Psychoneuroendocrinology 86 (2017) 104–109

Contents lists available at ScienceDirect

Psychoneuroendocrinology

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

Telomere length and procedural justice predict stress reactivity responses to unfair outcomes in African Americans

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ARTICLE INFO

Keywords:
Telomeres
Justice
Worldview verification theory
Stress reactivity
Health disparities

ABSTRACT

This experiment demonstrates that chromosomal telomere length (TL) moderates response to injustice among African Americans. Based on worldview verification theory – an emerging psychosocial framework for understanding stress – we predicted that acute stress responses would be most pronounced when individual-level expectancies for justice were discordant with justice experiences. Healthy African Americans (N = 118; 30% male; M age = 31.63 years) provided dried blood spot samples that were assayed for TL, and completed a social-evaluative stressor task during which high versus low levels of distributive (outcome) and procedural (decision process) justice were simultaneously manipulated. African Americans with longer telomeres appeared more resilient (in emotional and neuroendocrine response–higher DHEAs:cortisol) to receiving an unfair outcome when a fair decision process was used, whereas African Americans with shorter telomeres appeared more resilient when an unfair decision process was used. TL may indicate personal histories of adversity and associated stress-related expectancies that influence responses to injustice.

1. Introduction

Psychosocial factors fundamentally contribute to disparities among racial groups in health status, including cardiovascular disease, metabolic illness, and cancer (for review, Major et al., 2013). Although there are several known pathways (McEwen, 2012), psychosocial factors are thought to be especially influential by altering biological stress processes. To reduce stress-related health disparities, it is critical to better understand how psychosocial factors influence the stress responses of racial minority individuals (Matthews and Gallo, 2011). In addition to affecting racial health disparities through chronic stress and "weathering"(Geronimus, 1992), psychosocial factors influence biological responses to acute or momentary stressors (Kudielka et al., 2007), which are increasingly recognized as contributing to stress-related illnesses (Lovallo, 2015) through connections to chronic stress arousal (Obrist, 2012).

Stress responses reflect characteristics not only of individuals (van Dammen et al., 2014) but also of the environment or context of stressful situations (Boyce and Ellis, 2005). In turn, social psychological approaches have increasingly coalesced on the use of so-called "inconsistency models" to explain how psychosocial factors connect to stress responses (for overview, Proulx et al., 2012). Inconsistency models hold that discrepancies between people's expectations for social interaction and their actual social experience elicit stress responses and compensatory coping. One specific inconsistency model that might help explain racial health disparities is worldview verification theory (WVT), which posits that inconsistency between a preexisting expectation for justice and a lived experience of injustice can profoundly affect racial minority stress responses (Major et al., 2007; Townsend et al., 2010)

In this study, we consider whether the inconsistency predictions of WVT extend to racial minorities' experience with procedural justice, concerning whether people view the rules, treatments, or policies

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http://dx.doi.org/10.1016/j.psyneuen.2017.09.008
Received 22 February 2017; Received in revised form 5 September 2017; Accepted 6 September 2017

affecting them as fair (Lind and Tyler, 1988). A pervasive view among scholars of both justice and public health is that healthy coping with stressful experiences can be bolstered by ensuring that there is procedural justice (e.g., Jackson et al., 2006), especially because fair treatment can communicate social belonging and respect, which may reduce stress (Lind and Tyler, 1988). Fair treatment may be especially vital when distributive justice − concerning the perceived fairness of outcomes and allocations − is lacking. Yet, a key prediction of WVT is that procedural justice may be helpful only for individuals who possess a strong expectation for justice. For individuals who carry low justice expectations, the experience of fair treatment may not be helpful, due to inconsistency with initial expectations for justice (Lucas et al., 2016; Townsend et al., 2010) Moreover, an alarming possibility is that procedural justice could negatively affect coping among individuals with low justice expectations, if fair treatment threatens an existing world view (Major et al., 2007). Evaluating predictions of WVT on racial health disparities is important because racial minorities disproportionately experience unfair social treatment, which could strengthen expectations for low social justice.

