Belief Updating and Paranoia in Individuals with Schizophrenia

Supplemental Information

Supplemental Results

Group Differences in Belief Updating: Elevated/Low Paranoia

Given the lack of a significant group differences in schizophrenia and healthy participants on computational parameters, but a significant association with paranoia, we investigated whether splitting our sample into those with elevated and low paranoia scores (regardless of diagnosis) might reveal differences in belief updating. We used the cutoff score of ≤ 4 to represent elevated persecutory ideation. Green and colleagues[1] suggest a cutoff score of 5 for elevated persecutory ideation, however in this exploratory analysis, very few individuals met that definition of elevation (N=9). Therefore, we chose a cut-off of ≤ 4 to gain slightly more power (N=13) in the between-groups analysis.

Individuals with elevated paranoia had significantly higher μ_3^0 (F(1,84)=9.41, p=.003) and higher κ (F(1,84)=9.6, p=.003) (Figure S1). ω_2 (F(1,84)=3.93, p=.05) and ω_3 (F(1,84)=3.1, p=.08) did not reach statistical significance. Win-switch behavior was greater in high compared to low paranoia participants (F(1,84)=4.0, p=.05), though did not quite reach statistical significance, and lose-stay behavior (F(1,84)=.08, p=.78) was similar between paranoia groups.

Notably, the rates of healthy and schizophrenia participants in the elevated/low paranoia groups was similar (X^2=.66, p=.42). This suggests that belief updating computational parameters of prior on volatility and unexpected uncertainty are tracking with paranoia, not diagnosis.

Specificity Analysis

In schizophrenia, μ_3^0 was significantly more strongly correlated with paranoia than with social anxiety (z=-2.24, p=.01), general worry (z=-1.86, p=.03), depression (z=-2.12, p=.02), perseverative thinking (z=-2.37, p=.01) and, nominally, physiological anxiety (z=-1.68, p=.05). In addition, μ_3^0 and win-switch were significantly more strongly correlated with paranoia than unusual thought content (μ_3^0: z=-2.39, p=.01; win-shift rate (z=-2.08, p=.02).

Examination of covariates

<u>Demographic variables</u>

Although participants did not significantly differ at the group-level on age, sex, and race, we explored the impact of including these variables as covariates on our primary findings.

Regarding group differences in behavioral measures, win-shift (F(1,81)=7.97, p=.006) and lose-stay (F(1,81)=4.7, p=.03) behavior significantly differed between groups with covariates in the model.

In terms of correlations with paranoia, μ_3^0 continued to demonstrate a significant association with interviewer-rated paranoia ($\rho(37)$=.36, p=.03) and persecutory worry (r(80)=.29, p=.008 when controlling for age, sex, and race in the same model. Relationships between win-shift rate and self-reported paranoia (ρ=.12, p=.28) and interview-rated paranoia (ρ=.06, p=.71) were attenuated and no longer significant with the inclusion of all these covariates.

In order to better understand the impact of covariates on our results, we examined the elevated/low paranoia groups. These groups were highly similar on age (p=.94) and sex (p=.58), but had significantly different racial make-ups (p<.001). Specifically, those in the elevated paranoia group were significantly more likely to be African-American. Although the groups are of very different sizes (73 low paranoia, 13 elevated paranoia) this racial difference is notable. In fact, when only age and sex are included as covariates, associations between paranoia and win-shift were once again significant (interview-rated: ρ=.35, p=.03; self-reported: ρ=.25, p=.02).

That said, the elevated paranoia group continued to demonstrate significantly greater μ_3^0 , when controlling for age, sex and race (F(1,81)=5.36, p=.02) and group differences in κ were trending (F(1,81)=3.62, p=.06). This suggests that race is a potentially important demographic factor for understanding the relationship between belief updating parameters and paranoia, but that it does not fully explain the elevated prior on volatility, unexpected uncertainty, and win-switching observed in relationship to elevated paranoia.

