

FEEDBACK NEGATIVITY AND FEEDBACK-RELATED P3 DURING THE MONETARY INCENTIVE DELAY TASK IN INDIVIDUALS AT HIGH AND LOW FAMILY RISK FOR DEPRESSION

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BACKGROUND

- Two widely-studied feedback-processing ERPs components: **1) Feedback negativity (FN)**; = reward positivity [RewP]
 - relative negativity with peak at 200 – 300 ms after onset of feedback stimulus at frontocentral sites
 - early outcome valence (more negative amplitude after unfavorable than favorable/neutral stimuli)¹
 - amplitude inversely correlated with major depressive disorder (MDD) and predicts treatment outcome^{3,4,6}
 - blunted in adult/adolescent depression, but not reliably predicting depression in offspring of depressed parents⁵
- 2) Feedback P3 (Fb-P3)**
 - positivity with peak at 350 – 450 ms after onset of feedback stimulus at centroparietal sites
 - motivational salience and allocation of attention (more attention allocated when incentive is present)⁷
 - amplitude inversely correlated with depression^{2,8}
- Study aimed to examine**
 - if reward processing is impaired in individuals at high vs low family risk for MDD (HR/LR) or with vs without a lifetime history of MDD (MDD+/-)
 - effects of ERP transformation by directly comparing surface potentials (linked-mastoid [LM] = most commonly used EEG reference) and reference-free current source densities (CSD) (Tab. 1)

METHODS

- 61 individuals (15 – 58 years, mean ± SD = 30 ± 13, 30 male), enrolled in longitudinal study on families at risk for depression¹¹
- PHQ-9 ($M = 4.9 \pm 4.8$); MDD+ > MDD-
- IDAS-II ($M = 40.6 \pm 12.8$); HR > LR, MDD+ > MDD-

| | High risk (HR) (n = 29; 15 male) | | | Low risk (LR) (n = 31; 14 male) | | | p |
|---------|-------------------------------------|-------|---------|------------------------------------|-------|---------|------|
| | Mean | SD | Range | Mean | SD | Range | |
| PHQ-9 | 5.90 | 4.48 | 0 – 16 | 3.94 | 4.87 | 0 – 18 | n.s. |
| IDAS-II | 44.24 | 13.30 | 27 – 76 | 37.26 | 11.61 | 22 – 63 | .034 |

| | Prior history (MDD+) (n = 31; 14 male) | | | No history (MDD-) (n = 29; 15 male) | | | p |
|---------|---|-------|---------|--|-------|---------|------|
| | Mean | SD | Range | Mean | SD | Range | |
| PHQ-9 | 6.26 | 5.25 | 0 – 16 | 3.41 | 3.70 | 0 – 18 | .019 |
| IDAS-II | 44.68 | 13.81 | 23 – 76 | 36.31 | 10.26 | 22 – 63 | .005 |

Tab. 1 Symptom scores for participants ($n = 60$) of PHQ-9 and IDAS-II divided by risk and MDD groups.

- Monetary Incentive Delay (MID) task** to produce win, loss, or neutral outcomes with feedback⁹ (Fig. 1)
- 72-channel EEG** (Biosemi)
- LM (TP9/10) ERP and CSD waveforms (Fig. 2) quantified by temporal PCA → FN and fb-P3 PCA components for statistical analyses¹⁰ (Fig. 3)
- 3 conditions (Win, Loss, Neutral)** evaluated via unbiased permutation tests (Figs. 4-5)
- 4 multilevel modeling (MLM) models** using 2 data transformation schemes (ERP, CSD) × 2 PCA components (FN, fb-P3) (Tab. 2)
- Age as covariate
- No sex effects for depressive symptoms → sex not included
- Electrode (at representative sites ← permutation tests) as random effect

RESULTS

| Variable | FN | | Fb-P3 | |
|-----------------|--|--|---|---|
| | ERP (N309) | CSD (309) | ERP (P379) | CSD (383) |
| Condition | $F_{(2,2314)} = 285.9$, $p < 0.0001$, $\eta_p^2 = 0.198^a$ | $F_{(2,2728)} = 123.6$, $p < 0.0001$, $\eta_p^2 = 0.253^a$ | $F_{(2,6096)} = 2912.9$, $p < 0.0001$, $\eta_p^2 = 0.490^b$ | $F_{(2,2438)} = 403.2$, $p < 0.0001$, $\eta_p^2 = 0.249^b$ |
| Risk | n.s. | n.s. | $F_{(1,58)} = 4.57$, $p = 0.0368$, $\eta_p^2 = 0.0730^c$ | n.s. |
| Condition* Risk | $F_{(2,2314)} = 14.8$, $p < 0.0001$, $\eta_p^2 = 0.0127^e$ (Fig. 6a) | n.s. | $F_{(2,6096)} = 198.3$, $p < 0.0001$, $\eta_p^2 = 0.0611^f$ (Fig. 6c) | $F_{(2,2438)} = 16.9$, $p < 0.0001$, $\eta_p^2 = 0.014^g$ (Fig. 6e) |