In most inconsistency framework studies, individual differences in expectancies are assessed by self-report measures, such as those that capture the extent to which an individual endorses the status quo or believes in justice (Lucas et al., 2016; Townsend et al., 2010). Self-report, however, may lack the fidelity needed to fully evaluate WVT in health disparities contexts. Because people are strongly motivated to endorse the status quo and believe in justice (Jost et al., 2004), self-report is likely biased by agreeable responding. An alternative or adjunctive approach is to assess individual differences using biological markers, which can provide unbiased indicators. Moreover, because they usually have low to moderate correlations with self report (Hellhammer et al., 2009), biological indicators could provide new insights in evaluating inconsistency frameworks.

Telomere length (TL) is a biological marker that may be especially useful in evaluating WVT. Telomeres are repetitive sequences of DNA at the ends of chromosomes that protect against degradation during replication. Telomeres lose base pairs (shorten) with cell division until chromosomes are functionally impaired and become genetically unstable, resulting in cell death (Blackburn et al., 2006). TL is determined by many factors (Blackburn et al., 2015) including psychological stress (Epel et al., 2004; Mathur et al., 2016), and particularly racial stressors (Chae et al., 2016). Shorter telomeres are also linked to an increased risk of stress-related illnesses that occur disproportionately in racial minorities (D'Mello et al., 2015). Evaluating TL as an outcome has suggested a pathway through which chronic adversity gets under the skin to contribute to illness (Epel et al., 2004). Yet, little research has evaluated whether TL predicts stress responses, including stress reactivity (Tomiyama et al., 2012).

We pose that through reflecting past exposure to chronic adversity, TL indicates a social expectancy-related individual difference among racial minorities. Guided by WVT, we further pose that TL-indicated individual differences modify response to procedural justice. To test this, we obtained a TL measurement from a community sample of healthy African Americans. Participants then engaged in a social-evaluative stress task, during which high versus low levels of distributive (outcome) and procedural (decision process) justice were simultaneously experimentally manipulated using a 2 × 2 design. We assessed the joint effects of TL and justice manipulations on both emotional and biological stress responses. Specifically, we considered effects on positive and negative affect (PA and NA), and on salivary cortisol and dehydroepiandrosterone (DHEA) reactivity. Cortisol is the primary catabolic hormone released by the adrenal gland in response to stress. DHEA and its sulfate (DHEAs) are co-secreted with cortisol from the adrenal gland and serve as precursors for androgenic and estrogenic steroids (Friess et al., 2000). In the stress literature, DHEAs may indicate biological resiliency to a stressful experience due to anti-glucorticoid action (Crowley and Girdler, 2014). Moreover, DHEAs may functionally overlap with TL in indicating repair and resilience responses. To date however, DHEAs has rarely been evaluated in psychosocial TL research (Epel et al., 2009), despite that DHEAs could be an indicator of an adaptive stress response among racial minorities. We focus on the ratio of DHEAs to cortisol, which provides a picture of stress resiliency that is more comprehensive than merely assessing cortisol (Sollberger and Ehlert, 2016).

Consistent with WVT, we hypothesized a 3-way interaction, in which incongruence between TL and procedural justice would determine responses to receiving an unfair outcome (low distributive justice). Specifically, we predicted that two outcomes—high NA reactivity and low DHEAs:cortisol reactivity—in response to an unfair outcome would be most pronounced among low chronic adversity (long TL) African Americans when an unfair decision process was used, whereas these responses would be most pronounced among high chronic adversity (short TL) African Americans with use of a fair decision process.

2. Method

This study was conceptualized and performed in tandem to an alternate consideration of this data (Lucas et al., 2016) after obtaining subsequently described measurements of TL through blood-spot collection. Procedures for recruiting participants, implementing the stressor task, and experimentally manipulating fairness are therefore identical to a previous description.

