**Supplemental Material**

**Participants**

Out of the 222 individuals with psychotic disorders who were assessed, forty-one (18.5%) were excluded from analysis: 26 for poor task performance (<70% correct), 5 for committing zero errors, and 10 for poor quality data (<50% artifact-free trials). Out of the 254 never-psychotic adults who were assessed, 12 (4.7%) were excluded from analysis: 2 for poor task performance, 2 for committing zero errors, and 8 for poor quality data. Thus, a total of 181 individuals with psychotic disorders and 242 never-psychotic adults were retained for analysis.

**Laboratory Task**

An arrow flankers task was used to assess error processing ([Eriksen & Eriksen, 1974](#_ENREF_1)). On each trial, five horizontally aligned arrowheads were presented, with half of the trials being compatible (< < < < < or > > > > >) and half being incompatible (< < > < < or > > < > >). The arrows were presented in the center of a 19-in (48.3 cm) monitor and occupied approximately 1.3° of the visual field vertically and 9.2° horizontally. The arrows were presented for 200 ms and were followed by an inter-trial interval that varied randomly from 2300-2800 ms. Participants were instructed to press the left or right mouse button, corresponding to the direction of the center arrow, and to respond in such a way as to maximize speed and accuracy. Participants first completed a practice block of 30 trials; the actual task consisted of 11 blocks of 300 trials. At the end of each block, participants received performance feedback: performance <75% correct was followed by “Please try to be more accurate”; >90% by “Please try to respond faster”; and intermediate performance by “You’re doing a great job.”

**EEG Recording, Processing, and Data Reduction**

 The EEG was recorded using an elastic cap and the ActiveTwo BioSemi System (BioSemi, Amsterdam, Netherlands). The signal was digitized at 24-bit resolution with a sampling rate of 1024 Hz. Electrodes were measured with respect to a common mode sense active electrode that formed a monopolar channel. Recordings were taken from 34 scalp electrodes based on the 10/20 system (including FCz and Iz) and two electrodes on the left and right mastoids. The electro-oculogram was recorded from four facial electrodes.

 Offline analysis was performed using Brain Vision Analyzer software (Brain Products, Munich, Germany). Data were re-referenced to the mastoid average and band-pass filtered from .1-30 Hz. The EEG was segmented for each trial, spanning -400 to 800 ms relative to the response, and corrected for blinks and eye movements using a regression-based method ([Gratton, Coles, & Donchin, 1983](#_ENREF_3)). Channels were rejected in each trial using a semi-automated procedure, with artifacts defined as a step of more than 50 μV, a difference of 300 μV within a trial, or a maximum difference of less than .50 μV within 100-ms intervals; additional artifacts were identified visually. Response-locked ERP averages were created for correct and incorrect responses, and the activity from -400 to -200 ms served as the baseline. A difference wave approach was used to isolate error-related activity by subtracting the ERP waveforms on correct trials from error trials ([Luck, 2005](#_ENREF_4)). The ERN was scored as the mean activity from 0-100 ms at Cz, and the Pe as the mean from 300-500 ms at Pz.

**Measures**

**Cognition.** Trail Making involves connecting targets in order, in which the targets are either all numbers (Part A) or alternating numbers/letters (Part B). Stroop Color Word involves reading names of colors printed in congruous or incongruous font. Letter-Number Sequencing involves repeating back a sequence of numbers and letters, with the numbers in ascending order and the letters in alphabetical order. For the current analysis, executive function was measured as the time to completion on Trail Making B, number of correct items on Stroop Color Word, and number of correct items on Letter-Number Sequencing. General cognitive ability was measured with the Vocabulary subtest of the Wechsler Adult Intelligence Scale—Revised, which involves naming objects and defining words that are presented.

