Title: Longitudinal trajectories of post-election distress track changes in neural and psychological functioning

Abbreviated Title: Changes Associated with Post-Election Distress

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Abstract

The shift in political climate after the 2016 U.S. presidential election had a distressing effect on many individuals. To date, no research has identified how changes in societal-level distressing experiences affected ongoing neurobiological and psychological functioning. Fifty-five human participants ($M_{age}=21.746$, 37 female) were tested at two timepoints. Functional magnetic resonance imaging and psychological measures were used to test the hypotheses that increases in distress over one year would relate to worsening mental health symptomology and blunted neurobiological response to reward during the same period. Because individual experiences of distress occurred within a larger macroclimate of societal attitudes, measures were standardized to reflect relative change within the sample. Distress changes over one year were positively associated with problematic mental-health symptomology and nucleus accumbens (NAcc) response to reward, with dissociable effects for anticipation and outcome. Worsening distress was associated with increased NAcc response to reward anticipation but decreased NAcc response to reward outcome. Individuals who exhibited increased sensitivity to anticipatory reward were those who exhibited more avoidance distress symptoms whereas intrusion and hyperarousal were associated with decreased sensitivity to reward outcome. This study highlights the importance of considering individual variation in profiles of change in response to ongoing distress, suggests that individual response styles yield differences in reward sensitivity, and extends neurobiological understanding of exposure to stressful life experiences to political events.

Keywords: distress; fMRI; mental health; nucleus accumbens; reward

Stressful life events are robust precipitants of mental health problems (Bogdan & Pizzagalli, 2006) as well as deficits in functioning of reward pathways in the brain (Der-Avakian & Markou, 2012; Haglund et al., 2007; Keedwell et al., 2005). Exposure to laboratory-induced acute stressors and life-long chronic stressors have been shown to alter functioning of reward circuitry in the human brain. This body of research reveals that both chronic and acute stressors are linked to decreased sensitivity to rewarding stimuli (e.g., Berghorst et al., 2013; Boecker et al., 2014; Bogdan & Pizzagalli, 2006; Kumar et al., 2014; Pechtel & Pizzagalli, 2011). Stress induction in animal studies reliably produces behavioral symptomology (e.g., anhedonia) common to a variety of neuropsychiatric disorders identified, in part, by deficits in reward processing (Treadway & Zald, 2011; Wiborg, 2013). Here, we pivot from this research to leverage the shift in political climate following the 2016 U.S. presidential election as a means to study individual differences in responses to an ecologically-valid, societal stressor. This study paired longitudinal (two timepoints) functional magnetic resonance imaging (fMRI) with well-being measures to test how changes in relative election-related distress from the first to the second assessment corresponded with fluctuations in two outcomes associated with stressful experiences: mental health symptomology and neural response to reward.

Societal events, such as the 2016 U.S. presidential election, can act as a stressor at the individual level (Hagan et al., 2018; Hoyt et al., 2018; Stoler, 2016; Gold, 2017). Prior evidence suggests election-related distress was associated contemporaneously with psychological well-being (Tashjian & Galván, 2018). However, it remained unclear if, and how, changes in the initial effects of the election would correspond with changes in well-being as the new political landscape continued to unfold. Although experiences of distress in the immediate aftermath of a societal stressor may be normative, for most, distress symptoms typically dissipate within a year (Norris et al., 2002; Rubonis & Bickman, 1991). For those whom distress persists or worsens, negative outcomes may be exacerbated (Kaniasty & Norris, 2008). In this study, associations

were identified between changes in election-related distress and mental health symptomology, as well as responsivity of the nucleus accumbens (NAcc), a key region of the reward system.

Neural processing of rewards and losses in subcortical neural circuitry, including the NAcc, is crucial for directing motivated action toward minimizing harm and enhancing positive outcomes (e.g., Daniel & Pollmann, 2014; Haber & Knutson, 2010). Clinical work points to reduced responsiveness in this circuitry in individuals with depression and PTSD (Sailer et al., 2008; Pizzagalli et al., 2009). In the context of stressors, robust activation of reward-related neural systems can promote resilience by facilitating effective responses to environmental challenges. For example, high levels of dopamine transmission in the NAcc are observed in response to controllable stressors and support active coping responses (Cabib et al., 2012). However, uncontrollable stressors tend to illicit passive coping through inhibition of NAcc dopamine. Both reduced NAcc responsivity to reward and passive coping are associated with stress vulnerability and deleterious psychological well-being (Wood & Bhatnagar, 2015). Repeated exposure to controllable or uncontrollable stressors can influence the development of different coping styles and subsequent vulnerability to stress (Maier & Watkins, 2010). This is particularly relevant when examining societal events like the 2016 U.S. presidential election for two reasons: (1) individuals most likely to perceive the outcome as negative are those from marginalized identity groups who are also more likely to have experienced previously uncontrollable stressors, and (2) outcome-related shifts in societal attitudes and policies are relatively uncontrollable at the individual level, which has the potential to contribute to development of adverse coping styles.

