



available at www.sciencedirect.com



journal homepage: www.elsevier.com/locate/psyneuen



Stressful politics: Voters' cortisol responses to the outcome of the 2008 United States Presidential election

Steven J. Stanton^{a,*}, Kevin S. LaBar^a, Ekjyot K. Saini^b, Cynthia M. Kuhn^c,
Jacinta C. Beehner^{b,d}

^a Center for Cognitive Neuroscience, Duke University, Durham, NC, 27708, USA

^b Department of Psychology, University of Michigan, Ann Arbor, MI, 48109, USA

^c Department of Pharmacology and Cancer Biology, Duke University, Durham, NC, 27708, USA

^d Department of Anthropology, University of Michigan, Ann Arbor, MI, 48109, USA

Received 6 May 2009; received in revised form 5 October 2009; accepted 22 October 2009

KEYWORDS

Salivary cortisol;
Stress;
Hypothalamic–
pituitary–adrenal
(HPA) axis;
Hormones;
Election;
Politics;
Competition;
Dominance contest

Summary Social subordination can be biologically stressful; when mammals lose dominance contests they have acute increases in the stress hormone cortisol. However, human studies of the effect of dominance contest outcomes on cortisol changes have had inconsistent results. Moreover, human studies have been limited to face-to-face competitions and have heretofore never examined cortisol responses to shifts in political dominance hierarchies. The present study investigated voters' cortisol responses to the outcome of the 2008 United States Presidential election. 183 participants at two research sites (Michigan and North Carolina) provided saliva samples at several time points before and after the announcement of the winner on Election Night. Radioimmunoassay was used to measure levels of cortisol in the saliva samples. In North Carolina, John McCain voters (losers) had increases in post-outcome cortisol levels, whereas Barack Obama voters (winners) had stable post-outcome cortisol levels. The present research provides novel evidence that societal shifts in political dominance can impact biological stress responses in voters whose political party becomes socio-politically subordinate.

© 2009 Elsevier Ltd. All rights reserved.

Dominance hierarchies are found within every major class of vertebrate taxa (Wilson, 1975), including humans (Tamashiro et al., 2005). Such hierarchical organization results in social ranks that drastically affect the lives of the individuals involved (Sapolsky, 2005). In many species, social subordination can result in a physiological profile associated with a “stress response” – that is, the activation of the hypothalamic–pituitary–adrenal (HPA) axis resulting in elevated levels of glucocorticoids in the bloodstream. In its most extreme form,

* Corresponding author at: Duke University, Center for Cognitive Neuroscience, B203 LSRC Building Research Dr., Box 90999, Durham, NC 27708-0999, USA. Tel.: +1 919 668 2424; fax: +1 919 681 0815.
E-mail address: steven.stanton@duke.edu (S.J. Stanton).

chronic activation of the HPA axis can result in increased likelihood of pathophysiological disease states, suppression of sexual maturation, and dysregulation of affect (Sapolsky et al., 2000).

Elevated glucocorticoids in subordinates can result from several circumstances that afflict lower-ranking individuals. For example, subordinates may have access to fewer resources (Sapolsky, 2005) or experience decreased opportunities for social support (Abbott et al., 2003). One of the most common “stressors” for subordinates is losing a dominance contest (Bhatnagar and Vining, 2003; Koolhaas et al., 1997). Dominance contests are a critical determinant of the leadership of social hierarchies across a wide range of species. In modern human societies, this dominance contest is played out in democratic elections. A democratic election rearranges political parties into dominant and subordinate groups, in which the dominant group gains control of the political machine and holds the greatest power in making legislative decisions. By contrast, the losing, subordinate groups lack the political power to control policy decisions. The losing outcome of a dominance contest is the first stressful experience of subordination. The resulting subordination may be stressful both acutely as well as chronically if the newly formed dominance hierarchy is stable as is the case with party-based shifts in governmental power (Sapolsky, 2005). The present study used the 2008 United States (U.S.) presidential election to determine whether voters supporting the losing candidates experienced a biological stress response as reflected by elevations in cortisol levels after the outcome of the election.

Cortisol is a steroid hormone that has been consistently associated with acute psychosocial stress (Dickerson and Kemeny, 2004; Gunnar et al., 2009). When individuals experience acute and salient stress they have increases in cortisol release. Participants’ psychological stress and subsequent cortisol responses are particularly large when the stressor is uncontrollable, unpredictable, and has a social evaluation component (Dickerson and Kemeny, 2004). An election has these critical components for a voter, because the outcome is not in the control of a single voter, the outcome is difficult to forecast, and when one’s political party is voted out of office, that is the negative social commentary of the majority of voters (winning party members) on the voters of the losing party.