**Functioning.** QLS items relating to social and role domains were chosen to assess functioning relevant to all participants, independent of life context (e.g., partnered versus single, employed versus unemployed). Social functioning was operationalized as the sum of three QLS items that capture interpersonal relations: social activity, sociosexual relations, and relationships with friends. These three items have reasonable internal consistency (α=0.79), and scores ranged from 1 (worst functioning) to 17 (best). Primary role functioning was operationalized as the QLS item rating degree of impairment in expected role, which ranged from 1 (did not function) to 6 (no impairment, high functioning). Among individuals with psychotic disorders, social functioning and role functioning scores were moderately related to one another (*r* = .56, *p*<.001), indicating that they capture related but dissociable aspects of every functioning. To ensure a reliable rating of global functioning, SOFAS was rated independently by a consensus team of psychiatrists using all available information, including symptom, diagnostic, and functioning interviews, as well as interviews with significant others and medical records. This rating focuses on functioning but not symptoms, making it the functional component of the Global Assessment of Functioning (GAF). As expected, both social and role functioning were strongly related to SOFAS score (social: *r* = .69, *p*<.001; role: *r* = .81, *p*<.001).

**Number of Error Trials**

Among the clinical cohort, a mean of 22.45 error trials were retained for averaging (Range: 2-90). Among the NP group, a mean of 19.89 trials were retained for averaging (Range: 2-69). Previous analyses in this clinical cohort have shown that the ERN and Pe achieve adequate internal consistency with relatively few trials (5 for ERN, 12 for Pe) ([Foti, Kotov, & Hajcak, 2013](#_ENREF_2)). Having so few trials was relatively uncommon, however. Out of the 181 participants in the clinical cohort that were included for analysis, 16 (8.8%) had fewer than 5 trials. We opted to include these individuals in the current analyses in order to maximize statistical power. Taking a more conservative approach and restricting analyses to participants with 5+ available error trials did not meaningfully change the key findings: The main effect of diagnostic group (schizophrenia, other psychosis, NP) remained significant for the ERN and Pe (both *p*’s<.01). Among the clinical cohort, reduced ERN amplitude correlated with symptoms of inexpressivity (*r* =.25, *p*<.01), and Pe with avolition (*r* = -.19, *p*<.05) and global functioning (*r* =.19, *p*<.05). Both ERPs were correlated with composite executive function (ERN: *r* = -.36, p<.001; Pe: *r* = .21, *p*<.01).

Within the full sample, ERN amplitude was not significantly related to the number of trials averaged (*r* =.07, *p* = .16), whereas Pe amplitude was inversely related to the number of trials averaged (*r* = -.18, *p*<.001). Signal-to-noise ratio was inversely related to the number of trials: *M=*1.37 (*SD*=1.25) among individuals with 2-4 error trials, .37 (.48) with 5-11 error trials, and .20 (.22) with greater than 12 error trials. Critically, the main effects of group (schizophrenia, other psychosis, never psychotic) remained significant after adjusting for the number of averaged trials (ERN: *F*(2,419) = 21.67, *p*<.001; Pe: *F*(2,419) = 3.39, *p*<.05).