In this study, the extent to which changes in election-related distress corresponded to fluctuations in mental health symptomology and neural response to reward was assessed. Data were collected at two timepoints: T1 within 4 months of the 2016 election and T2 approximately one year later. At T1, participants varied in the extent to which they believed the election result would negatively affect them (see Tashjian & Galván for details). We hypothesized increases in

distress over the year would relate to worsening mental health symptomology over the same period. Depression, anxiety, and PTSD symptoms were combined in a composite measure of mental health symptomology. Neurobiologically, exposure to distressing events has been shown to reduce neural response to reward (Admon et al., 2013). Thus, we hypothesized increases in distress would relate to reductions in reward-related neural activation over the same period.

Materials and Methods

Participants

Fifty-five human adults between the ages of 19 and 30 years ($M_{age}=21.746 \pm 2.569$ years, 37 female) completed study measures at both timepoints. A young adult sample was selected to limit participants to those of voting eligibility and given evidence that identity, including political identity, develops during this time (Schwartz et al., 2013). Twenty-seven percent of participants identified as Asian, 25% as Hispanic, 25% as White, 15% as Black, and 7% as Middle Eastern. At T1, 60 participants were recruited via flyers and prior participation in laboratory studies. After receiving approval from the university's Institutional Review Board, participant eligibility was determined by a phone screening based on responses to three prescreening questions including two questions about the personal effect of the 2016 U.S. presidential election and one question about identification with various marginalized identity groups (see Tashjian & Galván, 2018 for full details). Although participants were originally assigned to one of two groups depending on whether they thought the election would personally affect them (affected and control groups; see Tashjian & Galván, 2018 for full details), all participants were treated as a single sample in present analyses to account for the possibility of increases and decreases in attitude changes within each group over the study duration. In addition to the prescreening questions, eligibility criteria included fluency in English, between the ages of 18 and 30 years at T1, and right handedness. Exclusion criteria included no prior developmental, psychiatric, or neurological disorder; no psychotropic medication; not claustrophobic; and no metal in the body. Five of the 60 T1 participants (8.3%) did not complete

the T2 scan due to relocation out of the country ($n=2$, 3.3%) or voluntary withdrawal ($n=3$, 5.0%).

Experimental design

Participants completed an MRI scan at two timepoints approximately one year apart (T1 and T2, respectively). T1 measures were collected between December 2016 to March 2017, within 4 months of the 2016 U.S. presidential election, and T2 measures were collected between December 2017 to July 2018, approximately one year after T1 (days between T1 and T2, $M=372.907$, $SD=37.923$, Range=290-515). Prior to each scan appointment, participants completed self-report measures of election-related distress and mental health symptomology. Written consent was obtained in accordance with the university's Institutional Review Board, and participants were compensated for their participation. MRI sessions lasted approximately 1.5 hours.

Self-report measures

Election distress. Participants completed the Impact of Events Scale-Revised (IES-R), a 22-item self-report measure that assesses subjective distress caused by traumatic events (Weiss, 2007). Participants were asked to respond to items on a five-point scale from 0 (not at all) to 4 (extremely) indicating for the past week how distressing or bothersome each difficulty had been with respect to the 2016 U.S. presidential election (sample items: "I thought about [the election result] when I didn't mean to;" "Reminders of [the election result] caused me to have physical reactions, such as sweating, trouble breathing, nausea, or a pounding heart"). Standardized scores were calculated for each timepoint. Change scores were calculated subtracting standardized scores for T1 from T2.

The IES-R is comprised of three subscales: IES-Avoidance indexing numbing of responsiveness, avoidance of feelings, situations, and ideas (8 items); IES-Intrusion indexing intrusive thoughts, nightmares, intrusive feelings and imagery, dissociative-like re-experiencing (8 items); and IES-Hyperarousal indexing anger, irritability, hypervigilance, difficulty

concentrating, heightened startle (6 items). Scores for each subscale were calculated and standardized for each timepoint. Change scores were calculated subtracting standardized scores for T1 from T2.