In humans, we know very little about how winning or losing a dominance competition affects changes in cortisol levels. The most common forms of competition used in such studies were sports competitions, with laboratory studies being more rarely employed (Salvador and Costa, 2009). In the majority of the sports/physical competition studies, the researchers failed to find an effect of winning or losing on changes in cortisol (Booth et al., 1989; Edwards et al., 2006; Filaire et al., 2001; Gonzalez-Bono et al., 1999; Kivlighan et al., 2005; Oliveira et al., 2009; Passelergue and Lac, 1999; Salvador et al., 1987; Serrano et al., 2000). Moreover, in a non-physical, laboratory study that examined contest outcome effects on changes in cortisol using a video game competition paradigm, Mazur et al. (1997) also failed to find an effect of outcome. In another non-physical chess competition paradigm, Hasegawa et al. (2008) also failed to find an effect of winning or losing on changes in cortisol. Among the few studies that have found an outcome effect, there has not been a consistent pattern of cortisol change as a function of

winning or losing. Some researchers found that cortisol rose from before to after a sports contest for all participants, but that post-contest cortisol was greater in losers than in winners (Bateup et al., 2002; Filaire et al., 2009). Elias (1981), as well as Suay et al. (1999), found that cortisol increased in all participants in response to a sports competition, but winners had higher post-contest cortisol in those studies, which stands in direct contrast to Bateup et al. (2002) and Filaire et al. (2009). Thus, our current knowledge of the effects of dominance contests on humans’ changes in cortisol remains murky. The physical contest studies have a large confound, which is that physical exercise drives large increases in cortisol release (Davies and Few, 1973; Sutton et al., 1973). Thus, non-physical contests are better suited to examine win/loss effects on cortisol change, but this study design has heretofore been underemployed. The few non-physical dominance contests that have been staged were ineffective (Hasegawa et al., 2008; Mazur et al., 1997), possibly because a non-physical dominance contest needs to be more salient and engaging to drive changes in cortisol in losing participants.

Unlike previously employed non-physical contests, the U.S. presidential election is a highly salient and engaging “real world” dominance contest for the tens of millions who vote, which makes it ideal for assaying the effect of dominance contest outcomes on cortisol responses in voters. To date, there has been no research testing the effects of dominance contest outcomes on cortisol change at the level of party-based shifts in political dominance. To address this issue, we measured voters’ cortisol responses to the outcome of the 2008 U.S. presidential election. We hypothesized that the losing voters would experience increases in cortisol levels after their candidate was declared the official loser.

Additionally, we aimed to test the association between voters’ cortisol responses after the election and their endorsement of right-wing authoritarian ideals. If the Democratic candidate won (Barack Obama), we hypothesized that there would be a positive association between cortisol levels and right-wing ideals, whereas if the Republican candidate won (John McCain), we hypothesized that there would be a negative association between cortisol levels and right-wing authoritarian ideals.

1. Methods

1.1. Subjects

Data were collected from 80 participants (27 men) in Durham, NC and from 103 participants (34 men) in Ann Arbor, MI. Eleven Durham participants’ data and nine Ann Arbor participants’ data were omitted from the analyses, because they did not vote in the election or failed to complete all aspects of the experiment. The final Durham sample ($N = 69$) consisted of 24 men and 45 women (21.07 ± 0.46 years old). The final Ann Arbor sample ($N = 94$) consisted of 33 men and 61 women (21.12 ± 0.49 years old). Three subjects who voted for third-party presidential candidates were excluded from statistical analyses. Subjects were recruited through flyers that were posted throughout the two communities as well as through university subject pools for both course credit and payment. In Ann Arbor, 17 participants voted for McCain and

75 voted for Obama and in Durham, 12 participants voted for McCain and 56 voted for Obama. Thus, in both study sites, exactly 18% of participants voted for McCain and 82% voted for Obama.

