Effects of Racial Bias on Working Memory During Competition for Attention: An ERP Study

Guadalupe D.S. Gonzalez, B.A., David M. Schnyer, Ph.D
The University of Texas at Austin

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Introduction

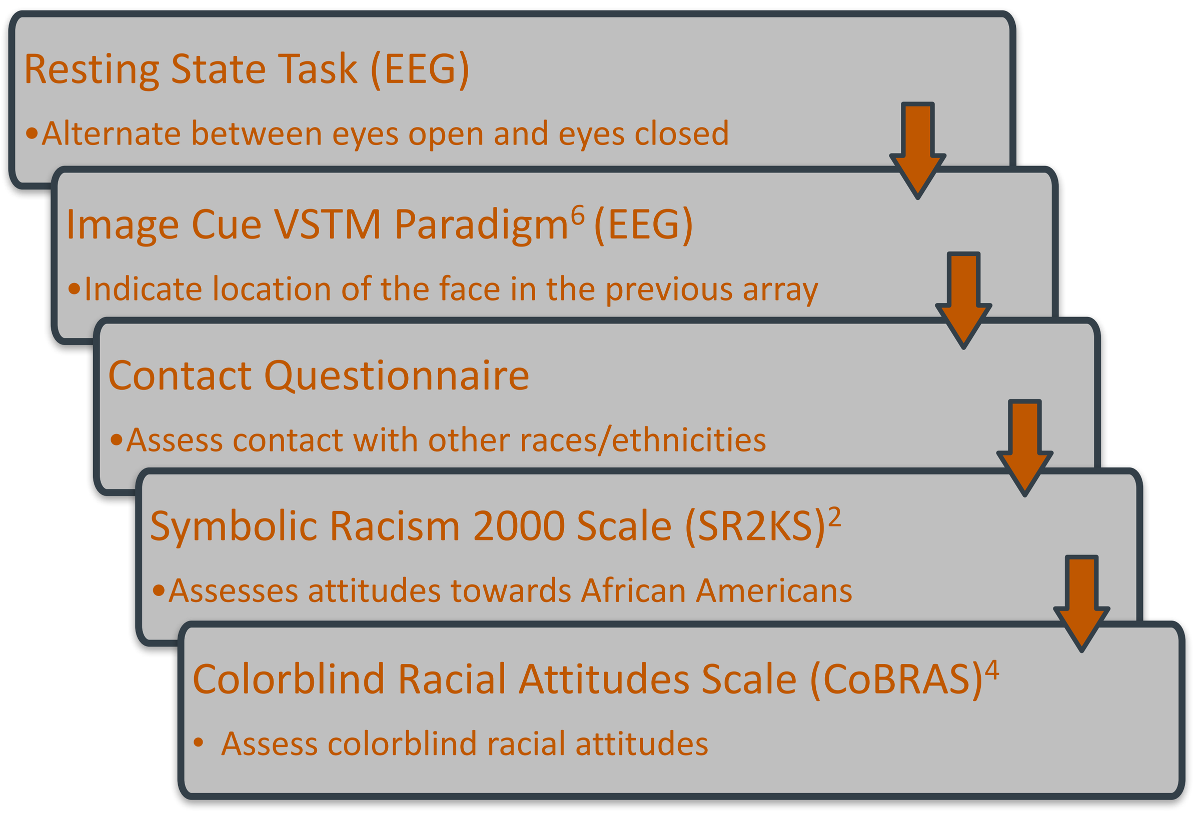
- Previous research has sought to understand the neurocognitive basis of racial bias.[1,5]
- Considerable research has focused on early perceptual processing differences between races.
  - Larger N200s to own-race faces[1]
  - Larger P200s & P300s to cross-race faces[1]
- Less research has focused on examining the effects of racial bias on memory.
  - Implicit racial bias affects basic neurocognitive processes including visual working memory (VWM).[5]
  - Never examined in the context of competition for attention between races
- Our goal was to examine the neurocognitive basis of racial bias effects where there is attentional competition in a visual working memory task using scalp-recorded EEG.