2.1. Participants

Participants were recruited from metropolitan Detroit via advertisements. Potential participants completed an online prescreen to determine eligibility; exclusion criteria were taking an interfering medication or having a pre-existing medical or psychiatric condition that would preclude undertaking a minor stress induction. A sample of 118 eligible African Americans (82 women, 36 men; aged 18–63, M = 31.63; SD = 13.82) provided informed consent and enrolled (Table 1). This sample size fulfilled the a priori recruitment goal of at least 25 observations per experimental condition, which is consistent

Table 1
Sample Characteristics (N = 118).

Gender	
Male	36 (30.51)
Female	82 (69.49)
Age	
18–20	28 (23.73)
21–30	44 (37.29)
31–40	14 (11.86)
41–50	9 (7.63)
51–60	21 (17.80)
Over 60	1 (0.85)
Missing	1 (0.85)
Income	
Less than $15,000	43 (36.44)
$15,000–$24,999	21 (17.80)
$25,000–$34,999	14 (11.86)
$35,000–$49,999	13 (11.02)
$50,000–$74,999	14 (11.86)
$75,000–$99,999	9 (7.63)
$100,000 and above	3 (2.54)
Missing	1 (0.85)
Education	
Less than High School	1 (0.85)
High School/GED	54 (45.76)
Some College or Trade School	33 (27.97)
College Graduate	19 (16.10)
Professional/Advanced Degree	11 (9.32)

Notes: Percentages in parentheses may add to less than 100 due to rounding.

with recent recommendations (Simmons et al., 2011) and was considered adequate to detect anticipated effect sizes based on related research. All participants received modest financial compensation for participating in a single laboratory session, which lasted about 3 h, and were fully debriefed afterward.

2.2. Procedure

2.2.1. Stress Task

The Trier Social Stress Test (TSST) was used to induce mild psychosocial stress and associated physiological responses (Kirschbaum et al., 1993). All sessions began in late morning or early afternoon to minimize diurnal influences. Sessions were conducted using two adjacent testing rooms in a laboratory on the campus of Wayne State University. Participants were first given 10 min to acclimate. The remaining TSST protocol was then presented and included a task description phase, a 10-min speech preparation period, and a 10-min performance (5-min speech and 5-min arithmetic task) given in front of a 2-person panel, consisting of one male and one female (see Supporting information for a consideration of panel ethnicity). Participants were given a 1-h recovery period following task performance.

2.2.1. Experimental Manipulation of Fairness

During the task description phase of the TSST, participants learned that they could be entered into a lottery to receive an additional $100 based on their performance on the speech and arithmetic tests, and that their performance would be immediately evaluated after the interview to determine their eligibility for the "strong performer" lottery. Two justice manipulations previously used in stress reactivity research were then adapted. These manipulations were specified as a fully crossed 2 × 2 experimental design and implemented 10 min prior to the fourth salivary collection timepoint. To manipulate distributive justice, participants were given written feedback indicating that their interview performance did (or did not) qualify them to be entered into the lottery. To manipulate procedural justice, the interview expert provided or denied participants an opportunity to actively participate in the decision process (i.e., voice) prior to the purported strong performers' lottery decision. Specifically, participants prepared a short written addendum to guide the expert evaluation, and they were led to believe that the interview expert either considered or ignored this information. All participants were randomly assigned to one of the four experimental conditions. Distributive and procedural justice manipulation checks were administered immediately following implementation of the manipulations (see Supporting information).

2.3. Measures

2.3.1. Perceived discrimination and racial identity

During prescreening, we assessed individual differences in perceived racial discrimination as well as racial identity. Perceived racial discrimination was assessed using the Everyday Discrimination Scale (Forman et al., 1997). This 9-item measure assesses perceptions of everyday discrimination. Items are rated from 1 (*Almost every day*) to 6 (*Never*). All items were reverse-scored so that higher scores indicated greater perceived discrimination. An overall score was calculated by averaging scale items (α = 0.85). Racial identity was measured using the 8-item centrality subscale of the Multidimensional Inventory of Black Identity (MIBI; Sellers et al., 1997). The centrality subscale measures the extent to which race is a core component of one's self-concept. Responses were rated from 1 (*Strongly Agree*) to 7 (*Strongly Disagree*). After reverse-scoring three items, an overall score was calculated by averaging all subscale items, with higher scores indicating stronger racial identity (α = 0.78).