**Table S1. Sample characteristics among diagnostic groups**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable** | **Schizophrenia** **(*n* = 93)** | **Bipolar****(*n* = 50)** | **Major Depression****(*n* = 16)** | **Substance/****NOS****(*n* = 22)** | **Group****Comparison** |
|  | *n* | % | *n* | % | *n* | % |  |  | *p-value* |
| Gender |  |  |  |  |  |  |  |  | .002 |
| *Male* | 64 | 68.8 | 26 | 52.0 | 4 | 25.0 | 17 | 77.3 |  |
| *Female* | 29 | 31.2 | 24 | 48.0 | 12 | 75.0 | 5 | 22.7 |  |
| Race |  |  |  |  |  |  |  |  | .04 |
| *White* | 70 | 75.3 | 45 | 90.0 | 14 | 87.5 | 14 | 63.6 |  |
| *Other* | 23 | 24.7 | 5 | 10.0 | 2 | 12.5 | 8 | 36.4 |  |
| Antipsychotic Medication | 73 | 78.5 | 18 | 36.0 | 7 | 43.8 | 5 | 22.7 | <.001 |
|  |  |  |  |  |  |  |  |  |  |
|  | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* |  |
| Age | 47.09 | 8.17 | 46.06 | 7.65 | 53.19 | 10.39 | 51.00 | 10.41 | .008 |
| Symptoms |  |  |  |  |  |  |  |  |  |
| *Reality Distortion* | 8.15 | 10.36 | 0.48 | 1.88 | 1.63 | 3.20 | 1.27 | 2.29 | <.001 |
| *Disorganized* | 6.59 | 7.55 | 1.97 | 3.45 | 3.42 | 5.88 | 4.29 | 4.98 | <.001 |
| *Inexpressivity* | 10.39 | 10.81 | 3.00 | 5.16 | 2.73 | 5.65 | 2.71 | 4.38 | <.001 |
| *Avolition* | 17.94 | 8.21 | 7.79 | 7.39 | 10.48 | 9.35 | 8.55 | 7.93 | <.001 |
| Everyday Functioning |  |  |  |  |  |  |  |  |  |
| *Role Functioning* | 2.32 | 1.29 | 4.46 | 1.62 | 3.38 | 2.02 | 4.06 | 1.71 | <.001 |
| *Social Functioning* | 8.45 | 4.45 | 12.20 | 4.18 | 10.27 | 3.75 | 12.32 | 4.05 | <.001 |
| *Global Functioning* | 39.52 | 12.21 | 60.44 | 16.39 | 53.13 | 14.10 | 58.82 | 16.60 | <.001 |
| Executive function |  |  |  |  |  |  |  |  |  |
| *Trail Making (B)* | 119.43 | 46.00 | 78.74 | 31.55 | 114.79 | 49.98 | 102.45 | 51.21 |  |
| *Stroop* | 82.89 | 20.17 | 98.38 | 17.42 | 86.00 | 31.85 | 86.80 | 25.03 | <.001 |
| *Letter-Number*  | 7.68 | 3.14 | 10.80 | 2.48 | 8.57 | 2.88 | 8.50 | 2.91 | .002 |
| *Composite* | -.74 | .87 | .17 | .67 | -.55 | 1.06 | -.48 | 1.01 | <.001 |
| Simple Attention |  |  |  |  |  |  |  |  |  |
| *Trail Making (A)* | 41.77 | 16.54 | 32.29 | 10.75 | 45.13 | 23.74 | 37.90 | 23.15 | .008 |
| General Cognitive Ability |  |  |  |  |  |  |  |  |  |
| *Vocabulary* | 18.79 | 5.96 | 22.31 | 3.84 | 18.87 | 6.12 | 19.50 | 5.25 | .003 |
| Task Accuracy | 90.79 | 6.53 | 91.93 | 5.38 | 91.98 | 7.47 | 91.90 | 6.60 | .69 |
| ERN difference (µV) | -.22 | 6.22 | -1.70 | 7.10 | -2.54 | 9.10 | -1.84 | 6.52 | .41 |
| Pe difference (µV) | 6.30 | 6.69 | 9.81 | 6.63 | 6.09 | 6.86 | 7.63 | 5.82 | .02 |

**Table S2. Flankers task performance and ERP amplitude among diagnostic groups**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable** | **Schizophrenia****(n=93)** | **Other Psychosis****(n=88)** | **Never Psychotic****(n=242)** | **Effect of Condition** | **Condition x Group** |
|  | *M* | *SD* | *M* | *SD* | *M* | *SD* | *p*-value | *p*-value |
| Accuracy (%) |  |  |  |  |  |  | <.001 | .85 |
| *Congruent* | 95.48 | 5.03 | 96.25 | 3.41 | 97.13 | 2.88 |  |  |
|  *Incongruent* | 87.52 | 9.12 | 88.89 | 8.98 | 89.43 | 6.64 |  |  |
| Reaction Time (ms) |  |  |  |  |  |  | <.001 | .20 |
|  *Congruent* | 555.12 | 135.24 | 515.89 | 111.85 | 461.89 | 73.01 |  |  |
|  *Incongruent* | 625.48 | 138.67 | 588.43 | 121.89 | 538.87 | 84.24 |  |  |
| Post-Error Slowing (ms) |  |  |  |  |  |  | <.001 | .062 |
|  *Correct after Correct* | 584.90 | 131.76 | 546.38 | 112.76 | 495.74 | 76.35 |  |  |
|  *Correct after Error* | 611.39 | 161.82 | 594.92 | 146.75 | 535.67 | 108.86 |  |  |
| ERN (µV) |  |  |  |  |  |  | <.001 | <.001 |
|  *Error Trials* | 2.45 | 6.74 | 2.11 | 6.81 | 1.90 | 7.37 |  |  |
|  *Correct Trials* | 2.67 | 6.75 | 4.00 | 6.66 | 7.40 | 5.68 |  |  |
| Pe (µV) |  |  |  |  |  |  | <.001 | .015 |
|  *Error Trials* | 5.28 | 8.26 | 8.28 | 8.71 | 10.24 | 8.44 |  |  |
|  *Correct Trials* | -1.02 | 5.86 | -.31 | 5.83 | 1.75 | 5.03 |  |  |