| Variable | FN | | Fb-P3 | |
|----------------|--|---|--|---|
| | ERP (N309) | CSD (309) | ERP (P379) | CSD (383) |
| Condition | $F_{(2,2314)} = 283.6$, $p < 0.0001$, $\eta_p^2 = 0.197^a$ | $F_{(2,2728)} = 124.0$, $p < 0.0001$, $\eta_p^2 = 0.254^a$ | $F_{(2,6096)} = 2772.4$, $p < 0.0001$, $\eta_p^2 = 0.476^b$ | $F_{(2,2438)} = 399.8$, $p < 0.0001$, $\eta_p^2 = 0.247^b$ |
| MDD | n.s. | n.s. | n.s. | $F_{(1,58)} = 6.88$, $p = 0.0111$, $\eta_p^2 = 0.106^d$ |
| Condition* MDD | n.s. | $F_{(2,2728)} = 3.55$, $p = 0.0293$, $\eta_p^2 = 0.00965^h$ (Fig. 6b) | $F_{(2,6096)} = 41.7$, $p < 0.0001$, $\eta_p^2 = 0.0135^i$ (Fig. 6d) | $F_{(2,2438)} = 6.29$, $p = 0.0019$, $\eta_p^2 = 0.00514^j$ (Fig. 6f) |

a. Loss > Win/Neutral
b. Win/Loss > Neutral
c. HR > LR
d. MDD- > MDD+
e. Neutral > Win for HR not LR
f. HR > LR for Win/Loss but not Neutral
g. Win > Loss for HR but not LR
h. Neutral > Win for MDD- not MDD+
i. Win > Loss for MDD- but not MDD+

CONCLUSIONS

- FN selectively increased for Loss vs Win/Neutral
- fb-P3 greater for Win/Loss vs Neutral
- Largely comparable feedback processing for LR vs HR and MDD- vs MDD+
- However, condition effects, particularly for fb-P3, more pronounced for HR (vs LR) and MDD+ (vs MDD-) which appears to contradict prior findings^{2,8}
- More localized topographies for CSD than LM
- Subtle (interaction) effects are prone to be influenced (biased) by data transformation choice
- Reference-free techniques for ERP data analysis are strongly recommended