2.3.2. Anticipatory stress appraisal

During the stressor task preparation phase, the 16-item Primary and Secondary Appraisal (PASA) measure was used to consider how TL would link to anticipatory stress appraisal (Gaab et al., 2005). The PASA is derived from transactional stress theory. Four lower order scales are each computed from four items that are rated from 1 (*strongly disagree*) to 6 (*strongly agree*). These scales assess perceptions of threat (α = 0.76) and challenge (α = 0.49) concerning a pending stressful event, as well as self-concept (α = 0.70) and control expectancy (α = 0.74) related to anticipated coping. The higher order primary appraisal scale (α = 0.64) combines threat and challenge subscales and measures the extent to which a pending event is viewed as stressful, positive, controllable, challenging, or irrelevant. The higher order secondary appraisal scale (α = 0.89) combines the self-concept and control expectancy and measures perceived coping resources and options when faced with a stressor. A global stress score is calculated by subtracting secondary from primary appraisal scores, with higher scores indicating greater anticipatory stress.

2.3.3. Post-task positive and negative affect

All participants completed the Positive and Negative Affect Schedule to capture momentary arousal of positive and negative emotion resulting from experimental manipulations of justice (Watson and Clark, 1999). Items were rated from 1 (*very slightly or not at all*) to 5 (*extremely*), and PA and NA calculated from the 10 items for each scale; scales were internally consistent (PA, α = 0.88; NA, α = 0.77).

2.3.4. Bloodspot collection and preparation

A bloodspot sample was collected from each participant before the stressor task, alongside the first oral fluid collection. Following a recommended research protocol (McDade, 2014), finger pricks entailed wiping the middle finger of the participant's non-dominant hand with an alcohol wipe, pricking the finger with a lancet, wiping away the first drop of blood, then collecting 3–5 blood spots dropped onto filter paper. The blood spot collection cards were allowed to dry before being stored at −80C until they were shipped frozen by overnight delivery.

2.3.5. Telomere length assay methods

Total genomic DNA was purified using QIAamp® DNA Investigator kit (QIAGEN, Cat#56504) from dry blood spots stored at −80 °C and quantified by measuring OD260. The telomere length assay is adapted from the published original method (Cawthon, 2002). Details of the adapted method can be found in Lin et al. (2010). The average coefficient of variation for this study was 2.9%.

2.3.6. Saliva collection and preparation

Six salivary samples were collected from each participant. An initial sample was collected following the 10-min acclimation period. The second and third samples were collected immediately before and after the TSST performance. Samples 4 through 6 were collected during the recovery period −15, 30, and 60 min after task completion. Participants were asked to refrain from consuming food, caffeine, citric drinks and dairy, and to avoid exercise or brushing teeth in the 30 min prior to saliva collection and to report adherence to these guidelines (Granger et al., 2007). Participants provided at least 2 ml whole saliva by passive drool at each timepoint. Two minutes were allowed for passive drool, and additional time was allotted if participants failed to produce 2 ml. Collection time and volume were recorded on each occasion. Saliva samples were divided into approximately 1 ml aliquots to minimize the impact of freeze-thaw cycles on salivary analyte data. Aliquoted samples were stored at −80 °C until shipped frozen overnight to Salimetrics laboratories (State College, PA).