1.2. Procedure

Participants came to the laboratory on November 3rd, 2008 between 10:00 am and 5:00 pm, at which point, they provided informed consent and filled out a biographical questionnaire and the right-wing authoritarianism questionnaire (Altemeyer, 1996). Participants were provided with a take-home saliva collection kit which included sampling vials, sticks of chewing gum, markers, and saliva collection instructions. On Election Night (Tuesday, November 4th), participants provided saliva sample 1 (T1) at 8 pm EST, a time at which many election polls were closing on the east coast of the United States. Participants provided saliva samples 2, 3, and 4 (T2, T3, T4) at 0, 20 and 40 min, respectively, after they had learned that Barack Obama had been declared the winner of the 2008 U.S. presidential election. Participants were specifically instructed to provide sample 2 “immediately after you learn who won the presidential election.” For all samples collected at home, participants recorded the exact time of collection on the caps of the collection vials. On average for all participants, saliva samples 1, 2, 3, and 4 were collected at 8:08 pm, 11:35 pm, 11:57 pm, and 12:20 am, respectively (all times are Eastern Standard Time). These times reflect participant compliance with the prescribed timing schedule of 20 min spacing between post-outcome samples and alignment with when television networks were declaring Barack Obama the winner of the election. We found no differences in time of saliva collection at the announcement of the winner between the groups as a function of voter group ($t(143) = 1.40, p = 0.17$). Thus, all participants were given a standard set of instructions, and based on collection times, participants from both voter groups defined the outcome time similarly. Participants returned to the lab on November 5th between 10:00 am and 5:00 pm with their saliva samples. On November 5th, participants also completed a questionnaire regarding their endocrine health status and a questionnaire regarding their affective state on the night of the election. Participants also provided saliva samples at 8 pm on November 3rd. After all measures were completed, participants were paid or given course credit for their participation and were fully debriefed about the study’s hypotheses. The research protocol was approved by the Duke University Institutional Review Board and the University of Michigan Institutional Review Board.

1.3. Self-report measurement of anxiety

In our retrospective affective state questionnaire, we used a 9-point, Likert-scaled item to assess participants’ self-reported feelings of anxiety (anxious to calm) at the moment when Barack Obama was declared the winner.

1.4. Political values

In our biographical data questionnaire, we included a 9-point Likert-scaled, single-item, self-report scale of political

values on a spectrum from conservative (1) to liberal (9), which was adapted from Jost (2006).

1.5. Right-wing authoritarianism

We also measured individuals’ endorsement of authoritarian ideals using the right-wing authoritarianism (RWA) scale (cf. Altemeyer, 1996 for a detailed description of validity and reliability data; see also Altemeyer, 2004; Fodor et al., 2008). The RWA scale includes items assaying individuals’ values on issues such as religion, homosexuality, abortion, the separation of church and state, marriage, feminist values, moral tradition vs. progression, free thinking, and strong leadership. The scale has 20 Likert-scaled items with 8 reverse-coded items. Higher scores reflect greater endorsement of right-wing authoritarian ideas. An example item from the scale is, “Our country desperately needs a mighty leader who will do what has to be done to destroy the radical new ways and sinfulness that are ruining us.” An example of a reverse-coded item from the scale is, “A ‘woman’s place’ should be wherever she wants to be. The days when women are submissive to their husbands and social conventions belong strictly in the past.” In the present samples, the 20-item RWA scale (Altemeyer, 1998) showed strong internal consistency, Cronbach’s $\alpha = 0.94$.

1.6. Salivary sampling

For each of the six salivary samples participants provided, participants used a stick of sugar-free chewing gum to facilitate collecting up to 7.5 mL saliva in a sterile polypropylene vial and then discarded the chewing gum (Dabbs, 1991; Schultheiss and Stanton, 2009). Participants sealed the vials immediately after each collection. Participants stored their samples in refrigerators overnight. When participants returned their saliva samples to the lab on November 5th, the experimenter immediately placed the vials in frozen storage. Samples were freed from mucopolysaccharides and other residuals by three freeze thaw cycles followed by centrifugation and removal of the aqueous saliva to a new tube.

1.7. Salivary cortisol

Salivary cortisol levels were assessed with solid-phase Coat-A-Count ¹²⁵I radioimmunoassays for Cortisol (TKCO) provided by Diagnostic Products Corporation (Los Angeles). To determine salivary cortisol concentrations, we prepared water-based dilutions of all standards (with a resulting range of 0.5–25 ng/mL) and controls (see below). 400 μ L of the saliva samples, standards, and controls were pipetted into antibody-coated tubes and allowed to incubate overnight. Next, 1 mL radio-labeled cortisol tracer was added to each tube and allowed to incubate overnight. Finally, tubes were aspirated and counted for 3 min (cf. Schultheiss and Stanton, 2009). Assay reliability was evaluated by including control samples with known hormone concentrations in each assay (Bio-Rad Lyphochecks from Bio-Rad Laboratories, Hercules, CA). Analytical sensitivity (B_0-3 SD) was at 0.04 ng/mL. The inter-assay cortisol CV for samples of known concentration was 14.3% (1.5 ng/mL) and 14.3% (3.5 ng/mL). Participants’

six saliva samples were counted in duplicate and had a mean intra-assay CV of 7.41%.