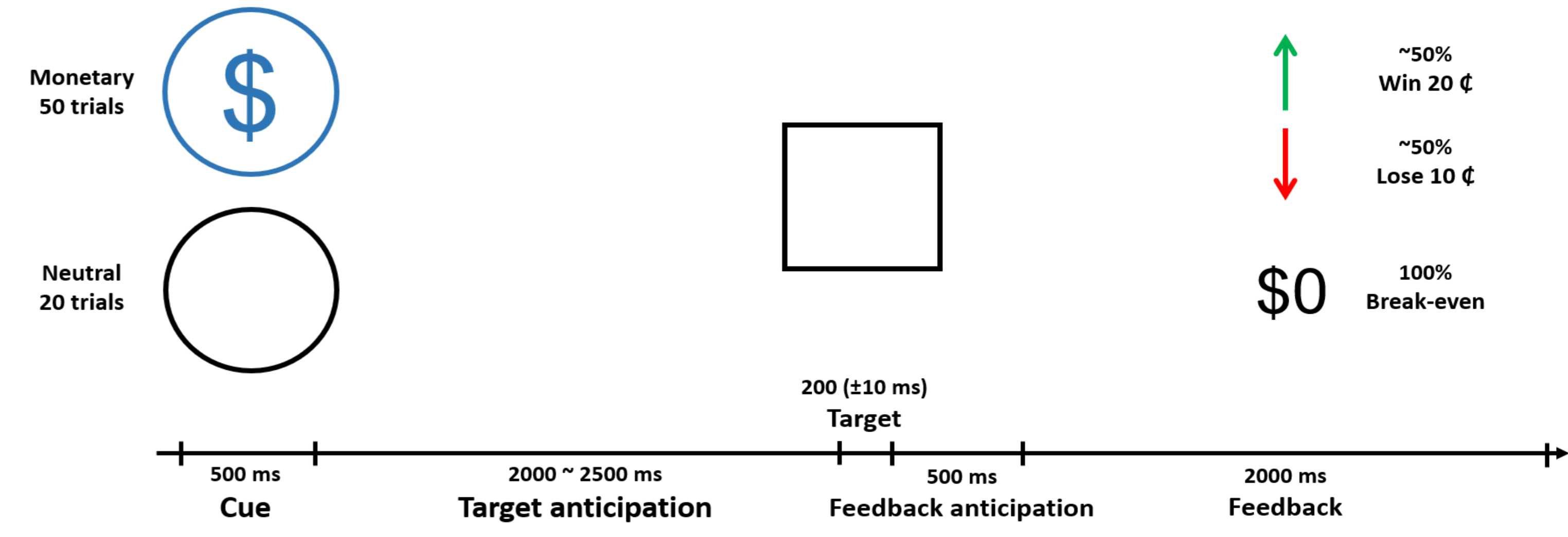


Fig. 1 MID task trial structure. On each trial, either a monetary or a neutral cue was presented for 500 ms. After a variable 2 to 2.5 s interval, the target was presented for 200 ms; however, this exposure time was continuously adjusted based on the performance on the preceding trial (i.e., a 10 ms in- or decrease). After 500 ms, a 2000-ms feedback indicated a monetary win, loss, or neutral outcome.