2.3.7. Salivary analyte determination

Cortisol was assayed in duplicate using a highly sensitive enzyme immunoassay (Salimetrics, State College, PA). The test used 25 µl of saliva per determination, has a lower limit of sensitivity of 0.007 µg/dl, standard curve range from 0.012 µg/dl to 3.0 µg/dl, an average intra-

assay coefficient of variation of 5.32% and an average inter-assay coefficient of variation less than 10%. *DHEAs* was assayed in duplicate using a highly-sensitive enzyme immunoassay (Salimetrics, State College, PA). The test used 100 µl of saliva per determination, has a lower limit of sensitivity of 43 pg/ml, standard curve range from 188.9 pg/ml to 15,300 pg/ml, an average intra-assay coefficient of variation of 5.20% and an inter-assay coefficient of variation less than 10%. DHEAS scores were also corrected for salivary flow rate prior to analysis. A total of five participants (3 cortisol, 2 DHEAs) were excluded from analyses because of missing or out of range values (i.e., above or below the acceptable detection threshold), resulting in a final sample size of 113 participants for the DHEAs:cortisol measure.

2.4. Statistical analysis

To assess the hypothesized interactive effects of TL and experimental justice manipulations on DHEAs:cortisol, separate summative measures were first calculated for each biological stress response. These summations were calculated as total activation across the six measurements using a well-established area under the curve (AUC) method of integration and mathematical formulas developed specifically for use in biological reactivity paradigms (Pruessner et al., 2003). This approach uses a trapezoidal method to summarize changes across time for each individual participant, and we calculated total activation (AUCg). The final ratio was calculated as AUCgDHEAs:AUCgcortisol. Four-step hierarchical multiple regressions were performed to assess interactive effects of TL and justice manipulations. Significance was assessed using R-squared change and individual regression weights of predictors newly entered at each step. Consistent with prior research, preliminary analyses revealed that age and gender (–1 = male, 1 = female) were significantly associated with TL and DHEAs, respectively. Therefore, these variables were entered as a covariates on the first step of each regression. To assess main effects, TL was mean centered and entered at the second step. Two vectors representing the distributive and procedural fairness manipulations (–1 = fair; 1 = unfair) were entered on the second step. 2-way interactions were entered and assessed at the third step and included the two TL-justice manipulation interactions, and the 2-way interaction of the distributive-procedural manipulations. The hypothesized 3-way interaction was assessed on the fourth and final step. This interaction was probed separately for high (low TL) versus low (high TL) adversity African Americans using mean ± 0.5 SD to ensure an adequate number of participants in each experimental cell. These probes used one-tailed planned comparisons that were derived from specific worldview verification hypotheses. Namely, the hypothesized low distributive-high procedural justice experimental cell mean was compared to all others for high adversity individuals, whereas the hypothesized low DJ-low PJ experimental cell mean was compared to all others for low adversity individuals (see Supplemental Information Table S1 for cell means).

3. Results

3.1. Psychological and social predictors of telomere length

Prior to considering justice manipulations, we examined how TL was associated with sociodemographic variables (age, gender, education, income) as well as measures of culturally-relevant individual differences (perceived discrimination, racial identity) that were collected during prescreening. Consistent with other research, TL was negatively associated with age ($r = -0.475$, $p < 0.001$). Controlling for age, TL was not significantly associated with education ($r = -0.073$, $p = 0.436$), income ($r = 0.008$, $p = 0.928$), or gender ($r = 0.137$, $p = 0.145$). Consistent with emerging literature, there was a non-significant trend showing a negative association between perceived discrimination and TL ($r = -0.139$, $p = 0.138$). TL was not associated with MIBI/racial identity scores ($r = -0.091$, $p = 0.331$).

Table 2
Telomere Length and Justice Manipulations Predicting Affect and DHEAs:Cortisol (N = 118).