Methods

Participants

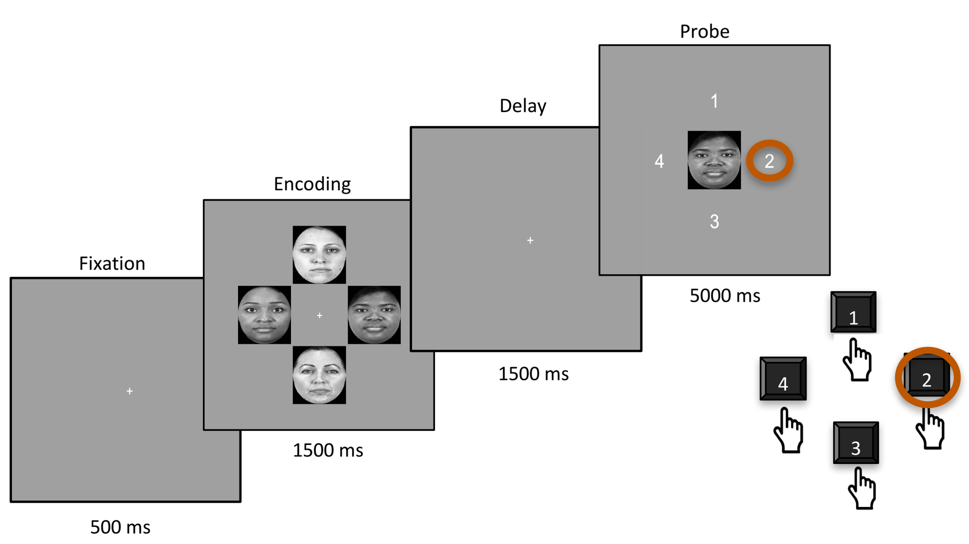
- 46 participants were recruited from UT Austin
- 35 participants were included in the final analysis (22 females, 13 males, 19.49 ± 1.94 years). 11 were excluded due to medications or EEG recording problems.
  - 25 White (12 Hispanic/Latino), 7 Asian, 3 Other

Procedure



Visual Short-Term Memory (VSTM) Paradigm[6]

- Stimuli: Chicago Face Database (CFD)[3]
- 12 practice trials
- 6 blocks: 3 blocks of male faces, 3 blocks of female faces
  - 60 trials/block
  - Encoding: 4 randomly presented faces (2 Black & 2 White)



- BioSemi Active II system - 64 channel electroencephalogram (EEG)

Data Preprocessing

Behavioral Data:

- Excluded trials with false starts (Reaction Times (RTs) < 300 ms)
- Excluded trials with long RTs (RTs > 2.5 SDs from mean)

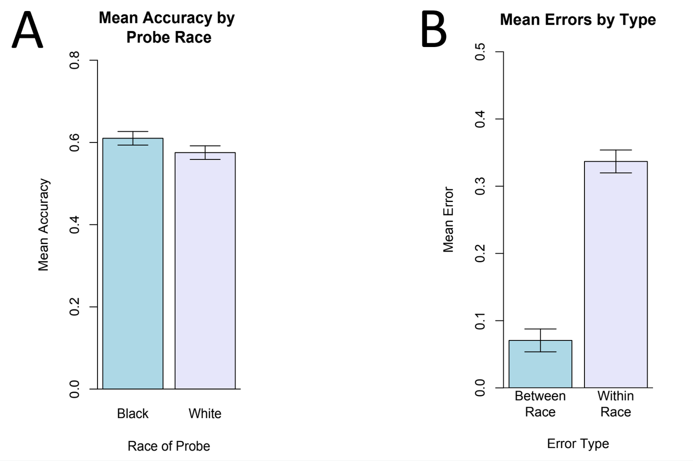
We examined three experimental periods:

1. **Encoding**
   - Butterworth Zero Phase Filter: 0.1 Hz (12 dB/oct) – 40 Hz (dB/oct)
   - Re-reference to linked mastoids
   - Ocular artifacts were rejected using ICA, non-ocular artifacts were also rejected
   - Baseline Correction: -200 ms – 0 ms pre-stimulus interval
   - Epochs: -200 – 1500 ms post-stimulus onset (presentation of 4 faces)
2. **Probe**
   - The same data preprocessing procedures for the encoding period were used
   - Epochs: -200 – 1500 ms post-stimulus onset (presentation of probe face)
3. **Delay**
   - Continuous wavelet transform using a 5-cycle Morlet wavelet
   - Z-transform baseline correction: -200 – 0 ms pre-stimulus interval
   - Frequency Range: 4 – 30 Hz
   - Epochs: -200 – 1500 ms

- Four conditions were examined for each experimental period: accuracy of location judgments (Correct or Incorrect) by race of probe (Black or White)

Behavioral Results

- Participants were more accurate at making working memory location judgments to Black than White faces ($F(1,34) = 9.16$, $p = .005$; Figure A).
- Additionally, participants made more within-race than between-race errors ($F(1,34) = 505.56$, $p < .001$; Figure B).



