Using Alpha and Theta Power to Assess the Indirect Relationship between Stereotype Threat, Self-Doubt and the Allocation of Attention and Memory Encoding Processes

Chad E. Forbes, Toni Schmader, & John J.B. Allen
Social Identity and Psychophysiology Laboratories, University of Arizona

Introduction

Research has found that when stigmatized minorities' intellectual merit is on the line, they may experience stereotype threat, or a fear of confirming a negative group stereotype that undermines their performance (Steele & Aronson, 1995). According to Schmader, Johns, and Forbes (2008), stereotype threat likely engenders an interaction between physiological threat responses, performance monitoring, and appraisal and suppression processes that tax attention and working memory resources and propagate feelings of self-doubt during the performance itself. However, examining how the interaction between these different variables may compromise attention and memory processes, particularly during a performance situation, is understandably difficult.

The present study examined the relationship between some of these processes on-line by employing a social neuroscience approach. Given that both increased and decreased neuronal oscillatory power within the alpha frequency band has been associated with enhanced attention to stimuli and increased power within the theta frequency band has been linked to enhanced memory encoding processes (Klimesch, 1997; Klimesch, 1999; Oakes et al., 2004), we measured White and minority students' alpha and theta power while they received error induced feedback on a response-conflict task that was described as either a perceptual task or an intelligence task. The relationship between alpha power, theta power, self-reported error estimates, and self-doubt was then examined.

Given that stereotype threatened minorities are likely to experience a decrease in executive resources and become hypervigilant for signs of failure (Schmader & Johns, 2003; Schmader et al., 2008), it was hypothesized that placing minorities under stereotype threat should engender a decrease in alpha and theta power in response to error feedback (H 1). Furthermore, if this decrease in alpha power denotes increased attention to error feedback, then poor performance estimates may be likely because error feedback was more salient. Thus we would expect to find a positive relationship between alpha power and students' post-hoc performance estimations (H 2). Finally, since situations of stereotype threat can lead individuals to monitor their performance for signs of failure and interpret their performance negatively (Schmader et al., 2008), these performance estimations should in turn be inversely related to feelings of self-doubt, such that stereotyped threatened minorities should report feeling greater self-doubt to the extent they thought they performed poorly on the supposed intelligence test (H 3).

Methods

➢ 94 undergraduates (34 Latino, 12 Black, 48 White) participated for credit or money
➢ Between Subjects Design:
-Ethnicity: Minority vs. White
-Task description: pattern recognition task (Non-diagnostic of IQ=Control) vs. intelligence test (Diagnostic of IQ =DIQ)
➢ Procedure
- Continuous EEG activity was recorded at 1000Hz from 32 channels during tasks, referenced online to Cz and offline to linked mastoids
- Baseline: 320 trials of Eriksen Flankers task (a task that induces response conflict)
- Manipulation: Description of task diagnosticity varied
- 480 trials of the Eriksen Flankers task
- Post-task questionnaire: Error estimations, self-doubt assessed
➢ Signal Processing
-Blinks were corrected using an ocular artifact regression correction procedure (Semlitsch et al., 1986). Epochs were baseline corrected by subtracting the average value of EEG 50 ms before the response from the entire epoch
-Wavelet analyses isolated 4-8 Hz (theta) and 8-12 Hz (alpha) range 50-300ms after error feedback. Identified maximum power at Fz & Cz, locked to the time of the maximum power at Fz.
➢ DVs
-Alpha and theta power elicited in response to "WRONG" feedback
-Error Overestimation (EO) = Error estimate - # Errors actually made
-Self-doubt (α=.90) = "Right now I'm feeling…" : doubtful, foolish, inferior, insecure, unsure."