Mental health symptomology. Anxiety, depression, and PTSD are among the most commonly reported mental health problems following distressing experiences (Rubonis & Bickman, 1991; Grant et al., 2008). To capture changes in these mental health problems, participants completed three self-report measures of symptomology: the Center for Epidemiological Studies Depression Scale (CESD; Radloff, 1977), the Zung Anxiety Self-Assessment Scale (SAS; Zung, 1971), and the Los Angeles Symptom Checklist (LASC; King et al., 1995). No questions on measures of symptomology were framed with regard to the election. Symptomology measures were positively correlated at each timepoint, $r_s > .713$, $p_s < .001$.

To calculate change in symptomology, all symptomology items were standardized individually and then averaged for each timepoint. Symptomology measures were aggregated into a composite symptomology score to capture generalized changes in mental health. Changes in mental health symptomology were positively correlated, $r_s > .487$, $p_s < .001$.

The CESD is a 20-item measure that assesses depression symptoms as defined by the American Psychiatric Association Diagnostic and Statistical Manual (Radloff, 1977). Participants were asked to respond to items on a four-point scale from 1 (rarely or none of the time) to 4 (most or all of the time) indicating for the past week how often they have felt or behaved in that way (sample items: "I did not feel like eating; my appetite was poor," "I talked less than usual"). Scores were transformed to a 0-4 scale and, consistent with standard cutoffs, scores of 16 or higher were considered to indicate depression (Weissman et al., 1977; Vilagut et al., 2016). At T1, 25.5% of participants met criteria indicating risk for clinical depression, which rose to 29.1% at T2.

The SAS is a 20-item measure that assesses anxiety symptoms (Zung, 1971). Participants were asked to respond to items on a five-point scale from 1 (none of the time) to 5

(most or all of the time) indicating for the past several days how often they have felt or behaved in that way (sample items: “I get upset easily or feel panicky,” “I feel like I’m falling apart and going to pieces”). Raw scores were converted to a 1-4 scale and then converted to anxiety index scores. Index scores below 45 were considered within the normal range (Zung, 1980; Dunstan, 2017). At both T1 and T2, 100% of participants had scores in the normal range.

The LASC is a 43-item measure of self-reported PTSD and associated features (King et al., 1995). Participants were asked to respond to items on a five-point scale from 0 (not a problem) to 4 (extreme problem) indicating how much each item on a list of problems is a problem for them (sample items: “nightmares,” “irritability”). Scores were translated using the categorical approach. Items must have been endorsed with a response of 2=“moderate problem” or higher for each of the three categories: reexperiencing trauma, avoidance and numbing, and increased arousal. Following Diagnostic and Statistical Manual of Mental Disorders criteria (DSM-IV; American Psychiatric Association 2000), if participants met endorsement criteria for all of the categories they were considered positive for PTSD, and if they met the criteria for 2 of the three categories they were considered positive for partial PTSD (Orsillo, 2002). At T1, 29.1% of participants met criteria for partial PTSD and 25.5% met criteria for PTSD. At T2, 18.2% of participants met criteria for partial PTSD and 32.7% met criteria for PTSD.

fMRI paradigm

At T1 and T2, participants completed a modified version of the MID task (Knutson et al., 2000) while being scanned with fMRI (Figure 1). The MID task has been widely used to elicit activation in reward circuitry. Participants received spoken and written instructions and completed a brief practice session outside of the scanner before beginning the experimental session. During each randomized event-related trial, participants viewed one of four types of monetary cues indicating a combination of incentive valence (gain, loss) and magnitude (large, \$5.00; small, \$0.20) or a cue indicating “no money at stake.” Cues took one of three forms: a

circle indicated a gain trial, a square indicated a loss trial, and a triangle indicated no money at stake. Each cue was presented for 2000 ms (anticipation phase). Cues were followed by a fixation cross (jittered, 1500-4000 ms), after which a target of the same shape as the cue was rapidly presented on the screen (150-500 ms). If the participant pressed the button after the target onset but before the target offset, they either gained or avoided losing the cued amount of money. The hit rate was targeted at 60% for each participant by an algorithm that adaptively changed target durations every three trials based on past performance. The average reaction time from the practice session plus 2 SDs, with a maximum of 500 ms, was used at the onset of the task for the purpose of target duration calculation. Feedback indicating the trial outcome was then presented (1500-1700 ms, titrated with cue and target presentation time) (outcome phase). Potential trial outcomes were money gained (gain trials with a correct response), money not gained (gain trials with an incorrect response), money kept (loss trial with a correct response), money lost (loss trial with an incorrect response), and no money at stake (no money at stake trials with correct or incorrect response). Ten repetitions of each of the five trial types were presented in a randomized order for each individual, summing to a total of 50 trials in each run. Participants completed two functional runs, and each run lasted 5.33 min.