1.8. Design

For the analyses, salivary cortisol on the night of the election (T1, T2, T3, T4) and self-reported anxiety were the dependent variables, and the 2008 Presidential candidate for whom participants voted (Obama (winner), McCain (loser)), the right-wing authoritarianism scale, and the political values scale were the independent variables.

1.9. Data analysis

SYSTAT 12.0 statistical software was used for all analyses. Descriptive statistics are shown as mean (\pm SEM). The statistical threshold for all analyses was set at $p < 0.05$.

2. Results

Salivary cortisol values were right-skewed, thus all subsequent analyses used log-transformed cortisol values. To examine how supporting the winning or losing candidate affected cortisol levels after the outcome of the election, we ran a repeated-measures ANCOVA with post-outcome cortisol at T2, T3, and T4 as a within-subjects factor, and candidate choice as a between-subjects factor. Covariates included cortisol level at T1 and saliva collection time at T2. We included saliva collection time at T2 in all analyses to control for any circadian driven variation in cortisol levels (for participants who started their post-outcome saliva collections at discrepant times). We failed to find a significant time \times win/loss interaction, $F(2, 266) = 0.25, p = 0.98$. To examine any effect of study site, we ran a repeated-measures ANCOVA with post-outcome cortisol at T2, T3, and T4 as a within-subjects factor, study site and candidate choice as between-subjects factors, and cortisol level at T1 as covariate. We found a significant time \times win/loss \times site interaction, $F(2, 262) = 3.14, p = 0.05$, which suggests that site was a significant factor in predicting differences between voter groups' cortisol responses over time.

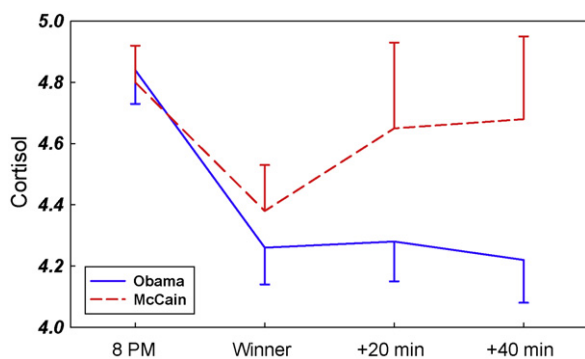


Figure 1 Time-course of salivary cortisol (log-transformed from fg/mL) in U.S. Presidential election voters in Durham, NC on November 4th, 2008. The 4 times depicted as 8 pm through +40 min correspond to the following average collection times reported by participants: 8:08 pm, 11:35 pm, 11:57 pm, and 12:20 am, respectively.

We then ran similar repeated-measures cortisol analyses for each location to test for win/loss effects at each study site. When analyzing the data at each site, we also included our 1-item measure of political values as a covariate in all subsequent ANCOVA analyses in an effort to control for differences in political values to isolate a win/loss effect. Using the data from Durham, NC participants, we ran a repeated-measures ANCOVA with post-outcome cortisol at T2, T3, and T4 as a within-subjects factor, candidate choice as between-subjects factor, and cortisol level at T1 as a covariate, and we found a highly significant time \times win/loss interaction, $F(2, 112) = 5.07, p = 0.008$ (see Fig. 1), which showed that cortisol levels changed over time in significantly different ways for each voter group. We also added participants' race as a covariate and found that race failed to account for a significant portion of the variance in the repeated-measures ANCOVA, $F(2, 106) = 0.05, p = 0.96$. Smoking status, endocrine health status, and use of prescription medication all failed to absorb a significant portion of the variance when added as covariates in the above ANCOVA (all $F_s < 1$). Using the data from Ann Arbor, MI participants, we ran a repeated-measures ANCOVA with post-outcome cortisol at T2, T3, and T4 as a within-subjects factor and cortisol level at T1 as covariate, and we failed to find a significant time \times win/loss interaction, $F(2, 142) = 0.90, p = 0.41$.