	Positive Affect	Negative Affect	DHEAs:Cortisol
Step 1 Model Δ r^2	**0.07***	**0.03**	**0.12*****
Gender	−0.22*	0.14	−0.09
Age	0.11	−0.08	−0.35***
Step 2 Model Δ r^2	**0.08***	**0.07 +**	**0.02**
Telomere Length	−0.001	0.02	−0.14
Distributive	**−0.29****	0.26**	−0.001
Procedural	−0.03	0.01	−0.09
Step 3 Model Δ r^2	**0.01**	**0.04**	**0.01**
Telomere x Distributive	−0.04	0.07	0.004
Telomere x Procedural	−0.09	0.19*	−0.07
Distributive x Procedural	0.001	0.01	−0.09
Step 4 Model Δ r^2	**0.00**	**0.04***	**0.04***
Telomere x Distributive x Procedural	0.02	0.19*	−0.21*

Notes: Coefficients are standardized regression weights. Gender (−1 = male; 1 = female) and age included as covariates. For distributive and procedural (−1 = fair; 1 = unfair). ***p ≤ 0.001, **p ≤ 0.01, *p ≤ 0.05, p ≤ 0.10.

3.2. Telomere length predicting anticipatory stress appraisal

We also examined whether TL was associated with anticipatory cognitive appraisal of the stress task, prior to manipulating justice. Consistent with emerging research (Epel et al., 2010), there was a non-significant trend between TL and stress appraisal ($r = -0.150$, $p = 0.108$), indicating that shorter TL was associated with anticipating that the stress task would be more stressful.

3.3. Telomere length and procedural justice predicting affective responses to distributive injustice

Multiple Regression results for affective stress responses are reported in Table 2 (see Supporting information for additional consideration of discrete emotions). For PA, the main effect of gender was significant, with men reporting more PA than women ($\Delta r^2 = 0.068$, $p = 0.022$; $\beta = -0.22$, $p = 0.020$). The main effect of the distributive justice (DJ) manipulation was also significant, with participants reporting less PA in the low DJ condition than in the high DJ condition ($\Delta r^2 = 0.081$, $p = 0.023$; $\beta = -0.29$, $p = 0.002$). However, the procedural justice (PJ) main effect was not significant for PA, and there were no significant interactions. For NA, the main effect of the distributive justice manipulation was again significant, with participants in the low DJ condition reporting more NA than participants in the high DJ condition ($\Delta r^2 = 0.067$, $p = 0.056$; $\beta = 0.26$, $p = 0.006$).

Of greater interest, the hypothesized 3-way interaction was also significant for NA ($\Delta r^2 = 0.035$, $\beta = 0.19$, $p = 0.040$). This interaction was probed separately for short versus long TL. Specifically, the hypothesized low-DJ/high-PJ experimental condition, in which participants received an unfair outcome (low DJ) but fair treatment (high PJ), was compared to all others for short TL participants. Alternatively, the hypothesized low-DJ/low-PJ experimental cell, in which participants received both an unfair outcome and unfair treatment, was compared to all others for long TL participants. We used one-tailed planned contrasts to consider significance and Cohen's d to consider effect size (see Supplemental Material for additional LSD pairwise comparisons). As seen in Fig. 1 upper, short TL participants expressed the most NA when low DJ was coupled with high PJ ($t(31) = 1.63$, $p = 0.057$, $d = 0.59$). Conversely, long TL participants expressed the most NA when low DJ was coupled with low PJ ($t(29) = 3.13$, $p = 0.002$, $d = 1.16$). Thus, results for NA were consistent with WVT in that TL-procedural justice congruency dictated NA responses to receiving an unfair outcome.