Figure 1. Representative large gain MID task trial with correct response. During each trial, participants first saw a cue indicating a potential gain or loss of different amounts (large, \$5.00; small, \$0.20) or a cue indicating “no money at stake” (anticipation phase). Next, participants saw a jittered fixation cross as they waited for a rapidly presented target to which they were instructed to respond with a button press. Finally, participants saw the outcome of their action and their success at responding while the target was on the screen (outcome phase).

fMRI data acquisition

Whole-brain fMRI data were acquired on a 3T Siemens Magnetom Prisma scanner. T1 parameters: voxel size=2.4 x 2.4 x 2.4 mm, repetition time (TR)=800 ms, echo time (TE)=30 ms, slice thickness=2.4 mm, flip angle=52 degrees, field of view (FOV)=216 mm, 60 interleaved slices. T2 parameters: voxel size=2.0 x 2.0 x 2.0 mm, TR=1000 ms, TE=37 ms, slice thickness=2.0 mm, flip angle=52 degrees, FOV=208 mm, 60 interleaved slices, multiband acceleration=6x. AutoAlign was used for automated positioning and alignment of anatomy-related slices using alignment perpendicular to the midsagittal plane and tilted along the corpus callosum contour. Structural images were acquired using a high-resolution, magnetization-

prepared rapid-acquisition gradient echo (MPRAGE) sequence for registration: voxel size=1.0 x 1.0 x 1.0 mm, TR=1900 ms; TE=2.26 ms; slice thickness=1 mm; flip angle=9 degrees, FOV=250 mm, 176 slices.

Stimuli were presented using E-Prime Professional 2.0 and were projected onto a flat screen mounted in the scanner bore. Participants viewed the screen using a mirror mounted on a 32-channel head coil. Extensive head padding was used to minimize participant head motion and to enhance comfort. Participants made their responses with their right index finger using a 4-finger-button response box.

fMRI data analyses

Preprocessing was conducted using FEAT (FMRI Expert Analysis Tool) Version 6.00, part of FSL (FMRIB Software Library). Preprocessing consisted of nonbrain removal using BET (Brain Extraction Tool), high-pass filtering (100-s cutoff), and spatial smoothing using a Gaussian kernel of FWHM 5 mm. The first three volumes were discarded to allow for image stabilization. Motion correction was performed with MCFLIRT (intra-modal motion correction tool) using 24 standard and extended regressors and additional individual spike regressors created using *fsl_motion_outliers* (frame displacement threshold=75th percentile plus 1.5 times the interquartile range). Functional data were registered to subject-space MPRAGE images using boundary based registration (BBR; Greve & Fischl, 2009) and then to MNI 2.0 x 2.0 x 2.0 mm stereotaxic space with 12 degrees of freedom via FLIRT (FMRIB's Linear Image Registration Tool). FILM (FMRIB's Improved Linear Model) prewhitening was performed to estimate voxelwise autocorrelation and improve estimation efficiency.

At the individual level, one general linear model (GLM) was defined for each run of the MID task. The GLM included 10 multiple regressors for each event type: anticipation of gains, anticipation of losses, anticipation of no money at stake, feedback of gains, feedback of losses, feedback of no money at stake, feedback of no money gained, feedback of no money lost, all targets, and all fixation crosses. The magnitude of gains and losses was collapsed. Events were

modeled with a canonical (double-gamma) hemodynamic response function for a duration from stimulus onset to stimulus offset. Temporal derivatives were included as covariates of no interest for all regressors, allowing a better fit for the whole model and reducing unexplained noise. The two runs for each participant were combined using a fixed effects voxel-wise analysis at the second level. Group-level analyses were performed using the FMRIB Local Analysis of Mixed Effects (FLAME-1) module in FSL (Beckmann et al., 2003). Outliers were de-weighted in the multisubject statistics using mixture modeling (Woolrich, 2008). Contrasts of interest were gain anticipation versus loss anticipation and gain outcome versus loss outcome. Reward versus loss contrasts were selected to isolate effects of reward processing from other salience and motivational processes involved in processing losses (Oldham et al., 2018).

Based on previous meta-analytic findings (Knutson & Greer, 2008; see also Tashjian & Galván, 2018) and our a priori hypotheses, analyses focused on activity in the bilateral NAcc (Figure 2). Consistent with prior work, the left and right NAcc regions of interest (ROIs) were specified as an 8 mm spheres centered on predicted foci derived from the meta-analysis ($x=\pm 10$, $y=10$, $z=-2$). Foci are reported here as Talairach coordinates consistent with the original meta-analysis and were converted to MNI coordinates using the *icbm2tal* transformation before analysis. Mean activation across voxels of the bilateral NAcc ROI were extracted using *fslmeants*. Contrasts of interest were reward outcome versus loss outcome and anticipation of reward versus anticipation of loss.