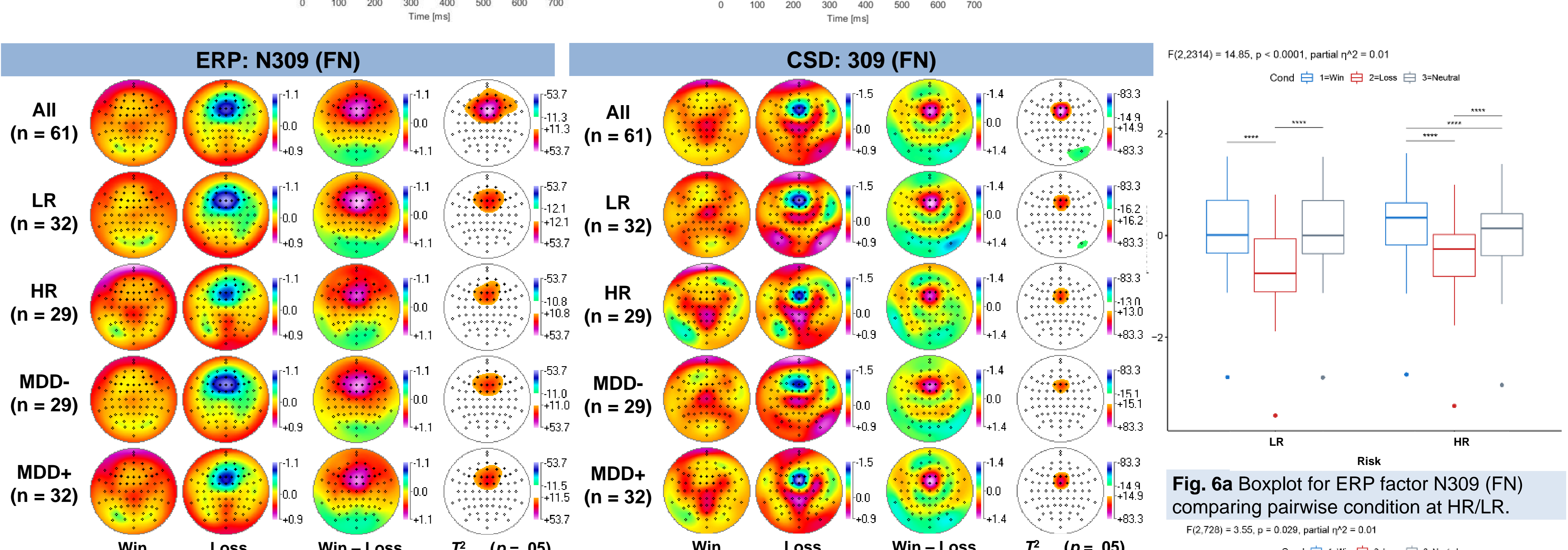
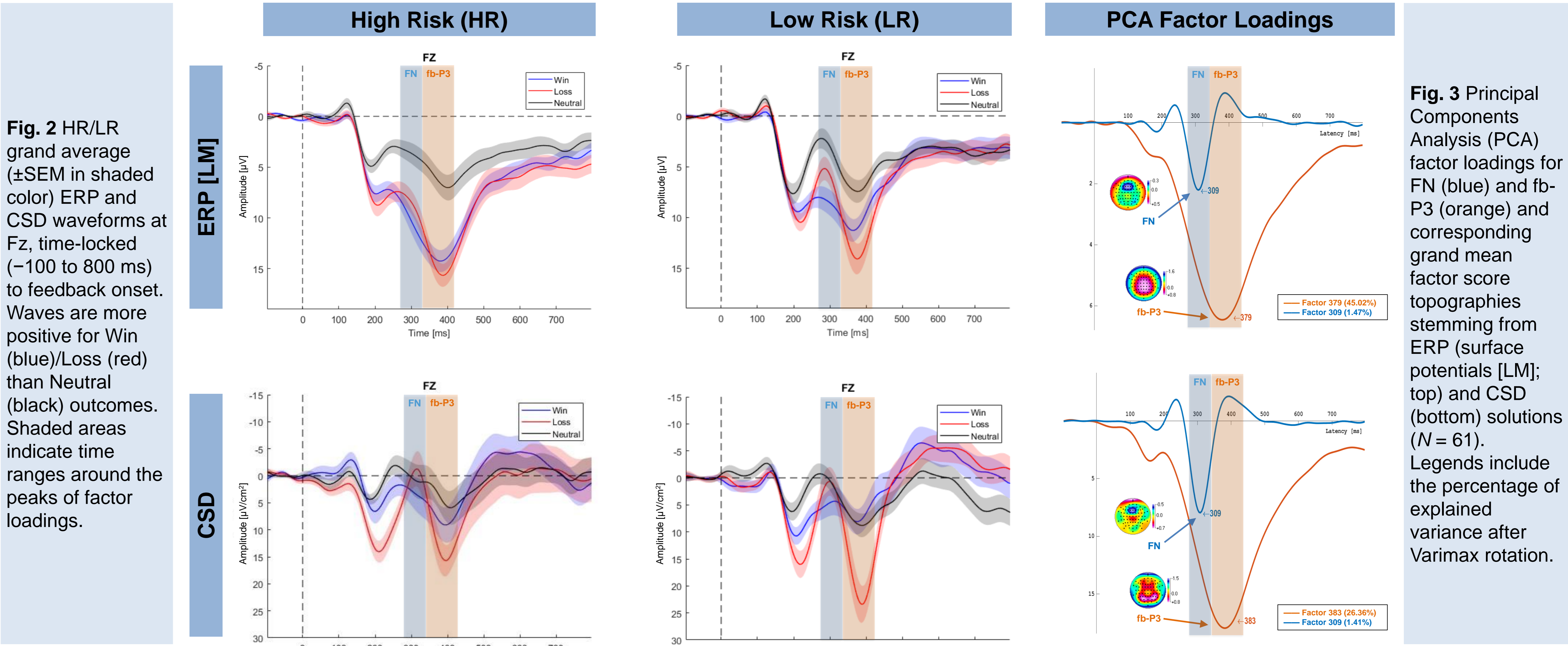


Fig. 4 Factor score topographies corresponding to FN for full sample and LR/HR and MDD+/- subgroups comparing Win versus Loss trials. Squared univariate (channel-specific) paired samples T statistics thresholded at the 95th quantile ($p = 0.05$) of the corresponding randomization distribution (maximum of all 72-channel squared univariate paired samples T statistics) of Win – Loss differences.