Encoding Results

N200

- Greater N200 amplitudes in parietal scalp regions for accurate location judgments of White faces relative to Black faces, as well as, greater N200 amplitudes for inaccurate location judgments of Black faces relative to White faces ($F(1.73, 58.90) = 6.59$, $p = .004$, $\eta_p^2 = .16$, $\varepsilon = 0.87$; Figure A).
  - Race x Accuracy interaction at parietal scalp regions: $F(1, 34) = 8.95$, $p = .005$, $\eta_p^2 = .21$; Figures A1 & A2

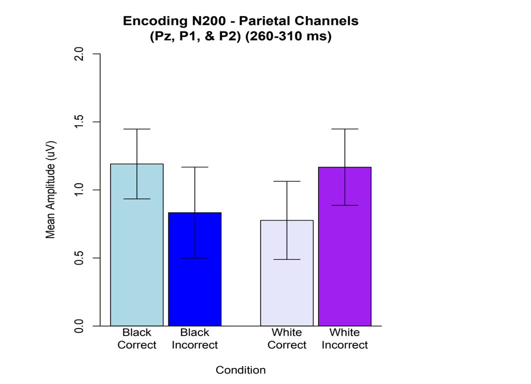


Fig. A1: Mean parietal N200 amplitudes for each condition with 95% confidence intervals.

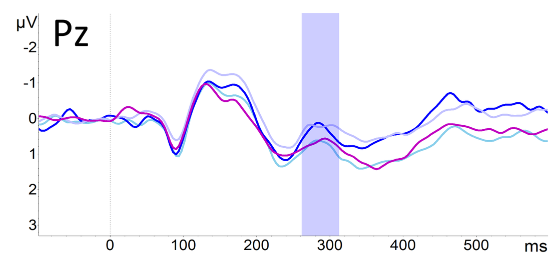
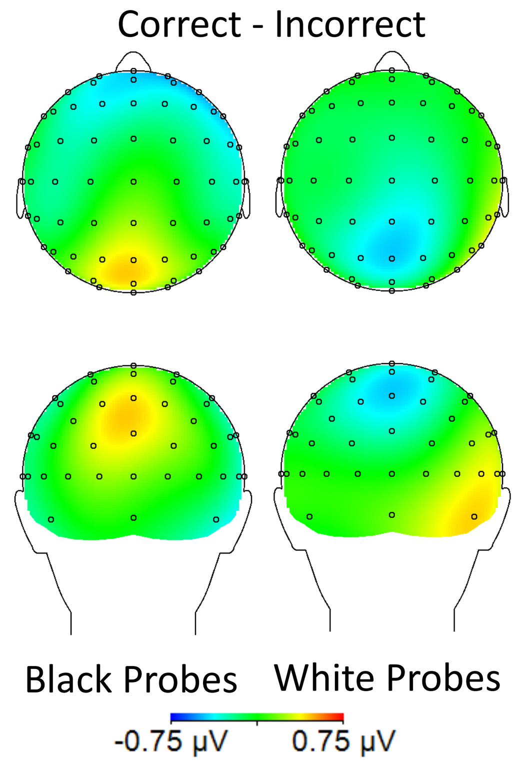


Fig. A2: ERP at Pz for each condition. The shaded region is the N200 time interval.



P300

- Greater P300 amplitudes in parietal scalp regions for accurate location judgments of Black faces relative to White faces, as well as, greater P300 amplitudes for inaccurate location judgments of White faces relative to Black faces ($F(1.63, 55.24) = 10.78$, $p < .001$, $\eta_p^2 = .24$, $\varepsilon = 0.81$; Figure B).
  - Race x Accuracy interaction at parietal scalp regions: $F(1, 34) = 13.50$, $p < .001$, $\eta_p^2 = .28$; Figures B1 & B2

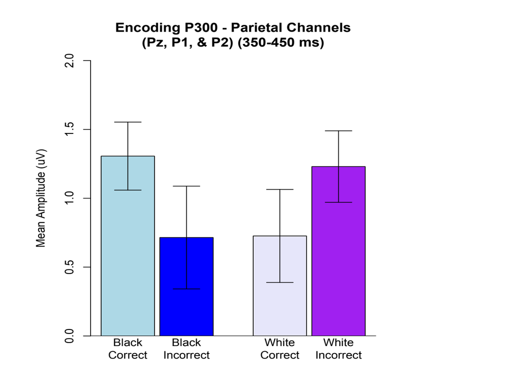


Fig. B1: Mean parietal P300 amplitudes for each condition with 95% confidence intervals.