Figure 2. Bilateral 8 mm NAcc ROI, ($x=\pm 10$, $y=10$, $z=-2$; Talairach) center foci based on meta-analytic findings (Knutson & Greer, 2008).

Statistical analyses

Data analyses were performed using R statistical software (version 3.5.3). Each variable was standardized at each timepoint to facilitate interpretability and to index relative functioning. For symptomology, each measure of mental health (see Methods for full details) was standardized individually and scores were averaged for each timepoint. Change scores for each variable were calculated subtracting T1 scores from T2 scores such that positive scores reflect an increase at T2 compared to T1 whereas a score of zero reflects no change in relative position from T2 compared to T1 and a negative score reflects a decrease at T2 compared to T1. Multivariate regression was used to investigate the effects of changing election-related distress on changes in symptomology and neural activation. P-values below .050 were regarded as statistically significant and p-values between .050 and .100 (inclusive) were regarded as marginally significant.

Data availability

Data, materials, and preregistration documents can be accessed at Open Science Framework <https://osf.io/wa5wf/>.

Results

Descriptive statistics for self-report measures at each timepoint are reported in Table 1.

Histograms and spaghetti plots of variables used in analyses are provided in Figure 3.

Table 1. Descriptive statistics for election-related distress (IES) and mental health symptomology at each timepoint.

	IES-R	IES-Avoidance	T1 IES-Intrusion	IES-Hyperarousal	CESD	T1 SAS	LASC
<i>M</i>	19.72	9.891	7.073	2.764	31.036	34.672	14.036
<i>SD</i>	7	7	7	7	7	7	7
Range	0-77	0-29	0-27	0-21	20-58	22-59	0-54
	IES-R	IES-Avoidance	T2 IES-Intrusion	IES-Hyperarousal	CESD	T2 SAS	LASC
<i>M</i>	12.74	6.891	4.200	1.655	31.818	34.764	17.018
<i>SD</i>	6	6	6	6	6	6	6
Range	0-44	0-27	0-16	0-12	20-64	20-57	0-76

Note. *N*=55.

Figure 3. Histogram (top) and spaghetti plots (bottom) of change scores for standardized variables of interest (A) election-related distress, (B) symptomology, (C) NAcc to reward outcome, (D) NAcc to reward anticipation. Histograms depict change scores of T2 minus T1 (x-axis), positive scores reflect increases over time whereas negative scores reflect decreases.

Spaghetti plots depict Z-scores (y-axis) at each timepoint (x-axis) and linear change from T1 to T2 is shown. $N=55$.

Age and sex associations

Age was not significantly correlated with change in distress, $r(55)=-.046$, $p=.740$, change in symptomology, $r(55)=-.217$, $p=.112$, or change in NAcc activation to anticipation, $r(55)=-.002$, $p=.988$. Age was significantly positively correlated with change in NAcc activation to reward outcome such that older participants demonstrated a greater reduction from T1 to T2 compared to younger participants, $r(55)=-.278$, $p=.040$. Sex was not associated with change in symptomology, $t(53)=.416$, $p=.679$, or change in NAcc activation to anticipation, $t(53)=.286$, $p=.776$, or outcome, $t(53)=-.191$, $p=.849$. Males and females significantly differed with respect to change in election-related distress such that males demonstrated greater distress increases than females, $t(53)=-2.368$, $p=.022$, $M_{males}=.332$, $M_{females}=-.161$ (male=0, female=1).

Concurrent changes

Multivariate linear regression was used to test the effects of relative changes in election-distress on relative changes in symptomology and neural activation. The multivariate result was significant, Pillai's Trace=.284, $F(3, 49)=6.488$, $p<.001$, $\eta_p^2=.284$. Univariate tests revealed individuals whose election-related distress increased at T2 compared to their relative distress at T1 demonstrated increases in symptomology (Figure 4A), decreases in NAcc activity during reward outcome (Figure 4B), and increases in NAcc activity during reward anticipation (Figure 4C) (Table 2).

Table 2. Multivariate linear regression model of change in election-related distress (IES-R) predicting change in symptomology and neural activation to reward anticipation and outcome, controlling for age and sex.