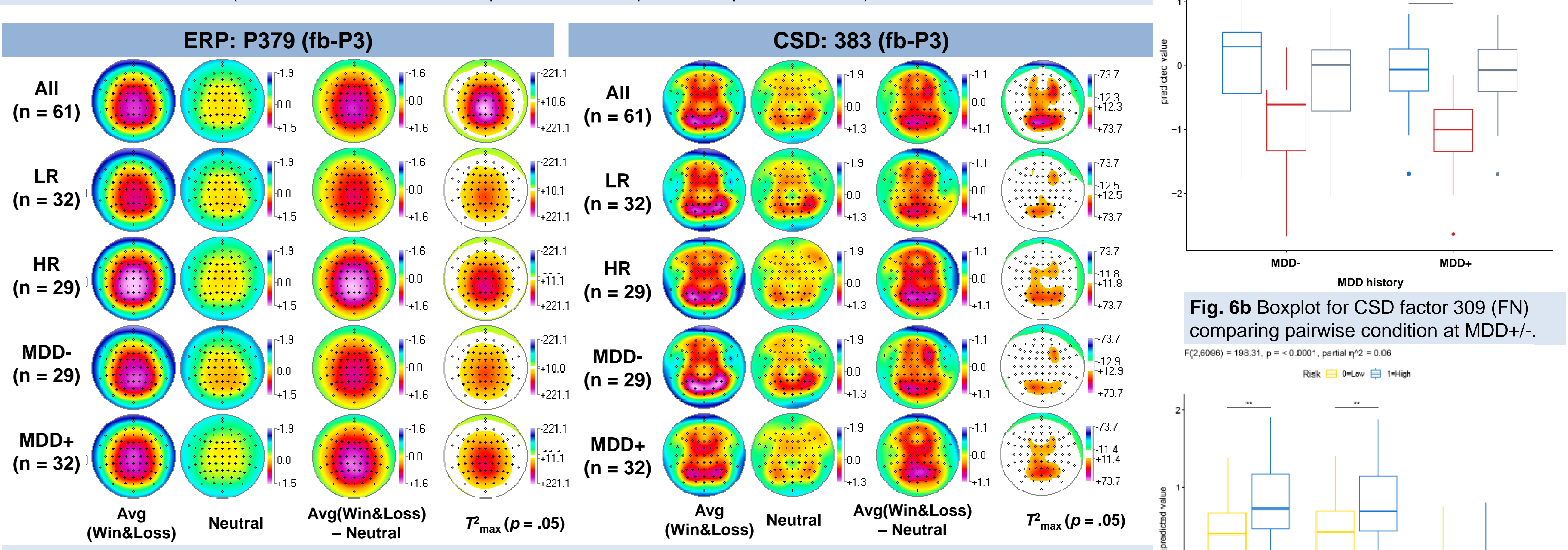


Fig. 5 Factor score topographies corresponding to fb-P3 for full sample and LR/HR and MDD+/- subgroups comparing Win/Loss versus Neutral trials (corresponding statistics as in Fig. 4).

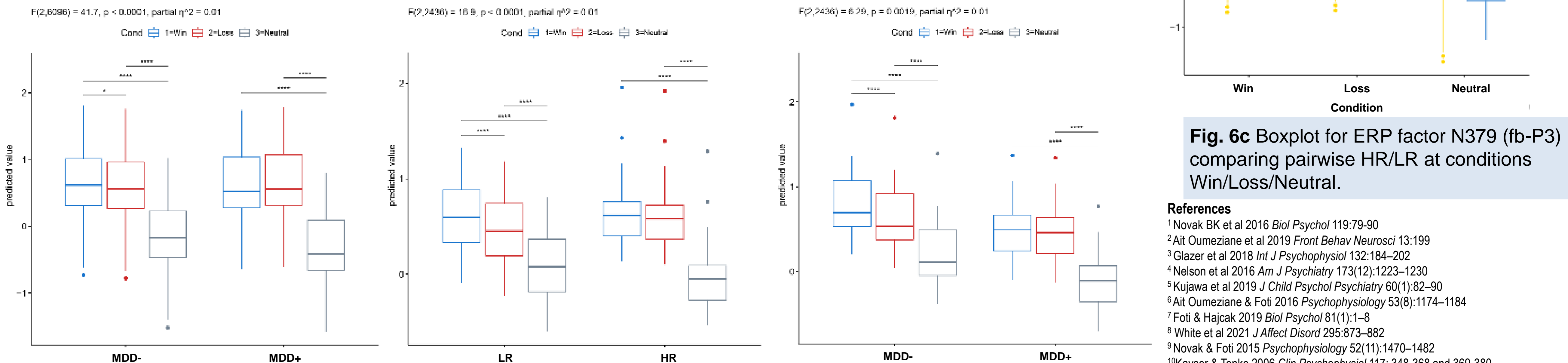


Fig. 6a Boxplot for ERP factor N309 (FN) comparing pairwise condition at HR/LR. Fig. 6b Boxplot for CSD factor 309 (FN) comparing pairwise condition at MDD+/-.

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