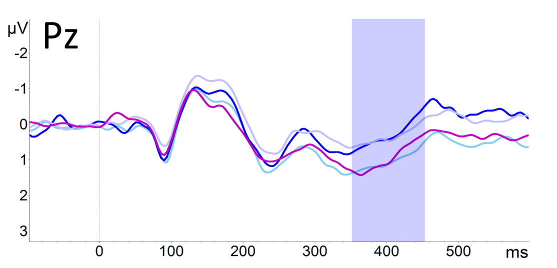
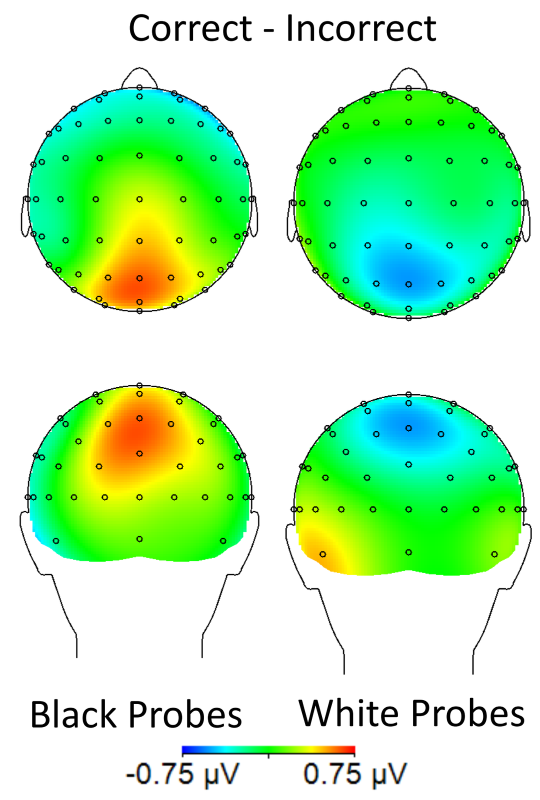


Fig. B2: ERP at Pz for each condition. The shaded region is the P300 time interval.



Probe Results

N170

- Greater N170 amplitudes for the left than right hemisphere ($F(1, 34) = 9.47$, $p = .004$, $\eta_p^2 = .22$; Figures C1 & C2). Additionally, there were greater N170s for correct relative to incorrect location judgments ($F(1, 34) = 5.66$, $p = .023$, $\eta_p^2 = .14$; Figures C1, C2, & C3). Finally, N170 amplitudes were greater for Black relative to White faces ($F(1, 34) = 17.25$, $p < .001$, $\eta_p^2 = .34$; Figures C1, C2, & C3).
- Negative correlation between N170 difference score (Black Correct – White Correct) and CoBRAS score ($r = -0.42$, $p = 0.01$; Figure C4).

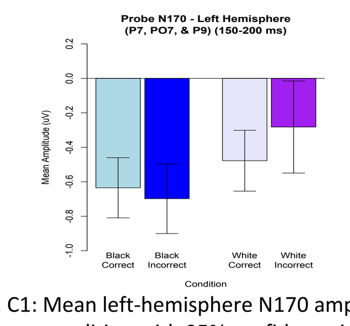


Fig. C1: Mean left-hemisphere N170 amplitudes for each condition with 95% confidence intervals.

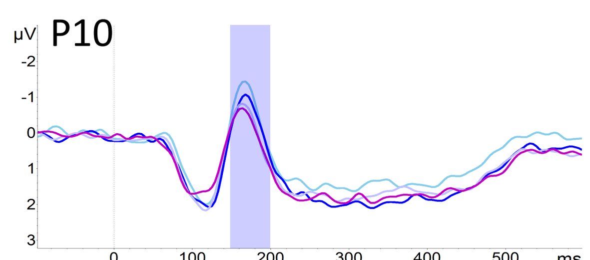


Fig. C3: ERP at P10 for each condition. The shaded region is the N170 time interval.