	Δ Symptomology				Δ NAcc Outcome Reward > Loss			
	β	<i>SE</i>	<i>t</i>	<i>p</i>	β	<i>SE</i>	<i>t</i>	<i>p</i>
Intercept	1.249	.868	1.439	.156	3.546	1.459	2.430	.019

Age	-.059	.038	-1.530	.132	-.154	.064	-2.388	.021
Sex	.037	.218	.171	.865	-.303	.367	-.825	.413
Δ IES-R	.325	.136	2.383	.021	-.590	.229	-2.573	.013
R ²	.148				.183			
$F(1, 51)$	5.677				6.622			

	Δ NAcc Anticipation Reward > Loss			
	β	<i>SE</i>	<i>t</i>	<i>p</i>
Intercept	-.312	1.554	-2.01	.842
Age	.009	.069	.135	.893
Sex	.164	.391	.420	.676
Δ IES-R	.542	.244	2.222	.031
R ²	.090			
<i>F</i> (1, 51)	4.937			

Note. $N=55$. Sex: 0=male, 1=female.

Figure 4. Plots of change in election-related distress predicting change in (A) symptomology, (B) change in NAcc activation to reward outcome versus loss outcome, and (C) change in NAcc activation to reward anticipation versus loss anticipation. Predicted linear regression lines plotted using the *lm()* function. $N=55$.

Alterations in reward-related neural functioning have been associated with psychiatric disorders including depression, anxiety, and PTSD (e.g., Hägele et al., 2015; Knutson & Heinz, 2015; Zhang et al., 2013). As such, follow-up analyses were conducted controlling for changes in symptomology to determine the effects of changes in election-related distress over and above changes in symptomology, also covarying for age and sex. Election-related distress changes remained significantly associated with decreases in NAcc activation to reward outcome and marginally significant with respect to increases in NAcc activation to reward anticipation: outcome, $B=-.676$, $SE=.241$, $t(50)=-2.804$, $p=.007$; anticipation, $B=.487$, $SE=.259$, $t(50)=1.884$,

$p=.065$. Distress changes also remained significantly associated with symptomology, controlling for NAcc changes as well as age and sex, $B=.354$, $SE=.154$, $t(49)=2.301$, $p=.026$.

Interpretation of counter-directionality in results for NAcc activity to reward outcome and anticipation is bolstered by a non-significant correlation between changes in NAcc activation for the outcome and anticipation phases of the MID task, $r=.018$, $p=.895$. In other words, the same participants who experienced increasing anticipatory activation were not the same participants who experienced decreasing activation during reward outcome.

Post-hoc analyses were conducted to investigate differential contributions of different distress profiles as indexed by three Impact of Events-Revised (IES-R) subscales (IES-Avoidance, IES-Intrusion, and IES-Hyperarousal) on changes in neural activation. IES-Avoidance was significantly correlated with IES-Intrusion, $r(55)=.324$, $p=.016$, but not IES-Hyperarousal, $r(55)=.077$, $p=.576$. IES-Intrusion and IES-Hyperarousal were significantly correlated, $p(55)=.642$, $p<.001$. Multivariate linear regression was used to test the effects of changes in each of the IES-R subscales on changes in NAcc activation during reward outcome and anticipation, controlling for symptomology as well as age and sex. The multivariate result was significant for all models: IES-Avoidance Pillai's Trace=.116, $F(2,49)=3.228$, $p=.048$, $\eta_p^2=.125$; IES-Intrusion Pillai's Trace=.150, $F(2, 49)=4.307$, $p=.019$, $\eta_p^2=.150$; IES-Hyperarousal Pillai's Trace=.202, $F(2, 49)=6.197$, $p=.004$, $\eta_p^2=.202$. Univariate tests revealed change in NAcc response to reward anticipation was only associated with change in IES-Avoidance, such that those whose distress avoidance increased at T2 compared to their relative distress avoidance at T1 demonstrated increases in anticipatory activation to reward, $B=.421$, $SE=.202$, $t(50)=2.078$, $p=.043$. Change in NAcc response to reward outcome was associated with changes in both IES-Intrusion, $B=-.571$, $SE=.213$, $t(50)=-2.681$, $p=.010$, and IES-Hyperarousal, $B=-.887$, $SE=.252$, $t(50)=-3.518$, $p<.001$, such that those whose distress on each subscale increased at T2 compared to their relative distress at T1 demonstrated decreases in activation to reward outcome. These results paralleled associations between change in NAcc responsivity and

change in overall election-related distress (Figure 5, see Figure 4B-C). Change in symptomology was significantly positively associated with change in IES-Intrusion, $r(55)=.400$, $p=.002$, and change in IES-Hyperarousal, $r(55)=.523$, $p<.001$, but not IES-Avoidance, $r(55)=.028$, $p=.840$ (Figure 6).

Figure 5. Association between change in IES-Avoidance and change in NAcc activation to reward anticipation (black), change in IES-Intrusion and change in NAcc activation to reward anticipation (blue), and change in IES-Hyperarousal and change in NAcc activation to reward anticipation (red), $N=55$.

