BPS) | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | number of parameters | AIC | BIC | log likelihood | deviance | Chi-squared | df | p-value |
| linear fit | 4 | 475043.0 | 475086.9 | -237517.5 | 475035.0 | NA | NA | NA |
| quadratic fit | 5 | 467752.9 | 467807.7 | -233871.4 | 467742.9 | 7292.1632 | 1 | 0 |
| cubic fit | 6 | 467614.5 | 467680.3 | -233801.3 | 467602.5 | 140.3606 | 1 | 0 |

| Model comparison on the linearity of trial number on stimulus-evoked pupillary response (SEPR) | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | number of parameters | AIC | BIC | log likelihood | deviance | Chi-squared | df | p-value |
| linear fit | 4 | 1186583 | 1186627 | -593287.5 | 1186575 | NA | NA | NA |
| quadratic fit | 5 | 1186584 | 1186639 | -593287.1 | 1186574 | 0.7436042 | 1 | 0.3885088 |
| cubic fit | 6 | 1186577 | 1186643 | -593282.7 | 1186565 | 8.7644318 | 1 | 0.0030716 |

| Model comparison on the linearity of trial number on mismatch negativity (MMN) | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | number of parameters | AIC | BIC | log likelihood | deviance | Chi-squared | df | p-value |
| linear fit | 4 | 175331.9 | 175368.2 | -87661.94 | 175323.9 | NA | NA | NA |
| quadratic fit | 5 | 175328.7 | 175374.1 | -87659.36 | 175318.7 | 5.148342 | 1 | 0.0232686 |
| cubic fit | 6 | 175324.7 | 175379.2 | -87656.37 | 175312.7 | 5.976667 | 1 | 0.0144964 |

supplement 12 - BPS linear mixed model - task progression

| Linear mixed model: baseline pupil size (BPS) - task progression | | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
|  | Sum Sq | Mean Sq | df1 | df2 | F | p adjusted |
| stimulus (S) | 1.778 | 0.593 | 3 | 425391.030 | 3.629 | 0.012 |
| group | 0.693 | 0.693 | 1 | 311.290 | 4.246 | 0.040 |
| task progression (TP) | 360.456 | 120.152 | 3 | 425392.199 | 735.892 | 0.000 |
| video luminance | 100.995 | 100.995 | 1 | 425391.183 | 618.563 | 0.000 |
| age | 10.808 | 10.808 | 1 | 311.054 | 66.192 | 0.000 |
| perceptual IQ | 0.504 | 0.504 | 1 | 311.004 | 3.089 | 0.080 |
| sex | 0.330 | 0.330 | 1 | 311.007 | 2.024 | 0.156 |
| sampling rate | 0.977 | 0.977 | 1 | 311.032 | 5.983 | 0.015 |
| gaze center deviation | 538.530 | 538.530 | 1 | 425427.173 | 3298.322 | 0.000 |
| data quality | 1170.123 | 1170.123 | 1 | 425509.275 | 7166.625 | 0.000 |
| S x group | 1.765 | 0.588 | 3 | 425391.029 | 3.603 | 0.013 |
| S x TP | 25.589 | 2.843 | 9 | 425391.035 | 17.414 | 0.000 |
| group x TP | 23.161 | 7.720 | 3 | 425391.758 | 47.285 | 0.000 |
| S x group x TP | 1.824 | 0.203 | 9 | 425391.025 | 1.242 | 0.264 |

| Covariate effects on baseline pupil size (BPS) | | | |
| --- | --- | --- | --- |
| covariate | estimate | lower bound (2.5%) | upper bound (97.5%) |
| video luminance | -0.02 | -0.03 | -0.01 |
| age | -0.37 | -0.46 | -0.28 |
| sampling rate (300Hz vs. 120Hz) | 0.23 | 0.03 | 0.43 |
| gaze center deviation | 0.04 | 0.02 | 0.06 |
| data quality / missing data | 0.09 | 0.08 | 0.10 |

supplement 19 - Bayesian posterior estimate MCMC chain convergence

Ein Bild, das Text, Schrift, Screenshot, Design enthält.

Automatisch generierte Beschreibung

supplement 20 - histograms of per-participant estimates

Ein Bild, das Diagramm, Text enthält.

Automatisch generierte Beschreibung

supplement 21- histograms of per-trial estimates

Ein Bild, das Diagramm, Text enthält.

Automatisch generierte Beschreibung