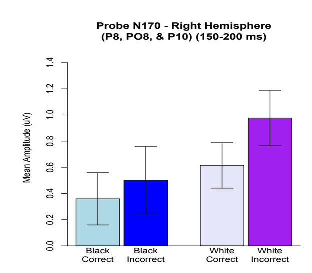


Fig. C2: Mean right-hemisphere N170 amplitudes for each condition with 95% confidence intervals.

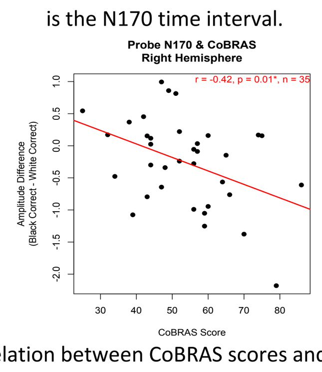


Fig. C4: Correlation between CoBRAS scores and right-hemisphere N170 difference score (Black Correct - White Correct).

Probe Results (cont.)

P300

- Greater P300 amplitudes for parietal scalp regions relative to the frontal or central scalp regions ($F(1.2, 40.79) = 57.07$, $p < .001$, $\eta_p^2 = .63$, $\varepsilon = 0.60$; Figure D1 & D3). Also, greater P300 amplitudes for correct relative to incorrect location judgments ($F(1, 34) = 24.44$, $p < .001$, $\eta_p^2 = .42$; Figure D).

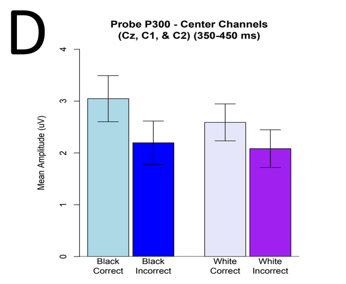


Fig. D1: Mean central P300 amplitudes for each condition with 95% confidence intervals.

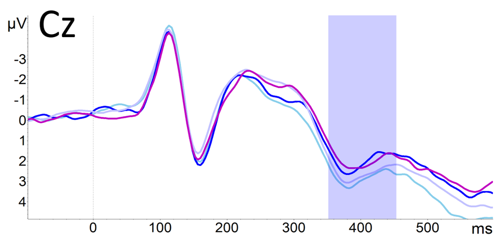


Fig. D2: ERP at Cz for each condition. The shaded region is the P300 time interval

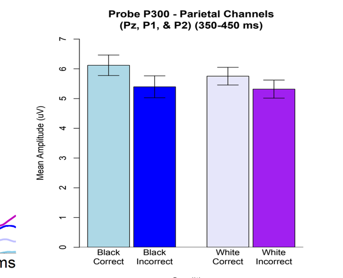


Fig. D3: Mean parietal P300 amplitudes for each condition with 95% confidence intervals.

LPC

- Greater LPC amplitudes for central scalp regions relative to frontal scalp regions ($F(1, 34) = 115.52$, $p < .001$, $\eta_p^2 = .77$). Also, greater LPC amplitudes for correct relative to incorrect location judgments ($F(1, 34) = 39.66$, $p < .001$, $\eta_p^2 = .54$; Figure E). Finally, LPC amplitudes were greater for Black relative to White faces ($F(1, 34) = 5.28$, $p = .03$, $\eta_p^2 = .13$; Figure E).

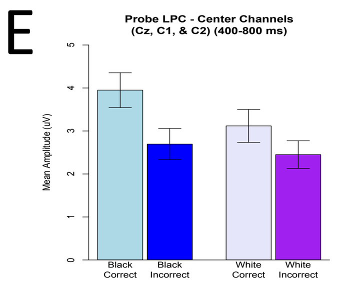


Fig. E1: Mean central LPC amplitudes for each condition with 95% confidence intervals.