Figure 6. Association between change in IES-Avoidance and change in symptomology (black), change in IES-Intrusion and change in symptomology (blue), and change in IES-Hyperarousal and change in symptomology (red), $N=55$.

Discussion

This study demonstrates that political events are associated with psychological and neural functioning at the individual level over time. Psychological measures and a brain imaging task revealed that over two timepoints relative increases in distress related to the 2016 U.S. presidential election paralleled increases in mental health symptomology and changes in neural response to reward. Dissociable associations were observed with respect to distress and neural response such that increased responsivity to reward outcome was associated with ameliorated distress whereas increased responsivity to reward anticipation was associated with worsening distress. Associations between changes in distress and changes in neural functioning held after

controlling for changes in symptomology. These findings elucidate some of the psychological and neural consequences of relative changes in distress due to political events.

This study complements and expands on prior work identifying changes in mental health symptomology after distressing events. In the current study, participants who experienced comparative increases in election-related distress over the year demonstrated corresponding increases in mental health symptomology as indexed by a composite measure of depression, anxiety, and PTSD symptoms. Exposure to negative messages about one's identity group as well as uncertainty for one's rights and liberties are two possible sources of increased distress (Frost & Fingerhut, 2016; Veldhuis et al., 2018). Unlike other discrete distressing events like natural disasters, the U.S. political climate is continuing to evolve and the majority of U.S. adults (56%) identify future political events like the upcoming 2020 election as a significant stressor (APA, 2019). It remains unknown whether future political developments will exacerbate present feelings of distress. Notably, vulnerable populations are most affected by current policy changes and these individuals are already at heightened risk for distress-related mental health problems given compounding effects of chronic minority stressors (Meyer, 2003). The present findings suggest that continued increases in election-related distress cannot persist without potentially significant consequence for well-being.

Worsening election-related distress over the year was related to distinct effects in NAcc activation changes to anticipation and outcome phases of the MID, with increases during anticipation but decreases during outcome. These findings correspond with prior work demonstrating increased striatal activation to anticipatory cues during the MID but decreased activation during reward outcome after acute, experimentally-manipulated stress in healthy individuals (Kumar et al., 2014). Utilizing reward unrelated to the election (i.e., monetary reward) broadens the implications of these findings to suggest increases in distress are associated with alterations in reward sensitivity in a broad sense. We focused on the NAcc, a key region of the striatum, because of its role in motivated behavior (Oldham et al., 2018) and relevance for

resilience in the face of trauma (Haglund et al., 2007). NAcc activation during reward outcome is thought to reflect a prediction error signal necessary for reward processing and learning (Haber & Knutson, 2010). During anticipation, the NAcc serves the function of encoding expected value to subsequently modulate approach behavior (Delgado et al., 2008). Stress-related reductions in striatal response to reward outcome is mirrored in the neural profile of individuals with depression (Pizzagalli et al., 2009; Keren et al., 2018). Thus, individuals demonstrating this blunted response to reward outcome may experience future worsening of distress-related mental health symptoms (Nikolova et al., 2012). Conversely, increased anticipatory striatal activation is not observed in clinical populations (Stoy et al., 2012) and may reflect motivation to undertake active steps to cope with worsening distress, thereby increasing the potential for stress-resilience (Lambert, 2006). Although further work is needed, the lack of correlation between change in NAcc activation to anticipation and outcome suggests the observed disparate profiles of distress-related NAcc activation in this study may lead to similarly disparate resilience trajectories in the future.

Changes in election-related distress were associated with NAcc functioning over and above mental health symptomology. Similarly, distress-symptomology associations held controlling for changes in NAcc functioning. The robustness of these results suggest that the two outcome measures (symptomology and NAcc functioning) were indexing psychological and biological processes with non-overlapping components. It is possible that the short timeframe of one year may contribute to the independence of these results and that with continued time the two outcomes will become more inextricably linked. For example, prior longitudinal work points to blunted striatal activation as a mechanism underlying subsequent development of mental health symptomology (Stringaris et al., 2015), suggesting the observed blunting to reward outcome in the present study might lead to worsening symptomology if distress does not abate, thereby reducing non-shared variance in these two measures. Additionally, acute and chronic stress have dissociable effects on functioning, with acute stress increasing reward sensitivity in

the short term but chronic stress contributing to reductions in mesolimbic responsivity and anhedonic behaviors in the long term (Ironside et al., 2018). It is possible that some participants in the present study are exhibiting profiles of acute distress whereas others have transitioned to profiles of chronic distress. This might explain not only the non-shared variance between neural response and symptomology, but also the lack of correlation in neural response to anticipation and outcome. It remains to be determined how the election-related distress in the present study will continue to manifest over time and which individuals are most vulnerable to the cumulative effects of continued distress.