For the North Carolinian participants, we then calculated residualized cortisol change scores from T1 to T4 to assess individuals' cortisol response to the outcome of the election from baseline to 40 min after the election outcome (i.e., when we expected the maximum change in salivary cortisol). Using ANCOVA, candidate preference significantly predicted differences in cortisol residuals, $F(1, 58) = 4.25, p = 0.04$, with supporters of McCain exhibiting significantly higher cortisol increases as reflected by cortisol residuals from T1 to T4 (see Fig. 2).

We also wanted to confirm that participants were not experiencing pre-election stress or anxiety with corresponding elevated cortisol levels before election polls closed at

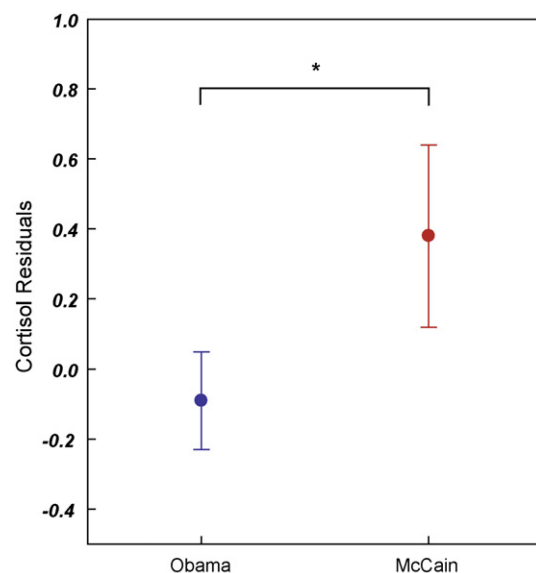


Figure 2 Cortisol residual change scores for those who voted for the winner (Obama) or the loser (McCain) in Durham, NC.

Table 1 Sample characteristics for the right-wing authoritarianism (RWA) scale, the self-reported political values scale, and raw salivary cortisol (in ng/mL) by study site and voter group.

	North Carolina				Michigan			
	Obama		McCain		Obama		McCain	
	Mean ± SEM	CV	Mean ± SEM	CV	Mean ± SEM	CV	Mean ± SEM	CV
RWA	47.33 ± 2.51		72.08 ± 5.02		42.56 ± 2.02		77.00 ± 4.35	
Political values	6.86 ± 0.13		4.42 ± 0.34		6.97 ± 0.14		3.71 ± 0.25	
Salivary cortisol								
T1	1.76 ± 0.22	7.56%	1.30 ± 0.14	5.91%	1.58 ± 0.12	7.87%	1.74 ± 0.26	6.05%
T2	1.10 ± 0.16	7.43%	0.91 ± 0.16	6.87%	1.33 ± 0.24	12.61%	0.99 ± 0.19	9.36%
T3	1.15 ± 0.18	7.90%	1.77 ± 0.80	9.56%	1.42 ± 0.27	11.11%	0.71 ± 0.11	16.04%
T4	1.14 ± 0.17	9.17%	1.63 ± 0.57	5.95%	1.43 ± 0.26	11.22%	0.74 ± 0.13	13.53%
November 3rd	1.86 ± 0.29	10.02%	1.23 ± 0.18	7.14%	1.54 ± 0.16	10.18%	1.84 ± 0.35	5.97%

8 pm on November 4th. To do so, we also collected data cortisol samples on November 3rd at 8 pm. If voters had pre-election stress, one would expect that they would have elevated cortisol levels on the day of the election compared to the prior day at the same time. However, for both sites, we found that there was no difference in cortisol levels between the days ($t(151) = -1.17, p = 0.24$); this is also true when separately looking at differences in cortisol between November 4th and November 3rd for McCain voters ($t(27) = -0.49, p = 0.63$) and for Obama voters ($t(120) = -1.01, p = 0.32$). In addition, we repeated this analysis for the Durham, NC voters, in which we observed our effect. We also found that there was no difference in cortisol levels at 8 pm on November 3rd and at 8 pm on November 4th for the whole Durham sample ($t(66) = -0.43, p = 0.67$), Durham-Obama voters ($t(53) = -0.14, p = 0.89$), nor Durham-McCain voters ($t(13) = -0.69, p = 0.51$). In addition, the voter groups did not differ in cortisol levels at 8 pm on election night ($t(64) = 0.20, p = 0.84$).