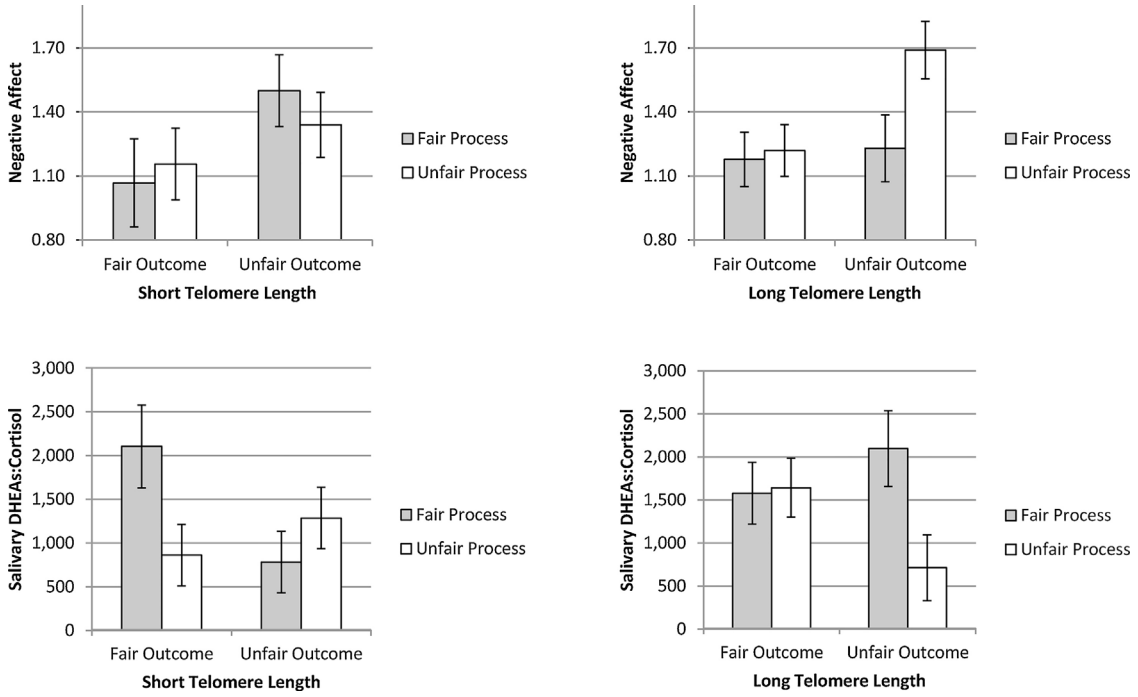

Fig. 1. Telomere Length and Justice Manipulations predicting negative affect (upper) and DHEAs:cortisol (lower) responses. DHEAs (pg/ml) to cortisol (ug/dl) ratio is expressed in thousands.

3.4. Telomere length and justice predicting DHEAs:cortisol reactivity

Multiple regression results for DHEAs:cortisol are also reported in Table 2 (see Supporting information for an analysis of DHEAs and cortisol as separate responses). Consistent with available literature, age was negatively associated with DHEAs:cortisol on the first step ($\Delta r^2 = 0.122$, $p = 0.001$; $\beta = -0.35$, $p < 0.001$). Of greater interest, only the hypothesized 3-way interaction was additionally significant for DHEAs:cortisol ($\Delta r^2 = 0.043$, $\beta = -0.21$, $p = 0.025$). This interaction was probed analogously to NA (Fig. 1 lower). As predicted, short TL participants had the lowest DHEAs:cortisol response when low DJ was coupled with high PJ ($t(28) = -1.49$, $p = 0.075$, $d = 0.56$), whereas long TL participants had the lowest DHEAs:cortisol response when low DJ was coupled with low PJ ($t(29) = 2.37$, $p = 0.012$, $d = 0.88$). Thus, results for DHEAs:cortisol were also consistent with predictions of WVT; incongruence between TL-indicated expectancies and procedural justice predicted lower DHEAs:cortisol in response to receiving an unfair outcome.

4. Discussion

A growing literature suggests that procedural justice may either reduce or elevate people's stress responses, depending on fit with individual differences characteristics that indicate justice expectations. The current analyses extend this literature by replicating these consistency-related effects, but showing that TL can be a proxy for justice expectations. In doing so, we demonstrates the utility of conceptualizing TL as an expectancy-related individual difference that predicts anticipatory, affective, and biological stress responses. This conceptualization is important because most psychosocial research has examined TL only as a consequence of stress. In considering TL as a predictor of stress responses, our results support the view that there is a bidirectional relationship between stress and TL, wherein TL reflects stressful experiences and also predicts response to stressors (Tomiyama et al., 2012). This bidirectional perspective highlights that TL can indicate a risk factor for subsequent stress-related illnesses (Epel et al., 2004). Another contribution of this study is showing that TL may be involved in acute psychosocial stress responses. Whereas numerous studies link chronic stress exposure and TL, few studies have considered connections between TL and acute stress responses. This study suggests that acute stress reactivity, as indexed by DHEAs:cortisol, is a specific biological response that is predicted by TL. To the extent that a high DHEAs:cortisol ratio may indicate adaptive stress coping, this result perhaps suggest links between TL and stress resiliency (Epel et al., 2009).