Older participants demonstrated a greater reduction in NAcc activation to reward outcome compared with younger participants. A young adult sample was selected due to the importance of identity formation during this developmental stage (Schwartz et al., 2013). However, responsivity of reward-related neural systems continues to change over the early adult years with age-related declines observed from late adolescence throughout adulthood (Schreuders et al., 2018). Thus, developmental changes in neural responsivity from T1 to T2 may contribute to this observed age-NAcc association. Males reported increases in election-related distress compared with females. This may be due, in part, to higher T1 levels of distress among women, although sex differences in distress were not significant at either timepoint. Additionally, this change may reflect sex differences in political engagement, although recent investigations suggest sex differences are not as stark as might be expected according to earlier work demonstrating greater political engagement among men (Bode, 2017; Verba et al., 1997). Analyses linking distress changes to neural and mental-health outcomes controlled for any potential age and sex effects, improving interpretability in light of these observed differences.

Considerable variability exists in the manifestation and maintenance of distress and psychological and neural response to societal-level distressing events is not well established. The sample in the current study consisted primarily of individuals who identify with one or more

historically marginalized groups, with 75% of participants reporting non-White ethnicities, 67% reporting female sex, and only two participants (3.6%) identifying as White males. Despite the demographic composition of our participants, 35% reported at T2 that they did not feel the election would personally affect them (29% at T1), making this sample sufficiently heterogeneous to generalize to the larger population. Individual differences in circumstances altered by ongoing political developments will likely contribute to future vulnerability and resilience in this sample. Although a strength and novelty of the present work is the use of relative change within the sample, these results should not be understood to reflect a need to acquiesce to distressing circumstances. Rather these findings suggest that prolonged, *comparatively* heightened levels of distress over time have compounding effects at the psychological and neurobiological level.

A closer examination of different profiles of distress aids interpretation of the neural findings. Opposite patterns were observed for distress subscales indexing intrusion and hyperarousal compared with avoidance. Increases in intrusion and hyperarousal were associated with increases in mental health symptomology as well as reductions in NAcc activation to reward outcome, whereas increases in avoidance were associated with increases in NAcc activation to reward anticipation and unrelated to symptomology changes. Greater preoccupation with the persistent perceived threat of an experienced trauma, including intrusion and hyperarousal features, relates to greater actual impact of the stressful event whereas avoidance is generally unrelated to event severity (Thompson, 1996; Weinstein et al., 2000). Although active coping styles are more commonly associated with improved outcomes and passive coping styles with deleterious outcomes, the purpose of coping responses is to manage the demands of a stressor in an attempt to terminate the stress response and prevent more serious health consequences resulting from allostatic load. As such, avoidance can be adaptive in the short term, particularly for stressful events perceived as uncontrollable (Wadsworth, 2015). The current data suggest that individuals who exhibited greater avoidance in response to

election distress also showed increased NAcc activation during reward anticipation over the year. It cannot be determined from this study whether avoidance will facilitate continued increases in NAcc activation as a buffer against development of negative outcomes as time progresses or whether it reflects a short-term adaptation to uncontrollable stress without implications for future resilience. Future work should seek to elucidate person-level and societal-level factors that contribute to the formation of these distress profiles.

Findings should be considered in light of study limitations. Although the sample was ethnically diverse and heterogeneous in feelings about effects of the election, individuals who felt positively about the election result were not recruited. The focus of this investigation was on distress as a consequence of shift political climate and, because testing was conducted in a liberal-leaning urban city, including conservative-leaning supporters would have conflated potential sources of distress in the sample. We did not collect measures of positive affect which has been shown to relate to stress-related mental health outcomes (Folkman & Moskowitz, 2000). Future work should consider the mechanistic role of affect changes in links between neurobiological and psychological functioning. Although the MID is widely used to probe reward-related neural circuitry, results may differ using social rewards, particularly given the importance of social context in political events. This study identified psychological and neural outcomes associated with divergent patterns of distress over time, but the fMRI paradigm was not optimized to explore mechanisms that may contribute to different perceptions of commonly experienced events.

This study provides empirical evidence of psychological and neural manifestations of individual experiences of election-related distress occurring within the societal macroclimate. Findings extend neurobiological understanding of stressful life experiences to political events and highlight the importance of considering individual variation in profiles of change in response to political distress. Additional progress in understanding the consequences of political events is increasingly necessary as the U.S. continues to become more politically polarized (PRC, 2014)

and marginalized individuals become more vulnerable to the deleterious effects of compounding distress.

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