Note: Reaction time for congruent and incongruent trials are presented for correct trials only. The sign of the ERN changed because values are for error and correct trials separately (rather than the error minus correct difference score).

**Table S3. Correlations between neural measures of error processing and performance-based measures of cognition among never-psychotic adults**

|  |  |  |
| --- | --- | --- |
| **Variable** | **ERN** | **Pe** |
| Executive Function |  |  |
|  *Trail Making (B)* | -.16a | .13 |
|  *Stroop Color Word* | -.29a | .11 |
|  *Letter-Number* | -.12 | .07 |
|  *Composite* | -.24a | .13 |
| Simple Attention |  |  |
|  *Trail Making (A)* | -.06 | .17a |
| General Cognitive Ability |  |  |
| *Vocabulary* | -.08 | .04 |

Note: N=242. The ERN difference score is a negative-going ERP, so positive correlation coefficients indicate a direct association, and vice versa. a*p*<..017 (critical value adjusting for false discovery rate).

**Table S4. Retrospective associations between error processing, negative symptoms, and functioning among individuals with psychosis across 20 years of follow-up**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Variable** | **20-year** | **10-year** | **4-year** | **2-year** | **6-month** | **Admission** |
| ERN |  |  |  |  |  |  |
|  *Inexpressivity* | .25a | .07 | .02 | .16 | .18a | .00 |
|  *Avolition* | .15a | .06 | .09 | .05 | .02 | .02 |
|  *Global Functioning* | -.19a | -.09 | -.08 | -.03 | -.07 | .03 |
| Pe |  |  |  |  |  |  |
|  *Inexpressivity* | -.10 | -.09 | -.08 | .06 | -.05 | .01 |
|  *Avolition* | -.17a | -.11 | -.18a | -.17a | -.10 | -.03 |
|  *Global Functioning* | .18a | .22a | .21a | .15a | .17a | .00 |

Note*:* The ERN is a negative-going ERP, so positive correlation coefficients indicate a direct association, and vice versa. The ERN and Pe were measured at year 20. Analyses used the mean symptom/functioning score across all assessments (admission through year 20). a*p*<.05 (uncorrected).

**Table S5. Retrospective associations between symptoms and functioning among individuals with psychotic disorders**

|  |  |
| --- | --- |
|  | **Retrospective Correlations** |
| 20-year Variables | 10-year | 4-year | 2-year | 6-month | Admission |
| Inexpressivity | .70 | .48 | .54 | .45 | .45 |
| Avolition | .62 | .55 | .51 | .46 | .40 |
| Global Functioning | .77 | .57 | .53 | .54 | .40 |

Note*:* All correlations are significant at *p*<.001.

**Supplementary References**

Eriksen, B. A., & Eriksen, C. W. (1974). Effects of noise letters upon the identification of a target letter in a nonsearch task. *Perception & Psychophysics, 16*(1), 143-149. doi:10.3758/BF03203267

Foti, D., Kotov, R., & Hajcak, G. (2013). Psychometric considerations in using error-related brain activity as a biomarker in psychotic disorders. *Journal of Abnormal Psychology, 122*(2), 520-531. doi:10.1037/a0032618

Gratton, G., Coles, M. G., & Donchin, E. (1983). A new method for off-line removal of ocular artifact. *Electroencephalography and Clinical Neurophysiology, 55*(4), 468-484. doi:10.1016/0013-4694(83)90135-9

Luck, S. J. (2005). *An Introduction to the Event-Related Potential Technique*. Cambridge, MA: MIT Press.