Lastly, we examined the relationship between right-wing authoritarian values and post-outcome cortisol levels at T1, T2, T3, and T4. For the participants recruited from Durham, NC, we found that individuals' scores on the right-wing authoritarianism scale were positively associated with cortisol levels at all three post-outcome time points: T2 ($\beta = 0.25, p = 0.04$); T3 ($\beta = 0.34, p = 0.004$); and T4 ($\beta = 0.25, p = 0.04$). Yet, before the outcome of the election at T1, right-wing authoritarianism and cortisol levels were not significantly associated ($\beta = 0.14, p = 0.25$). The participants from Ann Arbor, MI failed to show any association between their levels of right-wing authoritarianism and post-outcome cortisol levels (all $ps > 0.10$).

In retrospective reports of their affective state upon the announcement of Obama as the president-elect, McCain voters felt significantly more anxious ($t(158) = 2.29, p = 0.02$) than Obama voters. Sample characteristics on the RWA scale, the political values scale, and raw salivary cortisol are shown in Table 1.

3. Discussion

The present study provides novel evidence demonstrating that shifts in political dominance hierarchies are biologically

stressful for voters who supported the losing candidate in the 2008 U.S. presidential election. Our hypothesis that voters who supported the losing candidate would have increases in cortisol after the outcome of the election was affirmed at the Durham, North Carolina study site. The context of the U.S. presidential election is a salient stimulus to voters—as political elections are one of the public dominance contests among humans with far-reaching consequences for all participants and non-participants alike. Upon learning that their candidate had lost, McCain voters reported feeling significantly more anxious than did Obama voters. This evidence suggests that participants' levels of stress were manifested not only in a biological response (elevated cortisol levels), but also in their psychological response (self-reported affective state). In addition, voters in the 2008 U.S. presidential election demonstrated their motivation to wait in very long lines and sometimes to excuse themselves from work to take part in the election by casting a vote. Thus, voters' investment in the election outcome differentiates the present study from previously studied forms of non-physical, laboratory-based competition and may potentially account for the cortisol increase for voters whose presidential candidate lost the election. Of note, the voter groups did not have significantly different cortisol levels at 8 pm on the night of the election, which suggests that neither group of voters was more physiologically stressed than the other before the election outcome. Also, voters' cortisol levels were not different between 8 pm on November 3rd and 8 pm on November 4th, which suggests that voters did not show pre-election "jitters" on the night of the election before election polls closed. In sum, our results support the hypothesis that vicariously losing a salient dominance contest is stressful and elicits a physiological response. The present finding is unique since the confirmation of this hypothesis has been methodologically elusive in past research.

The observation that study location affected our results was surprising. However, at least two reasons might account for the rises in cortisol for those who voted for the losing candidate in North Carolina but not in Michigan. For the last four elections dating back to 1992, Michigan has been a "blue" state. In other words, Michigan's electoral votes were awarded to the Democratic candidate; a trend that continued in the 2008 election by having Barack Obama win Michigan's electoral votes. By contrast, for the last seven elections

dating back to 1980, North Carolina has been a “red” state, that is North Carolina’s electoral votes were awarded to the Republican candidate. As the election revealed, both Michigan and North Carolina were won by Barack Obama, an outcome that was historically incongruous to only North Carolina. It is plausible that the loss of the election compounded with a reversal of the historical tendency to vote for the Republican candidate led to the outcome being more stressful for North Carolinian Republican voters.

The states of North Carolina and Michigan were also separated by another critical difference during the campaigning period prior to the election. A month before the election, the McCain campaign had stopped buying advertising time for television campaign ads in the state of Michigan (Cooper, 2008). In effect, the McCain campaign conceded the state of Michigan to Barack Obama. However, in North Carolina, the investments in campaign advertising were large and persisted until the day of the election, because North Carolina was forecasted to be a closely contested state. As predicted, the election results were far closer in North Carolina than in Michigan. In North Carolina, 49.9% of voters voted for Barack Obama and 49.5% of voters voted for John McCain, whereas in Michigan, 57.4% of voters voted for Barack Obama and 40.9% of voters voted for John McCain. Thus, voters in North Carolina were continually confronted with the candidates waging battle for their vote in television advertising, which could have led to greater perception of uncertainty in the possible outcomes of the election. In conjunction, it is plausible that the deviation from historical voting tendency in North Carolina, the increased perception of conflict through continual campaign advertisements, the closeness of the race in North Carolina, and the actual loss of the election led to the significant cortisol response specifically among losing voters in North Carolina.