Results

H 1: Significant interaction for alpha (p < .05) and theta (p < .02) at Fz. Minority participants under stereotype threat demonstrated decreased alpha power in response to error feedback compared to Whites in either condition and minorities in the control condition at Fz, (p's < .05). Minorities under stereotype threat also demonstrated decreased theta power compared to Whites under threat (p < .02) and marginally less theta power compared to minorities in the control condition (p = .07). These patterns were consistent at Cz as well. No Main Effects or Interactions were found for EO or Doubt, p's > .09.
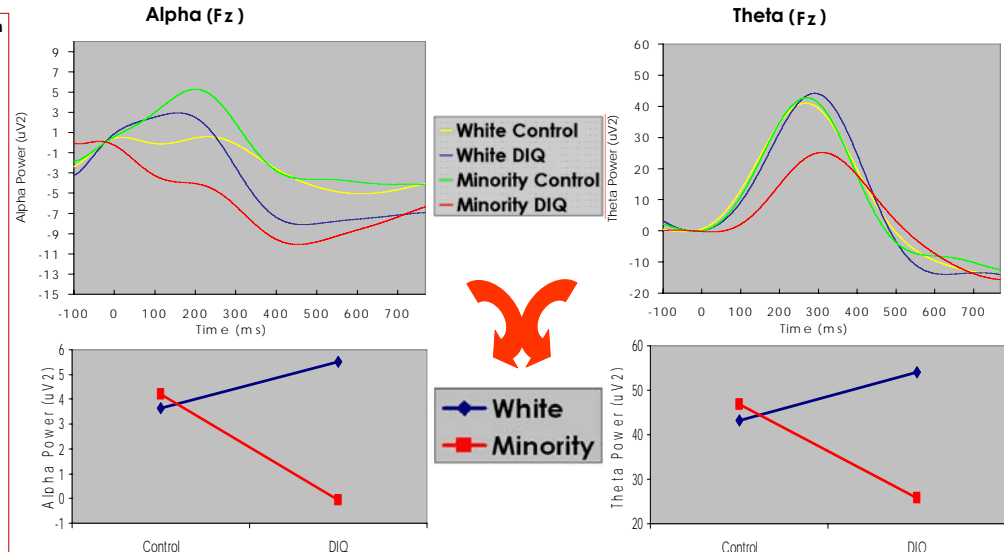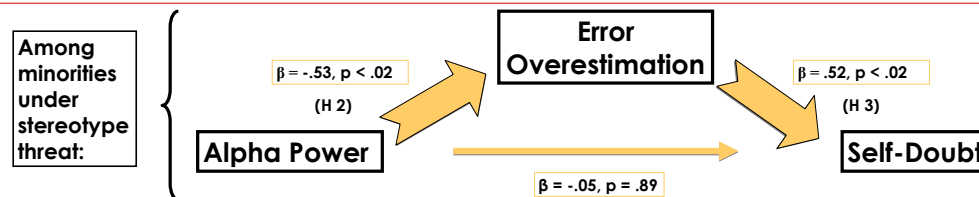
• H 2: To examine hypotheses 2 and 3 a series of regression analyses and sobel tests were conducted on the variables of interest. Results revealed that minorities under stereotype threat overestimated the number of errors they made on the supposed IQ test to the extent they elicited decreased alpha power at site Cz in response to error feedback, β = -.53, p < .02 (see figure below). This was not the case with theta power however.

• H 3: Minorities under threat in turn experienced increased self-doubt to the extent they overestimated the number of errors they made, β = .52, p < .02.

• But wait, there's more!: The indirect relationship between alpha power, EPA, and self-doubt was significant only for minorities in the stereotype threat condition, sobel statistic = -2.04, p < .05.

*No other pathways were significant, p's > .89, and these relationships were not found for minorities in the control condition or Whites in either condition, p's > .29.

Among minorities under stereotype threat:

Alpha Power → (H 2) β = -.53, p < .02 → Error Overestimation → (H 3) β = .52, p < .02 → Self-Doubt

Alpha Power → β = -.05, p = .89 → Self-Doubt

Conclusions

➢Minorities under threat:
-Exhibited *decreased* alpha and theta power in response to error feedback
-Overestimated the number of errors they made to the extent they exhibited decreased alpha power
-Experienced more self-doubt to the extent they overestimated the number of errors they made
-Decreased alpha power may have an indirect effect on self-doubt via inaccurate performance perceptions, however future research is needed to determine if this decreased alpha power represents decreased attention (e.g. Klimesch, 1997) or increased attention to the error feedback (e.g. Oakes et al., 2004). Both explanations could be possible in situations of stereotype threat.
➢Interestingly, Whites in the DIQ condition engaged in post-task discounting to extent they overestimated errors, i.e. they reported feeling the intelligence test wasn't a valid measure of their intelligence (r = .55**).
➢These findings suggest stereotype threat may interfere with minorities' ability to attend to and encode feedback that would be important for success.
➢In addition, the perceptions of underperformance that result from this interference may lead minorities to make negative internal attributions compared to Whites who may make external attributions.

References

Klimesch, W. (1997). EEG-alpha rhythms and memory processes. *International Journal of Psychophysiology, 26*, 319–340.
Klimesch, W. (1999). EEG alpha and theta oscillations reflect cognitive and memory performance. *Brain Research Reviews, 29*, 169–195.
Oakes, T.R., Pizzagalli, D.A., Hendrick, A.M., Horras, K.A., Larson, C.L., Abercrombie, H.C., Schaefer, S.M., Koger, J.V., Davidson, R.J. (2004). Functional coupling of simultaneous electrical and metabolic activity in the human brain. *Human Brain Mapping, 21*, 257-270.
Schmader, T., & Johns, M. (2003). Converging evidence that stereotype threat reduces working memory capacity. *Journal of Personality and Social Psychology, 85*, 440-452.
Schmader, T., Johns, M., & Forbes, C. (2008). An integrated process model of stereotype threat effects on performance. *Psychological Review, 115*, 336-356.
Semlitsch, H.V., Anderer, P., Schuster, P., Presslich, O. (1986). A solution for reliable and valid reduction of ocular artifacts, applied to the P300 ERP. *Psychophysiology, 23*, 695–703.
Steele, C.M., & Aronson, J. (1995). Stereotype threat and the intellectual test performance of African Americans. *Journal of Personality and Social Psychology, 69*, 797-811.
This research was funded by NIMH grant #5R01MH71749 awarded to the second author.