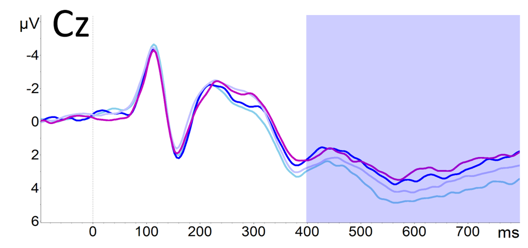
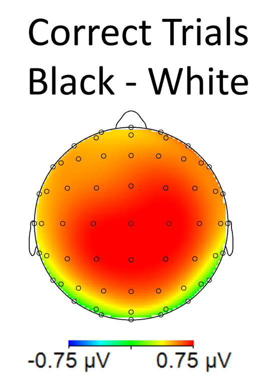
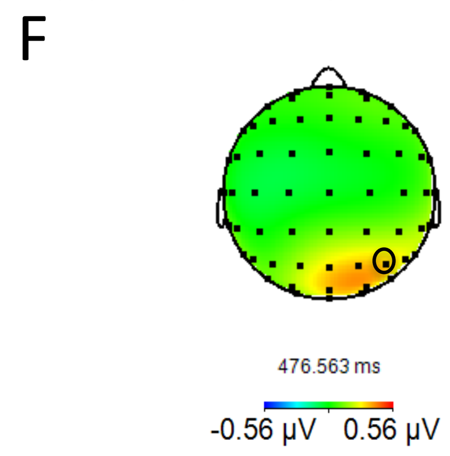


Fig. E2: ERP at Cz for each condition. The shaded region is the LPC time interval



Delay Results

- Greater low beta amplitudes for correct relative to incorrect location judgments during the delay period at the P4 channel ($F(1, 34) = 6.56$, $p = 0.015$; Figure F).



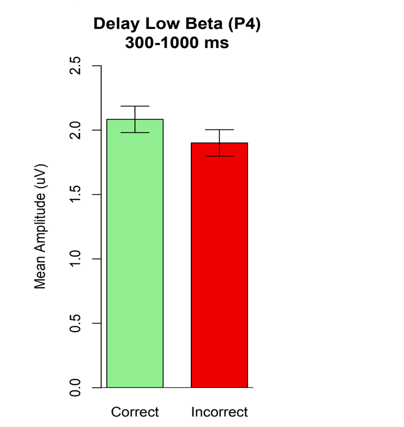


Fig. F1: Mean low beta amplitudes by accuracy with 95% confidence intervals.

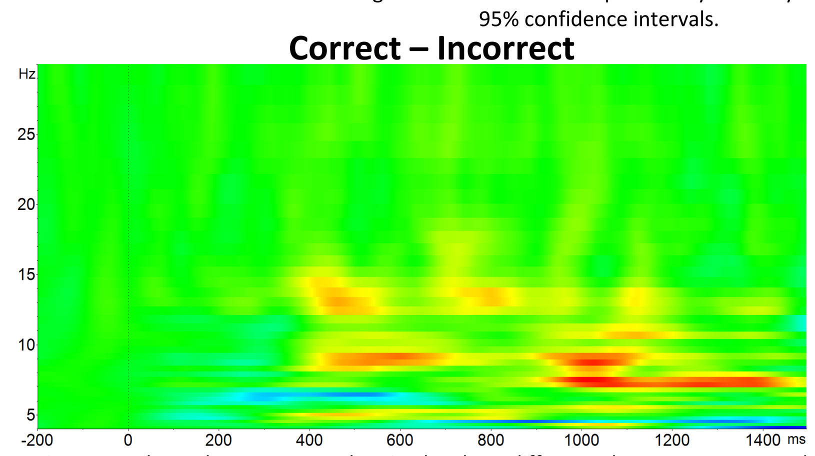


Fig. F2: P4 channel spectrogram showing low beta difference between correct and incorrect answers.

Discussion

- Under competition for attention, race affects working memory.
  - Better location accuracy for Black than White faces
- Individuals were using race information to categorize faces.
  - More within-race errors than between-race errors
- Neurocognitive signatures of racial bias during competition for attention:
  - N200
    - Smaller N200 → attentional allocation to White faces
    - Larger N200 → attentional allocation to Black faces
  - P300
    - Larger P300 → attentional allocation to Black faces
    - Smaller P300 → attentional allocation to White faces
- Greater color-blind racial attitudes associated with greater early processing differences, as indicated by the N170 difference score, between Black and White probes.
- Greater LPCs indicate increased recollection for Black than White faces, and correct than incorrect trials.
- Increased inhibition of irrelevant information for correct trials than incorrect trials during the delay period.

References

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Acknowledgments

This work was supported by a Ford Foundation Predoctoral Fellowship to Guadalupe Gonzalez.
We would like to thank Bianca Chavez, Marissa Hansen, Fariya Sahadat, and Jiazhou Chen for assisting with running participants, and Logan Trujillo for assisting with EEG data analysis.