This study also highlights the complexity of relationships among TL, psychosocial stress, and acute stress responses. Theoretical frameworks on the effects of inconsistency emphasize that jointly evaluating individual-level expectancies and actual social experience is key to understanding psychological origins of stress (Major et al., 2007). Our results are aligned with this perspective – negative emotion and DHEAs:cortisol secretion in response to receiving an unfair outcome depended on whether use of procedural justice was congruent with a biologically-indicated justice expectancy. Specifically, procedural justice benefitted only African Americans who possessed a high expectation for justice. Justice theory suggests that procedural justice might be well-received by these individuals because fair processes are consistent with expectations of respect and social belonging, which can reduce stress (Lind and Tyler, 1988). In contrast, a seemingly ironic and even alarming implication is that procedural justice may be harmful to people who have a low expectation for justice. That is, bolstering fair treatment may produce unintended negative stress-related consequences, if fair treatment is inconsistent with individual expectations (Lucas et al., 2016; Townsend et al., 2010). Fair treatment might threaten the existing worldview of an individual who possesses a low justice expectancy, or derail the effectiveness of deflective coping strategies, such as attributing a negative outcome to an unfair process (Major et al., 2007).

Most crucially, however, the current study supports the view that TL may reflect post exposure to chronic adversity and act as a biological proxy for social expectancy-related individual differences among racial minorities. TL may be useful in applying inconsistency frameworks to examine racial health disparities, and in refining understanding of when, and for whom, fair treatment is likely to be beneficial (Jackson

et al., 2006).

One limitation of our experiment is that we included only African Americans. Thus, we cannot address whether TL and justice would similarly predict stress responses in other racial groups (Townsend et al., 2010). Our experiment also was not well equipped to consider same-race versus cross-race social interaction, which may be an important determinant of worldview verification and accompanying stress responses. These limitations notwithstanding, new insight into racial health disparities may be gleaned through better understanding connections among and concordance between individual differences in TL, contextual features of stressful experiences, and acute stress responses. Justice expectations, as indicated by TL, may play a crucial role in navigating stressful social contexts. For racial minorities, justice expectations may also be a vital contributor to stress-related health disparities.

Conflict of interest

The authors declare that there are no conflict of interest.

Acknowledgments

This research was supported by Award Number R21HL097191 from the National Heart, Lung, and Blood Institute awarded to the first author. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Heart, Lung, And Blood Institute or the National Institutes of Health. Partial support also came from a Wayne State University Research Supplement Award to the first author. In the interest of full disclosure, DAG is founder and chief scientific and strategy advisor at Salimetrics LLC and Salivabio LLC and these relationships are managed by the policies of the committees on conflict of interest at the Johns Hopkins University School of Medicine and University of California at Irvine. We thank Mercedes Hendrickson, Nathan Weidner, Lenwood Hayman, Edyta Debowska, Kaitlyn Simmonds, Kevin Wynne, Stefan Goetz, Rhiana Wegner, and the Clinical Research Center at Wayne State University for assistance with data collection. We also thank the Blackburn Lab at the University of California San Francisco for biotechnical support with telomere assays, and Eleanor Brindle and the Center for Studies in Demography & Ecology at the University of Washington for support with dried blood-spot collection. Finally, we appreciate biotechnical support with salivary assays provided by Carla Slike, Becky Zavacky, and Jessica Acevedo.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.psyneuen.2017.09.008.

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