The present study is unique because while voters participate directly in the election by casting a ballot, they do not personally win or lose the election. Voters *vicariously* win or lose the election depending on whether or not the candidate for whom they voted wins or loses. This type of vicarious winning and losing of dominance contests has been studied in the context of men’s testosterone changes in response to sporting events (Bernhardt et al., 1998), but there have been no prior studies that reported cortisol changes as a function of vicariously winning or losing.

The present study also found that participants’ post-outcome cortisol levels were positively correlated with their endorsement of right-wing authoritarian ideals. Notably, the positive association between right-wing authoritarian ideals and cortisol levels was only present at post-outcome timepoints, but not before election polls closed. This suggests that the more participants endorsed strongly authoritarian values, the more biologically stressful the election outcome was for them. This result highlights the linear relationship between voters’ endorsement of right-wing ideals and the magnitude of their cortisol response to the outcome of the election, which suggests that the more conservative voters were, the greater their cortisol response to the outcome.

To conclude, we demonstrated that vicariously losing a dominance contest leads to increases in cortisol levels. This research is among the few contest studies to find that losing a dominance contest was specifically associated with increases

in the stress hormone cortisol and is the first non-physical contest study to find such a cortisol response. Finally, the contest itself was also novel, since the present study broke free of the previous trend of contest studies that used face-to-face competition paradigms by examining the effects of party-based shifts in a political dominance hierarchy on cortisol changes in voters.

Role of funding source

This research was supported by departmental funds from the University of Michigan (to JCB) and Duke University (to KSL), and the McClelland Postdoctoral Fellowship from the Hay Group (to SJS). Our funding sources had no further role in study design; in the collection, analysis and interpretation of data; in the writing of the report; and in the decision to submit the paper for publication.

Conflicts of interest

All authors declare no conflicts of interest.

Acknowledgements

We thank Matt Fecteau, Eila Roberts, and Sonali Mohanty for assistance in scheduling and testing participants.

References

- Abbott, D.H., Keverne, E.B., Bercovitch, F.B., Shively, C.A., Mendoza, S.P., Saltzman, W., Snowdon, C.T., Ziegler, T.E., Banjevic, M., Garland, T., Sapolsky, R.M., 2003. Are subordinates always stressed? A comparative analysis of rank differences in cortisol levels among primates. *Hormones and Behavior* 43, 67–82.
- Altemeyer, B., 1996. *The Authoritarian Specter*. Harvard University Press, MA.
- Altemeyer, B., 1998. The 20-item RWA Scale. Unpublished Manuscript, University of Manitoba.
- Altemeyer, B., 2004. Highly dominating, highly authoritarian personalities. *Journal of Social Psychology* 144, 421–447.
- Bateup, H.S., Booth, A., Shirtcliff, E.A., Granger, D.A., 2002. Testosterone, cortisol, and women’s competition. *Evolution and Human Behavior* 23, 181–192.
- Bernhardt, P.C., Dabbs, J.M., Fielden, J.A., Lutter, C.D., 1998. Testosterone changes during vicarious experiences of winning and losing among fans at sporting events. *Physiology and Behavior* 65, 59–62.
- Bhatnagar, S., Vining, C., 2003. Facilitation of hypothalamic–pituitary–adrenal responses to novel stress following repeated social stress using the resident/intruder paradigm. *Hormones and Behavior* 43, 158–165.
- Booth, A., Shelley, G., Mazur, A., Tharp, G., Kittok, R., 1989. Testosterone, winning and losing in human competition. *Hormones and Behavior* 23, 556–571.
- Cooper, M., 2008, October. McCain abandons his efforts to win Michigan. *New York Times*, Retrieved April 23, 2009, from: <http://www.nytimes.com/2008/10/03/us/politics/03michigan.html>.
- Dabbs, J.M., 1991. Salivary testosterone measurements: collecting, storing, and mailing saliva samples. *Physiology and Behavior* 49, 815–817.
- Davies, C.T., Few, J.D., 1973. Effects of exercise on adrenocortical function. *Journal of Applied Physiology* 35, 887–891.