Medication

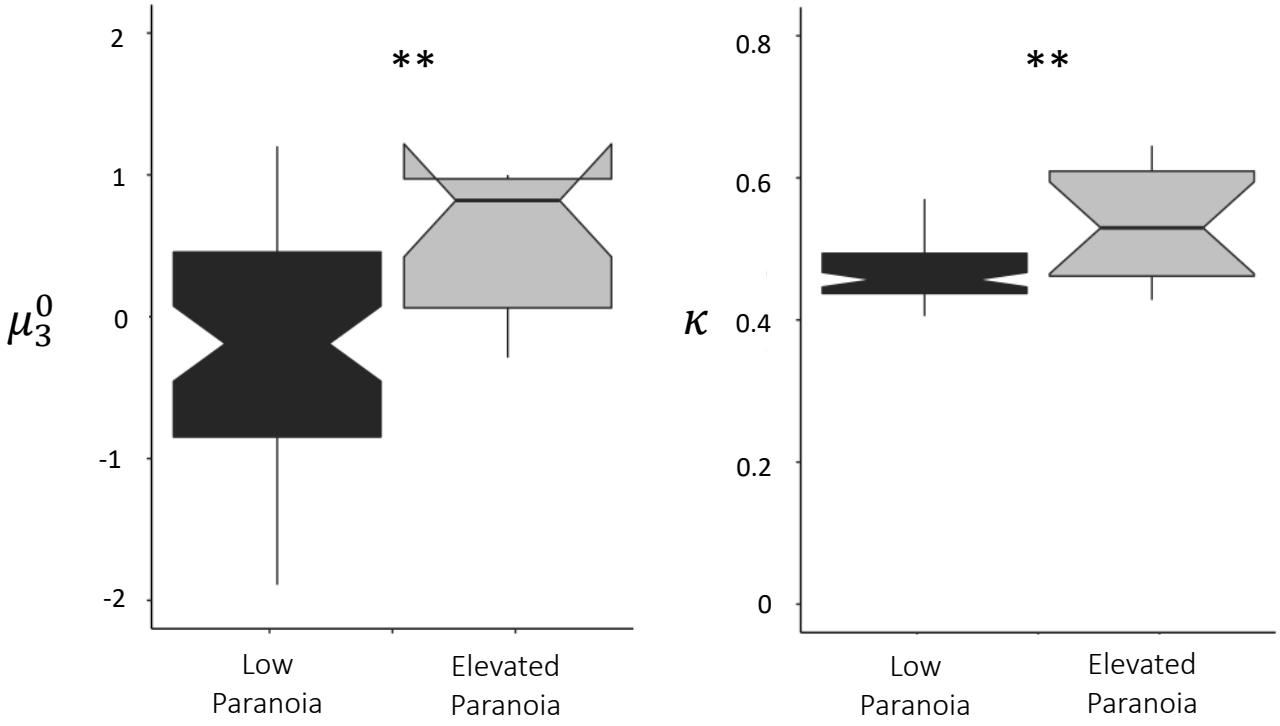
Additionally, we investigated the relationship between antipsychotic medication dose and belief updating in our schizophrenia cohort using Chlorpromazine (CPZ)-equivalence estimates. CPZ-equivalence was unrelated to belief updating parameters (μ_3^0: p=.91; κ: p=.72; ω_2: p=.97, ω_3: p=.95). Inclusion as a covariate in relationships between belief updating and suspiciousness (P6) did not impact statistical significance μ_3^0 (ρ=.49, p=.001).

IQ

Finally, we examined the impact of premorbid IQ on elevated win-switch rate in schizophrenia and on our primary relationships with paranoia. When IQ was included, win-switch rate was no longer significantly different between groups (F(1,83)=1.75, p=.19) and the relationship between win-shift rate and paranoia was also attenuated (self-reported: ρ=.17, p=.12; interview-rated: ρ=.24, p=.13). The relationship between μ_3^0 and paranoia in the schizophrenia group, however, remained robust to the inclusion of IQ (ρ=.43, p=.005).

1. Freeman D, Loe BS, Kingdon D, et al. The revised Green et al., Paranoid Thoughts Scale (R-GPTS): psychometric properties, severity ranges, and clinical cut-offs. *Psychol Med*. 2021;51(2):244-253. doi:10.1017/S0033291719003155

Figure S1: Differences in belief updating computational parameters based on paranoia group



Group differences in μ_3^0 and κ for individuals with low paranoia (R-GPTS scores ≤ 4) and elevated paranoia (R-GPTS 5+). The elevated paranoia group demonstrated higher μ_3^0 and κ.