- Dickerson, S.S., Kemeny, M.E., 2004. Acute stressors and cortisol responses: a theoretical integration and synthesis of laboratory research. *Psychological Bulletin* 130, 355–391.
- Edwards, D.A., Wetzel, K., Wyner, D.R., 2006. Intercollegiate soccer: saliva cortisol and testosterone are elevated during competition, and testosterone is related to status and social connectedness with teammates. *Physiology and Behavior* 87, 135–143.
- Elias, M., 1981. Serum cortisol, testosterone, and testosterone-binding globulin responses to competition in human males. *Aggressive Behavior* 7, 215–224.
- Filaire, E., Maso, F., Sagnol, M., Ferrand, C., Lac, G., 2001. Anxiety, hormonal responses, and coping during a judo competition. *Aggressive Behavior* 27, 55–63.
- Filaire, E., Alix, D., Ferrand, C., Verger, M., 2009. Psychophysiological stress in tennis players during the first single match of a tournament. *Psychoneuroendocrinology* 34, 150–157.
- Fodor, E.M., Wick, D.P., Hartsen, K.M., Preve, R.M., 2008. Right-wing authoritarianism in relation to proposed judicial action, electromyographic response, and affective attitudes toward a schizophrenic mother. *Journal of Applied Social Psychology* 38, 215–233.
- Gonzalez-Bono, E., Salvador, A., Serrano, M.A., Ricarte, J., 1999. Testosterone, cortisol, and mood in sports team competition. *Hormones and Behavior* 35, 55–62.
- Gunnar, M.R., Talge, N.M., Herrera, A., 2009. Stressor paradigms in developmental studies: what does and does not work to produce mean increases in salivary cortisol. *Psychoneuroendocrinology* 34, 953–967.
- Hasegawa, M., Toda, M., Morimoto, K., 2008. Changes in salivary physiological stress markers associated with winning and losing. *Biomedical Research* 29, 43–46.
- Jost, J.T., 2006. The end of the end of ideology. *American Psychologist* 61, 651–670.
- Kivlighan, K.T., Granger, D.A., Booth, A., 2005. Gender differences in testosterone and cortisol response to competition. *Psychoneuroendocrinology* 30, 58–71.
- Koolhaas, J.M., De Boer, S.F., Ruiters, A.J.H., Meerlo, P., Sgoifo, A., 1997. Social stress in rats and mice. *Acta Physiologica Scandinavica* 69, 69–72.
- Mazur, A., Susman, E.J., Edellbrock, S., 1997. Sex difference in testosterone response to a video game contest. *Evolution and Human Behavior* 18, 317–326.
- Oliveira, T., Gouveia, M.J., Oliveira, R.F., 2009. Testosterone responses to winning and losing experiences in females soccer players. *Psychoneuroendocrinology* 34, 1056–1064.
- Passelegue, P., Lac, G., 1999. Saliva cortisol, testosterone, and T/C ratio variations during a wrestling competition and during the postcompetitive recovery period. *International Journal of Sports Medicine* 20, 109–113.
- Salvador, A., Costa, R., 2009. Coping with competition: neuroendocrine responses and cognitive variables. *Neuroscience and Biobehavioral Reviews* 33, 160–170.
- Salvador, A., Simon, V., Suay, F., Llorens, L., 1987. Testosterone and cortisol responses to competitive fighting in human males. *Aggressive Behavior* 13, 9–13.
- Sapolsky, R.M., 2005. The influence of social hierarchy on primate health. *Science* 308, 648–652.
- Sapolsky, R.M., Romero, L.M., Munck, A.U., 2000. How do glucocorticoids influence stress responses? Integrating permissive, suppressive, stimulatory, and preparative actions. *Endocrine Reviews* 21, 55–89.
- Schultheiss, O.C., Stanton, S.J., 2009. Assessment of salivary hormones. In: Harmon-Jones, E., Beer, J.S. (Eds.), *Methods in Social Neuroscience*. Guilford Press, NY, pp. 17–44.
- Serrano, M.A., Salvador, A., Gonzalez-Bono, E., Sanchis, C., Suay, F., 2000. Hormonal responses to competition. *Psicothema* 12, 440–444.
- Suay, F., Salvador, A., Gonzalez-Bono, E., Sanchos, C., Martínez, M., Martínez-Sanchis, S., Simon, V.M., Montoro, J.B., 1999. Effects of competition and its outcome on serum testosterone, cortisol and prolactin. *Psychoneuroendocrinology* 24, 551–566.
- Sutton, J.R., Coleman, M.J., Casey, J., Lazarus, L., 1973. Androgen responses during physical exercise. *British Medical Journal* 1, 520–522.
- Tamashiro, K.L.K., Nguyen, M.M.N., Sakai, R.R., 2005. Social stress: from rodents to primates. *Frontiers in Neuroendocrinology* 26, 27–40.
- Wilson, E.O., 1975. *Sociobiology: The New Synthesis*. Harvard University Press, Cambridge, MA.